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Abstracts

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Morphology, reduction, and loss of the postfrontal bone in dicynodonts (Synapsida)

Caroline Abbott, Mallory Irizarry, Kenneth Angielczyk

Dicynodonts ancestrally retain a postfrontal, but it is reduced or lost in multiple lineages. Its presence or absence is frequently used in phylogenetic analyses. Externally, the postfrontal is visible as a sub-triangular element between the frontal, postorbital, and parietal, but µCT data reveal that the postfrontal is more complex internally. In basal dicynodonts like Abajudon, the postfrontal is exposed anteriorly on the dorsal and ventral surfaces of the skull, contacting the frontal and postorbital along scarf joints. Posteriorly, the dorsal surface narrows more rapidly than the ventral, so that a process projects dorsally. Bidentalian dicynodonts with wide anterior exposures, like Oudenodon, are similar, but the lateral and medial surfaces of the postfrontal interdigitate with the frontal and postorbital. Other Permian bidentalians retain a substantial internal portion, with only a blade-like dorsal process between the frontal and postorbital. These observations suggest that ontogenetic “loss” of the postfrontal in some taxa stems from overgrowth of the dorsal portion by the postorbital and frontal, with a distinct postfrontal still present internally. Postfrontals are also lost in some emydopoids. However, in these taxa, there is no manifestation of the postfrontal whatsoever, suggesting that it never forms or it co-ossifies early in ontogeny. These data show that refined treatment of the postfrontal is warranted in phylogenetic datasets; characters describing its internal morphology may be feasible as CT datasets grow.

Bent out of shape: Alternative methods to geometric morphometrics in deformed vertebrate fossils

Caroline Abbott

Geometric morphometrics (GM) is a methodological cornerstone of evolutionary paleobiology. Inherently, GM is sensitive to shape variation, biological or not. The shape of fossils, unlike neontological specimens, are heavily affected by taphonomic deformation. Deformation severity and mode varies widely by the geologic setting and anatomy of fossils. Even mild deformation can have significant effects in shape analysis, and can both alter the structure of variation and increase variance in GM analyses. In spite of this, GM remains the preferred method of quantifying phenotype in vertebrate fossils.

To assess the influence of deformation on GM, I conducted separate ordination analyses of landmark and multistate character data to quantify either’s effectiveness in capturing taxonomic versus deformation signal in the dicynodont genus Lystrosaurus. Using 70 crania from museum collections, I 1) scored 20 characters regarding ornamentation and sutural relationships of bones, 2) compiled 2D landmark data for each specimen from the literature, 3) grouped specimens by species and deformation mode, and 4) analyzed these data using ordination and statistical analyses. Overall, the character approach effectively captured taxonomic signal while the GM approach effectively captured deformation signal, but not taxonomy. This demonstrates that for this dataset of Lystrosaurus crania, the character approach better reflects the observed variation that dicynodont paleontologists seek to quantify. Broadly, vertebrate paleontologists should be open to alternatives to GM that better serve their system and questions.

Effects of micro- and nanoplastic exposure on olfactory neural responses in fathead minnows

Samina Abedi, Rachelle Belanger, Levi Storks

Plastic pollution is an increasingly urgent environmental concern, but its effects on aquatic organisms remain largely obscure. We investigated how exposure to microplastics and nanoplastics impacts olfactory function in fathead minnows (Pimephales promelas). Fish were exposed for 28 days to control water, microplastics, or nanoplastics, and were then tested in behavioral assays to assess their responses to odorants. In the second phase of the experiment, we quantified neural activation in the olfactory epithelium of odorant-exposed fish. We used pERK staining to visualize and quantify the amount of recently activated cells in the olfactory epithelium of the fish. We then compared the number and type of activated neurons in control fish and micro- and nanoplastic exposed fish. By comparing the number of activated cells across treatment groups, we will determine whether exposure to plastics altered the ability of olfactory receptors to effectively respond to odorant molecules. We hypothesized that fish exposed to microplastics and nanoplastics would show reduced activation compared to controls because of receptor damage and impaired odorant binding. The broader goal of this study is to investigate how environmental contaminants interfere with essential sensory processes and behavior in aquatic organisms faced with human-induced environmental change.

Investigating the impacts of an industrial pollutant on songbird physiology

Keegan Abeson, Molly Mantle, Mikus Abolins-Abols

Birds are uniquely sensitive to air pollutants due to respiratory anatomy and physiology. Yet, the response of birds to some major air pollutants is unknown or poorly understood. For example, ethylene dicholoride is a persistent chemical released by industrial plants. In humans, ethylene dichloride exposure is known to have negative effects on the liver and kidney health, and it increases the risk of certain cancers. In animal models, ethylene dichloride has been shown to result in DNA damage. However, the effect of ethylene dichloride exposure on birds is, to our knowledge, unknown. The industrial park in Calvert City, KY, is an NPL superfund site and it is a major source for active ethylene dichloride emissions. Reports of mass bird mortality near the factories coinciding with ethylene dichloride emissions suggest acute toxic effects of this pollutant on avian health. We will assess markers associated with genotoxic damage in blood from birds near the pollutant point source as well as control areas in nearby nature preserves. We predict that birds near ethylene dichloride emission point source will have elevated levels of genotoxic damage compared to birds from control areas. Specifically, we predict elevated hematopoiesis, shorter telomeres, and elevated 8-oxo-guanine formation in birds from polluted areas. Preliminary red blood cell count data shows a general trend of exposure sites having negative effects on sampled individuals.

Variation in urban air pollution and vegetation predicts avian stress markers at a local scale

Mikus Abolins-Abols, Aruni Bhatnagar, Ted Smith, Jay Turner, Ray Yeager

Air pollution is known to negatively affect bird health, and some air pollutants have been suggested to drive changes in bird population size at regional level. Despite a recent growth in studies investigating the effect of air pollution on avian health, several outstanding questions remain. While urban-rural gradient in pollution has been shown to be associated with differences in avian health, air pollution can show strong spatial variation in urban areas. How air pollution exposure is associated with avian health at a local scale is not known. Also unclear is the extent to which avian health may be affected by vegetation, which modulates pollutant deposition and dispersion. Here we combine high-resolution mapping of major air pollutants (NO2 and ultrafine particles) and vegetation types with dense spatial sampling of American robins, an urban adapter, to ask how air pollution exposure and vegetation predict metrics of stress and inflammation at a small spatial scale. We show that increasing air NO2 concentration is associated with increasing baseline corticosterone levels, but not with expression on pro-inflammatory cytokine IL6 or telomere length. Increasing canopy volume was associated with lower corticosterone in female but not male birds. Our results show that variation in air pollution and vegetation at a local intra-neighborhood scale predicts variation in stress-related markers in an urban songbird.

Plastics exposure alters olfactory responses to food, social, and alarm cues in fathead minnows

Amira Abuhmoud, Samina Abedi, Zayna Hamdan, Brandon Kenaya, Mona Khalil, Luna Sharak, Levi Storks, Rachelle Belanger

Plastic pollution has emerged as one of the most pervasive threats to aquatic ecosystems, with microplastics (<5 mm) and nanoplastics (<1 μm) infiltrating freshwater and marine environments worldwide. Microplastics are plastic particles that persist in aquatic environments and can accumulate in the tissues of organisms. Nanoplastics are even smaller particles that can cross biological membranes and cause intracellular damage. Because fish rely extensively on olfactory cues to locate food, identify conspecifics, and detect predators, their sensory systems represent a critical but vulnerable target of plastic exposure. To investigate these impacts, we exposed male and female fathead minnows to polystyrene MPs (30 μm) and NPs (0.5 μm) for 28 days at concentrations of 0 mg/L (control) and 1 mg/L. Motion tracking analysis will be conducted to quantify avoidance and preference responses to ecologically relevant odorants including L-alanine (food), taurocholic acid (social), and conspecific alarm cue. Given their smaller size we do anticipate that the fathead minnows exposed to nanoplastics will experience more severe olfactory deficits compared to those exposed to microplastics. By understanding the impacts of plastic exposure on the olfactory system and impairments in olfactory-driven behavior, this study will provide insights into how micro- and nanoplastics may jeopardize fish survival.

Teaching biology to blind and visually impaired students at the college level

Susana Acheampomaah

College biology courses for visually impaired (VI) students pose unique challenges that call for creative and innovative teaching strategies, adaptive technology, material adaptations, and strong institutional support. A growing body of research and experience shows that, irrespective of biology's traditional reliance on visual observation, VI students can engage in and succeed in these challenging STEM subjects with careful planning and committed resources. This review discusses five research studies on teaching inclusive biology lessons to college students with visual impairments, focusing on research-based instructional strategies. It explores active learning approaches, adaptations, and technologies, examining their impact on conceptual understanding, engagement, and academic outcomes. The review identifies common themes, effective practices, and gaps in research, providing insights for inclusive biology education at higher institutions.

Constraints on lunge feeding: krill can clog the baleen of filter-feeding whales

Ingrid Ackerman, Dave Cade, Jeremy Goldbogen, Mark Denny

Rorqual whales grow to exceptional size by engulfing entire swarms of fish or krill, then concentrating engulfed prey by sieving them through a baleen filter. A 20-m-long fin whale can engulf 60 m3 of water and 144 kg of krill in a single gulp and expel the water in 31 s, allowing the animal to make several lunges in a single dive. But there is a problem hidden in this apparently efficient scheme. Spread uniformly across the 2.9 m2 of the baleen window, 144 kg of krill forms a layer 4 cm thick. If accumulated krill clog the filter, it could increase the time needed to expel water, decreasing lunge rate and negatively impacting foraging efficiency. We measured the hydraulic resistance of accumulating krill and incorporated this into a model along with buccal-pouch pressure generation from contraction of muscles and elastic rebound of blubber in the pouch's walls. Given force typical of mammalian muscle, our model suggests that nearly 5 minutes would be required to empty the buccal pouch, more than two-thirds the duration of typical foraging dives severely reducing feeding efficiency. Filter time could be reduced to the observed 31 s if a fraction of the baleen window is maintained clear of krill, but it is unclear how that might be achieved. Important questions remain as to how baleen whales feed.

Headbutting goats self-inflict brain injury

Nicole Ackermans, Caroline Smith, Ayodele Oyadeyi

Animal brain injury has historically been investigated through the framework of human disease prevention, or that of protective equipment and their material properties. Consequently, head impact studies on non-model animals have been framed by the assumption that headbutting species, like goats were immune to brain injury.

To directly assess this claim, we conducted a six-month pilot experiment on freely headbutting goats (n=3), adapting longitudinal clinical diagnostic procedures. Biomarkers were measured monthly in blood plasma and cerebrospinal fluid (CSF) targeting markers of neurodegeneration and the same markers were assessed via immunohistochemistry (IHC) on brain tissue.

Our results demonstrated that goats self-inflict brain injury by headbutting, and that pathology severity likely increases with headbutting frequency. IHC characterization resembled early stages of impact-related brain injury which included gliosis, varicose astrocyte projections, and pTau accumulation. CSF biomarkers showed that astrocytic markers increased and Aβ42/Aβ40 ratio decreased significantly in correlation with increased headbutting frequency.

These findings corroborate and expand histological patterns previously documented by our group in wild bighorn sheep and muskoxen, indicating that susceptibility to brain injury is widespread across headbutting bovids. Our results refute the prevailing assumption of natural immunity to brain damage in these animals and underscore the need to reframe both biological and biomedical perspectives on head impacts to better understand how repetitive brain injury develops into chronic neurodegeneration.

Influence of early-life aggression on hormones and subsequent behavior in dyeing poison frogs

Melina Acosta, Hannah Justen, Eva Fischer

Juvenile aggression is prevalent across species, yet the physiological and behavioral consequences of early-life aggressive experiences —either as the aggressor or the aggressed—across the lifespan are poorly understood. Dyeing poison frog (Dendrobates tinctorius) tadpoles exhibit intense aggression and cannibalism, making them an ideal model to test how early social conflict shapes stress physiology and behavior across development. We staged repeated aggressive encounters at three tadpole developmental stages (early, middle, late). Contest outcomes were experimentally biased by pairing unequally sized tadpoles, such that focal individuals experienced repeated wins (larger tadpole) or losses (smaller tadpole) across development. We quantified latency to attack, number of bites/bite attempts, duration of chasing, and duration of fleeing during aggressive encounters. We also sampled water-borne corticosterone levels 60 min before and after encounters to explore the underlying mechanisms of stress and aggression. We predict that repeated winners will show reduced attack latency, increased biting, and blunted corticosterone responses, enhancing subsequent aggression. In contrast, repeated losers are expected to exhibit increased fleeing, fewer bite attempts, and elevated baseline corticosterone, promoting defensive behavior in later contests. By following individuals across ontogeny, the results of this study may reveal how early-life aggressive experiences shape subsequent aggressive behavior via developmental changes in the hypothalamic–pituitary–interrenal axis.

Effects of transdermal corticosterone on hormones and partner interactions in dyeing poison frogs

Melina Acosta, Lucy Tao, Eva Fischer

Glucocorticoids (GCs) regulate stress responses and influence social behavior across taxa. In dyeing poison frogs (Dendrobates tinctorius), changes in GCs are associated with stress, development, and parental care. Previous work in poison frogs demonstrated GC state-matching between breeding pairs. To investigate the importance of behavioral interactions in this phenomenon, we tested the effects of transdermal corticosterone administration on male hormone levels, untreated female partner hormone levels, and pair interactions. Male frogs received either a low (5 μg) or high (10 μg) dose of corticosterone and a vehicle control, using a counterbalanced within-subjects

design. Following each treatment, males were reunited with their female partners, and pair interactions were recorded for one hour. Water-borne hormone levels were sampled from both sexes one hour before, 1 hour after, and 4.5 hours after treatment. Preliminary analyses indicate that corticosterone treatment influences behavior in a dose-dependent manner, suggesting a potential behavioral mechanism for hormonal coordination between partners. We predict that corticosterone-treated males will exhibit increased corticosterone levels, and their untreated partners will also show elevated corticosterone levels, consistent with physiological state-matching. By establishing an effective method for manipulating GCs in D. tinctorius, this study provides a critical step toward understanding the causal role of these hormones in social regulation in amphibians.

Effects of cold stratification duration on laboratory germination of Asclepias syriaca L.

Laila Acquavella, Lauren Cirino, Paul Engevold

Common milkweed (Asclepias syriaca L.) is a member of the Apocynaceae family native to eastern North America. It is a food source for over 450 insect species, including the monarch butterfly (Danaus plexippus) and the red milkweed beetle (Tetraopes tetrophthalmus), both of which have evolved to use milkweed exclusively as a host plant. As a result, A. syriaca is a crucial species for ecological research and conservation initiatives. However, guidance for cultivating milkweed indoors is highly inconsistent, particularly with respect to the duration of cold stratification necessary to achieve optimal germination success. We investigated the impact of cold stratification duration on the germination success of A. syriaca and applied these findings to develop an effective laboratory protocol for establishing healthy plants from seed. Three groups of 100 seeds were subjected to cold stratification treatments of 8, 4, and 2 weeks under refrigeration before being germinated under controlled conditions with a 14:10 h light:dark cycle and temperatures 30°C and 15°C, respectively. By assessing germination across treatments, this work contributed to the creation of a standardized approach for laboratory propagation of A. syriaca, supporting both experimental reproducibility and broader conservation goals. Establishing an efficient protocol for the cultivation of common milkweed in a lab setting gives individual labs the ability to affordably and reliably maintain a healthy environment for research into many essential native species.

Graded variation in chickadee D notes: the role of call structure and context on receiver response

Colton Adams, Hwayoung Jung, Todd Freeberg

Variation in vocal signals is associated with contexts directly related to fitness, including predator and food detection. Vocalization repetition rate and graded acoustic properties, like call frequency and duration, are often the aspects of signals that are context-dependent. Carolina chickadees demonstrate context-dependent vocalizations, especially within D notes during predator and food contexts. D notes are attended to by numerous species, including tufted titmice, but the call properties driving receiver behavioral changes are unknown. We tested whether variation in call acoustic fine structure and repetition rate–based on context–altered the behaviors of receivers. We generated 4 different playback treatments using D notes recorded from either a predator or food context that repeated at either a high or low calling rate. We detected an effect of playback call repetition rate on the latency for the first chickadee to approach within 10 m of the speaker, the number of chickadees to approach within 10 m of the speaker, and the number of species to approach within 10 m of the speaker. We detected no effect calling rate alone on any of our response variables for titmice. We detected no effect of acoustic fine structure alone or acoustic fine structure and calling rate in conjunction on any of our response variables. These results reveal individual sensitivity to acoustic signal variation and highlight the role that context plays in receiver responses.

Evolution of bone material properties in the skulls of artiodactyls and cetaceans

Danielle Adams, Brad Boyce, Kevin Garber, Benjamin Klitsner, Daniel Hooks, Lisa Cooper, Joy Reidenberg, Samantha Price, Richard Blob

Transitions to new environments expose species to new ecological demands, which play a major role in shaping morphological adaptations. Cetaceans (whales, dolphins, and porpoises) are ideal for studying extreme ecological transitions, having evolved from terrestrial ancestors into a fully aquatic environment. This study gathered one of the largest comparative datasets of skull elastic modulus and density in Cetartiodactyla and applied a phylogenetic framework to test how bone material properties vary across the skull and mandible of cetaceans and their terrestrial relatives. Material properties were measured using nanoindentation and microCT instrumentation, and tempo and mode of evolution were assessed using phylogenetic comparative methods. We found cetaceans occupy a broader range of material properties morphospace than their terrestrial relatives, indicating differences in selective pressures between habitats. The mandible elastic modulus and cortical density of cetaceans are lower than that those of artiodactyl mandibles. This supports previous work that suggests that the mandible is an acoustic window for soundwaves transmitted to the inner ear of aquatic mammals. However, there is substantial overlap in bone material properties across cetaceans that use different foraging modes and types of echolocation. The elastic modulus of the nasal bone showed habitat-dependent evolution, with the cetacean nasal evolving three times faster than the artiodactyl nasal. This supports the hypothesis that bone properties have shifted in response to the ecological transition to an aquatic environment.

Thermoregulatory posture alters predicted activity and fecundity in a spatially explicit model

David Adams, Matthew Gifford, Jaclyn Reifeiss

Behavioral thermoregulation helps ectotherms avoid overheating, but the fitness consequences of different strategies are not well understood. Models predicting the impacts of climate change on ectotherms incorporate behavioral thermoregulation by simulating movement between sun, shade, and burrows. However, subtler mechanisms of thermoregulation, like adjusting body posture, have received less attention. Animals can alter their posture to influence conductive, convective, and radiative heat exchange with their environment, changing their overall heat exchange. To investigate the role of posture in ectotherm thermoregulation, we generated fine-scale operative temperature maps for three different postures used by the Eastern Collared Lizard (Crotaphytus collaris). We combined temperature data from 3D printed models with thermal imagery to produce hourly operative temperature maps that were incorporated into a spatially explicit individual-based model (IBM) of C. collaris thermoregulation and energetics. We simulated minute-by-minute behavior and physiology across a 61-day period for which thermal maps were available. Predicted operative temperatures differed by posture, averaging 2.0 °C ± 2.5 (SD) between the coolest and warmest postures, with the largest gaps occurring midday. By slowing body warming, midday posture changes extended surface activity during the hottest hours by 13-19% and potential egg production by 34-48% compared to models without posture. Overall, our results suggest that models excluding posture may underestimate ectotherm resilience to climate change.

Elucidating the role of shed skins in the persistence of *Ophidiomyces ophiodiicola* in soils

Jonathan Adamski, Alessandro Catenazzi

One of the major problems that wildlife face in the 21st century is that of emergent infectious disease (EID). Particularly, there has been an increase in emergent fungal pathogens that have caused widespread declines or mortality across numerous vertebrate taxa. The disease triangle has historically been used to assess the interactions of the host, the pathogen, and the environment. Here, we explore the role of the environment in the persistence of the snake pathogen Ophidiomyces ophiodiicola (Oo), utilizing microcosm experiments. This fungal pathogen is implicated in the death and decline

of various snake populations within the United States, primarily in the rattlesnakes. Soil has long been implicated in the transmission and persistence of Oo, though there has been little evidence provided for this relationship.

Here we aim to assess the ability of soils to act as reservoirs of Oo utilizing microcosm experiments, with a focus on how shed skins may aid in the persistence of spores in the environment acting as an analog to den soils. This work will contribute knowledge to the disease triangle, filling in gaps in the role the environment plays in Oo longevity and transmission. This fungal pathogen appears to be an extreme generalist of snake species and having a complete understanding of the disease dynamics of Oo will be vital to conserving snake species.

Evidence of waterproofing lipids in amphibians and prevalence across tissue types

Sneha Adayapalam, Savannah Weaver, Brandie Ehrmann, Cristina Arciniega, Eric Riddell

Water loss can lead to dehydration, which can reduce fitness by constraining opportunities for important activities, like foraging and reproduction. Minimizing water loss is thus beneficial to organisms and, in birds and mammals, partially accomplished by lipids in the skin. This suggests that lipids act as a mechanism for reducing water loss, which should be an important step in the evolution of terrestriality. We used paired liquid chromatography-mass spectrometry (LC-MS) lipidomics to test the presence and relative concentration of waterproofing lipids such as cerebrosides and ceramides in the skin tissue, fat body (fat storage organ), and parotoid (poison) gland secretions of toads. We found these lipids in all tissue types, suggesting that waterproofing lipids could be an adaptation present throughout terrestrial taxa. High sensitivity tests like LC-MS have rarely been used before and have never been used for lipid analysis in amphibians. We also explore the relationship between lipids and water loss within and across species. Mapping lipids across amphibian tissues and linking them to evaporative water loss measurements will help identify which lipids contribute to waterproofing functions. Studying these relationships in the pivotal taxa for the evolution of terrestriality will help us understand universal constraints on terrestrial life.

Linking trait variation and population dynamics across an elevational gradient

Brett Addis, Zachary Cheviron, Jon Velotta, Nathan Senner

Environmental gradients are ubiquitous globally and known to influence many aspects of species' life histories – from their paces of life to the types of interspecific interactions in which they engage. One unexplored axis along which environmental gradients could influence species is their potential to have predictable effects on the amount of trait variation that populations along a gradient possess. If populations predictably vary in their genetic and phenotypic patterns, they might, in turn, predictably vary in their population dynamics as well. Using data from deer mouse (Peromyscus maniculatus) populations spanning an elevational gradient from 2100-4200 m, we have found that higher elevation populations predictably have less genetic and phenotypic variation than low-elevation populations. Here we extend those results to explore whether these patterns also have consequences for mouse population dynamics across this gradient. Specifically, we explore whether populations at different elevations differ in the amplitude of their seasonal fluctuations in abundance, the degree of variation in the amplitude of those fluctuations across years, the relative contribution of fecundity and survival to their abundance, and the extent to which environmental factors influence fecundity and survival. Taken together, we hope that our results can better link individual- and species level processes and be used to develop predictive frameworks that forecast how populations inhabiting different environments should be expected to respond to ongoing environmental changes.

Effects of urbanization and invertebrate diversity on body condition in deer mice

Elizabeth Addis, Brooke Robertson, Breckan Robertson, Laurie Dizney, Ashley Beck

Many omnivores are found in ecosystems that are being rapidly transformed by urbanization. This urbanization also reshapes invertebrate communities. For omnivores, like Western deer mice (Peromyscus sonoriensis), declines in invertebrate diversity due to urbanization could affect body condition, an important indicator of fitness closely tied to the diet. Invertebrates are primary sources of lipids and proteins for deer mice. We hypothesize that invertebrate diversity will be positively associated with higher body condition due to increased dietary quality. We further predict that invertebrate diversity will decline with urbanization, and, therefore, that urban mice will have lower body condition than rural mice. Captured mice were assessed using four different body condition metrics. At each mouse capture location, we used pitfall traps to collect invertebrates. Invertebrate specimens were identified to the family level, and diversity was calculated using the Shannon-Weiner Index. Statistical analyses were conducted to examine relationships among urbanization, body condition metrics, and invertebrate diversity. Our hypotheses were not supported by our results. Instead, urban sites had higher invertebrate diversity compared to rural sites. Furthermore, we found that the body condition of urban mice was higher than rural mice. Urban environments in this study supported higher invertebrate diversity, which was positively associated with deer mouse body condition. Given that our results did not align with our initial hypotheses, they suggest that additional factors influence wildlife health.

Linking thermal tolerance, phylogeny, and distribution in freshwater mussels

Hannah Adkins, Kaelyn Fogelman, Evelyn Pieper, Jessica Radich, Emalyn Blackwell, Jonathan Miller, Brian Helms, James Stoeckel

Freshwater mussels (Unionidae) are highly imperiled and vulnerable to altered surface water temperatures resulting from anthropogenic activities and changes in climate. Estimates of lethal thermal tolerance limits in unionids exist for only ~10% of North American species, and the relationship between thermal tolerance, phylogeny, and distribution is not well understood. We evaluated a combination of sublethal physiological (respiration), behavioral (foot extension, gaping), and lethal (lack of response) endpoints to acute thermal stress (+2°C/h) to better understand the sequential relationships among endpoints, differences in endpoints among tribes and populations, and whether sublethal endpoints were predictive of differences in lethal endpoints. We examined eight species from Texas, New Mexico, and Alabama including two assemblages of sympatric species. Species showed variation in the order of responses to acute thermal stress: foot extension could occur before or after a peak in respiration rate (RMRpeak), which was always followed by gaping, then lack of response to probing (CTM). Preliminary results indicate that differences in RMRpeak occurred among sympatric species and differences in CTM occurred among allopatric species and two populations of a single species but not sympatric species. Furthermore, some species showed evidence of adaptive temperature-insensitive metabolism, a response known to occur in some intertidal marine mollusks but not previously described for unionids. These patterns suggest that sublethal endpoints may play a more important role in local distribution than lethal limits.

The seasons in flight: seasonal variation in female Pieris rapae butterfly wing apex melanization

Samaa Afoke, Carly Jordan

Pieris rapae is an invasive butterfly in North America that exhibits phenotypic plasticity, which influences the amount of melanization on its wings. Females possess two melanized forewing spots, and environmental factors such as temperature and season may influence these pigmentation patterns. The butterflies use reflectance basking to reflect sunlight from lightly colored

wings onto their dark bodies. While past studies have explored seasonal and climatic influences on wing melanization, few have focused on the forewing apex area.

This study investigates whether seasonality (specifically spring relative to summer) correlates with apex melanization in adult female Pieris rapae butterflies. I hypothesize that butterflies collected during spring will exhibit less intense melanization at the apex of the forewings compared to those collected in summer.

To explore this question, I compiled specimen images from iDigBio, a database of digitized natural history collections, focusing exclusively on female P. rapae butterflies collected in North America during the 20th century. Seasonal classification was based on Julian calendar dates aligning with solstices and equinoxes. Using ImageJ software, I measured the area of apex melanization on each forewing of a sample of specimens. I compared average melanization across seasonal groups and found no significant difference.

This research addresses a gap in current literature that can inform broader conversations in entomology, climate studies, and evolutionary biology.

Comparative behavioral impacts of neuroactive pharmaceuticals on crayfish locomotion

Jalen Aftimos, Liberty Prevost, Noah Greiner, Caden Harleton, Grace Smith, Daniel Bergman

Pharmaceuticals are increasingly recognized as contaminants of concern in aquatic ecosystems, often entering waterways due to incomplete removal by wastewater treatment plants. Despite frequent detection, the effects of these compounds on non-target, neurochemically sensitive organisms such as crayfish remains underexplored. Gabapentin, an anticonvulsant that binds to presynaptic voltage-gated calcium channels and reduces excitatory neurotransmitter release, is one such emerging contaminant. Given crayfish's ecological importance and sensitivity to neuroactive substances, exposure to gabapentin may disrupt key behaviors such as locomotion. To place gabapentin's effects in context, we also examined escitalopram (Lexapro), a selective serotonin reuptake inhibitor that elevates synaptic 5-HT, and carbamazepine (Tegretol), which primarily blocks voltage-gated sodium channels and modulates GABAergic transmission. Each alters neuronal excitability through distinct mechanisms, allowing for differential behavioral effects to be observed. We assessed locomotor behavior in a Y-maze under simulated current conditions by measuring time spent moving, both before and after injection with saline (control), gabapentin, escitalopram, or carbamazepine. Comparisons across treatments suggest drug-specific patterns of behavioral change. These findings offer insight into how commonly prescribed neuroactive pharmaceuticals may affect freshwater species and suggest that crayfish could serve as useful model for evaluating sublethal ecological impacts of aquatic pharmaceutical pollution.

Liver responses to dietary alkaloids in poison dart frog Ranitomeya Imitator.

Galina Aglyamova, Adam Stuckert, Salavat Aglyamov, Amandeep Singh, Andrew Rubio, Sheila Yap, Neil Nolazco, Tyler Adams

Aposematic species combine secondary defenses – often multiple toxins – with conspicuous coloration. Poison dart frogs are an excellent model to study various ecological and evolutionary questions like Müllerian and Batesian mimicry, convergent evolution, and unique parental strategies. They exhibit striking inter- and intraspecific variations in both coloration and toxicity. Over 1200 alkaloids representing 28 classes, discovered in Neotropical poison frogs, are acquired from their arthropod diet and likely channeled to the skin glands by lipoproteins in the blood.

Despite ongoing research, the precise mechanism of alkaloid sequestration, cellular-level detoxification, and the causes of individual variability remain poorly understood. The liver, being a primary detoxifying organ, likely plays a key role in alkaloid processing, which is supported by the expression of putative sequestration proteins and the elevated Hepatosomatic Index (HSI) - (Liver weight/Total weight) *100.

In this study, we investigated the liver's role in the mitigation of autotoxicity in Ranitomeya Imitator. Using non-invasive imaging, Ultrasound and Optical Coherence Elastography, we monitored changes in liver size and stiffness as a coping mechanism to dietary alkaloids. Toxin-induced liver damage could lead to fibrosis and increased stiffness, resembling features in human cirrhosis. Field data from the San Martin region in Peru aid comparison of HSI across different species and with laboratory-reared frogs, revealing liver changes consistent with long-term alkaloid exposure.

Feeding morphology of deep-sea fishes

Jennifer Aguilera-Fonseca, Chloe Kirgan, Zebulun Soper, Emily Wynne, Emily Spina, Tristin Rose-Morley, Stephanie Billharz, Ryan Bohen, Chryssanthi Tzetzis, Taylor Oleyourryk, Mackenzie Gerringer

The deep sea is characterized by high pressure, cold temperatures, and low food abundance. To meet the challenges of these environmental conditions, deep-sea fishes have evolved a broad range of specialized adaptations, many of which remain poorly understood. To understand how deep-sea conditions impact feeding in fishes, we examined the skull morphology and feeding structures of marine fishes in five demersal families across the full bathymetric range of vertebrates. Three of these families, the cusk eels (Ophidiidae), snailfishes (Liparidae), and tripodfishes (Ipnopidae) are suction feeders, expanding their buccal cavities to generate a unidirectional flow of water to bring prey into the mouth. In contrast, the cutthroat eels (Synaphobranchidae) and rattails (Macrouridae) feed by biting, primarily scavenging on sunken carrion. We examined the three-dimensional functional morphology of these deep-sea fishes using micro-computed tomography (micro-CT) scanning. We compared tooth shape, jaw size and shape in proportion to head and body size, and pharyngeal jaw structure, and we calculated the mechanical advantage of jaw opening and closing. Even in relatively soft-bodied deep-sea fishes, pharyngeal jaws of suction feeders remained well-ossified and well-developed. Our results suggest that the closing mechanical advantage of biting fishes may decrease as depth increases, suggesting that less force may be exerted upon prey at deeper depths. This study sheds new light on evolution and feeding in the deep oceans.

Corticosterone receptor expression varies across tissues in chronically stressed budgerigars

Negin Ahmadi Jazi, Alondra Villalba, Alyssa Hernandez, Amelia Clayshulte Abraham, Tim Wright

Early life stress can trigger the release of glucocorticoid (GC) hormones and have profound impacts on the development and function of various physiological systems. Early life stress can also alter the expression of the glucocorticoid and mineralocorticoid receptors (GR and MR) that bind corticosterone and mediate the body's response to stress. The impact of chronic stress on peripheral GR and MR expression across different organs remains poorly understood. In this study, we compared GC receptor density across both reproductive and non-reproductive tissues in budgerigars (Melopsittacus undulatus) that were exposed to either a 3-week chronic stress protocol or a non-stressed control protocol during the juvenile period and/or during adulthood in a fully crossed design. We then used qPCR to measure the concentration of corticosterone receptors GR and MR in various tissues including kidney, liver, pectoralis muscle, pancreas, and gonads. We observed tissue-specific differences in GR and MR expression in response to stress exposure. Expression of GR in the pancreas was suppressed in all stress-exposed groups compared to controls, while MR expression showed an increase. Expression of MR in muscle was relatively stable across treatments, whereas stress reduced GR for both muscle and kidney. In contrast, gonadal tissues and liver showed more variable patterns of GR and MR regulation. These results suggest that peripheral organs may differ in their responsiveness to chronic stress across different life stages.

Adaptive mechanism to high-sugar diet in drosophila melanogaster: a model for diabetes resistance

Elmira Ahmadian, Mark Phillips

The global rise in diabetes prevalence demands innovative research models to uncover the genetic and physiological mechanisms underlying susceptibility and resistance. Drosophila melanogaster, with its genetic and metabolic parallels to humans, serves as an excellent system for studying complex disorders such as type 2 diabetes. This project investigates adaptive mechanisms in fruit fly populations exposed to a high-sugar diet (HSD) across generations, establishing a model for diabetes resistance. In the initial phase, we exposed control and treatment groups to either a standard diet or HSD and evaluated lifespan, mortality, and reproduction to characterize phenotypic responses. Preliminary data show that HSD-fed flies display reduced median lifespan and elevated mortality, particularly in males. Reproductive assays indicate lower egg production in HSD females, highlighting negative impacts on fecundity. These findings align with prior studies linking HSD to insulin resistance and metabolic dysfunction in Drosophila. Current analyses include quantifying glucose and triglyceride levels to track physiological markers of diabetes-like states under HSD. These measures will clarify metabolic adjustments linked to HSD adaptation across generations. We hypothesize that adaptive physiological changes will offset fitness costs of HSD, revealing pathways of resistance. This research provides a foundation for advanced molecular studies—transcriptomic and metabolomic profiling—that will illuminate genetic and metabolic mechanisms underlying diabetes resistance and guide biomarker discovery for metabolic disorders.

Hidden in plain sight: A novel symbiotic haplosclerid sponge species revealed by its mt-genome

Momin Ahmed, Jan Vicente, Dennis Lavrov

An unusual third mitochondrial genome was discovered in the genomic data from the symbiotic association between the sponges Haliclona plakophila (Haplosclerida, Demospongiae) and Plakortis symbiotica (Homoscleromorpha). This mitogenome exhibited an unusually high GC content, lacked cox2, and could not be reliably positioned among animals based on molecular phylogenetic analysis. Nevertheless, conserved gene clusters and the presence of atp9 indicated that this species is a sponge, while phylogenetic analysis using 18S and 28S places it in the order Haplosclerida of Demospongiae. Since no tissue of the cryptic sponge was found in the investigated association, its relationship with other sponges remained unclear. Therefore, we collected 10 additional samples of the H. plakophila – P. symbiotica associations to search for the mysterious third sponge. PCR analysis revealed that only one of these samples contained the novel sponge, which was distinct from H. plakophila. Morphological investigation revealed that this sponge, dubbed Haplosclerida sp. nov., while superficially indistinguishable from H. plakophila, differs in skeletal organization and spicule composition. Here, we report the unusual mitochondrial genome of the new species, phylogenetic analysis using 18S and 28S sequences, and demonstrate that Haplosclerida sp. nov. belongs to a new clade of Haplosclerida. We also report the mitogenome of Xestospongia deweerdtae, another haplosclerid species described in association with multiple Plakortis species, including P. symbiotica. Our results support multiple origins of Haplosclerida-Plakortis symbiosis and open new avenues for its investigation.

Comparative neuroanatomy of sympatric shallow-water octopuses occupying different ecological niches

Natasha Ahrweiler, Chelsea Bennice, Lauren Simonitis, W. Brooks

Octopuses have the largest nervous system of all invertebrates, allowing for complex behaviors like higher order problem-solving and decision-making skills. Such sophistication and behavioral adaptations are necessary for these shell-less mollusc occupying diverse ecohabitats. There has been a significant increase in research investigating octopus nervous systems centered on a few select species. Our understanding of their comparative neuroanatomy is limited, especially when it relates to their ecological niche. Octopuses occupy a range of ecological niches and investigating comparative neuroanatomy may aid in the understanding of how environmental pressures impact the evolution of the central nervous system for octopus species. Comparisons between benthic versus pelagic octopuses exist; however, there has yet to be a detailed study examining the nervous system of sympatric species that occupy different ecological niches. This study aims to investigate the neuroanatomy of the central nervous system between two sympatric, shallow-water octopus species (Octopus americanus and Macrotritopus defilippi) that exhibit different ecological niches (i.e., diet, behavior, and habitat use). Here, we will use contrast-enhanced (phosphotungstic acid) micro-CT as a non-destructive method to illuminate the gross anatomical and volumetric differences of neurological structures in preserved specimens. Investigating the differences between two shallow-water benthic dwelling species with dramatically different ecological niches will offer a more comprehensive analysis of how ecological niches may be mirrored in the central nervous system's structure.

Bioluminescent symbioses of fish and cephalopods with bacterial symbionts.

Hasna Akther

Bioluminescent symbioses between marine organisms and bacteria represent a fascinating intersection of ecology, evolution, and molecular biology. This review explores the symbiotic interactions of cephalopods and fishes with bioluminescent bacteria, focusing on the mechanisms of light production, host-symbiont specificity, and ecological functions. The Hawaiian bobtail squid (Euprymna scolopes) and its bacterial partner Vibrio fischeri serve as a model system, illustrating how quorum sensing regulates bioluminescence for counterillumination, a camouflage strategy that matches ambient light to evade predators. Similarly, ponyfishes (Leiognathidae) and flashlight fishes (Anomalopidae) harbor Photobacterium species in specialized light organs, using bioluminescence for predator deterrence (via startling displays), camouflage through ventral light-matching (counterillumination), prey attraction or disorientation, and intraspecific signaling such as mate selection or territorial displays.

The biochemical basis of bioluminescence involves the conserved lux operon, where luciferase oxidizes luciferin to produce blue-green light, optimized for marine environments. Hosts exhibit remarkable adaptations, such as light organ shutters and circadian control, to modulate bacterial light emission. Despite these advances, critical gaps remain, including the evolutionary origins of these symbioses, molecular determinants of host specificity, and the resilience of these partnerships to climate change and pollution.

Future research should integrate genomic, ecological, and experimental approaches to explore bioluminescent diversity. Understanding these symbioses not only illuminates fundamental biological processes but also inspires biomedical innovations, such as biosensors and tumor-tracking tools.

Cracking the case: ghost shark head development & the emergence of novel chimaera facial structures

Campbell Al-Khafaji, Ella Nicklin, Lily Frierson, Gareth Fraser

The hatching gland is an embryonic structure clustered at the anterior head of aquatic vertebrates that functions to break down the mucus and the egg case to facilitate hatching. Here, we document the development of the understudied Australian Ghost Shark (Callorhinchus milii), an oviparous chimaerid that undergoes unique head development compared to previously studied chondrichthyans. Our study shows that chimaeras undergo a morphological transition from a unique embryonic structure called the rostral bulb toward the development and functionality of the hatching gland.

We document ghost shark staging and head development through high-quality imaging to reveal the incremental stages of their unique head development. Using a combination of light microscopy, histology, and micro-computerized tomography (microCT), we confirm the appearance of a hatching gland from the rostral bulb at the rostral part of the C. milii embryonic head. We draw comparisons to other chondrichthyan species at corresponding stages, including the viviparous Bonnethead shark (Sphyrna tiburo) and oviparous Small-spotted catshark (Scyliorhinus canicula). Our findings contribute to a deeper understanding of hatching gland development, providing greater context for future hatching gland studies, such as exploring the potential role

of the hatching gland in the development of tenaculum – an articulated cartilaginous facial appendage of male chimaerids that is adorned with tooth-like structures.

Sequential temperature acclimation and metabolic rate: order-dependent effects in lizards

Richard Alarcon, Charles Watson, Ashley Sandoval, Sam Hall

Environmental temperature fluctuations strongly influence the physiology of many ectothermic species, including the brown anole (Anolis sagrei). Scientists often measure the metabolic rate of these animals at different temperatures as part of a suite of variables used to determine how they may react to environmental change or how they partition their thermal environment with other species. Current methodologies for measuring oxygen usage over time as a proxy for metabolic rate are not standardized across the discipline, but it does involve either ramping up or ramping down the temperature and measuring oxygen consumption rate at different temperatures. We hypothesize that each previous experimental temperature experienced affects the subsequent measurements and, therefore, biases the measurement depending on sequence. In this study, we measure oxygen consumption across the same set of conditions using three different sequences of acclimation temperatures prevalent in the literature and one novel methodology. Our findings will help scientists interpret their future results and make better comparisons between and within species. Understanding how measurements of this species's metabolism is affected by the design of the experiment will have much broader implications on physiological research on all ectotherms.

All life stages are not created equal: Linking density regulation, mortality, and pathways of change

Molly Albecker

Modern challenges in ecology and evolution, whether the expansion of invasive species, the decline of endangered populations, or the question of whether species can adapt fast enough to persist in a changed environment, are shaped by two fundamental processes: mortality and density dependence. Together, they determine population dynamics and the identity of the critical life stage, the stage that exerts the greatest influence on population dynamics. Yet mortality is often considered separately from density-dependent regulation, even though these forces rarely act in isolation. For species with complex life cycles, their sequence and magnitude can interact to produce nonlinear and sometimes counterintuitive outcomes. To investigate these processes, I combine stage-structured simulations with meta-analytic data, using amphibian life cycle diversity as conceptual foundation. Simulations reveal that the timing and intensity of mortality and density dependence determine population dynamics and evolutionary potential. When regulation follows mortality, the identity of the critical life stage depends on how early in life mortality occurs. When regulation precedes mortality, the timing and severity of mortality strongly influence which stage becomes critical. When both forces are strong, the critical life stage shifts over time, highlighting ecological conditions that favor the evolution of complex life cycles. In conclusion, our understanding of ecological and evolutionary dynamics improves when the timing and magnitude of mortality and density dependence are jointly incorporated into research, management, and prediction.

Integration and evolution of complex morphologies: Lessons from the cichlid feeding apparatus

Craig Albertson

How do complex morphologies arise over development, and evolve over time? These questions have been a central focus of biology for decades, and are typically addressed by distinct disciplines. This symposium is concerned with the overlap between these two questions – e.g., how does the development of complex morphologies influence long-term patterns of evolution? More specifically, it explores the concept of phenotypic integration, and the hypothesis that the coevolution of traits is due to linkages that arise over development. Given its explicit connection to evolvability, phenotypic integration has become a core principle of evo-devo, yet connections between its molecular causes and evolution consequences remain elusive. Here I synthesize research from my lab, using the cichlid craniofacial skeleton as a model, to identify the developmental genetic determinants of trait covariation, and link these to adaptive covariation in the wild. Our work implicates developmental processes, such as load-induced bone remodeling, that operate over long periods of life history, as well as genes and signaling pathways that sensitize the craniofacial skeleton to respond to such inputs as drivers of phenotypic integration at multiple levels.

Pax2 reveals a novel perinuclear structure in germ cells of the red-eared slider turtle

Scarlett Albertson, Boris Tezak, Barbora Strakova

Many reptiles, including most turtles, lack genetic determinants of sex, instead displaying temperature-dependent sex determination. Our lab uses the red-eared slider turtle (Trachemys scripta) to model relationships between temperature, gonadal fate, and germ cell (GC) biology. While examining the contribution of Pax2 transcription factor-positive cells from the neighboring mesonephros to the gonad, we noticed a conspicuous staining pattern of Pax2 around the nucleus of GCs. Due to the definition and clarity of these "Pax-hats", we hypothesized that they were labeling one of two structures previously identified in primordial GCs: Germ granules and "microtubule (MT) domes". Germ granules are thought to contain various proteins and RNAs that allow for maintenance of GC pluripotency. The MT dome, only described in medaka (Oryzias latipes), is believed to contribute to early polarization of female GCs during oogenesis. The goal of this project is to describe a previously unknown structure and identify its potential biological significance in T.scripta GCs. Comparison of Pax2 staining revealed the structure's presence across development in both male and female promoting temperatures. We then leveraged our single-cell RNA-seq data to identify candidate proteins associated with germ granules and compared their staining patterns. Finally, we investigated whether Pax2 labeled a similar MT dome as observed in medaka by staining for MT components, revealing a separate Tubb4b-positive structure reminiscent of the MT dome, only in female GCs.

Swimming efficiency and visual field dynamics in blacktip shark (*Carcharhinus limbatus*) schools

Brynne Alcorta Ordonez, Stephen Kajiura, Ashkaan Fahimipour, Marianne Porter, Darien Satterfield

Schooling behavior is widely hypothesized to provide energetic and informational advantages, yet direct evidence in large, free-swimming marine predators remains limited. Blacktip sharks form dense schools along Florida's shallow east coast, providing an ideal system to investigate the functional consequences of collective behavior. Here, we leverage modern drone and deep learning-based animal detection technologies to remotely track blacktip shark swimming and extract kinematics. Additionally, we reconstructed first-person visual fields, using computer graphics algorithms from video games, to assess how spatial position within the school affects access to visual information, quantifying how many conspecifics each individual can access information from. We tested the hypothesis that group living enhances locomotor efficiency and that position within the collective affects access to social information. We found that blacktip sharks in schools exhibit slower swimming velocities, lower tailbeat frequencies, longer stride lengths, and reduced Strouhal numbers compared to solitary estimates, indicating greater locomotor efficiency. However, positional trade-offs were evident: peripheral individuals worked harder (higher tailbeat frequencies) and had access to only half as many conspecifics as centrally positioned sharks. These results demonstrate that while schooling improves locomotor efficiency, individual position within the group mediates both energetic costs and informational benefits, revealing nuanced trade-offs in the ecology of group living.

Linking leg morphology to web architecture in Theridiosomatid spiders

Symone Alexander, Matthew Garnett, Jonathan Coddington, Hannah Wood, Tom Nguyen

The Theridiosomatidae family of spiders are fascinating due to their unique prey capture strategies and web-building behaviors. Of the 22 known genera, three (Epeirotypus, Naatlo, and Theridiosoma) construct 3D conical webs used in a slingshot motion to capture prey. These spiders can store elastic energy in both their limbs and webs for extended periods before launching at speeds and forces beyond normal muscular limits. In contrast, other genera in the family build 2D or 3D webs without using the slingshot strategy. Despite their discovery in the 19th century, key aspects of Theridiosomatid morphology, particularly how leg structure contributes to prey capture, remain unclear. Our work investigates whether differences in web architecture correlate with variations in leg morphology across the family. The use of nano-computed tomography (nano-CT) with new sample preparation techniques allows for the investigation of both leg morphologies for Theridiosomatidae species that slingshot their webs to capture prey and those that remain stationary. Segmentation of the legs fills a critical gap in fundamental understanding of how some Theridiosomatids can slingshot and withstand large tensile forces over an extended period. These insights will shed light on the evolutionary adaptations of Theridiosomatid leg morphology in relation to prey capture and offer potential inspiration for designing novel materials and microscale mechanical systems.

Incubation salinity shapes scale morphology in the brown anole

Sabrina Alfaro Mata, Daniel Warner, Sydney Wayne, Matthew Smith, Anthony Gilbert, Chris Norris, Jillian Cate

Climate change is intensifying the strength of hurricanes that impact the southern USA and is also responsible for rises in sea level that inundate terrestrial habitats with saltwater. Saltwater can act as a desiccant for taxa that rely on environmental moisture for thermo- or hydro-regulation, such as tropical lizards. The reptile integumentary system, specifically scale morphology and density, is important for water retention in arid and saline environments. The brown anole (Anolis sagrei) is an invasive lizard found throughout coastal habitats of the southern USA, particularly in Florida. This lizard often nests in sandy soils close to the shoreline, suggesting developing embryos may be able to withstand occasional saltwater exposure through mechanisms such as developmental plasticity. We investigated how exposure to saltwater affects skin development in hatchling A. sagrei. Eggs were subjected to either a saltwater submersion event followed by incubation in sand mixed with freshwater, or incubation in saline-saturated sand without prior submersion. We then quantified integumentary traits, including scale size and number, to assess the integumentary response to osmotic stress during development. We hypothesize that elevated salinity induces plastic changes to skin morphology that may serve to enhance water retention. This project aims to elucidate a critical mechanism by which brown anoles may be able to survive repeated saltwater incursions.

Sex and context mediate antipredator behavior in an urban lizard species

Carrie Alfonso, Jonathan Adamski, Nicole Chlebek, Cara Giordano, Isabella Alarcon, Lisette Elgueta, Maria Kokorelis, Ayanah Lugo, Chelsea Mercado, Gabriel Quinones, Gabrielle Romano, Bryan Rubi, Michael Valdes, Christopher Robinson, Ian Clifton, Christian Cox

Predator-prey interactions are mediated by a complex decision-making process on the part of the prey species. Individuals of the prey species strive to maximize fitness through the defense of resources while minimizing risks imposed by the predator. Therefore, individuals must weigh the costs and benefits of flight before determining when and how far to flee. Here, we examined how the timing and distance of flight from a potential predator varied as a function of sex, microhabitat, and performance ability to test what factors influence escape behavior in a successful urban colonizer, the brown anole (Anolis sagrei). Contrary to our expectations, we found no evidence of intersexual variation in flight initiation distance, but males consistently fled further than females once flight was initiated. Interestingly, we found that flight distance varied as a function of perch temperature, with lizards on warmer perches fleeing shorter distances than those on cooler perches. Finally, we found no evidence of an effect of performance ability on escape behavior in individuals of either sex. However, the reluctance to completely abandon warmer perches may suggest individuals at higher body temperatures perceive their ability to escape a predator to be high enough that the benefits of maintaining the perch outweigh the risks associated with a shorter flight. Our study indicates sex and context play important roles in mediating antipredator behavior in an urban setting.

How do phenotypic traits predict parental care in barn swallows (*Hirundo rustica erythrogaster*)?

Mira Allen, Madeleine Campbell, Sarah Verner, Toshi Tsunekage, Iris Levin

In species with biparental care, an individual's mate has the potential to contribute both direct (genetic) and indirect (e.g. parental care) benefits to offspring. Biparental care is common in passerine birds who raise altricial young, but the amount and type of care is variable between sexes and individuals. In North American barn swallows (Hirundo rustica erythrogaster) who pair socially to raise young, ventral plumage color (VPC) is a trait used in mate choice. Barn swallows mate assortatively according to VPC and older, darker males tend to have higher reproductive success. Less is known about whether and how VPC signals parental quality, and/or if care is coordinated within the pair relative to phenotype. We asked how individual and mate phenotype (VPC, age, tail streamer length, body condition), brood size, and the proportion of extra-pair vs. within-pair offspring affect parental care. To quantify rates of feeding, incubation, and nest maintenance, video cameras were mounted at each nest on set days during laying, incubation, and twice during nestling feeding. We predicted that females with higher rates of care would be older, have longer tail streamers (associated with age), have darker VPC, better body condition, and would be mated to older males with darker VPC. We predicted that males who provide more care would be older, in better condition, and mated to older females with darker VPC.

Food from inside out: Endosymbiont contributions to host surface mucus change with the environment

Luella Allen-Waller, Catherine Pfister, Dakota McCoy

Climate change imperils the nutritional symbioses that power iconic ecosystems. As ocean temperatures soar, devastating coral reefs worldwide, it is crucial to decipher how warming alters exchanges between key microbes living in different tissues of foundational symbiotic reef animals. Cnidaria (including reef-building corals and anemones) is one of the earliest phyla to evolve organized tissues, and many cnidarians rely on both (1) endocellular dinoflagellate symbionts for fixed carbon from photosynthesis, and (2) a diverse surface-associated microbiome to cycle nutrients and defend against pathogens. Yet despite the importance of these different microbial players, we don't understand how they affect one another across the cnidarian body, or how climate change might alter these interactions. Here we test the hypothesis that environmental stress impairs cnidarian surface mucosal production by lowering photosynthate transfer from their endosymbionts. We found that light limitation reduces photosynthate enrichment in mucus of the model symbiotic sea anemone Exaiptasia diaphana, confirming that endosymbiont productivity could provide a food source for ectosymbiotic bacteria. Moreover, mucus energetics were more sensitive to low light than energetics of host or endosymbiont tissues were, suggesting cnidarians can restrict photosymbiont-derived energy away from mucus as an early response to environmental change. Results of an ongoing heat stress experiment will also be shared. Ultimately this project will yield important insights about microbe-microbe crosstalk in an early-branching and ecologically critical animal taxon.

Home range size and overlap vary by age and activity in a polygynous ground squirrel

Austin Allison, Cole Deal, Sarah Kerr, Lise Aubry, Cory Williams

Animal home ranges can provide insight into the causal agents of decision-making and the resource needs of a species. Yet, relatively little is known about how and why home ranges vary by intrinsic traits other than body size. Reproductively mature adult male Arctic ground squirrels (Urocitellus parryii) amass and defend food caches prior to hibernation for use as energetic capital during the subsequent spring breeding season. Immature juvenile males do not cache food, and hence, may utilize larger home ranges to facilitate exploration and attain additional food to promote costly growth because they are freed from the need to return collected food to a central place and the defense of a cache. We tested this hypothesis by fitting free-ranging male Arctic ground squirrels with GPS-collars during the pre-hibernation period when food caches are amassed by reproductive individuals. As predicted, juvenile males utilized 109% larger home ranges than adults, with 63% more overlap among juveniles compared to adults. Home range size was further positively correlated with above-ground activity and movement, as measured by light-loggers and accelerometers, but was not associated with personality traits measured via open field and mirror image stimulation tests. Our results suggest that an individual's life-history stage and future reproductive requirements play an integral role in shaping pre-hibernation space use in these polygynous squirrels that compete for mates via physical contests.

The metabolic cost of steady state hopping on sand vs solid surfaces in desert kangaroo rats

Jeremy Almazan, Angela Horner, Craig McGowan

Desert kangaroo rats (Dipodomys deserti) are bipedal desert rodents that rely on rapid hopping locomotion for both foraging and predator evasion. While prior work has shown that their hopping kinematics (hop period, hop length, duty cycle) remain largely unchanged across firm and granular substrates, the energetic consequences of moving over sand remain unclear. To investigate substrate-dependent energetic costs, we compared post-exercise oxygen consumption (EPOC) in kangaroo rats following controlled bouts of locomotion on flat versus sandy surfaces. Animals (n=5) performed three consecutive bouts of exercise on a custom-built rotary treadmill outfitted with or without sand until fatigue, after which EPOC was measured during recovery in a fully integrated metabolic chamber system. We hypothesized that locomotion on sand would elevate EPOC relative to firm ground due to increased mechanical demands and reduced elastic energy storage. Preliminary findings on a single kangaroo rat (n=1) indicate that EPOC prior to exercise on the sand substrate was higher compared to the solid substrate.This study helps link the physiological costs of locomotion in sandy environments to locomotor performance and, ultimately, to musculoskeletal adaptation in desert-dwelling mammals

Effects of noise on oxygen uptake, cortisol, and saccular hair cell damage in Atlantic croaker

Ariel Alonso, Kelly Boyle, Bernard Rees

Noise pollution increasingly threatens fishes that rely on sound production and detection for spawning, feeding, and predator avoidance. High ambient noise can damage hair cells of the saccule in the ear and affect fish behavior. However, less is known about the effects of noise on fish metabolism and the stress response. In this study, we asked whether the oxygen uptake, cortisol levels, and auditory system of Atlantic croaker (Micropogonias undulatus) were affected by exposure to elevated ambient noise. Oxygen uptake rates were measured over 30 h using intermittent-flow respirometry, with the last 24 h under control conditions (120 dB re: 1 µPa) or exposure to white noise at 150 dB. Water samples were taken at the start and end of control or exposure periods to determine cortisol release rates by fish. At the end of the experiment, plasma was sampled for cortisol, and the ears were fixed to assess hair cell damage. Preliminary results showed an immediate increase in oxygen uptake upon noise exposure, but no difference in standard, routine, or peak oxygen uptake over 24 h. Plasma cortisol levels did not differ between control and noise-exposed fish. Thus, elevated noise immediately affects oxygen uptake but not sustained aerobic metabolism or plasma cortisol in Atlantic croaker. Ongoing analyses will evaluate cortisol release rates and hair cell damage.

Investigating the relationship between soil microbiome diversity and immune function in deer mice

Tiffany Altermatt, Abbigail Amend, Joel Moore, Elizabeth Addis, Laurie Dizney, Ashley Beck

Soil microbiota impact every aspect of the Western deer mouse (Peromyscus sonoriensis) diet, including plants and arthropods as major food sources. Diet has been shown to influence immune function in similar species such as Mus musculus; however, research has not examined underlying factors such as soil microbial diversity, particularly in a wild setting. We employed a field-based approach to investigate the relationship between immune function and soil microbiome among a variety of urban and rural habitats in Spokane, Washington. Deer mice were live-trapped across 14 different sites during May 2025. White blood cell counts were estimated for 88 individual blood samples via hemacytometer. Soil samples were collected from each field site in triplicate, and 16S profiling was performed with Nanopore sequencing for diversity analyses. While Shannon diversity differed significantly between urban and rural soil samples, no direct correlation was found between soil microbiome diversity and deer mouse white blood cell counts. Ongoing analysis is investigating effects of intermediate factors linking soil microbial diversity with immune effects, such as arthropod diversity or mouse gut microbiome diversity. This study provides a better understanding of the complex relationship between wildlife health and urbanization-related dietary impacts, using the Western deer mouse as a model organism for translation to other mammalian populations.

Elastocapillary imbibition of *Tillandsia* trichomes

Anna Alvarez, Nami Ha, Elliot Hawkes, Emilie Dressaire

Tillandsia usneoides are capable of transporting water externally and vertically through the use of flexible trichome wings This rapid transport system relies on elastocapillary imbibition; water surface tension flattens thin, elastic trichomes wings, which in turn advances the water meniscus to an adjacent trichome in a domino-like manner. Merits of this system include the ability of the trichomes to passively restore their initial positions once dry and the lack of external energy needed to advance the wetting front. In the following work, we model the meniscus position between trichome wings through a 6th order partial differential equation and compared said model to experimental data of the wetting front advancement in Tillandsia usneoides. A bio-inspired trichome structure could be utilized as an alternate method of vertical water transport. The presented model can be used to both inform the design of artificial trichome wings and to further understand the biological mechanism.

The interaction between bird flight styles and their airfoil aerodynamics

Faiza Alvi, Huanglun Zhu, Andrew Engilis Jr., Tyson Hedrick, Jonathan Rader, Peter Sharpe, Christina Harvey

Birds fly in many ways; they flap, glide, hover, or do a combination of these and other maneuvers. Previous work found evidence that the aerodynamic efficiency—quantified by the maximum lift to drag ratio—of bird wing airfoils did not depend on whether the dominant flight style was flapping or gliding. However, that study was limited by the number of specimens included and a rudimentary method to categorize flight style. In this work, we hypothesize that birds that are specialist gliders have a significantly higher maximum aerodynamic efficiency than birds with other flight styles. To test this hypothesis, we collated a dataset of 1065 preserved bird wings from 181 species. The 3D scanned wings were sliced using custom software that extracted airfoil shapes along the wingspan at intervals of 5% of the specimen's estimated wing length. Next, we estimated the maximum aerodynamic efficiency for each airfoil using an augmented version of NeuralFoil, an open-source neural network trained on XFOIL data. Concurrently, the dataset was clustered into flight style groups by leveraging museum expertise combined with a network theory-based methodology. In summary, this work will directly test our hypothesis linking

flight style morphology to aerodynamic efficiency. The findings of the study will provide inspiration for engineered designs using relevant avian geometries with desirable qualities and build out a foundational understanding of how morphology dictates flight performance.

Host plants' effect on *Bicyclus anynana* butterfly development

Jonas Amenyo, Erica Westerman

Host plant nutrients and chemical composition play a crucial role in lepidopteran evolution and population dynamics, influencing growth rates, survival, and reproductive success. Here, we assess the role of within-species host plant variance in nutrient and chemical composition on the butterfly Bicyclus anynana. We utilized two different popcorn strains, our standard Jollytime (yellow) popcorn, and a blue popcorn, hypothesized to provide different nutritional profiles from yellow corn, including higher anthocyanin antioxidants, increased protein content, and altered carbohydrate structure. Using a split-family design, caterpillars were reared on either yellow or blue popcorn strains until pupation. We measured fitness-related parameters, including development time, pupal weight, fifth instar larval weight, and adult emergence time. We also analyzed the composition of plant carbon and nitrogen and measured micronutrients to assess nutritional variation. We found that yellow corn contained significantly higher levels of carbon, nitrogen, and essential micronutrients (Boron, Iron, and Manganese) than blue corn. While corn strains did not affect pupal or larval weights, families showed distinct developmental responses: some families developed faster on yellow corn, while others performed better on blue corn. This pattern across pupation and emergence timing reveals genetic-by-environment interactions where family genetic background determines which corn variety promotes faster overall larval-to-adult development.

Role of cold induced metabolic upregulation in mitochondrial respiration dynamics in house sparrows

Sampath Kumar Anandan, David Swanson, Chelsi Marolf, Soren Coulson, Yufeng Zhang

Cold challenges induce shivering thermogenesis in birds to generate metabolic heat and involves increased rates of ATP generation and hydrolysis in the mitochondria to support the thermogenic demands. We compared mitochondrial respiration rates using high resolution respirometry in house sparrows acclimated to warm (25°C), stable cold (3°C) and fluctuating cold (3°C average; range of -10 to 16°C) conditions for six weeks. We hypothesized that mitochondrial respiration rates would be higher in cold than in warm treatments and might be further elevated in fluctuating cold treatments if temperature variability influences mitochondrial respiration capacity. We isolated mitochondria from pectoral muscle and liver and measured mitochondrial respiration through the individual components of the electron transport chain in a sequential manner according to standard protocols. Pectoralis muscle showed no significant differences in resting (state 2), active (state 3, for both complex 1 and complex 2 substrates), or leak mitochondrial respiration rates, suggesting little impact of mitochondrial respiration on increased thermogenic performance in cold-acclimated groups. In contrast, resting, active (for both complex 1 and complex 2 substrates), and leak mitochondrial respiration rates in liver were higher in the fluctuating cold group compared to both stable cold and warm groups. These differences were consistent with treatment differences in basal metabolic rate (BMR), suggesting that fluctuating cold may mediate, at least in part, changes in BMR through adjustments in liver metabolic capacity.

Buckle up for buckling: behavior of poacher fish scales under compression

Brody Andersen, Karly Cohen, Megan Vandenberg, John Michael Racy, Katherine Corn, Cassandra Donatelli

Poacher fishes (Agonidae) are a family defined by their bony armor. Unlike the flexible scales possessed by many fish, poachers are encased in rigid plates that overlap in rows. Uniquely, when viewed in the hoop direction, rows appear as distinct geometric rings which can be dissected out both digitally and physically. These rings vary across species in both number and arrangement of plates, forming octagons, hexagons, and squares. The diversity in row count and overlap across species implies different ring designs may be specialized for different functions. To test this, we 3D-printed models of poacher armor rings as regular polygons with flexible joints at either the center or corners, varying the number sides to match the diversity seen in nature. We used a material testing system to compress the models to a locking position, recording force displacement curves for each model. We found that, across most shapes, models with central joints, which most closely match poacher scale morphology, require more force to reach a locked position than models with joints in the corners. This means the models that closely resemble fish, despite being contradictory to conventional engineering design, resist compression better. Poacher fish are not fast swimmers and thus hide under rocks, compressing themselves, but due to their scales resistance, they can prevent damage to their soft internal structures.

Taxonomic names reveal inequity and coloniality - a study of three vertebrate classes

Emily Andersen, Suraj Prakash, Rubi Rivera, Imaandeep Bual, Landin Burdeshaw, Landon Chipps, Eduardo Garcia, Melissa Jauregui, Maya Rodriguez, Mico Sarsozo, Ivan Soto, Diya Taha, Rodrigo Tapia-Baca, Radjeep Toor, Ulrike Muller

Taxonomic species names offer a historical record of who participated in natural history as a scholar. Few studies have focused on binomial species names as data to assess past and current inequities and coloniality patterns. In this study, we compared data from six taxonomic groups within the vertebrates (such as sharks, bats, carnivores, insectivores, corvids, and other songbirds). We collected data on the people listed as part of the binomial species names (names of the describers and year of the description). We found that the vast majority of species (60 to 80 percent) examined in this study has been described by men of European birth or European ancestry. Women account for roughly one to six percent of describers. Women and non-European describers began to contribute in significant numbers in the 20th century, often as co- rather than sole describers, with the average year of description for women describers being 100 years later than the average for men describers. Our pilot data show consistent patterns across taxonomic groups. Future expansions of this project will analyze historic trends in geographic and gender disparities in more detail. We expect that gender and geographic disparities are largest and remain larger for taxonomic groups that require considerable resources to collect specimens, such as marine species, in contrast to taxonomic groups that require fewer resources, such as flowering plants.

Brain transcriptional patterns following behavioral cross-sexual transfer in a biparental cichlid.

Andrew Anderson, Suzy Renn, Helena Dobiecka

Julidochromis transcriptus, a biparental cichlid, forms pairs where the male is typically larger than the female and there are distinct roles for each partner. In situations where the female is larger than the male, she plastically takes on the behaviors of male. Using the Ancestral Modulation Hypothesis framework, we predicted this cross-sexual transfer would recruit male-biased signaling pathways. We previously showed females increase circulating androgens and now we are investigating transcriptomic patterns in the brain. Overall transcriptomic patterns are matched by size of the individual and large females are recruiting regulatory genes suggesting females are using the male-biased expression patterns to generate these behaviors and are doing so by altering their own regulatory patterns. Further, we find large females alter gene expression associated with the gonadal hormone signaling pathway, with androgen receptors correlating with the observed behaviors. Interestingly, androgen receptors alpha and beta show different patterns based on the observed behavior indicating unique regulatory roles within the androgen signaling pathway.

Flexible tongue, constrained hyoid: Bearded dragon hyolingual kinematics vary with prey size

Dylan Anderson, Nikole Schneider, Amelia Brady, Hannah Shideler, Helaina Callis, Ani Smith, Maressa Kennedy, Harlow Smith, Cate Pradhan, Thomas Stroud, Elska Kaczmarek, Armita Manafzadeh, Paul Gignac, Christopher Anderson, Christopher Mayerl

An organism's ability to consume food with variable properties is critical for survival. In squamates, the hyolingual system is responsible for acquiring food and transporting it through the oral cavity. While numerous studies have examined food acquisition in lizards, the mechanisms underlying intraoral processing and transport remain poorly understood, especially in the context of variable prey properties. To explore possible variation in hyolingual function during processing as a function of prey size, we used marker-based X-ray Reconstruction of Moving Morphology (XROMM) to quantify bone kinematics and muscle shortening in bearded dragons feeding on insect prey that ranged in size by over three times. We found that the hemimandibles used long-axis rotation during occlusion to process prey between the teeth. When feeding on increasing prey size, the tongue and jaw exhibited larger excursions during acquisition, processing, and transport, especially in the lateral movement of the tongue during processing. In contrast, the kinematics of the hyoid were similar when feeding on large and small prey, suggesting consistent hyoid function across prey size. Together, these results indicate that prey size influences certain aspects of hyolingual function, particularly mediolateral tongue movement, while other components, such as hyoid biomechanics, may be more constrained and stereotyped. Furthermore, these data indicate that squamates possess substantive neuromotor flexibility to accommodate variation in food properties and match functional demands with biomechanical output.

Feywild invasion biology: Scientific outreach activities using cosplay and role play

Philip Anderson, Avalon Feiler, Lisa Lundgren, Gabriel-Philip Santos

Our world is deeply dependent on the understanding and application of scientific data and inquiry particularly for issues of conservation and environmental change. However, the public's scientific literacy appears to be on a decline. This is not a simple problem to solve as the public are often exposed to scientific concepts in artificial or incoherent ways and even when scientific communicators seek to make science more accessible through professional development, audiences often perceive such communicators as ineffective.

Here, we describe Heroes Wanted: Invasion of the Feywild, a series of community outreach events my lab led this past year in collaboration with Cosplay for Science. Cosplay For Science is an initiative that researches and implements best practices in science communication using cosplay and role play. Scientists participate in immersive experiences for general audiences built on popular culture. For our events, a collection of graduate, undergraduate and community volunteers dressed as Dungeons and Dragons characters and ran visitors through training activities themed around an invasion of Illinois by magical creatures to introduce them to concepts from invasion biology. These events attracted over 200 visitors and garnered requests for further events both locally and across the state. We present our approach as a method for community outreach that explores new ways to reach audiences while removing barriers to engagement with scientists who might otherwise seem intimidating or unrelatable.

Biological reality complicates universal theory: A decade of work on puncture across organisms

Philip Anderson

Puncture, using sharpened tools to penetrate a target, is widespread in biology, with examples found across phyla spanning several orders of magnitude in size (rhinoceros horns to jellyfish nematocysts), speed (cactus spines to cone snail harpoons) and a variety of functions (predation, defence, intraspecific competition and reproduction). For the past decade, my lab has explored the fundamental mechanics that underly these examples, developing a mathematical framework for the energetics of puncture applicable to any biological system. Unified underlying mechanics, coupled with the seemingly ubiquitous long, thin shape of puncture tools has lead several studies to suggest that there is a universal design principle for biological puncture tool morphology.

However, this focus on universality often ignores the actual diversity of biological reality. Using our energetics framework as a baseline, my lab has further explored how biological reality complicates the ideal puncture scenario. We have identified aspects of tool morphology beyond the universal design (flatness, ornamentation, curvature) that significantly alter puncture performance between species. We have examined complex relationships between tool shape, target structure and puncture dynamics, suggesting shape may not always be the most important factor to puncture. Synthesizing this work with biological datasets reveals trade-offs in tool shape that belie the idea of a universal design. By exploring how biological complexity interacts with common physical principles, we gain a more holistic understanding of biological puncture.

Behavior, body and brain temperature correlates of a desert lizard in the field

Roger Anderson, Peter Zani

In the northern extreme of the Great Basin desert scrub, the nanoclimate conditions vary markedly within and among days during the peak of the activity season of the Long-nosed Leopard Lizard, Gambelia wislizenii. Maintaining a presumed high and narrow range of body temperatures is expected to require spatial and temporal adjustments of behaviors, postures and nanohabitat use. Hundreds of opportunistic captures of undisturbed lizards across a variety of environmental conditions were made during a 27-year study of the effects of interannual climate variation on a desert community. Hence, a variety of ecologically relevant spatial and temporal correlates of deep cloacal (body) temperatures with behaviors could be made. Moreover, simultaneous comparisons of head (brain) and body temperatures in field-captured lizards in 2025 permitted new perspectives on thermoregulation in this lizard species.

The relationship between epigenetic signaling and growth patterns in chestnut-crowned babblers

Susan Anderson, Andrea Liebl

All developmental conditions are expected to have lasting effects on phenotypes; those that impact individual size and growth, however, likely have an outsized effect. Such phenotypic variation is likely mediated by differences in physiology (e.g. metabolism differences). However, few studies have explored the underlying molecular mechanisms mediating these differences. Here, we investigate how variable developmental environments can influence DNA methylation of promoters of genes related to body condition and growth. Specifically, we used chestnut-crowned babblers, an avian system endemic to the Australian Outback, where developmental environments are particularly harsh and often variable. DNA was extracted from blood collected from chicks (~15 days) and enzymatically converted DNA was sequenced (EM-seq) to identify methylated cytosines. Whole-genome analysis was performed using MethylKit and regression analyses to identify differentially methylated regions related to morphological traits (e.g., mass, tarsus length, body condition, and wing length). We predict that methylation of areas important for growth (e.g. growth hormone, metabolic genes) will be related to differences in size and condition in nest-bound chicks. Understanding the relationship between methylation and phenotypic variability will increase our knowledge generally about how molecular processes help shape phenotypes through phenotypic plasticity and flexibility.

Neuroanatomical correlates of ecological specialization in two mustelid species

Blake Andrea, James Bates, Dominik Valdez, Heather Smith, Leigha Lynch

Understanding the morphological variations of neuroanatomy among Carnivorans can provide insight into how ecological specializations shape sensory processing across species. In this study, we investigated and compared the 3D morphology of the brain and cranial nerves in two closely related species: the North American river otter (Lontra Canadensis) and the

long-tailed weasel (Mustela Frenata). We utilized diceCT images of both species, acquired from Morphosource, and processed them in AVIZO software to segment and reconstruct 3D models of the brain and cranial nerves. Volumetric analyses were conducted to compare the relative sizes of brain regions and cranial nerve branches, providing a quantitative framework for assessing interspecific differences. The North American river otter exhibited a greater lateral expansion of the cerebral hemispheres and a maxillary branch (V2) of the trigeminal nerve with greater volume, likely supporting its enhanced vibrissae sensitivity that is crucial for detecting prey and navigating aquatic environments. In contrast, the long-tailed weasel exhibited a greater olfactory bulb-to-brain ratio, which is consistent with its reliance on olfaction for terrestrial hunting and predator detection. These findings highlight sensory trade-offs between semi-aquatic and terrestrial mustelids and point toward future investigations of how neuroanatomical specializations correlate with ecological strategies across diverse mammalian lineages.

Modular robots as experimental tools for studying reptile locomotion

Duncan Andrews, Baxi Chong

Reptiles exhibit a remarkable diversity of body forms, ranging from fully limbed lizards to completely limbless snakes. Over the past century, extensive research has suggested that limblessness has evolved independently more than 25 times, often hypothesized as an adaptation to locomotion in cluttered environments. Yet, despite this recurring pattern, tools to test such hypotheses and compare them with alternative evolutionary pathways remain limited. A key challenge lies in the limited data available on both species (e.g., extinct intermediates) and behaviors (e.g., infrequent or uncoordinated locomotion). Here, we introduce a robotics-based framework to explore "what-if" questions in the evolution of locomotion. For example: How would lizards perform if they moved like snakes in cluttered environments? Are short-limbed, elongate lizards evolutionary intermediates, or are they specialized for their niches? To address these questions, we developed modular reptile-like robots and associated models that enable systematic testing of morphology–locomotion relationships. These robots navigate terrains with controlled levels of complexity, allowing for quantitative comparisons between movement strategies. Preliminary results indicate that locomotor performance is not strongly dependent on limb placement along the body (e.g., closer to head vs. tail). By integrating robotics with evolutionary biology, our platform offers a novel, experimental complement to traditional approaches, which provides new opportunities to interrogate the principles underlying reptilian body form evolution.

Effects of temperature on haemolymph macromolecules and active metabolism in adult American Lobster

Nicholas Angeli, Joseph Covi, Andrij Horodysky

The metabolic responses of decapod crustaceans to changing environmental conditions have been fairly well-studied in the laboratory. Yet, there remains an exigent need to explore the mechanisms through which American lobster adults respond to thermal and ocean acidification stressors. To begin to address that question with adult American lobsters (Homarus americanus) from continental shelf habitats with fairly stable physicochemical conditions, we used an interdisciplinary approach that applied a combination of intermittent-flow respirometry and biochemical assays to examine the effects of temperature on lobster active metabolic rate. Lobsters were acclimated for 2 weeks at 10°C or 20°C. On each experimental day, two lobsters were removed from treatment tanks and exercised to exhaustion using standard chase protocols. Of each daily pair, one lobster was placed directly in a Loligo Systems respirometer for 24 hours to measure oxygen consumption. The second lobster had 30 CCs of haemolymph removed for biochemical assays of glucose and protein before and after exhaustion. Results demonstrate that high temperatures increase active metabolism, time-to-baseline-recovery, and biochemical proxies of stress compared to lower temperatures. When active metabolic rate data are combined with outcomes of resting metabolism experiments, lobsters at 20°C have reduced aerobic scope relative to those at 10°C. This suggests that higher bottom temperatures may cause biochemical stress and increased metabolic costs in adult lobsters from deeper continental shelf habitats.

Balancing the costs: effects of thermoregulatory behavior on fitness in altricial nestlings

Sydney Anglin, Emmy James, Elizabeth Derryberry

Behavior is a versatile tool organisms use to navigate challenges such as disease, competition, sensory pollution, and heat, but these responses often come with costs. This is the case for thermoregulatory behaviors, which, while useful in mitigating heat, may impose sublethal costs that ultimately reduce fitness. For example, panting facilitates evaporative cooling but can lead to significant mass loss, and time spent thermoregulating may trade off with other fitness-related behaviors, such as acquiring food. Altricial young are especially vulnerable to heat, and while studies suggest thermoregulatory behaviors carry costs at the nest level, little is known about their scope and consequences at the level of the individual chick. Here, we present a comprehensive analysis of how individual chick behavior during a heat challenge influences mass change and fledging success in tree swallows (Tachycineta bicolor). We focused on panting and movement within the nestbox as thermoregulatory responses, examined their relationship with begging behavior, and measured outcomes including mass immediately after the heat challenge, mass one day after the trial, and fledge success. Using heat packs, we experimentally elevated nestbox temperatures, filmed nestling behavior with mounted cameras, and scored the behavior of each chick individually. Our findings illuminate possible sublethal effects of heat on fitness, demonstrating how thermoregulatory behaviors can directly and indirectly affect survival outcomes.

Histological and biochemical assessments on the impact of DCOIT in the American oyster

Srabanti Das Ankhi, MD Rahman

Antifouling biocides are frequently used to prevent fouling organisms from harming ships and boats. DCOIT (4,5-dichloro-2-n-octyl-4-isothiazolin-3-one) is a common biocide in antifouling paints, but it can adversely affect nontarget organisms. This study examines the effects of short-term exposure (5 days) to environmentally relevant concentrations of DCOIT (low dose: 1.8 µg/L, high dose: 3.6 µg/L) on the American oyster (Crassostrea virginica). Histological analyses showed significant ($P < 0.05$) changes in gill and digestive gland structures, including gill filament atrophy and an increase in the cross-sectional area of digestive gland tubules. Periodic acid Schiff (PAS) staining confirmed a significant ($P < 0.05$) reduction in mucus production in both organs, which is vital for their defense and food processing. Additionally, immunohistochemical analysis showed increased expression of 3-nitrotyrosine protein (NTP) in the gills and digestive glands of DCOIT-exposed oysters. These findings suggest that environmental concentrations of DCOIT may impair physiological functions in oysters.

Morphological differences accumulate before mating preferences between populations of walnut flies

Sophia Anner, Jenna Burns, Isabella Bastien, Marlee Mincher, Brianna Neubacher, Alycia Lackey

Crucial to our understanding of speciation is how populations diverge and accumulate differences. Walnut-infesting Rhagoletis speciated allopatrically with geographic isolation as the primary barrier to reproduction between species. When this barrier is experimentally removed, sexual isolation is maintained, suggesting behavioral mechanisms underlie mating decisions between closely related species. We performed mate choice assays by pairing a female R. juglandis with a conspecific and a heterospecific male. We found strong assortative mating (91% of females mating within species) which is not surprising given ~0.5 million years of divergence and morphological differences, notably in body size.

To further understand how sexual isolation develops within species, we conducted behavioral trials between two geographically separated (~150

km) populations of R. juglandis. We also measured body size to evaluate morphological variation. We found that individuals from one population were significantly larger. However, we found no evidence of assortative mating; only 42% of copulations were between flies of the same population. These results suggest that morphological divergence between populations may precede divergent mate choice preferences. While species of Rhagoletis exhibit strong sexual isolation in experimental settings, geographically separated populations of R. juglandis do not, despite evolving morphological differences. Divergence in courtship behavior may additionally clarify patterns of sexual isolation. Understanding the full scope of variation within and between Rhagoletis species can clarify how mating decisions contribute to early stages of speciation.

Investigating the impact of bottlenose dolphin fluke shape on the cost of swimming

Gabriel Antoniak, Enric Xargay, Nicole West, Bogdan-Ioan Popa, Kenneth Shorter

Fluke parameters such as span, area, and shape vary between individuals, but the effect of these differences on movement costs during swimming is still an open question. In this work we used data from six individual dolphin flukes and used principal component analysis to identify key features that describe the variation in fluke shape. Key parameters that captured variance between the individual flukes were associated with the span, the sweep back angle, and fluke tip shape. The PCA analysis was then used to create a series of flukes spanning this parameter space. The dolphin flukes from the PCA analysis were combined with a low order five segment rigid body model with a flexible fluke to investigate how mechanical costs and efficiencies during steady state swimming varied with fluke shape. Simulations were run over a range of speeds (0.5 – 2.0 BL/s) for hundreds of combinations of fluke parameters. Simulation results indicate that speed has the largest impact on cost-of-transport, varying approximately threefold over the range of parameters and speeds investigated. For any given speed, fluke area plays a significant, if more modest role, with about a 6% change in the cost of transport depending on fluke geometry. These simulation results indicate that fluke geometry has the potential to impact swimming energetics.

Linking heart rate and locomotor effort: fitness metrics for dolphins

Gabriel Antoniak, Tshepo Yane, Nicole West, Kira Barton, Kenneth Shorter

Marine mammals experience increasing environmental stressors including acoustic disturbances, climate change, and pollution events, yet current health assessment methods provide only fragmented snapshots of physiological condition. In this work, we simultaneously measured heart rate and swimming kinematics in bottlenose dolphins to investigate fitness in dolphins and address methodological gaps in marine physiology. Biologging tags equipped with ECG sensors and accelerometers were attached to dolphins using suction cups. Measurements were made during quiet breathing (n=3), breath holding (n=3), and swimming while breath holding (n=6) to investigate the interaction between the mammalian dive response and exercise-induced cardiac demands during locomotion. We hypothesized that increased swimming speed would reduce the magnitude of bradycardia as metabolic demands override this physiological response. Heart rate was calculated from the EKG data, and a drag based modeling approach was used to estimate power output during swimming. Results showed a positive relationship between swimming speed and heart rate change (ΔHR = HRlap - HRbreath-hold), with $R^2 = 0.128$. When referenced to breath-hold baselines, faster swimming speeds corresponded to higher heart rates, indicating metabolic override of the dive response despite bradycardic conditions. This work provides a framework for non-invasive, integrated physiological analysis of dolphins

Speciation between grains of sand: A new Caribbean species of *Humesiana* (Crustacea: Cumacea)

Samantha Grace Antonio, Sarah Gerken

Cumaceans are characteristic benthic crustaceans that reside in the sediment all over the ocean floor. They have been known since the 17th century and include 8 known families, approximately 170 genera and around 2000 species, although new species are frequently discovered. Recently, cumaceans of the genus Humesiana were identified amongst the sand grains of meiofaunal samples collected in Bocas del Toro, Panama. The genus Humesiana was described in 2001 off Guadeloupe island, and contains one known species. Cumaceans are poor dispersers because of their limited swimming legs and minuscule body size, which ranges from 1-10 millimeters in tropical waters. Guadeloupe Island is about 1,600 km away from Bocas del Toro, and given the distance and poor dispersal capacity of cumaceans, the Panama specimens are likely to be a new species. The new species is being described integratively, including classical morphological taxonomy combined with a transcriptome. This meticulous process includes many components: microscopy, dissection, line drawing, digitization, RNA extraction and sequencing. This new species description continues the historical work of past carcinologists and increases our knowledge of the biodiversity of the Caribbean sea.

Neuromuscular and respiratory coordination forges a hammer-like mechanism for woodpecker drilling

Nicholas Antonson, Stephen Ogunbiyi, Margot Champigneulle, Thomas Roberts, Franz Goller, Matthew Fuxjager

Woodpecker drilling and tapping behaviors have long garnered significant interest for their high force, high frequency strikes. However, how these birds integrate muscular and respiratory coordination to produce these extreme behaviors remains poorly understood. We combined multi-muscle electromyography across the woodpecker body plan with air sac pressure and syrinx airflow measures to quantify the physiological coordination used to produce these behaviors. Based on analyses of EMG timing and activation, we put forth a hammer-like model of muscle activation for these behaviors where head and neck muscles contract to forge a stiffened cephalon-cervical lever arm that efficiently transfers kinetic energy from the bird's bill into the wood. Further, we present evidence that hip protractors may help power protraction while the tail appears to provide a brace for the bird's body against the substrate. Respiratory recordings of drilling showed that birds actively exhaled through each strike with slight pressure dips at impact (i.e. a grunt-like maneuver) while keeping the syrinx open. During repetitive tapping, we show that respiration is phase-locked 1:1 to the strike rate and abdominal muscle activatoin, implying the presence of minibreaths for repetitive striking in woodpeckers. These results demonstrate that drilling and tapping behaviors are achieved through exquisite coupling between muscular and respiratory systems, providing a mechanistic framework for how woodpeckers produce their extreme behaviors.

Diving and thermoregulatory behavior of green sea turtles in San Diego Bay

Aniela Anuszczyk, Cameron Mullaney, Garrett Lemons, Jeffrey Seminoff, Andrew Maurer

Green turtles in Southern California occur in foraging habitats at the northern extreme of their eastern Pacific range. These temperate habitats are both relatively cold, and adjacent to dense human populations and the associated anthropogenic impacts. In this context, information on potential thermoregulatory behavior and patterns in surface time is needed, but lacking. We used a compact biologging device manufactured by Customized Animal Tracking Solutions (CATS), mounting it on sea turtles in San Diego Bay. The CATS sensors, collecting measurements including temperature and depth at 5 hz, provided information on fine-scale behavioral patterns, including diving behavior, and its potential relationship to thermoregulation. We found that green sea turtles spend most of their time in the top two meters of the water column. The deepest water accessed by green turtles do not tend to exhibit the coldest temperatures, which could suggest the use of deep water thermal refugia in San Diego green sea turtles.

Electrojellies and their energetic wakes

Simon Anuszczyk, John Dabiri

Electrical stimulation of gelatinous marine invertebrates allows the study of swimming animals with prescribed motions. One key question is the effect of electrical stimulation on swimming hydrodynamics, biomechanics, and associated energy consumption. Here, we experimentally investigate jellyfish wake hydrodynamics using 3-dimensional, 3-component, particle image velocimetry. These experiments enable measurements of wake momentum loss and vortex characteristics spatially across the jellyfish exumbrellar surface, and temporally during the contraction and relaxation phases. Repeating these measurements with natural and electrically stimulated jellyfish allows the comparison of wake energetics and biomechanics of the swimming stroke. While previous work found electrically stimulated jellyfish consume more energy than natural jellyfish, the origin of this energy consumption is not well understood. Suboptimal muscle activation could play a role in reducing energetic efficiency as has been documented in other animals. These measurements inform an analytical model of jellyfish wake dynamics.

At what spatial scale can top-down effects be detected? A field test with lizards and leaf herbivory

Miles Appleton, Georgi Bumbray, Noah Cepeda, Renzo Moreno, Anabelle Barrantes, James Stroud

Understanding the spatial scale at which predators influence prey communities is fundamental to eco-evolutionary theory, as it determines trophic cascade strength and shapes how local interactions scale up to influence ecosystem-wide patterns and responses to environmental change. While top-down effects of predators on herbivores are well-documented, the spatial scale at which these patterns operate (or can be detected) remains poorly understood. We investigated whether top-down effects are detectable at fine spatial scales using an island population of insectivores (Anolis lizards) in Miami, Florida USA. We quantified herbivory rates by estimating proportional damage on 10 leaves at 220 systematically placed locations across a 5x5m standardized grid covering the entire island (n=8,800 individual leaves across ca. 5,000m2 total area). Using comprehensive island-wide lizard census data, we calculated local lizard density at each of these 220 locations (n=825 lizards). We hypothesized that areas with high lizard density would exhibit significantly reduced rates of leaf herbivory compared to low lizard density areas due to the top-down effects of predation on herbivorous arthropods. These findings demonstrate that vertebrate insectivores create highly localized areas with reduced herbivory, suggesting that the patchy distribution of predators may be a key driver of plant community structure and that top-down theory should consider predator distributions at much finer scales than previously recognized.

Effects of male population age structure on competitive trait selection in the Forked Fungus Beetle

Miles Appleton, Charlotte Greene, Clara Stahlmann Roeder, Vincent Formica, Edmund Brodie III

Sexual selection varies widely across time and space, driven by intraspecific demographic factors such as density and operational sex ratio. Population age structure is another demographic variable that may influence competitive environments by altering male–male interactions and female mate choice. We tested whether age structure modulates selection on competitive traits in the Forked Fungus Beetle (Bolitotherus cornutus), predicting that old-biased populations would exhibit heightened competition and stronger selection on male traits. We established 12 semi-natural populations differing in male age composition (young-biased vs. old-biased) and measured body size, aggression, and reproductive success (via mate guarding behavior) over four weeks. Across both treatments, large male body size was under strong positive selection, while aggression showed no correlation with fitness. Older males had higher fitness than younger males regardless of treatment. Contrary to expectations, selection on body size and aggression did not differ between our population treatments, suggesting that either age structure did not measurably alter the competitive landscape or body size is under consistent selection. We propose that body size may be of great importance across multiple mating contexts, while aggression may operate under context-dependent "neighborhood" selection not detectable at the population level. These findings highlight the complexity of sexual selection dynamics and suggest that the influence of age structure on trait evolution may depend on behavioral plasticity and localized social interactions.

Hydrodynamics of Bioinspired Armored Fish

Jonah Armendariz, Nolan Sankey, John Michael Racy, Megan Vandenberg, Bart Boom, Cassandra Donatelli

Poacher fishes (Agonidae) are morphologically diverse benthic fishes encased in rigid armor plates. These fishes live in habitats marked by tidal forces, meaning hydrodynamic performance is an important facet of armor function. We used micro computed tomography scans of eleven species to describe the body shape diversity in the group by measuring hydrodynamically relevant characteristics such as; head height and width, tail and body length, and number of armor plate rows. We utilized this data to develop twelve models, varying in cross-sectional shape—circle, square, hexagon, and octagon—based on the number of armor plate rows and the head length to total length ratio. We 3D printed the models and attached them to a 6-axis force sensor in a flume to measure the coefficient of drag (Cd) for each model. We used this data to generate drag profiles across an angle sweep from 0-180 degrees. Finally, we used computational fluid dynamics (CFD) to test a wider range of morphotypes, and particle image velocimetry to visualize the flow and validate our CFD models. The results show that as the model is rotated the force recorded is increased then decreases after 90 degrees. Interestingly for 2 models the force varies sinusoidally rather than staying constant. These measurements can be used to create bioinspired models for underwatercraft and reveal the hydrodynamic impact of small shape changes in bioinspired models.

Characterizing Ae. aegypti ammonia transporters' role in olfaction, reproduction using CRISPR/Cas9

Victoria Armitage, Jamie Cochran, Andrea Durant

The Amt/MEP/Rh family of ammonia transporters are involved in a suite of biological functions in animals, bacteria, fungi, and other organisms. The mosquito Aedes aegypti, a major vector of arboviruses such as dengue and zika, possesses the most ammonium transporters from the Rh and Amt families identified among animals to date. One of these, AeAmt1, is expressed throughout all stages of sperm development and may play a vital role in sperm survival. However, this phenotype has yet to be confirmed with a complete knockdown, and the mechanism remains unknown. Another, AeAmt2, may have critical functions in ammonia sensing for host-seeking behaviors. Within the antennae of other flies, a single Amt homologous to AeAmt2 acts as an ammonia receptor. All other known odorant receptors are ligand-gated ion channels from the OR or IR families, and this 'non-canonical' Amt-based odorant reception may generalize to related species. We are using a CRISPR-Cas9 mediated QF2 knock-in to examine the localization and function of AeAmt1 and AeAmt2 in adult Ae. aegypti. We first cross QF2 knock-in animals with QUAS-GFP to localize Amt1/Amt2 and report here the cell-specific expression of Amts in Ae. aegypti. We will characterize the potential role of Amt2 as an odorant receptor by measuring electrophysiological and behavioral outcomes for homozygous mutants. We will characterize the role of Amt1 in sperm survival using reproductive assays.

Patterns of cranial integration & modularity in air-breathing fishes (Anabantaria)

Sarah Arnette, Lindsey DeHaan, Luke Rose, Matt Friedman, Matthew Kolmann

Key innovations provide ecological opportunity by enabling organisms to interact with resources in a new way. For example, the evolution of jaws in gnathostomes paved the way for vertebrates to go beyond ancestral suspension feeding and become active predators. Bimodal breathing using an air breathing organ (ABO) has long been hypothesized to be a key innovation within Anabantaria, given the marked morphological and ecological diversity of the group. The ABO of Anabantiformes (labyrinth fishes, snakeheads, and

leaffishes) is derived from the first epibranchial and forms a large, convoluted structure spanning the posterior orbit through the opercle; given the expanse of such an organ, we hypothesize there has been a re-patterning of the skull, particularly with respect to anterior-posterior coordination. Here, we use 3D geometric morphometrics and phylogenetic comparative methods to explore the effect of the ABO on cranial phenotypic diversity in Anabantiformes. Specifically, we: (1) describe the primary axes of phenotypic diversity in anabantarians, (2) compare skull shape disparity between air breathing and non- air breathing taxa, (3) define patterns of modularity, and (4) contrast patterns of modularity between airbreathing and non air-breathing taxa. We find that lineages with an ABO exhibit slightly higher degrees of integration and different patterns of modularity compared to taxa without. This work was supported by the National Science Foundation awards DEB-2333683 and DEB-2333684.

Microbiome mirrors host population structure in Grand Canyon desert bighorn sheep.

Holly Arnold, Anna Jolles, Brianna Beechler, Emma Little, Sara Carpenter, Kate Stange, Lindsay Milward, Clint Epps, Rachel Crowhurst, Bee Hoffman

Microbiomes—complex communities of bacteria, viruses, fungi, and other microorganisms—are essential components of all living organisms. These microbial communities play critical roles in host digestion, immune function, metabolism, and even behavior. In wildlife species, microbiomes are increasingly recognized as key factors influencing health, fitness, and adaptation to environmental conditions. Despite this, relatively little is known about how microbiomes vary within and among populations in natural settings, particularly across geographic barriers.

Characterizing microbiomes in natural populations provides insight into host-environment interactions, disease susceptibility, and local adaptation. Factors such as diet, climate, genetics, and social structure shape microbial communities, meaning that distinct populations of the same species may harbor unique microbiomes. In desert bighorn sheep (Ovis canadensis nelsoni), these microbial differences could have important implications for digestion and nutrient absorption, immune responses to pathogens, and overall health.

In this study, we examined the gut microbiomes of two bighorn sheep populations separated by the Grand Canyon. This geographic barrier represents a significant divide that has shaped the genetic and ecological divergence of many species. Given the influence of environment and host-related factors on microbiomes, we hypothesize that bighorn sheep on either side of the canyon may harbor distinct microbial communities. These differences could reflect diet variation, habitat-specific microbial exposures, or historical isolation leading to unique microbial assemblages.

Beyond fixation: evidence for selection maintaining genetic variation after intense selection

Kenneth Arnold, Zachary Greenspan, David Hubert, Laurence Mueller, Michael Rose, Mark Phillips

Combining experimental evolution with whole-genome sequencing has become a powerful approach for uncovering the genetic basis of adaptation and complex traits. In sexually reproducing populations, such studies consistently show that adaptation is highly polygenic and largely driven by standing genetic variation. This raises a key theoretical question: how is such diversity maintained despite strong directional selection? One explanation is balancing selection, which can preserve alleles that contribute to adaptive potential, even if they are not currently advantageous.

To test this, we used long-term experimental evolution in Drosophila melanogaster to examine genomic and phenotypic responses to divergent life-history selection. We focused on populations selected for accelerated (A) and delayed (C) reproduction, and re-selected them on the opposite regime. With differing starting genetic profiles, we asked whether newly derived A and C populations could evolve traits and genetic patterns similar to their ancestral counterparts.

We found that both genomic and phenotypic assays demonstrated rapid convergence towards their ancestral counterparts in relatively few generations. Mixed-effects modeling identified 169,994 SNPs significantly influenced by the interaction of selection regime and generational time, with ~53% of the genome showing significant differentiation across 10 kb windows. Despite initial genetic depletion, new C populations in particular exhibited a strong rebound in variation and on par with ancestral C populations, providing empirical evidence for balancing selection helping to maintain adaptive potential over time.

Transcriptional comparison of stinging cells in two cnidarians that diverged 650 million years ago

Sarah Arnold, Leslie Babonis

Changes in gene expression lead to differences in morphologies and functions that drive cell type diversification. Cnidocytes are the stinging cells used for prey capture and defense present in all cnidarians. There are over 30 morphologically distinct types of cnidocytes described that vary widely in size and shape, making them an excellent system to investigate how changes in gene expression lead to the generation of different cell types. Previous work characterized the cnidocytes of the sea anemone, Nematostella vectensis. To understand how cnidocyte diversity is generated, we have established the stony coral, Astrangia poculata, as a tractable model for studying development in cnidarians. While some types of cnidocytes are shared between these two species, A. poculata has an additional type not found in N. vectensis. To compare gene expression between shared and different cnidocyte types, we generated a developmental scRNA-seq time course dataset for A. poculata. Morphological analysis reveals six cnidocyte types in A. poculata which is supported by scRNA-seq data. Comparing this dataset to N. vectensis scRNA-seq data, we found that shared cnidocyte types express many of the same genes in both taxa, while the cnidocyte unique to A. poculata expresses many stony coral-specific genes . This work suggests taxon-specific genes are important for driving the generation of new cell types and identifies genes important for maintaining shared morphologies and functions over evolutionary time.

Foraging and peak auditory sensitivity are unaffected by motorboat noise in bluegill sunfish (*Lepomis macrochirus*)

Kristin Arola, Mathea Jorgenson, Dayna Wiley, Brooke Vetter, Trevor Keyler

Anthropogenic sound can alter behavior and sensory function in fishes. We tested the effect of motorboat noise on bluegill sunfish (Lepomis macrochirus) collected from a quiet, no-motor lake and a noisy, motor-use lake. Fish were observed in 48-h foraging trials under four treatments (quiet vs. noisy lake × sound vs. no sound). Prey consumption did not differ across treatments ($H = 6.22$, $p = 0.102$), but fish consumed significantly more prey on Day 1 than Day 2 ($p = 0.04$), suggesting satiation effects. Video analysis indicated shifts in swimming activity near sound onset and offset. To assess sensory mechanisms, we measured auditory evoked potentials (AEPs) under baseline and masking (150 dB re: 1 µPa boat noise) conditions. Bluegill exhibited lowest hearing thresholds at 80 Hz. Masking noise elevated thresholds primarily at higher frequencies (≥200 Hz), with greater shifts in fish from the motor-use lake, while thresholds were not consistently elicited above 500 Hz. Sensitivity in the most responsive frequency range (80–100 Hz) was unaffected. These findings suggest that while motorboat noise reduced auditory sensitivity at higher frequencies, it did not alter feeding behavior across lake or sound treatments. Together, the results support previous studies indicating that bluegill may be relatively resilient to motorboat noise in natural environments.

Exploring the thermal biology of *Culex* mosquitoes collected along a latitudinal gradient in the USA.

Helle Aronson, Benjamin Gregory, Clement Vinauger, Megan Fritz, Chloe Lahondere

Climate change is causing shifts in mosquito distribution, including Culex spp., posing global human health risks. Thus, a better understanding of their biology is needed to improve prediction models for their distribution and for the development of control strategies. In this project, mosquitoes were collected along a latitude gradient from Maine to Florida. The role of food availability was also

studied by feeding populations two different types of food during larval development. Behavioral assays were conducted to determine these populations' thermal preference and tolerance. We also explored the effect of relative humidity on thermal preference by varying the level of humidity in our assays. In parallel, we assessed these populations' thermal tolerance by determining their knockdown (CTmax) temperature. We performed colorimetric analyses to uncover mechanisms behind these behaviors by quantifying nutrient contents of adults from each population. We show that different populations, despite variations in food type, were driven to the same humidity, demonstrating that this factor may be more important than temperature when selecting resting sites. Food type, affecting nutrient stores, affected thermal preference for one population. Additionally, CTmax was constant between all populations except for one autogenous population. This lays the groundwork for further investigation of the role of humidity and food availability on the thermal behavior of mosquitoes and the evolutionary mechanisms driving these traits, to better understand response to climate change.

Ultra-rapid droplet ejection via leg spreading enhances vertical flight in water boatmen

Sarahi Arriaga-Ramirez, Victor Ortega-Jimenez

Water boatmen (Corixidae) are a highly diverse group of aquatic bugs known for their remarkable adaptations for both swimming and flight. However, how they overcome the trade-offs involved in transitioning from water to air remains unclear. We found that, despite having unwettable bodies —an adaptation essential for scuba-like diving and smooth emergence— they retain water on their rear legs during takeoff. Surprisingly, leg detachment from the water's surface during ascent occurs smoothly, as insects bring their rear legs together to form a sharp tip, thereby reducing contact area and capillary adhesion. We discovered that individuals flying vertically at ~100 BL/s consistently eject a liquid droplet mid-air in ~6 ms through rapid leg spreading. This quick reaction effectively sheds the added water, reducing flight costs and enhancing vertical ascent. Our findings offer insights that could inform the design of microrobots capable of transitioning smoothly from underwater to aerial environments without incurring penalties associated with wetting.

Integrating pollen metabarcoding and computer vision to understand bumble bee niche breadth

Kaysee Arrowsmith, Madeleine Strait, Manogya Chandar, Shalene Jha, Berry Brosi

Bumble bees and other insect pollinators carry valuable records of their foraging efforts in the pollen on their bodies. These pollen loads not only demonstrate which flowers these insects have interacted with but also, in the case of bumble bees, represent the specific resources that individuals are collecting to support their colonies. However, analysis of these pollen loads has been limited in large part by the difficulty in definitively identifying and quantifying pollen grains. Two emergent technologies––pollen metabarcoding and computer vision––offer complementary opportunities for better understanding pollinator foraging patterns. While pollen metabarcoding is undoubtedly a more precise method of determining the taxonomic identity of pollen grains, it cannot adequately determine the quantity of pollen in a sample. In an effort to circumvent this shortcoming, we built a computer vision model that can count and sort pollen grains from microscope images. We demonstrate how these two methodologies can be integrated to more completely categorize the identities and quantities of pollen carried by bumble bees in the Colorado Rocky Mountains and provide new insights about the patterns of pollen foraging by these bees.

Exploring the effect of ORco (Odorant Receptor Co-Receptor) on reproductive behavior in a butterfly

Nandini Arunachalam, Keity Farfan-Pira, Erica Westerman

Olfaction underlies essential insect behaviors, including foraging, predator detection, and mate selection. Disruptions in the chemosensory pathway can alter these essential behaviors. One of the genes central to the insect chemosensory pathway is the Odorant Receptor Co-Receptor (ORco), a gene highly conserved across insect taxa. The effect of knocking out ORco has been characterized in several insect species; however, it remains unclear whether it influences mating in butterfly species that use multimodal signals. Previous studies have shown that Bicyclus anynana females base their mating preference on both visual and olfactory cues, preferring to mate with males with visual signals that align with attractive odors. To determine ORco's role in mating and male-courtship behavior, we microinjected B.anynana eggs with CRISPR-Cas9 and gRNAs that target ORco, creating knockout mutants. Following the first round of injections, 22.5% of eggs hatched; of these, 37.03% of larvae pupated, and 90% of pupae emerged as adults. F0 mosaic mutant individuals were identified, confirming the presence of indels. Mutants were then crossed with wild-type individuals to assess the effect of the ORco mutation on survivorship and to build a pure mutant line. Ongoing behavioral assays aim to elucidate changes in courtship and mating success. Characterizing the function of the ORco gene in B.anynana butterflies will contribute to expanding our understanding of behavioral genetics and the role of odor detection in mating.

Capture success and prey spectrum of the carnivorous plant Utricularia australis, a mesocosm study

Celia Arzola, Lukyon Mendrin, Luz Gonzalez Ponce, Ulrike Muller, Otto Berg

Utricularia, or Bladderwort, a genus of carnivorous plants with more than 200 species that use minute underwater suction traps to catch planktonic prey. Previous studies suggest that bladderworts are generalist predators. Aquatic bladderwort traps have elongate structures around their entrance, which have been hypothesized to improve prey capture. Previous experiments that tested this hypothesis by removing these appendages found a significant effect for only one prey species. We used a mesocosm approach to test how removal of the appendages affects capture rates and prey spectrum. We suspended bladderwort plants in the two different regions of a small pond (deep and shallow water). We found that removal of the antennae had no detrimental effect on prey capture success in three bladderwort species when the bladderworts hunt in the deep section of the pond, but found a small effect in strands suspended in the shallow region of the pond, where traps with intact appendages performed better in terms of number and diversity of prey items caught. In the future, we will examine alternative explanations, such as prey spectrum composition and abundance.

Natural variation of radiation tolerance in Drosophila melanogaster

Maame Asiamah, Samyah Smalley, Shahrzad Hajiarbabi, Erin Kelleher

Ionizing radiation (IR) can severely damage DNA, leading to sequence mutations and structural rearrangements. DNA damage caused by IR can cause cell mutations leading to cancer, yet it is also a tool for eliminating cancer cells. Sources of natural genetic variation in tolerance to IR is therefore of major interest to human health, predicting both our individual susceptibility to cancer and our response to radiation therapy. In this project, we investigate the expression differences between wild-type strains of Drosophila melanogaster that differ with respect to radiotolerance.. We compared gene expression levels between wild-type Drosophila strains that differ in radiotolerance through RNA sequencing analysis. We compared expression in between radiotolerant and radiosensitive strains at 1 hr and 4 hrs post-IR exposure, as well as in the absence of IR exposure. Our goal was to identify genes that differ between radiotolerant and radiosensitive flies, as well as genes whose expression is altered by radiation exposure. Our preliminary results suggest differences in gene expression that point to potential mechanisms of radio tolerance, including DNA repair pathways and the innate immune responses. This research can push forth novel insights in the treatment of radiation-induced diseases, as well as radiation therapy.

Placental adaptations to high altitude hypoxia involve both the suppression of plastic methylation a

Braulio Assis, Megan Hemmerlein, Emily Moore, Jeffrey Good, Zachary Cheviron, Kathryn Wilsterman

High elevation hypoxia is associated with negative reproductive outcomes for mammals, including lowering birth weights and increasing rates of perinatal mortality for both the gestational parent and offspring. The placenta is considered a major player determining these outcomes because it both influences gestational physiology in the gestating parent and facilities nutrient and gas exchange for the offspring. Indeed, in both humans and the North American deer mouse (Peromyscus maniculatus), populations that are genetically adapted to high elevations exhibit differences in placental development and gene expression that are associated with improved fetal growth under hypoxia. To better understand the regulatory processes that lead to differential expression and development in the placenta, we performed whole genome bisulfite sequencing on placentas from highland or lowland ancestry deer mice gestated in either environmental normoxia or hypoxia. Surprisingly, we found relatively limited evidence for hypoxia-dependent plasticity in methylation in the placenta even in lowland-ancestry mice. However, we did find stable, genome-wide differences in methylation wherein highland-ancestry deer mice display >10% reduction in genome-wide methylation across placental development. We found limited but interesting associations between differential methylation and differential expression or fetal growth. These results demonstrate that methylation patterns can vary dramatically between populations within the same species and identify promising candidate genes for future functional work.

How changes in body condition influence stress and immune responses in the toad Rhinella icterica?

Vania R Assis, Stefânia dos Reis, Débora Prado, Alan Lima, Milena Pedrão, Lucas Moreira, Fernando Gomes, Stefanny C Titon

Physiological trade-offs among energy balance, endocrine reactivity, and immune function are central to understanding how animals cope with stressors. In amphibians, evidence suggests that stress-induced immune enhancement depends on good body condition. We are testing the hypothesis that toads with higher body condition indices (BI) are more responsive to stressors and exhibit stronger immune responses when challenged compared with those in poorer BI. Free-living Rhinella icterica adult males were brought to the laboratory and, after twenty days, were subjected to standardized restraint stress (24h). Preliminary results indicate that initial restraint did not alter immune responses. Animals were then subdivided into three feeding groups: control (10 roaches + vitamin powder/week), mild fasting (5 roaches + vitamin/week), and severe fasting (2 roaches + vitamin/week). We expect body mass to be maintained in controls but reduced by ~12.5% and ~25% in fasting groups, thereby altering BI. We also predict that BI will modulate endocrine and immune reactivity during a second restraint challenge once toads reach target mass loss. Stress and immune function will be assessed using bacterial killing ability, hemagglutination assay, plasma corticosterone and leptin levels, alongside BI and morphometry. This experimental design will clarify how body mass loss, through reduced BI, modulates stress-induced endocrine-immune interactions, providing new insights into how energetic state influences amphibian resilience to stressors.

The Cahaba Biodiversity Center: a living lab for research and conservation in Alabama

Vania R Assis, Joan Rundles, Brian Keener, Hannah Millwood

Tucked into the heart of central Alabama, the Cahaba Biodiversity Center (CBC) is a vibrant hub for research, education, and conservation. Located at the southwestern tip of the Appalachian Mountains where they meet the Coastal Plain, the CBC lies in one of the most biologically rich areas east of the Mississippi River. Alabama ranks #1 in the eastern U.S. for overall biodiversity, leading the nation in species of crayfish, freshwater mussels, snails, turtles, and fish, while also ranking among the highest in amphibian diversity. Alabama also leads in richness of trees, woody vines, and carnivorous plants, reinforcing its position as a national biodiversity hotspot. The Cahaba River system is well known for his high biodiversity and endemism in several groups including fish, mussels, and snails. Thanks to a generous gift from Mr. Bill Hubbard, the CBC now protects over 2,100 acres in Bibb County, managed by the University of West Alabama Foundation. Its landscapes span longleaf pine uplands, limestone glades, pristine river stretches, and numerous caves and sinkholes. But the CBC is more than a preserve, it's a living lab. Through hands-on student research, university partnerships, and conservation efforts, it's training the next generation of scientists and stewards. As we face growing threats to ecosystems, the CBC stands as a model for how local action, immersive education, and field-based science can shape global biodiversity efforts.

Analyzing the role of spinal joint dynamics in the movement of a sprawling robot

Merve Atasever, Ali Okhovat, Azhang Nazaripouya, Jyotirmoy Deshmukh, Yasemin Ozkan-Aydin

Sprawling locomotion leverages a flexible spine to produce stable and adaptable gaits through the integration of body undulation and coordinated limb movements. Prior studies in robotic locomotion have shown the benefits of spinal flexibility, but typically have relied on either open-loop gait designs that lack adaptability or data-intensive, end-to-end learning methods prone to generating unstable or inefficient gaits. To address this gap, we propose a hybrid framework that embeds a biologically inspired gait design within a reinforcement learning policy. Specifically, we integrate the Hildebrand gait classification system, prescribing rhythmic footfall patterns (duty factor 0.75; phase shift 0.25) with a Soft Actor-Critic deep reinforcement learning algorithm to adaptively control the spinal joint of a salamander-inspired robot that features four 2-DoF legs and a horizontally undulating body, allowing for synergistic limb–spine coordination. We evaluated fixed-spine (8-joint) and active-spine (9-joint) configurations in a MuJoCo during a target-directed navigation task. Results showed that unconstrained DRL generated fast but unstable gaits, whereas our hybrid approach achieved both stability and efficiency. The active-spine configuration substantially expanded the robot's kinematic range and reduced traversal time by up to 75% compared to the fixed-spine design. This work highlights how spinal dynamics integrate morphology and control to optimize propulsion, offering a pathway toward more adaptive robotic locomotion strategies.

From changing oceans to confused physiology: Endocrine adaptations in marine mammal populations

Shannon Atkinson, John Moran, Suzie Teerlink, Douglas DeMaster, Kendall Mashburn, Valentina Melica, Heidi Pearson

Migratory whales are excellent sentinels of the health of marine ecosystems as they traverse whole ocean basins. Their metabolic, body condition and reproductive suppression during marine heatwaves reflects their sensitivity to ocean conditions. Corticosteroids were used as biomarkers of metabolic stress responses in a pilot study to conduct validations and HPLC profiles on extracted blubber for each sex. No immunoreactivity of female blubber corresponded to the corticosterone peak, while 60% total immunoreactivity in the males was corticosterone. Conversely, no immunoreactivity of male blubber corresponded to cortisol, whereas 41% total immunoreactivity in females was cortisol. The disparity in glucocorticoids between sexes likely reflected differential metabolism of the hormones in blubber. Additionally, biopsies from humpback whales with long-term sighting histories near Juneau, Alaska had pregnancy rates, (0.33-0.60), detected from elevated progesterone concentrations in 2020-2024. Minimum calving rates were predictably lower (0.17-0.36), and a stable realized population growth rate was evaluated using age-structured Lotka model. The difference between the pregnancy rate and the minimum calving rate in late spring to summer, post oceanic migration, indicated this is a key period when pregnancy may be disrupted and perinatal mortality may occur. Annual monitoring of unique subpopulations will improve knowledge of individual's physiological well-being, and assessing pregnancy, calving, and realized population growth rates aids our understanding of endocrine adaptations that influence population's stability during changing ocean conditions.

Maternal effects on the innate immune system in nestling Tree Swallows

Alizabeth Atkison, Jennifer Houtz

Avian offspring can inherit maternal antibodies (i.e., adaptive immunity) through the egg yolk, but little is known about innate immunity transfer in birds. The innate immune system includes “complement” plasma proteins that initiate the lysing of pathogens (i.e., bacterial killing ability). I hypothesize that nestling Tree Swallows (Tachycineta bicolor) inherit complement-mediated innate immunity from their mothers. I collected blood samples from day 12 nestlings (n=95 nestlings) and adult females (n=19 females/boxes) across 19 boxes at M. K. Goddard State Park in Pennsylvania. Bacterial killing ability was conducted using a 12 hour Escherichia coli challenge against nestling and adult female blood plasma. Inheritance of innate immunity was measured by comparing the similarity of bacterial killing abilities of plasma from mothers and offspring. We found no significant correlation between bacterial killing ability of a nestling and its mother, suggesting there is no maternal effect on nestling bacterial killing ability in nestling Tree Swallows. Complement-mediated innate immunity may be determined by individual nestling developmental conditions (e.g., ecological stressors), rather than inheritance from the mother. Future research includes measuring different innate immunity markers (e.g., macrophages) and hormones (e.g., corticosterone) that may impact innate immunity.

Maximum acceleration during takeoff in the bumblebee (*Bombus impatiens*) revisited

Herbert Aumann, Nuri Emanetoglu, Francis Drummond

We discovered that some bumblebees, probably foragers, take off from the hive entrance almost explosively, on a straight, slightly ascending flight path before veering off in some other direction. We measured the maximum acceleration of commercial bumblebees (https://www.koppert.com) with a 24 GHz Doppler radar (https://innosent.de). The acceleration was determined from the slope of lines found by Hough transform in Doppler-Time-Images. We discovered that bumblebees exhibit a maximum acceleration numerically identical to the gravitational acceleration constant. We observed the same maximum acceleration in honeybees (Apis mellifera). At this time, we have no physical explanation for this coincidence.

In the 2009 SICB Annual Meeting, Abstract 87.3, the maximum vertical acceleration on takeoff was determined by video camera in a laboratory setting to be 3.8 m/s/s. Our outdoor Doppler radar measurements indicate that the anisotropic acceleration is much higher. We made 14,981 observations over the course of 62 days. We found the maximum acceleration of bumblebees during takeoff to be 9.8 +/- 1.8 m/s/s. We have shown that the 24 GHz radar return from a bumblebee is equivalent to the radar return from a 3 mm ball bearing. This allowed us to validate our measurements by comparing them to the gravitational acceleration of a ball bearing in free fall.

Faster, not harder: wing posture affects performance of a muscle actuator for rapid mating displays

Alexander Avalos, Matthew Fuxjager, Franz Goller

There exists a plethora of examples of how sexual selection has co-opted biomechanical systems for complex mating displays. One example is the scapulohumeralis caudalis (SH) muscle in white-collared manakins. Normally in birds, this muscle retracts the wings during flight. However, in manakins, it is also used to actuate blindingly fast mating displays known as wing- and roll-snaps. Here we explore how performing the wing-snap in a wing position that deviates greatly from those reached during flight might pose a challenge to the SH of male manakins. Using an in-situ muscle prep with sonomicrometry and force transducers, we compared SH performance in the vertical wing-snap position to three other wing positions typical of the up- and down-stroke cycle of flapping flight. We found that manakins produce significantly less force in the wing-snap position as compared to the three flight wing positions. This marked decrease in force coincides with dramatic passive shortening of the SH muscle when placed in the vertical position. Altogether, this suggests that during the snap, the SH does not operate in a length regime that permits maximal force production. This may hint at the tension between the directionality of sexual selection and the stabilizing force of natural selection as it pertains to the co-option of a body part for a mating display.

Sharpening our understanding of insect weapons: Analyzing puncture performance in Coreidae

Giovanna Avellar Figueredo, Alexandre Palaoro

Animals can use their spines to compete with rivals for mates, fend off predators, or other multitude of functions. However, puncture performance depends on various factors, including how the spine and opposing object come into contact, the force exerted, and the spine’s sharpness. Leaf-footed insects (Hemiptera: Coreidae) exhibit a startling morphological diversity on the hind leg femur and spine combination. However, we have little understanding of how exaggerated hind femurs evolve in these bugs. Given that spine performance has a spotlight in natural selection contexts, we bring these insights to sexual selection, where puncture performance may influence how sexually-selected weapons are shaped. We tested how spine’s puncture performance is tied to hind femur exaggeration by comparing performance metrics across eight species. We characterized four spine puncture performance metrics: aspect ratio, tip sharpness, tip curvature, and tip area. Tip sharpness and spine tip area were related to femur expansion, where expanded (stronger) femurs were wider and had sharper spines. Aspect ratio and spine curvature had no relation with femur expansion. Thus, even though spines are present in most coreids, stronger legs bore the sharpest spines. This suggests that spine performance and leg shape are correlated across Coreiodea. Future work should test how femur and spine traits are related to fighting behavior to better understand how biomechanical properties and morphological diversity arise in sexually selected weapons.

Flow-induced aggregation and deformation in plumose sea anemones

Adetokunbo Awonusi, Arvind Santhanakrishnan

In the presence of ambient currents, the plumose sea anemone (Metridium senile) exhibits downstream bending of its trunk that is attached to numerous frilly tentacles. M. senile reproduces sexually or asexually, and the latter often results in clone aggregation. The formation of aggregations is expected to affect flow and particle transport at various downstream locations within the colony. While previous studies have shown that the presence of intermediate-sized prey prompts aggregation, the effects of flow-induced deformation of the trunk and the filtering structure (i.e., tentacles) on particle capture and drag in a clone aggregation remain unclear. Particle image velocimetry (PIV) measurements were conducted on dynamically similar, flexible physical models of M. senile to examine the effects of flow-induced deformation of the trunk and filtering structures. Computational fluid dynamics (CFD) simulations were conducted on a numerical model of M. senile aggregation, where the tentacles were idealized as a porous hemispherical bell via Darcy approximation. Discrete phase modeling was used to examine the particle dynamics around various deformed M. senile models within an aggregation. The findings suggest that at high flow, plumose sea anemones in an aggregation can capture prey comparable to those of individuals, due to flow-induced bending. Aggregations also provide structural support to prevent individuals from dislodgement.

The ontogenetic scaling of braking in largemouth bass: morphology and kinematics

Erik Axlid, Tim Higham

For animals in nature, locomotion is often unsteady and involves frequent linear and angular accelerations. In fishes, deceleration is not only critical for avoiding obstacles in complex environments, but also plays an important role in prey capture. Most fishes brake by increasing drag, primarily through protraction of the pectoral fins. According to isometric scaling predictions, larger fishes should have smaller fin areas relative to their mass (and therefore momentum). Thus, assuming no behavioral compensation such as changes to fin kinematics, larger fishes should exhibit reduced braking ability. However,

this has not been empirically tested. We addressed this by asking three questions: 1) How does pectoral fin area scale with body mass in largemouth bass? 2) If pectoral fin area scales isometrically, is the braking performance of large individuals reduced? and 3) If larger individuals do not show decreased braking performance, how do they compensate behaviorally for their relatively smaller pectoral fin area? To answer these questions, we captured 3D high-speed video of 18 largemouth bass, spanning an order of magnitude in body mass, braking while feeding on cichlid pellets. From these sequences, we quantified rates of deceleration and fin kinematics. We also measured their maximal pectoral fin surface areas. The results of this project shed light on the consequences of body size for fish function and may have implications for fish ecology through ontogeny.

Tactile sensing instrumental in mole cricket backwards walking

Amir Ayali, Avi Amir, Omer Yuval

Mole crickets are among the few families of insects possessing fossorial (digging) front legs. Among other modifications related to the mole cricket life in an underground network of tunnels and burrows is a well-developed cercal system. Insect cerci, a bilateral pair of appendages extending posteriorly from the last abdominal segment, are covered with filiform mechanoreceptive hairs that are known to be sensitive to wind currents on the body surface. In the dark subterranean network of narrow tunnels, tactile sensing is critical for the mole cricket to successfully negotiate its environment.In this work we investigate the tentative role of the antennae and cercal system during mole crickets' backward locomotion. Utilizing video analysis and machine-learning tools, we comparatively monitored and quantified mole crickets' antennae and cerci movements and wall contact during forward and backward locomotion in a tunnel-like experimental arena. While wall contacts by the antennae were found to be instrumental in both forward and backward walking, the cerci played a dominant role during backward locomotion. Cerci wall contact during backward walking was found to be mostly passive and result from abdomen wiggling. We also observed, however, independent cercal movements that may suggest active tactile sensing. We conclude that active tactile sensing assists mole crickets in navigating and exploring their subterranean environment, mostly in assessing the width of the burrow and locating suitable places for turning.

Effects of morphology on soft flagellated robotic locomotion at low Reynolds numbers

Elif Pinar Aydin, Nnamdi Chikere, Yasemin Ozkan-Aydin

Low Reynolds number locomotion is challenging because viscous forces dominate over inertial forces. Inspired by flagellated microorganisms, we investigate non-reciprocal locomotion in a robotic swimmer with a single, soft flagellum, actuated only at its base, to generate planar wave propagation. Through systematic experiments, we examined how flagellum stiffness, actuation frequency, and length affect propulsion and trajectory stability. Our results show that increased stiffness enhances propulsion at high actuation frequencies, while excessive rigidity hinders effective wave propagation at lower frequencies (up to ~38% higher displacement per cycle at 6.3 Hz for the stiffest design – 5.92 mm/s, and ~5% higher for the soft configuration at 2 Hz – 1.43 mm/s). Furthermore, we found that increasing flagellum length enhances propulsion speed and directional stability up to a specific threshold, after which passive rotation increases, compromising the forward path (peaking at an optimal length of ~119 mm with a maximum speed of ~5.1 mm/s). We also demonstrate that passive turning can be reliably induced by flagellar asymmetry, created by bonding a passive, curved rod to the soft flagellum, and lateral body weight distribution. Our findings demonstrate that subtle morphological variations in a single flagellum influence propulsive kinematics, transitioning between linear and rotational swimming modes, and establish key design rules for stable motion and maneuverability for soft robots in a low-Reynolds environment.

Development of a Biohybrid Subterranean Robotic Platform via Direct Printing of Soft Sensors on Earthworms

Elif Pinar Aydin, Qiang Jiang, Brayden Kolb, Yanliang Zhang, Yasemin Ozkan-Aydin

Subterranean environments present significant challenges for traditional robotics, necessitating platforms that leverage biological efficiency. We propose a biohybrid robotic system integrating the earthworm, *Lumbricus terrestris*, with biocompatible soft sensors for real-time mapping of soil characteristics like moisture and temperature. *L. terrestris* was chosen for its robust burrowing and large size, facilitating sensor integration. Our approach utilizes an autonomous aerosol co-jet printing method to fabricate conductive gold pathways directly onto the earthworm cuticle at ambient temperatures. To ensure reliable adhesion and animal welfare, we established a surface preparation protocol involving ethanol-induced anesthesia and thorough rinsing to remove mucus. Preliminary experiments validated the principle of printed thermoresistive sensors on specimens across a range of 5°C to 20°C. The printing process was optimized to achieve uniform 250 µm traces with an initial resistance below 15 ohms. Additionally, we developed a fallback strategy using pre-fabricated flexible films to ensure system resilience. These results demonstrate the feasibility of a deployable biohybrid platform capable of navigating underground environments with minimal disruption. This work provides a framework for distributed living sensor networks for environmental monitoring, offering insights into the complex interdisciplinary intersection of soft robotics, multi-material additive manufacturing, and subterranean biomechanics for future underground exploration efforts.

Backyard Brain's neuron spikerbox as a pedagogical tool for experiential learning of neurophysiology

Kathryn Bachand, Lorian Schweikert

Neurophysiology is a core component of animal physiology curricula, though it is often considered challenging for students to master due to the highly conceptual nature of the discipline. Experiential learning is known to improve student outcomes; however, tools for experiential learning in neurophysiology have not been widely accessible. Backyard Brains© Neuron Spikerbox is a simple and accessible bioamplifier that offers practical approaches for introducing electrophysiology in the classroom. We used the Neuron Spikerbox to test the hypothesis that experiential learning improves student understanding of neural conductivity more than problem-based learning alone. For experiential learning, earthworms (Lumbricus terrestris) were used as a study system to measure nerve conduction velocities, allowing students to examine how axon diameter influences signaling speed. For problem-based learning, students were given pre-collected data on signal conduction velocities to achieve the same goal. Using a repeated measures design (n=20 per learning group), a Likert scale survey was used to evaluate student learning before and after each learning experience. The differences in survey responses (before and after) were calculated, and then using an independent t-test, the average differences in survey responses were compared between groups. Outcomes of this study may encourage the incorporation of Backyard Brains© Neuron Spikerboxes in undergraduate physiology courses to improve student learning.

Changes in female reproductive strategy accompany the evolutionary loss of paternal care

Annika Bagazinski

The reproductive strategies of males and females are inextricably linked together. The recent evolutionary loss of paternal care in an unusual stickleback ecotype ("whites") provides an opportunity to study coevolutionary changes in female reproductive strategies. Unlike typical ("common") sticklebacks (Gasterosteus aculeatus) which provide extensive paternal care to developing embryos and fry, males of the white ecotype remove the eggs from the nest immediately after fertilization and scatter them. Here, we test the hypothesis that the reproductive strategy of female whites has coevolved with the evolutionary loss of paternal care. Relative to female commons, female whites produce smaller, less pigmented eggs, with lower fatty acid and carotenoid content. Clutches of white eggs are also less adhesive, which may

facilitate males' egg scattering behavior. Altogether these results suggest that female whites match the relatively low level of parental investment by male whites and that they facilitate offspring abandonment by the father. Ongoing work is characterizing females' ovarian fluid, egg coat protein, and steroid hormones. Additionally, the loss of care in other populations of stickleback provide an opportunity to determine whether these changes to female reproductive strategy are consistent across multiple independent evolutionary losses of paternal care.

Directional swimming variance in salp colonies may underpin diel vertical migration behavior

Sophie Bagoye, Kelly Sutherland, Alejandro Damian-Serrano

Salps are pelagic tunicates that swim with jet propulsion. Their life cycle involves a colonial stage where multiple zooids pulse asynchronously to swim. Across the 48 described salp species, there is a diversity of colony forms depending on the positioning of zooids, referred to as colony architecture. Recent work shows that swimming speed differs across architecture types, indicating that colony architecture influences locomotion. To test whether salp species vary in their directional swimming behavior and orientation, we used in situ SCUBA-based videography to analyze swimming tortuosity (crookedness of path) and directionality (swimming angle) across colony architectures. We found that in many cases streamlined colony architectures (Linear) swarm straighter than less streamlined architectures (Whorl). Because some salp species are strong diel vertical migrators, we also tested how swimming behavior varies with light level and found significant differences in swimming directionality between night and day. In the daytime, non-streamlined colony architectures that are considered non-migrators or shallow migrators were more common and swim angle was predominantly upward towards the surface. At night, streamlined colony architectures that are deep migrators dominated, and swim angle was predominantly downward. Our findings therefore indicate that colony architecture connects to diel vertical migration. Overall, we find evidence for an association between colonial morphology, diel vertical migration, and swimming behavior.

Salt in the wound: mechanical and material responses of sea urchin tube feet under hyposalinity

Nathan Bailey, Austin Garner

Anthropogenic climate change is forecasted to increase the frequency and intensity of low-salinity events (hyposalinity) in coastal marine habitats. Hyposalinity is particularly harmful to marine organisms that are intolerant to extreme variations in salinity, such as sea urchins. Sea urchins have specialized hydrostatic appendages called tube feet, which are crucial for several biological functions (e.g., locomotion, adhesion, feeding). Previous studies found that exposure to moderate hyposalinity (22 parts per thousand [ppt]) has adverse effects on tube foot mechanical behavior. Specifically, tube feet of sea urchins exposed to hyposalinity break at lower tensile forces than those exposed to a more typical salinity level (32 ppt). Here, we sought to further explore the mechanisms driving these previous findings. Specifically, we exposed Caribbean rock-boring sea urchins (Echinometra lucunter) to moderate hyposalinity for 24 hours and measured tube foot mechanical behavior (breaking force, stiffness, extension, work to break) under tensile loading. We then used histological techniques to quantify potential geometric changes to tube foot tissues and produce geometry-independent material properties (breaking strength, Young's modulus, extensibility, toughness). This approach allowed us to determine whether tissue degradation or simple geometric changes to tube foot tissues (e.g., shrinking or swelling) are driving this mechanical failure under hyposalinity. Our findings enhance our understanding of how sea urchins, globally important benthic marine animals, and their communities will fare under global climate change.

Comparing immune function and parasite diversity between native and non-native lizard assemblages

Leah Bakewell, Rokeya Ahmed, Carrie Alfonso, Ian Clifton, Stephen Greiman, Noah Gripshover, Elizabeth Hoffman, Yanileth Lopez, Claire Williams, Kelly Wuthrich, W. Owen McMillan, Michael Logan, Christian Cox

Climate change can influence host-parasite dynamics by altering the abundance and distribution of hosts and their parasites. Additionally, as temperatures become more variable, some organisms are at greater risk of infection due to the temperature dependence of immune function. Together, exposure to novel parasites and decreased immune function can severely reduce organismal fitness. Moreover, non-native species might be less vulnerable to these negative fitness effects due to factors such as broader heat tolerance, generalist behaviors and diets, and enemy release. Finally, an organism's thermal ecology might buffer these negative effects. While the effects of temperature and parasites on the immune system have been studied, rarely have these studies evaluated the effects of an organism's thermal ecology and native status on the temperature dependence of immune function and parasite diversity and abundance. Anole lizards are an ideal study system to explore these factors as they are extremely abundant, vary in their thermal ecology, host a variety of generalist endoparasites, and have been introduced as non-native species worldwide. We compared the parasite diversity, parasite abundance, and temperature dependence of immune function of assemblages of native and non-native anoles in Panama and south Florida, respectively. Using these data, we can better understand host-parasite dynamics in native and non-native species as well as understand how variation among species in thermal ecology might mediate host-parasite dynamics under climate change.

Surveying habitat distribution of invasive Argentine Ant populations on Santa Catalina Island

Dylan Baldiviezo, Makenzie Henk, Shawn McEachin, Katie Elder, Lindsay Darjany, Benjamin Perlman

Argentine ants (Linepithema humile) are an invasive species on Santa Catalina Island, CA, USA, that might have negative ecological effects on the endemic ornate shrew (Sorex ornatus willetti), and on other native island species. Argentine ants appear to disrupt and possibly outcompete the native species, depriving shrews and other natives of essential resources. We investigated the distribution of invasive ants by conducting ant population surveys in common riparian habitats across Santa Catalina Island each July from 2022 through 2025. Traps consisted of individual 50 ml conical tubes with one cotton ball soaked in sucrose, placed within two cm of the front of the tube with the cap off to attract ants. Traps were placed approximately 100 m apart in shaded areas and collected after one hour. Traps were set out by 11 AM to account for the greatest ant activity. Upon collection, tubes were capped and GPS location and time were recorded for each tube. Captured ants were brought to the lab and frozen in a freezer for 30 minutes. Ants were then individually placed under a compound microscope for identification based on their physical characteristics, and counted to record species abundance. We found Argentine ant populations were prevalent in areas that were associated with the native shrew and other native species, suggesting the invasive ants may be contributing to the displacement of native species.

Hydrodynamic consequences of body extensions in barnacle nauplii from contrasting ecological niches

William Ballentine, Mimi Koehl, Kit Yu Karen Chan

Although many planktonic organisms have spine-like body extensions, their hydrodynamic effects on ecologically important functions remain poorly understood. We examined nauplius larvae of three barnacle species from distinct ecological niches to determine how the size of their spine-like horns and tails affects the performance of activities critical to success in their niches: Lepas anserifera (pelagic flotsam-dweller with feeding nauplii bearing long extensions); a rhizocephalan (parasite with non-feeding nauplii with short spines); Tetraclita japonica, (intertidal barnacle with feeding nauplii bearing intermediate-length spines). To assess the hydrodynamic consequences of these morphologies, we 3D-printed dynamically-scaled physical models of each species. Models were towed through a viscous fluid at Reynolds

numbers matching larval swimming speeds, and hydrodynamic forces and moments were measured. Models of feeding larvae (Lepas and Tetraclita) had long spines and experienced greater drag resisting their motion than did the short-spined model of the non-feeding larva (Rhizocephala). While drag slows swimming, it can enhance feeding by anchoring the body so that flapping appendages sweep through the water and encounter food particles. Thus, long spines on nauplii promote feeding at the cost of swimming performance, whereas reduced spines on non-feeding nauplii favor swimming performance. Rapid swimming enhances the ability of parasitic nauplii to locate hosts and non-parasitic nauplii to encounter settlement sites, but there is a trade-off between such swimming versus feeding performance.

Tendon response to early versus late life exercise in mice

Kevin Banda, Noel Calderon, Sadie Sandoval, Apolo Ibanez Rincon, Angela Horner

Physical activity is a critical determinant of musculoskeletal condition in vertebrates. Tendons transmit muscle forces to bone and may undergo limited remodeling after skeletal maturity, with most structural development occurring during early ontogeny. To further investigate the role of exercise intensity on tendon's ability to remodel, this study examined how early-life (aged 3 weeks) versus late-life (aged 18 weeks) exercise influences tendon morphology in mice. Using a cohort of outbred mice, we assessed plantaris and tibialis anterior tendon morphology in old mice (aged >52 weeks) previously exposed to exercise during early life or late middle age. Previous results suggested that early-life exercise alters tendon morphology at 3 months but these effects all but diminish by 6 months, with no significant differences in morphology across exercise treatments. Our preliminary results for a subset of mice from this study demonstrated no significant differences of tendon length or CSA among mice exposed to early life, later life, or no exercise. These findings suggest that while tendon morphology is responsive to early-life exercise, structural adaptations may not persist into adulthood, highlighting the limited window for tendon remodeling.

Exploring the genetics of performance: morphology, kinematics, & genomics of salt marsh harvest mice

Julian Banuelos Torres, Mark Statham, Sergio Nigenda-Morales, Diego Sustaita

The salt marsh harvest mouse (Reithrodontomys raviventris) is an endangered species endemic to the San Francisco Estuary, where these mice encounter a wide variety of vegetation types and levels of periodic inundation. Given their historical legacy of marsh occupancy, they have presumably evolved morphologies and locomotor behaviors to thrive in this dynamic wetland environment. We present a two-step approach to explore the potential genetic basis to these putative adaptations, through a multivariate analysis of morphology and performance, coupled with a genome wide association study for genetic markers linked to putative locomotor and morphological traits. We captured/ released northern salt marsh harvest mice in the Suisun Marsh, CA, took a series of morphological and locomotor performance measurements during swimming and climbing, and sampled them for downstream genetic analyses. We then subjected the morphological and performance data to multivariate analyses to derive latent variables that explain most of the variation in the data. Finally, we describe our plans to integrate these analyses with forthcoming genomic analyses. Salt marsh harvest mice are understood to be the only mammals fully restricted to tidal marshes, and therefore these results may help elucidate the adaptive basis of their distribution and lend insight into their abilities to carve out a niche in this dynamic wetland environment.

PoseAnyFish – new software for AI-assisted morphometrics

Shir Bar, Iris Eting, Samantha Price, Christopher Martin, Shai Avidan, Roi Holzman

Quantifying morphological traits across taxa is essential for understanding ecological and evolutionary patterns. However, traditional measurement methods require intensive manual effort by trained workers. As a result, most datasets capture either a few traits across many species or many traits across a small number of species. We present PoseAnyFish, an AI-based pose-estimation framework for the detection of morphological landmarks and the measurement of morphometric traits from images. While pose-estimation tools such as SLEAP and DeepLabCut have transformed animal kinematics, their application to morphological analysis has been limited.

We trained PoseAnyFish on datasets spanning four fish families (Cichlidae, Cyprinodontidae, Cyprinidae, and Epinephelidae) and eighteen traits. Across these datasets, median error rates were below 3.5% of trait length. Larger traits yielded lower error, with under 1.5% error on standard length and body depth, while shorter traits like jaw length showed higher error. We further demonstrated PoseAnyFish's ability to generalize to new species and datasets using a subset of Jack Randall's reef fish collection, measuring 27 landmarks from which 20 functionally-relevant morphometric traits can be derived. PoseAnyFish shows comparable accuracy to SLEAP on trained datasets but generalizes more effectively to novel species and imaging setups.

PoseAnyFish will be released as open-source software with a user-friendly interface, enabling researchers to annotate, validate, and export trait datasets with minimal technical overhead, and lowering barriers to large-scale comparative and ecological studies.

Antennas for every job: antennal variation in tropical army ants

Nicole Barbera, Sean O'Donnell

Eciton burchellii, a tropical army ant species, is known for its large-scale raids and dramatic morphological variation among specialized worker subcastes. Physical trait differences categorize the sterile workers into four behaviorally distinct subcastes: soldiers, porters, media, and minims (largest to smallest). Eciton burchellii subcaste polymorphisms are outstanding examples of body shape allometry including head capsule and leg length variation. In this study, we examine the allometric relationship between antennae, body size, and head size of all E. burchellii subcastes. Antennae play a crucial role in insect communication, detection of prey odors, navigation, and raid behaviors. We show that minims, the smallest body sized subcaste, exhibit distinct variation in antennal lengths, suggesting potential divergences in colony roles, sensory capabilities and antenna structural development within the minim subcaste.

Effects of perchlorate exposure on mouse behavior

Rebecca Barker, Marcelino Mashanda, Carly Abelson, Michael Minicozzi

Perchlorate is a known widespread environmental contaminant that disrupts thyroid hormone function by blocking iodide uptake. Due to thyroid hormones being critical for brain development, exposure may alter behavior later in life and environmental contaminants induce stress related behavioral changes. In this study, we asked if perchlorate exposure alters mouse behavior, and if the timing of exposure, before birth or after weaning, also affects this system. Mice were exposed to either 0 ppm (control) or 100 ppm perchlorate. In the in-utero exposure group, mothers were exposed one week prior to breeding, and offspring remained exposed into adulthood. In the juvenile exposure group, exposure began during weaning and continued through adulthood. Anxiety-related behavior was measured using an elevated plus maze, which tracks the mouse and measures time spent and movement in open arms, closed arms, and the center. Movement patterns were analyzed with Noldus EthoVision software. Mice exposed in-utero spent less time in open arms, moved less overall, and showed slower movement compared to controls. This is consistent with increased anxiety-like behavior. Juvenile-exposed mice, however, did not differ significantly from controls. These results suggest that perchlorate has the greatest impact when exposure occurs during early development, emphasizing the sensitivity of the developing mice and the importance of considering timing when evaluating contaminant effects on behavior.

Reproducible data from circadian and long-duration insect behavior: an open-source vision pipeline.

Jack Barnhart, Andrew Swafford, William Beckerson, Emmeline van Roosmalen, A.M. (Charissa) de Bekker

Video recording of insect behavior has opened a window to test a wide range of comparative hypotheses, from physiology and gene expression

to the mechanisms behind social interactions and host-parasite dynamics. However, manually extracting quantitative results from insect behavior is a time consuming process that requires sacrificing either temporal resolution by dropping frames, or valuable researcher time clicking through frames; issues exacerbated by the longer video durations required for circadian rhythm analysis. Although machine learning-based computer vision solutions exist, they often fail to produce reproducible, traceable results and are typically difficult to apply outside model organisms. To address these problems, we created an accessible, semi-automated pipeline to extract spatiotemporal data from raw video footage of insects with additional circadian rhythm functionality. Here, we apply this pipeline to analyze circadian rhythms in ant colonies, demonstrating its use at-scale on challenging video data. We demonstrate a 120 fold increase in the amount of data analyzable in a given timeframe with minimal loss in accuracy — maintaining an accessible workflow while providing traceable outputs and reproducible results. The pipeline makes computerized behavioral analysis more accessible, saving precious research hours while simultaneously unlocking the fine temporal resolution necessary to connect insect behaviors to molecular mechanisms.

Treatment of winter fireflies with a juvenile hormone mimic increases pheromone production

Trace Barnhart, Douglas Collins, Sarah Lower, Gregory Pask, Josephine Green, Anna Cerveny, Greg Fahrner

A number of species in the firefly family Lampyridae are diurnal and lack light organs in their adult stage. These insects likely utilize sex pheromones to attract mates in lieu of bioluminescent displays. Photinus corruscus (P. corruscus) is one such diurnal firefly and females of this species release the sex pheromone hydroxycamphor to attract mates. One primary challenge in Lampyridae pheromone research is that the quantity of pheromone produced by these insects is often so miniscule that it cannot be identified using gas chromatography-mass spectrometry (GC-MS). As P. corruscus produces measurable amounts of pheromone with a known structure it is an ideal system for identifying methods to increase pheromone production in Lampyridae. Methoprene is a synthetic juvenile hormone mimic which has been shown to increase pheromone production in several adult insects. Here we demonstrate the efficacy of methoprene in the Lampyridae family by treating female P. corruscus with the hormone and examining the amount of hydroxycamphor produced using GC-MS. We show that hydroxycamphor production in female P. corruscus increases with methoprene treatment over vehicle control in a dose-dependent manner. This study represents a promising new approach to identify sex pheromones in Lampyridae when traditional sampling methods are unsuccessful.

Effects of nest thermal manipulations on Eastern Bluebird growth, metabolic rate, & triiodothyronine

Salvador Barraza-Del Barco, Sarah DuRant, William Kirkpatrick, Vansh Singhal, Sarah Heissenberger

Avian development is affected by environmental temperature. Under expected climate change, nesting environments will become warmer and more variable. Understanding how changes in temperature affects avian physiological development is crucial for understanding how climate change will impact birds. To estimate the effect of shifting thermal conditions on hatching traits we examined offspring growth, thyroid hormone levels, and metabolic rate in nestling Eastern Bluebirds in unmanipulated nests or nests exposed to either an experimentally increased mean temperature or increased thermal variability. We collected growth measurements from nestlings on days 1, 5, 10, and 12. Resting metabolic rates and T3 hormone levels were collected on days 5 and 10. Preliminary analysis revealed that nestlings exhibited increased mass and skeletal growth in response to higher temperature variation than those in increased mean temperature boxes. Previous data showed no difference in metabolic rates in nestlings from the two experimentally manipulated treatment groups, however unmanipulated nests added this year could differ from experimental nests. We expect nestlings from increased variation boxes to have higher T3 levels on day 5, due to exposure to lower temperatures triggering greater T3 release to induce development of homeothermy. This study will provide valuable data indicating how current and future generations of Eastern Bluebirds are adapting to changing temperature conditions physiologically and morphologically, and how these changes could potentially affect them throughout their life history.

Spatial and temporal variations of larval crabs in Puget Sound

Lane Barron, Kit Yu Karen Chan

Most marine invertebrates have complex life histories, including crabs that metamorphose from planktonic larvae (zoea and megalopae) to benthic adults. Despite their commercial, ecological, and cultural importance in the Pacific Northwest, larval crab transport are not well characterized. Puget Sound is a dynamic fjord in Washington that encompasses multiple subbasins. Using field plankton survey, we explored how physical conditions shape abundance, distribution and taxonomic composition of larval crabs. Oblique tow samples were collected from the Strait of Juan de Fuca, Hood Canal, and Main Basin in spring, summer, and fall. Zoea and megalopae were identified to the family level through microscopy. Zoea were present across all seasons, and as expected, were more abundant than megalopae, which were not observed in spring. Surprisingly, Hood Canal, a shallow site with sluggish flow, had the highest zoea abundance, although individuals were smaller in size, suggesting potential local retention. The Strait had the most megalopae, suggesting potential outer coast supplementation. Pinnotheridae zoea dominated the Strait, while Cancridae zoea were most prevalent in Hood Canal; both families were present in the Main Basin throughout all seasons. Correlating abundance data with physical conditions, e.g., temperature, chlorophyll concentration, and pH, help us understand the environmental drivers underlying crab population supply in Puget Sound. These insights are critical for informing management strategies in the face of changing ocean conditions.

Metabolic responses to elevated temperature in lake sturgeon (*Acipenser fulvescens*)

Nicholas Barts, Scott Lankford, Brady Blede, Dustin Mathena

Anthropogenic change represents one of the largest threats to freshwater fishes, with altered thermal conditions being among the greatest challenges. Populations of species with wide latitudinal distributions, such as the lake sturgeon, will likely experience varying levels of stress in the face of global change, and understanding this will be key to predicting how species cope with future environmental threats. Previous work in northern populations of Lake Sturgeon documented temperature effects across levels of biological organization, with warmer temperatures generally resulting in increased stress. In our study, we investigated whether temperature acclimation altered organismal and enzymatic metrics of health and metabolism in juvenile lake sturgeon collected from a hatchery in Missouri, but sourced from northern broodstock. We found that fish raised at 15°C had the highest overall survivability and hepatosomatic index when compared to warmer temperature treatments. Routine metabolic rate did not vary across temperature treatments, but maximum metabolic rate increased with rising temperature; however, this did not result in any significant differences in metabolic scope. At the enzymatic level, citrate synthase activity did not respond to changes in temperature, while lactate dehydrogenase activity trended towards greater activity in fish reared at 15°C. Overall, our results suggest that increasing temperatures may have a negative impact on the survival and condition of juvenile lake sturgeon, but the exact physiological mechanisms underlying this phenomenon remain unclear.

Chemosensory influences on voluntary exercise, behavior, food consumption, and body composition

Juliana Base, William Lampman, Chenkun Jiang, Theodore Garland

Variation in voluntary exercise is influenced by complex interactions among physical abilities, motivation, reward pathways, and environmental cues, yet the underlying mechanisms remain poorly understood. This work investigates the potential role of chemosensory signals in exercise motivation. Previous studies with both human beings and rodents show that chemosensory cues (e.g., from urine or fragrance compounds) can influence activity levels, but no previous study has directly tested if essential oils can alters voluntary exercise

behavior in a rodent. We studied both sexes from 4 replicate High Runner (HR) lines selectively bred for voluntary wheel-running behavior, and from 4 non-selected Control (C) lines. Mice were first given 6 days of wheel access, as in the usual protocol for choosing breeders. Then, to examine the effects of olfactory stimulation, peppermint essential oil or mineral oil (control) was applied to the cage lids on blotter paper for 8 additional days. Across the experimental period, we collected data on wheel-running activity, body mass, food consumption, and took behavioral observations. We predicted that peppermint exposure would alter voluntary running, with differences between HR and C lines reflecting underlying genetic differences in motivation and ability for exercise. This study provides insight regarding how olfactory cues may modulate physical activity and highlights the potential role of sensory stimuli in shaping exercise-related behaviors. NSF IOS-2038528 and USDA CA-REEOB-5205-H.

Comparative cranial musculature of two mustelids: insights into functional morphology and ecology

James Bates, Blake Andrea, Dominik Valdez, Heather Smith, Leigha Lynch

This study investigated cranial musculature of the North American river otter (Lontra canadensis) and long-tailed weasel (Mustela frenata), two species with differing ecologies for which little is known about cranial soft tissue anatomy. Despite the importance of soft tissue variation in shaping functional morphology and behavioral adaptations, few comparative studies have addressed how differences in cranial musculature arise among closely related carnivores. Using diceCT micro-CT scans from Morphosource and Aviso software, we segmented and generated 3D models of muscles of mastication and extraocular muscles. Our results revealed distinct interspecies differences, including a single lateral pterygoid muscle belly in L. canadensis compared to two in M. frenata; differences in temporalis muscle belly prominence, with the superficial belly dominant anteriorly in L. canadensis but the intermediate belly more prominent in M. frenata; and contrasting orientations of the inferior oblique muscle, which spans laterally in L. canadensis but extends inferiorly to inferior rectus in M. frenata. Functionally, the expanded lateral pterygoid in M. frenata may represent an adaptation for enhanced jaw stability, consistent with its behavior of hunting and subduing prey larger than its body size, whereas cranial musculature of L. canadensis may reflect specialization for its piscivorous diet and aquatic foraging. These findings provide novel insights into the diversity of cranial muscle morphology within Mustelidae and highlight how soft tissue variation may reflect ecological and behavioral adaptations.

Steroid hormones modify peptide receptors that regulate parental care in brood parasitic brains

Alexandria Baum, Laura Perez Revilla, Kathleen Lynch

Avian brood parasites do not care for their own offspring. Instead, they lay their eggs in the nest of other species and allow the host parent to provide care for their young. Previous comparative studies from our lab indicate that prolactin receptor density is lower in the hypothalamus of the brood parasitic brown-headed cowbirds compared to the red-winged blackbird, a non-parasitic species. Additional studies from our lab show that both the hypothalamic pituitary gonadal (HPG) and adrenal (HPA) axes are modified in female cowbirds compared to red-winged blackbirds and that mesotocin (avian homolog of oxytocin) can modify prolactin receptor density in the cowbird but not the redwing brain. Here, we investigate whether testosterone or dexamethasone (a synthetic corticosteroid) or saline (control) administered to female cowbirds modified the density of peptide receptors involved in regulating parental care including prolactin (PL-R), arginine vasotocin (AVT-R), mesotocin (MT-R) and galanin receptors (GAL-R). Results reveal that treatment with either of these steroids significantly modified density of some of these receptors compared to non-treated cowbirds. These results indicate that evolutionary shifts in the function of the HPG or the HPA axes possibly result in receptor density changes in the brain that can ultimately result in changes in social behavior such as parental care.

Chick lung development: revisiting the past and preparing for the future

Stephanie Baumgart, Raul Diaz Jr, Claire Zimmerman, Emma Schachner

Over 100 years ago, detailed descriptions of avian lung development using chick (Gallus gallus) as the model were drawn and described by Locy and Larsell. Since then, technology has improved immensely, yet research on avian lung development remains mostly molecular with little attention given to qualitative or quantitative analysis of morphology. Here we use contrast-enhanced staining, micro-computed tomography, and three-dimensional digital modeling to evaluate development of the chick bronchial tree and air sacs from E4-E21 (hatching day). We use centerline trees in the visualization program Avizo to draw comparisons between bronchial tree morphologies at key developmental time points (e.g., when secondary airways emerge, or when air sacs extend beyond the horizontal septum) to test the hypothesis that bronchial tree development is constrained by the inspiratory valve. We also demonstrate differences between hatchling chicks and the first complete adult chicken respiratory model – which shows extensive post-hatching pneumatization expansion into the postcranial skeleton and elaboration of non-ventilatory diverticula relative to the E21 chicks. In contrast to other adult taxa (e.g., Anhinga anhinga) where cervical diverticula emerge directly from the cranialmost parabronchi, in the chick they develop directly from the cervical air sac and extend cranially up the neck. Knowing how the lungs develop in the chick embryo will help us set the stage for perturbation studies and evaluation of pneumatization patterns in the fossil record.

Investigating short-term dynamics of gut microbiome composition in the Western deer mouse

Ashley Beck, June LePage, Hunter Wetherelt, Elizabeth Addis, Laurie Dizney

The gut microbiome plays an important role in mammalian host health and ability to adapt to environmental conditions. While the gut microbiome is often thought of as relatively stable over short periods of time in the absence of a dramatic stressor, relatively little is known about the actual time scale of microbiome shifts under real-world conditions. Most existing temporal studies utilize captive subjects, while here we employ the Western deer mouse, Peromyscus sonoriensis, in a field-based study to assess microbiome dynamics in the wild. Mice were live-trapped at a variety of field sites, including both urban and rural parks, over a two-night trapping period in the Spokane, Washington area in May of 2024. We collected fecal samples from 43 different individuals, with a range of two to four time points captured per individual. Samples underwent 16S profiling with Nanopore sequencing to determine bacterial community composition. Genus-level profiles were compared across time points for each individual, showing relative consistency in most mice, but distinctive shifts in Ligilactobacillus in some mice. Ongoing analysis is investigating potential associations with short-term stress hormone levels and environmental parameters like dietary factors. These results provide important insight into the understudied area of host microbiome dynamics and highlight the complex relationships between microbiome, health, and environment.

The evolution of feeding mechanics in Rasborine fishes

Samantha Beck, William Cooper, Hatcher Manning, Carter Thompson

Zebrafish (Danio rerio: Hamilton 1822) have been extensively studied as a model organism for evolutionary and developmental research. Despite their importance within these fields, the morphological and behavioral evolution of the greater zebrafish lineage, the Danionidae, remain mostly unexplored. Understanding the evolution of danionid feeding mechanics can support experimental investigations of the developmental factors that have shaped this successful radiation. Jaw protrusion is an important aspect of danionid feeding. This feature often coevolves with other aspects of trophic morphology and can play a large role in determining ecological niche. Here we use a high-speed camera to record feeding strike videos from fishes within a species-rich subfamily of the Danionidae that has not been previously examined, the Rasborinae. Motion data from these videos were used to characterize the evolution of jaw protrusion ability and associated aspects of feeding mechanics among rasborine fishes. This research sets the stage

for subsequent experimental work with zebrafish to determine how shifts in skull development have promoted the diversification of danionid feeding mechanics.

Two evolutionary strategies to adapt to low environmental oxygen in Hooded siskins in the Andes.

Libby Beckman, Michael Nachman

Interspecific introgression may facilitate adaptation by introducing an advantageous allele from one species to another. Alternatively, introgressed alleles are often deleterious and eliminated through selection. To understand the opposing roles of selection on introduced alleles, we examined the evidence of introgression and selection across the genome in the Hooded siskin (Spinus magellanicus). Compared to its closest relatives at low elevation, Hooded siskins in the Bolivian Andes experience a low partial pressure of oxygen in ambient air, a known selective pressure. We hypothesized that selection in the Bolivian Hooded siskin has favored high elevation derived alleles from the Black siskin, a high elevation restricted species known to hybridize with Hooded siskins. We applied a population genomic approach using whole exome sequencing and population sampling to test this hypothesis. We identified introgressed regions originating from the Black siskin across the Bolivian Hooded siskin genome, including genes impacting hypoxia-tolerance traits. Further, the most divergent gene regions between high and low elevation Hooded siskin populations included genes involved in oxygen transport and the hypoxia response. Thus, Bolivian Hooded siskins with lowland ancestry may benefit from two evolutionary strategies, adaptive introgression and divergent selection, to meet the environmental challenges of mid-elevation.

Sea anemone size limits the density and contribution of algal symbionts

Samuel Bedgood, Matthew Bracken

Surface-area-to-volume (SA:V) ratios fundamentally influence organismal physiology, from respiration and nutrient exchange to light capture. Photosynthetic organisms often evolve structures that maximize light exposure, and corals with their algal endosymbionts are a clear example, forming complex morphologies (e.g., branching, plating) to increase surface area. In contrast, sea anemones hosting algal symbionts typically maintain a uniform morphology regardless of size, resulting in a declining SA:V ratio as they grow. This morphological constraint may reduce the proportion of tissue available for symbiont colonization relative to total volume. We hypothesized that algal symbiont density decreases with increasing anemone size. To test this, we analyzed whole-body symbiont densities in three congeneric temperate species of Anthopleura and one tropical species, Exaiptasia diaphana. The results support the hypothesis: larger anemones harbor fewer symbionts per unit tissue. However, tissue-specific analyses (tentacles, oral disk, column) suggest potential compensatory mechanisms, as tentacle tissue have disproportionately high algal densities in large anemone. These results highlight morphological constraints that shape algal symbiont density and contribution.

Will climate change impact posterior lateral line development in brook trout?

Janelle Beduya, Ruby Le, Lauren Simonitis, Aubree Jones

Climate change is warming freshwater streams and accelerating salmonid development, with impacts on sensory systems essential for fish survival. The mechanosensory lateral line system is comprised of neuromast receptor organs on the head, trunk, and tail. Neuromasts detect water flows, mediating key behaviors throughout ontogeny such as prey detection and predator avoidance. In salmonids, elevated rearing temperature has been shown to accelerate life history transitions, increase body size, enlarge some neuromasts, and accelerate cranial lateral line development. However, temperature effects on posterior lateral line development and neuromasts located on the trunk have not been examined. In this study, larval and juvenile brook trout (Salvelinus fontinalis) reared at the historical temperatures of streams within their native range (~5-18 °C) and projected temperatures under climate change (~9-22 °C) were analyzed using immunohistochemistry (neuromast size and hair cell number) and vital fluorescent staining (ontogenetic changes in neuromast number and patterning). Fish reared at higher temperatures are predicted to reach key transitions in neuromast maturation earlier in the growing season. However, temperature is not expected to impact total neuromast numbers since temperature was documented to affect developmental rate, not overall patterning of the cranial lateral line. Shifts in developmental timing may affect sensory capabilities for lateral-line mediated behaviors during ontogeny, which may potentially reduce juvenile foraging success and survival under future warming scenarios.

Escaping competition through care: beetle parents feed offspring more in competitive environments

Samantha Beebe, Ahvi Potticary

Parental care is expected to buffer offspring development, yet parenting strategies vary extensively and this variation strongly impacts offspring phenotypes. Why does parental care vary? One possibility is that variation in care is driven by the likelihood of securing future breeding opportunities, where parents in high competition environments invest more in care than parents experiencing low competition. Alternatively, parents may decrease care in competitive environments due to the costs of finding and defending breeding resources. We investigated these ideas in the burying beetle Nicrophorus sayi, which shows extended parental care and requires a limited resource - small carrion - to breed. Nicrophorus sayi is the first Nicrophorus species to emerge from winter diapause. As such, early season beetles experience both lower intra- and inter-specific competition relative to N. sayi breeding in late season. We took advantage of this temporal pattern to investigate how competition influences the expression of parental care behavior. Early season parents spent less time feeding offspring, resulting in longer larval developmental periods and larvae that were heavier at dispersal. On the other hand, late season parents fed offspring more, larvae developed faster, and were smaller at dispersal. These results may indicate that late season parents invest more in care behaviors directed towards rapid development of the larvae, potentially to reduce the risks inherent to developing on a coveted resource in a high competition environment.

Assessing recovery from thermal extremes in Anolis carolinensis

Joshua Beggs, Shannan Yates, Alex Gunderson

Much recent research has focused on the effects of climate change on ectotherm physiology. Climate variability has exposed ectotherms to temperatures far beyond their normal thresholds. Two commonly used measures in thermal physiology, critical thermal maximum (CTmax) and minimum (CTmin), mark the extreme temperatures at which organisms lose neuromuscular function. However, one aspect that has been overlooked in the literature is thermal stress recovery. Our research uses A. carolinensis to examine recovery of neuromotor function after exposure to extreme temperatures. Following heat and cold exposure, we monitored recovery using two criteria: with stimuli (pinching of hindlimbs every ten seconds) and without stimuli. Due to hypothesized adaptations to warmer temperatures, we predicted higher CTmax recovery temperatures and lower CTmax recovery times in urban lizards and lizards tested during the day. Due to hypothesized adaptations to colder temperatures, we predicted lower CTmin recovery temperatures and lower CTmin recovery times in rural lizards and lizards tested at night. No significant difference was found in the recovery of urban vs. rural lizards. However, we found that recovery temperatures differed based on time of day regardless of population. Heat tolerance recovery temperature (without stimuli) was greater at night than during the day ($p=0.029$). Cold tolerance recovery temperature (with stimuli) was greater during the day than during the night ($p=0.031$). These results may indicate an increased ability to recover from extreme temperatures at night.

When Life Gives You Lemon Frosts, Knockout TFEC

Ashmika Behere, Juliana Luzete, Sydney Ward, Douglas Menke, Tony Gamble

Color and pattern are used by animals for inter- and intra-specific communication. Studies on the genetic basis of color in mammals and fish have had a profound impact in evolutionary biology. Unlike mammals which can only produce melanin, reptiles have specialized cells for producing different pigments and structural colors. Yet, few studies have focused on reptiles and even less have used functional experiments to verify candidate color genes. Within reptiles, leopard geckos (Eublepharis macularius) have multiple color phenotypes, or morphs, that have been developed in the commercial pet trade making them a great system for learning more about the genetic basis of color. Here, we investigate an incomplete dominant morph that overproduces structural iridophores resulting in brightened white and yellow body coloration, and white eyes. This increase in iridophore production also leads to a high frequency of tumors (iridophoromas) in these geckos. TFEC is a gene that is known to be critical for iridophore production in Anolis lizards. However, its role in iridophore production is not conserved in all squamates (snakes and lizards) as TFEC in, iridophore lacking, ball pythons is instead involved in melanophore and xanthophore production. Here, we tested if TFEC function is conserved between anoles and geckos by using CRISPR-Cas9 to knockout TFEC function in a leopard gecko. Additionally, by doing so in the high-iridophore morph, we aimed to rescue the phenotype.

Form and function: Investigating leafhopper brochosome nanomechanics, structure, and hydrophobicity

Elizabeth Bello, Marianne Alleyne

Leafhopper insects produce and coat themselves with unique nanoparticles called brochosomes. These hollow geometric granuoles, made of proteins and lipids, make the cuticle antireflective and superhydrophobic, serving an important role to keep leafhoppers undetected, clean, and dry. The majority of brochosomes, called integumental brochosomes, resemble a hollow soccer ball shape. However, some female leafhopper species produce solid cylindrical pitted brochosomes, called egg brochosomes, that are used to coat egg nests laid in plant tissue. It is hypothesized that egg brochosomes are equally superhydrophobic as their integumental counterparts. In this study, we compare the hydrophobicity of these two distinct brochosome morphotypes. Additionally, we use compressive force to artificially deform integumental brochosomes, followed by wettability testing to investigate the importance of three-dimensional nanostructure on the brochosomes' waterproofing capability. We confirm prior theories that egg brochosomes are superhydrophobic, we demonstrate that compressive forces decrease the hydrophobicity of integumental brochosomes, and we show that variations in brochosome structure contribute to their nanomechanical durability. Our work provides valuable insight into the guided design of durable particle-based multifunctional material coatings.

Picky plants: do carnivorous plants with active traps exhibit size selective predation?

Danica Belman, Otto Berg, Ulrike Muller

Bladderworts (Utricularia) are a genus of carnivorous plants that use tiny suction traps to catch their planktonic prey. A single specimen can possess hundreds of traps, accounting for the large proportion of their biomass. While they are the fastest suction feeders in the world, there are significant energetic costs associated with trap firing, and Darwin hypothesized that carnivorous plants with active traps should catch the largest possible prey to maximize benefits. This study aimed to determine whether the traps of Utricularia australis are size selective. In particular, we tested the hypothesis that larger traps will select for larger and/or against smaller prey to maximize the cost-benefit ratio of trap firing. We recorded 540 capture events and measured capture success as a function of prey and trap size. We compared our experimental results to a theoretical model that predicted capture trends based on encounter probability, accounting for the size and speed of both the predator and prey. Our results show that large traps preferentially captured large prey, a trend predicted by the theoretical model. However, the model did not correctly predict the lower size limit to prey capture. All traps rejected prey under a consistent size threshold regardless of trap size. Our study expands mechanistic predator-prey models to plant predation and contributes to our understanding of how predator and prey characteristics influence prey capture strategies.

From the field to fiber: How atrazine exposure affects skeletal muscle function

Aeelin Beltran, Jeffrey Olberding

Atrazine is a common pesticide used globally in agriculture and is discarded via runoff into natural water resources. Stagnant water resources are particularly affected due to their lack of flow; allowing atrazine concentrations to accumulate. The detrimental effects of atrazine exposure on many organisms has been well documented, but the effects on the musculoskeletal system are poorly understood. Disruption to musculoskeletal function could significantly impair locomotion and performance, thus reducing an organism's chance of survival. We hypothesize that acute atrazine exposure affects skeletal muscle contraction through interactions at the neuromuscular junction. Using Xenopus laevis as a model organism, we predicted that frogs exposed to atrazine would have reduced swimming performance and reduced contractile properties in isolated muscle experiments. We exposed adult frogs to atrazine concentrations of 50mg/L, 100mg/L and 200mg/L for two weeks. Swimming performance was measured after the exposure period, then animals were euthanized and the plantaris longus muscle was dissected for in vitro muscle experiments to test for differences in contractile properties. Preliminary results indicate a trend of decreasing performance at the highest concentration. Future experiments will test the effects of chronic atrazine exposure during development and look for structural changes following exposure. Results of this study will add to the knowledge of how ecological contaminants interact with physiological systems to influence individual fitness.

When the Perch Swings: How two distal muscles keep guinea fowl balanced

Caitlin Bemis, Monica Daley

Muscle must adapt rapidly during unsteady locomotion, but their specific roles in stabilization remain unclear. We investigated how two distal muscles—the lateral gastrocnemius (LG) and digital flexor-III—contribute to take-off, landing, and stabilization in guinea fowl (Numidea meleagris) as they jumped unto unstable perches. Based on their structure, we hypothesized the DF-III would play a larger role reactive stabilization and energy modulation than the LG.

Birds jumped to 20, 30, and 40cm perches mounted on a low-friction pivot (25cm arm), which allowed swinging up to 80 degrees (typically DF-III consistently produced more positive and net work per unit muscle mass than LG, especially during landing and stabilization. It also showed greater force and activation variability with rapid EMG bursts tightly coupled to perch motion. LG contributed to take-off and maintained higher baseline force during standing but generated less work overall.

Our findings reveal distinct muscle strategies for managing force and work across phases of destabilizing task, highlighting the importance of distal muscle properties in dynamic balance and neuromechanical control during non-steady locomotion. NSF DBI 2319710

Buried alive: sand burial behaviors of the round stingray (*Urobatis halleri*)

Noah Benasfre, Dylan Baldiviezo, Shyanne Thompson, Amanda Do, Leon Rubarts, Jasmin Dudley, Roberta Mancone, Keira Spiller, Savanna Kastigar, Lessli Cruz, Priscilla Millan, Benjamin Perlman

Round stingrays (Urobatis halleri) are commonly occurring along Southern California's coastlines. In lab, we previously observed that the rays buried themselves by fluidizing sand from beneath their bodies, settling on their dorsal surface in a highly controlled manner. We were interested in quantifying the kinematics of sand burial. We used n = 8 rays (n=4 males and n=4 females) of various sizes; rays and sand were collected at Seal Beach, CA, USA. Two high-speed Edgertronic cameras were used to film the sand burial, a voluntary

behavior, in both the lateral and dorsal views at 250 fps for 4.5 seconds. We imported videos to MATLAB software where we digitally tracked the kinematics of the snout, pectoral fin, and tail motion in 3D for the entire sand burial behavior. We found the sand burial behavior to be a highly controlled set of simultaneous movements characterized by a shovel-like motion of the snout, the undulation of the pectoral fins, and oscillation of the tail. The stingrays displayed a well-coordinated set of motor control systems, most likely used to bury themselves for camouflage from predators and prey. Understanding the mechanics of sand burial behavior in round stingrays will allow for interspecific comparisons with diverse fish body plans and burial behaviors.

The role of size and color in *Bombus sandersoni* learning abilities

Catherine Benavides, Patricia Jones

Learning and memory enable animals to forage efficiently for variable resources in shifting environments. Floral traits, such as color and scent, can be associated with varying levels of pollinator reward. Workers of social bee species, who forage within these complex settings and depend on cognitive abilities to succeed in the acquisition of nectar and pollen, vary in size owing to differential received larval nutrition. As brain size scales allometrically with body size in Bombus spp., larger bees may outperform smaller bees in reward-associated choice trials due to increased cognitive ability. This gap in ability may expand when assigned a more difficult task. Using wild-caught Bombus sandersoni from the Bowdoin Scientific Station at Kent Island, NB, Canada, we utilized Free-Moving Proboscis Extension Response (FMPER) reward-associated choice trials with four different color-pairings that varied in the degree of chromatic contrasts between the stimuli. All rewarded colors were learned by tested bees, but bees showed strong preferences for yellow stimuli in their respective color pairings. Body size did not affect the success of bees in choice trials across any color pairing. We propose that B. sandersoni learning ability is not influenced by body size, which may reduce negative impacts on colony health from developmental differences. The consistent color bias for yellow may have emerged from the floral species available on Kent Island.

Conservation and taxonomic assessment of a rare Appalachian endemic - Penstemon canescens

Rebecca Beneroff, Chris Martine, Scott Schuette

Penstemon canescens (Britton) Britton (Plantaginaceae), known colloquially as Appalachian Beardtongue, is a shale-barrens endemic species distributed through much of the Appalachian Mountain range. Recently, observations of P. canescens at the upper extent of its range have raised the question whether it may be a lumped taxon warranting examination of its functional systematic traits. Questions regarding the taxonomic identity of the species date back to Francis Pernell's 1935 field description, where he noted the species "varied greatly in the width and hairiness of the leaves, and especially in the size of the flowers". The combination of taxonomic uncertainty and unclear distribution in Pennsylvania has led the Pennsylvania Natural Heritage Program to prioritize P. canescens as a species in need of assessment, in part because of its frequent occurrence in globally rare shale-barrens communities. This study seeks to clarify both the taxonomy and the range of P. canescens in Pennsylvania by employing field observations, records on community science platforms, and the combined study of living plants and historical herbarium collections.

The genetic basis of parallel climatic adaptation within and among Junco taxa.

Phred Benham, Kristen Ruegg, Amanda Carpenter, Benjamin Winger, Abby Kimmitt, Teresa Pegan, Borja Mila, Javier Sala, Maria Stager

Understanding the degree to which convergent adaptation to common environmental pressures reflects shared genetic mechanisms across taxa is an outstanding question in comparative and evolutionary biology. While several studies have approached this question through comparisons of deeply divergent species, few have explored patterns of genetic parallelism among very recently diverged taxa. Investigating this question at different timescales of divergence will be important for testing the roles of shared standing genetic variation versus independent mutations in shaping convergent evolution. Juncos include five species and over 20 subspecies that rapidly diversified and adapted to diverse climatic regimes throughout North America. We explored patterns of genetic adaptation across juncos using whole genome sequence data from 548 individual juncos. Demographic analyses confirmed a recent expansion of all subspecies following the last glacial maximum 20 kya. Population structure supports divergence among the different species, but shallow divergence within species. After accounting for neutral population structure, variation in elevation was the biggest environmental parameter explaining genomic variation across lineages this was followed by measures of precipitation and then temperature. Within each subspecies group we found similar overall patterns, but little overlap in the genes significantly associated with each axis of climatic variation. These results suggest that selection targeted variation in multiple distinct genes across subspecies to enable adaptation to climatic extremes.

Comparing bonnethead and blacktips lateral line morphology in 3D

Yasmine Bennett, Aubree Jones, Lauren Simonitis

The lateral line is a machanosensory system found in fish that is used to detect local movements, pressure gradients, and vibrations. The lateral line system has been far less studied in elasmobranchs than inteleosts. In elasmobranchs lateral line morphology has only been described in depth in a handful of species, leaving many neuroecological questions uninvestigated. In this study we compare the well-described cranial lateral line system of the bonnethead shark, Sphyrna tiburo, and the less-characterized blacktip shark, Carcharhinus limbatus. Since previous comparative lateral line behavioral data exists for both speciesm they are ideal for morphological comparison. They also differ in hunting strategy- bonnetheads primarily hunt along the seaflorr, while blacktips hunt in the water column. The lateral line system was mapped using Slicer on reconstructed contrast-enchanced micro-CT scans. With this data, we aim to enrich the existing 2D lateral line maps of the bonnethead, generate complete morphometrics of the blacktip cranial lateral line system, and make preliminiary comparisons among morphometric trends and behavior and ecology. Expanding our knolwedge on the morphology of these speciwes allows for greater understanding of the sensory basis for their foraging behaviors.

Survey of raccoon roundworm (*Baylisascaris procyonis*) across urban-rural gradients compared to diet

Yonah Bennett, Nicholas Barts

The continued urbanization of natural habitats creates an ever-growing area for human-wildlife conflicts, including the exchange of disease. Raccoons (Procyon lotor) are a common vector of zoonotic diseases, including raccoon roundworm (Baylisascaris procyonis). Raccoon roundworm transmits to humans orally through the consumption of contaminated material like latrine soil. Cases are rare, often specific to infants displaying pica, but can lead to death if not treated quickly. Within raccoons, individuals that have survived to adulthood without becoming infected must consume infected prey to gain the parasite. If urban raccoons stray from their natural diets, the overall prevalence of raccoon roundworm may decrease. Studies into the effects of urbanization on raccoon roundworm and raccoon diet have previously been conducted separately and have produced contradicting results. This project aims to combine these studies to gain a clearer understanding of the influence diet plays on raccoon roundworm prevalence. Surveys were conducted for raccoon latrines and hair across St. Louis and Kansas City, Missouri, along urban-rural transects defined by impervious surface. Zoonotic disease trends were determined by surveying for B. procyonis and general disease load in fecal floats. Diet assessments to correlate raccoon reliance on anthropogenic foods were done using stable isotope analysis on collected hair. Results indicating a reliance on anthropogenic foods and a reduction in disease within urban areas would indicate raccoons' synanthropic nature unknowingly benefits humans.

Heatwave impacts on reef symbioses: resilience and collapse in anemonefish–anemone populations

Morgan Bennett-Smith, Peter Buston, Helena Villela, Melissa Versteeg, Micaela Santos, Michael Berumen, Susana Carvalho, Viktor Peinemann, Francisca Garcia, Neus Garcias Bonet, Theresa Rueger, Raquel Peixoto

How reef populations respond to extreme climatic events is a fundamental question for ecology and conservation. We monitored anemonefish (Amphiprion bicinctus) and their host anemones (Radianthus magnifica) across three central Red Sea reefs from 2022–2024, encompassing an unprecedented marine heatwave that peaked at ~22 °C-weeks of Degree Heating Weeks. The consequences were severe: 100% of host anemones bleached, 94.3–100% of anemonefish died, and 66.4–94.1% of anemones themselves perished. These declines represent one of the most extreme documented collapses of a coral reef symbiosis, contrasting with outcomes from other Indo-Pacific sites we surveyed, where lower-intensity heat stress caused bleaching and other sublethal impacts but not near-total mortality. For example, Amphiprion percula in Papua New Guinea shrank in body size during bleaching over the same time period, a rare example of reversible growth in vertebrates. Together, these studies illustrate the spectrum of responses to marine heatwaves, from sublethal plasticity to lethal collapse, and highlight the urgent need to identify thresholds beyond which reef symbioses cannot recover and the underlying mechanisms.

Scaling analysis of spotted lanternfly (*Lycorma delicatula*) jumping mechanics

Michael Bennington, Yutong Hu, Sarthak Tiwari, Kiyn Chin, Gregory Sutton, Victoria Webster-Wood

The spotted lanternfly, Lycorma delicatula, is a large planthopper invasive in North America with remarkable jumping abilities. Recent work has investigated their adult anatomy and jumping abilities in a subset of instars. However, these analyses have been isolated to either nymphs or adults, and an investigation of their jumping has not been conducted throughout maturation. Here, we investigate how lanternfly jumping scales with maturation to investigate the governing biomechanical mechanisms driving their behaviors. High-speed videography jumping experiments were conducted with wild-caught lanternflies of different sizes to determine the scaling relationship between the jumping kinetics and mass. 3D trajectories were fit to a ballistic model to calculate the take-off velocity and average acceleration. Log-transformed mass and jump kinetics metrics (41 animals, 213 total jumps, ranging from 6g to 185g) were fit to linear regression models to determine the scaling exponents (β), reported as mean [95% confidence interval]) for velocity (βvel), acceleration (βacc), and acceleration duration (βt). The average take-off velocity for females was 1.59±0.15 m/s and did not scale with mass (βvelF = 0.026 [-0.023,0.075]), agreeing with spring-driven jumping models. For males, the average take-off velocity was 1.59±0.21 m/s and scaled slightly with mass (βvelM = 0.055 [-0.013,0.120]). Finally, for immature nymphs (where sex could not be determined), jumps differ from the sex-specific models. Future work will investigate the scaling of jumping anatomy in young nymphs to investigate possible allometry.

Exploring opsin expression patterns across snapping shrimp (*Alpheus*) species in Hawai‘i

Jackie Benson, Mireille Steck, Megan Porter

Hawai‘i is known as a critical hotspot for marine biodiversity, boasting over 40 different species of snapping shrimp in the genus Alpheus. Members are ecologically diverse, with some being solitary while others form complex mutualisms with non-shrimp invertebrates or gobies. Snapping shrimp also serve as important bioindicators through their “snaps,” indicating reef health as well as aiding in larval settlement. The snaps result from powerful cavitation bubbles necessitating an orbital hood for eye protection. Biologists assumed this hood limited their vision, especially in species that live in mutualistic relationships. However, recent research has revealed that one Alpheus species possesses the fastest visual sampling rate known among aquatic animals. Despite extensive physiological work, the molecular side of their vision remains understudied. This project aims to explore variations in the expression of genes associated with vision (opsins) between ecologically distinct snapping shrimp species through a transcriptomics approach. Preliminary results from three different species not engaging in mutualisms show expression of three opsins specialized for middle wavelength detection, two sensitive to long wavelengths, and one UV sensitive opsin. Unexpectedly, an extra UV sensitive opsin was found in only one species despite all occupying similar niches. To build upon this, more species both living in solitude and in mutualistic relationships will be analyzed. This work aims to further uncover whether ecological diversity drives variation in opsin expression within Alpheus.

Harbor seal (*Phoca vitulina*) haulout behavior in and near Morro Bay

Lucy Bentsen, Heather Liwanag

Harbor seals are coastal marine mammals that haul out close to areas of human activity, but they are notoriously reactive to human disturbance. There is currently no formal monitoring program for harbor seals along the central coast of California. Plans for a windfarm offshore of Morro Bay are likely to increase ship traffic and other human activity in the area. This project expanded upon a dataset documenting the location and timing of harbor seal haulout behavior in Morro Bay and surrounding areas. To do this, we used binoculars and a spotting scope to conduct frequent ground surveys of harbor seals at three sites in and around Morro Bay. We examined the relationship between harbor seal haulout behavior and abiotic factors, including tide level, air temperature, and wind speed. Preliminary results indicate that these factors significantly affect harbor seal abundance, but in different ways at different sites. For example, harbor seal abundance was positively associated with tide height at one site but inversely related at another. These data will be used to assess when scat collection would be possible– in the absence of the seals, and before the tide washes it away– to facilitate future scat sampling for diet composition and health markers. Ultimately, we hope to understand the impacts of increased activity associated with the offshore windfarm on our local harbor seals’ abundance and health.

Accumulated social experience impacts neurogenomic state in sensory processing regions of the brain

Ehren Bentz, Lindsay Sailer, Rikki Laser, Alexander Ophir, Nora Prior

Social information processing occurs within integrated neural circuits. Typically, sensory regions are viewed solely as static entry points for social information. However, sensory and social processing are highly dynamic, integrated, and shaped by social experiences. We investigated gene expression as a putative mechanism underlying functional plasticity in sensory and social brain regions in prairie voles (Microtus ochrogaster), a common model for investigating neural mechanisms of pair-bonding. Our study represents an ethologically relevant context in which we compared pair-bonded, offspring-rearing animals to sex-naïve controls. We examined six regions associated with sensory processing or pair-bonding: the olfactory bulb, accessory olfactory bulb, main olfactory epithelium, vomeronasal organ, medial amygdala, and nucleus accumbens. Females showed a substantial number of differentially expressed genes (DEGs) in the medial amygdala (3,386 DEGs), olfactory bulb (2,372 DEGs), accessory olfactory bulb (545 DEGs), and vomeronasal organ (130 DEGs). Males showed moderate differences in the olfactory bulb (189 DEGs) and main olfactory epithelium (76 DEGs). The nucleus accumbens, despite being a central node in the mammalian pair-bonding circuit, showed minimal differences. Functional enrichment analyses suggest these patterns of differential gene expression are associated with biological processes including cell proliferation, chromatin organization, and synaptic functions. We conclude that accumulated life history and social experience may result in long-term functional plasticity within sensory processing regions, highlighting the functional integration of the social and sensory brain.

Genomic response of guppies following a novel parasite invasion

Rachel Berg, Ronald Bassar, David Reznick, Joseph Travis, Tim Coulson, Julian Torres-Dowdall

Anthropogenic movements are accelerating the global spread of parasitic invasions, highlighting the need to understand host responses to novel parasites. These interactions can drive rapid evolutionary change, yet the underlying genomic signatures remain unclear. A parasitic nematode (Camallanus cotti) recently invaded natural streams in Trinidad, infecting transplanted populations of guppies (Poecilia reticulata). These guppy populations originated from a single source population and were part of a previously established capture-mark-recapture experiment. Guppy populations first experienced reduced survival, followed by population recovery despite continued parasite presence. Here we ask whether there is a genomic basis for this rapid population recovery and test for signatures of selection. We compared genome-wide variation of four infected guppy populations to previously published genomes sampled from the same four locations prior to invasion, and included the original source population to differentiate parasite driven changes from background divergence. Preliminary analyses suggest continued divergence of transplanted populations from their source. Genome scans reveal no single genomic region under strong selection, rather several loci distributed across the genome show signals of differentiation compared to pre-invasion samples. Some differentiated regions are shared across multiple infected populations, suggesting potential parallel evolution in response to the parasite invasion. Our results emphasize the complexity of genomic responses to parasite exposure and establish a basis for understanding how hosts adapt to emerging infectious threats.

Regional calcium depletion during embryo development in avian eggshells

Avi Berger, Juliana Alvarez, Philip Anderson

The study of birds' eggs is an important facet of avian reproductive biology, yet many questions remain unanswered or current understanding lacks satisfactory detail. As interest in the study of eggs grows, we can begin to fill in these gaps to better understand the circumstances in which chicks develop. The most obvious aspect of the avian egg is the hard, calcified shell. The shell serves not only a protective purpose but a developmental one as well, thinning throughout incubation as minerals in the shell are reallocated to comprise the bones and muscles of the developing embryo. This process may be more complex than it may appear, as eggshells are not the same thickness across all regions to begin with, and the details of where and when shell thickness diminishes is poorly understood. To describe patterns in shell thickness variation and reduction during embryo development, we incubated fertile eggs of commercially available domestic birds and measured shell thickness periodically throughout the course of incubation. We also evaluated embryo development under different incubation conditions to understand the relationship between calcium depletion in the eggshell and the physical development of the embryo.

Genomic analysis of Medusozoa reveals a decline in molecular convergence over deep timescales

Cory Berger, Paulyn Cartwright, Maria Pia Miglietta, Marina Stoilova, Rebecca Varney, Todd Oakley

Convergent phenotypes may be achieved by convergent molecular adaptations, but we do not generally understand the factors influencing the predictability of the genetic basis of convergence. Molecular convergence between lineages may decline with divergence time, suggesting that the genetic basis of adaptation is more predictable for recently-diverged lineages. However, it is unclear whether this trend holds over long timescales (>100 Mya). Using molecular clock analyses and ancestral state reconstructions, we show that Medusozoa (jellyfish and hydroids) is a powerful system to study convergence across deep time, as it contains striking examples of phenotypic convergence—including at least 9 origins of eyes and dozens of losses of the free-swimming medusa stage—that span ~200-650 Mya. We then quantify molecular convergence in Medusozoa by identifying genes with excess convergent amino acid substitutions—a signature of adaptive evolution. Although there was no clear relationship between molecular convergence and divergence time for lineages that independently lost the medusa stage, there was a decline over time among lineages that convergently gained eyes. Notably, however, eye-bearing species separated by ~600 Ma still had a non-negligible amount of molecular convergence. Our results suggest that gene re-use between convergent lineages declines slowly with time, but that some homologous genes may repeatedly be recruited into convergent phenotypes even after hundreds of millions of years of divergence.

Robot mudskipper to measure efficiency of water hopping and energy recapture from water cavity

Ian Bergerson, Daehyun Choi, Chandan Bose, Paras Singh, Kenny Zhang, Saad Bhamla

Mudskippers are amphibious fishes that can hop on the water surface by using its pectoral fins to create a splash, and its caudal fin to propel itself out of the water. In this study, a robot mudskipper is studied to determine the energy efficiency of this phenomenon, and the water cavity dynamics are analyzed using two-phase computational fluid dynamics simulations with kinematics implemented to estimate the pressure distribution on the mudskippers surface from the collapsing cavity. This robot was 3D-printed with a characteristic body length of 60 mm and optimized to mimic this water hopping behavior. A parametric study was performed by scaling the relative area of the mudskipper fin, the location of the fins, and the timing of the motor activation, to increase stability of water hopping and to maximize the energy recapture. Additionally, a drag enhancer was added to test higher velocity regimes. This model behavior is governed by approximate Weber and Froude numbers 830 and 1.3, respectively, showing significant splashing. Finally, using this robot the relationship between energy and swimming speed is determined, identifying a velocity region where this hopping technique becomes more efficient. These findings could provide new cost-effective water traversal methods.

How small, arboreal lizards run on water: Surface tension, morphology, behavior and kinematics

Philip Bergmann, Samantha Reed

The vast majority of water-walking animals are tiny invertebrates. Most water running vertebrates are larger and specialized for this behavior. As size increases, the roles of surface tension decrease and inertial mechanisms dominate. We report how Anolis sagrei, a small, quadrupedal, arboreal lizard with adhesive pads runs on water, using behavioral observations, high-speed video, and disrupting surface tension with soap. We quantified how frequently these anoles ran on water, and if this was affected by soap. We also compared their running performance and kinematics in water with and without soap. Finally, we tested whether certain morphological features affected performance, and what kinematic variables were used to modulate performance in water. Anoles ran successfully in ~17% of trials and this decreased in soap. Animals attempted to run ~24% of the time in both types of water, and floated more frequently in soapy water. Maximal velocity of running decreased in soap, but average velocity, Froude number, and the proportion of the body out of the water were unaffected. Anoles used faster slaps and shorter undulatory wavelengths in soapy water. Relative mass, foot area and leg length did not affect water running performance. Increased stride and undulatory frequencies were the primary strategies for increasing water running performance. We compared our results to often-studied basilisks and to small house geckos that have also been documented to run on water.

Blood traces of dietary specialization in bats

Andrea Bernal, Alejandra Perea-Vásquez, Jasmin Camacho, Alejandro Rico-Guevara, Sharlene Santana

Bats' dietary diversity has been studied for centuries; however, the physiology behind their fast metabolism and glucose regulation is a more recent field of study. Frugivorous and nectarivorous bats show high blood glucose levels after ingesting a sugary meal, quickly decreasing these levels through insulin signaling and exercise stimuli. We examined how wild Neotropical bats assimilate nutrients in their natural diet and the long-term effects of their

dietary specializations. We found that frugivorous bats assimilate their natural diet at a faster rate than when fed a single-sugar solution (glucose, fructose and sucrose), which could have dramatic long-term implications at the cellular level. To test this, we measured A1C levels (glycated hemoglobin) in bats with different diets, which reflect the average blood glucose levels for the last 2 to 3 months of an individual's life. We found that insectivorous bats show A1C levels similar to humans without diabetes (lower than 5.7%), while most frugivorous, omnivorous and nectarivorous bats show A1C levels corresponding to those in humans with pre-diabetes and diabetes (5.7% to > 6.5%), reaching extraordinarily high levels (11%). These results are an important step in determining the physiological dietary adaptations of bats for sugar consumption and assimilation.

Thermal tolerance of Galápagos corals during El Niño: implications for restoration

Ava Besecker, Nicolas Davalos, Margarita Brandt, Cheryl Logan

Climate change has driven widespread coral bleaching and mortality, yet some corals persist through repeated marine heatwaves. In the Galápagos, where extreme conditions provide a natural laboratory for studying resilience, some corals have persisted even after major declines during the 1982–83 El Niño. This study investigates coral thermal tolerance in an existing restoration site during warming and cooling events of the 2023–2024 El Niño. We monitored survival, bleaching, and growth using structure-from-motion photogrammetry, while examining the role of symbiont composition and genotype in driving thermal tolerance during El Niño. Clonal fragments were monitored within the Reef Revival nursery on Isabela Island and at two nearby outplanting sites with differing conditions. Coral growth varied within and between sites, with 96% of colonies growing faster at the more protected site (Bahía), where Pocillopora corals showed significantly higher growth rates (2.96 cm/year; ANOVA, $p < 0.05$) compared to the exposed site (2.10 cm/year). Growth differences may reflect variation in wave exposure, substrate slope, or other ecological factors. Unexpectedly, no widespread bleaching was observed despite the predicted El Niño. Ongoing genetic analyses will show how genotype and symbiont composition contribute to interindividual differences in growth. Understanding the drivers of growth and thermal tolerance is vital for site design, genotype selection, and fragment survival. Identifying heat-resistant corals will advance climate-resilient nurseries in the Galápagos and beyond.

Scintillating Scales: Examining butterfly scale microstructure through synchrotron-based 3D imaging

Emma Beverley, Peter Oboyski, Elizabeth Clark

Butterfly wings exhibit a dazzling array of visual variation in color, pattern and texture that is integral to survival and niche specialization. It has been well demonstrated that this visual expression is an emergent property of scale structure and organization; however, research on this topic is typically reliant on 2D imaging, which limits the relevant structural metrics that can be harnessed. Understanding and comparing microstructural wing anatomy in 3D across species (e.g., shape and arrangement of scales) is necessary to better understand how microstructural anatomy generates variation in visual signaling. We used synchrotron-based micro-CT imaging at the Advanced Light Source to examine the microstructure of the wings of various butterfly taxa from the Essig Insect Museum disparate in color, reflectivity, and opaqueness. We identified 3D structural differences associated with these visual anatomical disparities. Identifying these insights shed light on functional traits that may influence these underlying visual characteristics and their evolution.

Shedding light on the hidden diversity of deep-sea Platyctenida (phylum: Ctenophora)

Nicholas Bezio, Allen Collins, Steve Haddock, Dhugal Lindsay

Our understanding of the diversity and systematics of Ctenophora (comb jellies) is poorly understood due to a lack of reliable literature, poor preservation, difficulty in genetic barcoding, and limited sampling, resulting in a situation where species identities and ecological interactions are often challenging to determine. As a result, only three deep-sea (>200m) species of Platyctenida (benthic ctenophores) have been formally described including; Lyrocteis imperatoris (Komai, 1941), Savangia atentaculata (Dawydoff, 1950), and Tjalfiella tristoma (Mortensen, 1910). However, through recent advancements in primer/genome skimming techniques that are able to successfully recover mitochondrial and nuclear marker genes, along with the use of microCT imaging/high-definition video we are able to explore the hidden diversity of deep sea platyctenida species for the first time. Our results uncover that aside from samples morphologically matching L. imperatoris and T. tristoma, we are able to successfully identify and extend the range of the Antarctic species L. flavapallidus. Our findings also suggest the presence of additional species of Lyrocties, and numerous species which fail to match descriptions of any known species and likely represent several new genera or platyctenida. MicroCT/video analysis additionally provides evidence that small variations in internal structures are diagnostic for these new species. This work provides the first phylogenetic framework for deepsea Platyctenida and highlights the transformative role of new approaches in resolving long-standing challenges in ctenophore systematics.

How microsporidia pathogens use a ballistic organelle to invade host cells

Gira Bhabha, Damian Ekiert, Paris Watson, Nicolas Coudray, Mahrukh Usmani, Kacie McCarty

Microsporidia are tiny, single-celled parasites similar to fungi that infect a wide range of animal species, from worms and honey bees to humans. In humans, these opportunistic pathogens can cause life-threatening infections in immunocompromised individuals. To initiate an infection, microsporidia harness a specialized harpoon-like invasion apparatus called the polar tube (PT) to gain entry into host cells. The PT is tightly coiled within the transmissible extracellular spore, and is about 20 times the length of the spore. Once triggered, the PT is rapidly ejected, within milliseconds, and is thought to penetrate the host cell, acting as a conduit for the transfer of infectious cargo into the host, to initiate infection. Once inside host cells, microsporidia create a niche which is permissive to their development. We combine optical microscopy, Volume electron microscopy and structural cell biology to decipher the 3-dimensional organization, dynamics, and mechanism of the polar tube, parasite development, and host-parasite interactions. Here, we will discuss insights into the invasion mechanism via the ballistic PT organelle.

Population-specific transcriptional programs shape heat stress responses in *Nematostella vectensis*

Janki Bhalodi, Adam Reitzel

The sea anemone Nematostella vectensis inhabits highly variable estuarine environments where temperature can shift dramatically over short time scales. Populations of N. vectensis occur across a broad geographic range, from the Atlantic and Pacific coasts of North America to parts of the United Kingdom, providing an excellent system to investigate how local adaptations shape responses to temperature stress. We used RNA sequencing and bioinformatic analyses to characterize transcriptional programs in N. vectensis from Nova Scotia (NS), Maryland (MD), and Florida (FL) under acute temperature treatments at 10°C and 38°C. Anemones exhibited a stronger transcriptional response at 38°C than at 10°C, with NS and MD responses being more similar to each other and FL exhibiting a unique response. To evaluate the role of a key transcription factor, heat shock factor (HSF), we analyzed the presence of HSF binding sites (HSEs) in promoters of differentially expressed genes. Genes containing more promoter HSEs were strongly induced at 38°C across all populations. To identify the involvement of other transcription factors, we searched for overrepresented motifs in the promoters of the top 100 upregulated genes at 38°C. This analysis revealed a strong enrichment of HSF motifs in NS, but other motifs (bZIP binding site) in MD and FL. Together, these findings suggest that N. vectensis populations utilize diverse transcriptional programs in response to heat stress.

Worm buoys

Saad Bhamla

In this talk, I will share the discovery of "worm buoys" in California blackworms, where individuals latch their tails to the air–water interface under low oxygen and entangle into stable, floating structures. I will discuss how these buoys generate topological lift and move in response to stimuli. Finally, I will connect their interaction with duckweed roots to show how blackworms exploit both physics and ecology to survive and move in hypoxic freshwater habitats.

The art of stealing and sequestering organelles

Gaurav Bhardwaj, Corey Allard

The integration of foreign biological entities, such as mitochondria and chloroplasts, into eukaryotic cells has played a key role in the evolution of eukaryotes. A similar phenomenon of acquiring foreign organelles is observed in sea slugs such as the nudibranch Berghia stephanieae. These slugs feed on sea anemones and sequester their stinging organelles called nematocysts. These are elongated, capsule-like structures containing coiled, harpoon-like eversible threads, used to inject toxins. How these organelles are specifically acquired, maintained, and integrated into a functional system within the slug is largely unexplored.

First, taking advantage of the slug's amenability to microinjection, we explored whether and how specificity for nematocysts is determined by externally providing fluorescent beads, labeled and modified organelles into the slug. We use live-cell assays, electrophysiology, and high-resolution microscopy approaches to explore the properties of the slug cells that harbor these foreign organelles. We reveal the cellular basis of organelle integration by examining the organization of the cytoskeleton, complement of organelles, and sensory properties intrinsic to these cells. At the tissue scale, we investigate the sensory system controlling the nematocyst discharge for effective stinging control.

Together, our findings contribute to the understanding of the cellular and molecular mechanisms that enable organelle theft and storage and offer new insights into host-organelle interactions.

Who Survives the Winter? Linking thermogenic capacity to survival in Black-capped Chickadees

Akshiti Bhat, Maria Stager, Dai Shizuka, Wentao Yang

Winter presents severe energetic challenges for small resident birds, requiring sustained heat production through long, cold nights while maintaining sufficient foraging to fuel thermoregulation. Black-capped Chickadees, common winter residents in Massachusetts, provide an ideal system to examine how individual variation in thermogenic capacity affects winter survival. Here, we integrate physiological measurements with capture-recapture analysis to test whether metabolic traits predict survival in free-living birds. We measured summit metabolic rate (VO_2max) via flow-through respirometry as an index of maximal heat production capacity. Birds were fitted with passive integrated transponder (PIT) tags, enabling automated detection at 10 RFID-equipped feeders throughout the winter season. Using Cormack-Jolly-Seber models, we estimated weekly apparent survival while accounting for imperfect detection. Over 22 weeks (Nov 2024–Mar 2025), we tracked 30 individuals with ~800K detections. Our results suggest that individual variation in heat production capacity may influence overwinter survival. This work provides a framework for linking cellular physiology to population-level fitness consequences in small endotherms facing winter stress.

Effects of streamwise vortex impingement on free-swimming robotic tuna performance

Vinay Bhimavarapu, Hilary Bart-Smith, Joseph Zhu, Tianjun Han

Inspired by the energetic benefits of fish schools in nature, researchers have developed schooling bio-robots that exhibit power savings and speed enhancement. Most previous studies focused on bio-robot schools in side-by-side or staggered formations, which did not include streamwise vortex impingement in the school. Biologists at Harvard University have shown that by swimming right behind a bluff body in a water channel and interacting with vortices shed from the body, fish experienced reduced head pressure and gained energetic benefits, demonstrating the importance of streamwise vortex impingement regarding propulsive performance. However, the effect of streamwise vortex impingement on the performance of bio-robots remains unknown. To address this unresolved issue, we conducted experiments on a tuna-like robot freely swimming behind a bluff body in a water channel. We placed an Aruco marker from open CV on the bluff body so that the tunabot could maneuver itself to hold positions in the water channel by visually sensing its position relative to the CV marker. Power measurements were taken at different locations in the bluff body wake. The effect of streamwise vortex impingement on the performance of the free-swimming tunabot are presented. This study will help the design of high-performance bio-robots schooling in in-line formations or swimming in the wake of underwater bluff bodies, such as rocks and coral reefs.

Mixed messages: characterizing conflict and evaluating filters in phylogenomics

Leann Biancani, Rachel Schwartz

Despite the ever-increasing availability of genomic sequence data, many controversial evolutionary relationships remain unresolved. While large datasets provide more phylogenetic signal, they also amplify conflicting signal and can support incorrect relationships. Using a large-scale phylogenomic analysis of placental mammals as a case study, this study investigates the characteristics of conflicting phylogenetic signal and evaluates the efficacy of data filtering methods. We characterize sources of conflict by examining properties of loci supporting competing hypotheses for relationships at the root of placental mammals. Three filtering methods are evaluated on simulated datasets: support for uncontested clades, branch length correlation, and a novel random forest machine learning model. The best-performing methods are then applied to the empirical dataset to examine the impact on the quantity and characteristics of loci supporting competing hypotheses. This provides valuable insights into how data preprocessing can mitigate phylogenetic conflict and improve the accuracy of tree inference. This understanding is vital for developing strategies that maximize phylogenetic signal while minimizing sources of error in phylogenomic datasets.

Impact of metamorphosis on the expression of visual system genes in the eyes of Brook Salamanders

Emily Bierbaum, Ronald Bonett

Many animals rely on vision to navigate their surrounding environment. However, if an animal transitions from an aquatic to terrestrial habitat, the selective pressures on the visual system distinctively shift. This results from a change in media (water vs air) and fluctuations in available light. To quickly transition to a new habitat, animals with complex life cycles can undergo dramatic morphological changes across development. During metamorphosis, which is a thyroid hormone mediated process, the structure and function of the visual system remodels. Little is known about how metamorphosis impacts the evolution of the visual system at the molecular level, especially across closely related species that occupy disparate habitats. Salamanders offer an excellent model to study visual system adaptations because of their diverse life cycles and extreme habitats transitions. As typically seen in frogs, salamanders exhibit a metamorphic life cycle mode where the aquatic larvae transform into terrestrial adults. However, larval form paedomorphic salamanders remain in water due to the loss of metamorphosis and a terrestrial stage. In metamorphic salamanders, eye size increases post-metamorphosis with shifts in retinal composition and organization, yet obligate paedomorphic salamanders retain smaller eyes more similar to larvae. We sequenced whole-eye transcriptomes of larvae and adults across 13 lineages of Brook Salamanders to explore what molecular mechanisms might permit the visual system to adapt across species with different life cycle modes.

It takes half to be two. How widespread is hemizygosity in binary mating systems?

Sylvain Billiard, Vincent Castric, Susana Coelho, Tatiana Giraud, Pierre Saumitou-Laprade, Henrique Teotonio

Binary mating systems, where individuals are divided into two and only two mating groups, are widespread. Examples include binary mating types in many algae, yeasts, ciliates, and fungi species; heterodichogamy, distyly, and binary self-incompatibility systems in angiosperms; as well as dioecy, androdioecy, and gynodioecy in both animals and plants. The genetics and genomics underlying these systems are being increasingly well characterized, raising new questions such as: to what extent is hemizygosity, whether primary or derived, common? Hemizygosity, defined as the presence of only a single copy of a gene or chromosomal region in a diploid organism, may indeed represent the simplest and most direct mechanism for partitioning a population into two mating groups. Here we aim to: 1) compile data across lineages, from ciliates to animals, to assess the prevalence of hemizygosity relative to other genetic systems (e.g., allelism or idiomorphism); 2) evaluate whether hemizygosity has been a causal factor in the emergence of binary mating systems or instead represents a derived state; 3) discuss the evolutionary scenarios and consequences associated with hemizygosity compared to other genetic systems.

Eat smart! Invasive plant diets impact food choices, growth, and survival in juvenile crayfish

Stephanie Bilodeau

Invasive aquatic plants are the dominant vegetation in many freshwater ecosystems, but little is known about their sufficiency as food for local herbivores, beyond single-species studies targeted at biological control. Do animals choose between different plants in their environment, especially non-native plants, and do feeding choices map onto long-term growth and survival of consumers?

We offered adults and juveniles of two local crayfishes single species and multispecies options of native and non-native plants to assess preferences and growth/survival performance. Crayfish of different ages expressed different preferences, and juveniles chose plants which provided them with the best growth and survival outcomes.

Juvenile Procambarus spiculifer preferred native fanwort over two invasive plants and had ~500% greater survival (5 of 14) on this native plant than when feeding on either invasive species (only 1 of 23 survived on these plants). Juvenile P. clarkii also experienced higher survival on their preferred plant species or on diets of mixed species (79% survival after 7.5 weeks) relative to other single-plant diets (67% and 43% survival). While local consumers may prefer native species, mixed species assemblages of invasive plants can still serve as a valuable food source in a way that certain invasive monocultures may not.

Size isn't everything: dorsal fin morphology and aggression in status resolution of *Lythrypnus dalli*

Payson Bingham, Makenzie Reed, Beverlly Victoria, Devaleena Pradhan

In social species, morphological features are used in aggressive displays to establish and maintain status. The size-advantage model states that larger-bodied individuals attain higher social ranks than smaller conspecifics. The bluebanded goby, Lythrypnus dalli, is a bidirectional sexually plastic fish that organizes into social hierarchies composed of one dominant male and several subordinate females. While there is a positive relationship between standard length of L. dalli and higher social status, we hypothesized dorsal fin morphology is an additional anatomical feature used in hierarchy formation. We predicted that dominant fish will have greater dorsal fin morphological measurements than subordinate fish. We formed groups of three fish with various standard lengths and dorsal fin sizes. During various timepoints in hierarchy formation, dominant and immediately subordinate fish were determined using a matrix of aggressive, territorial, and parental behaviors. Fish were then photographed for morphological feature analysis and analyzed using ImageJ. Dominant fish had greater measurements than subordinate fish in all continuous variables such as fin area, longest fin ray length, and dorsal fin width. Behaviorally, fish with greater dorsal fin morphological measurements performed more fin raises and had a higher agonist efficiency. We conclude that dorsal fin morphology is important in determining social status of L. dalli. Integrating fin morphology, standard length, and behavior will give us a comprehensive understanding of the multiple characteristics involved in determining hierarchy.

Solitary to swarming: Density-dependent locomotion in whirligig beetles

Megan Bishoff, Rosario Montana, Nicole Abaid, Jake Socha

Whirligig beetles (Gyridae, Dineutus Macleay, 1825) are a genus of aquatic beetles that spend the majority their adult lives on the water surface in groups of hundreds to thousands. When disturbed by potential predators, they swim away quickly, executing fast collective maneuvers. In this study, we endeavor to understand how their individual and collective behaviors change with group density and flow regimes. Preliminary 2D footage on groups of whirligig beetles in placid and flowing regimes was collected. Beetles were collected on the New River, VA and housed in the lab for experiments. Recordings were performed at densities of 2, 5, 10, 20, 40, and 80 animals for 20 seconds, in triplicate, in a standardized container of room-temperature still water, after a 20-minute acclimation period, at 100 fps. Future goals will be to model behavior of the animals to capture how avoidance, speed, or pivoting movements change with the density variation and to collect analogous videos in a flow chamber to understand how rheotaxis may affect these interactions. The analysis of whirligig beetles at the air-water interface is an opportunity to explore unique collective dynamic interactions unlike the current terrestrial (e.g., ants), aerial (e.g., birds), and fully aquatic (e.g., fish and coral larvae) studies. This work will provide insights into collective dynamic air-water interface interactions and inspiration for bio-inspired swarm robotics and surface-bound communication.

The influence of symbiosis on the cellular response to heat stress in the Hawaiian Bobtail squid

Lacey Bishop-Schouster, Madison Emery, Elizabeth Heath-Heckman

Host-microbe associations are vital for global ecosystems, especially as climate change alters biodiversity. Understanding how temperature stress affects these interactions is key. To investigate these dynamics, we use the interaction between the Hawaiian bobtail squid (Euprymna scolopes), and its the bioluminescent symbiont Vibrio fischeri, which is housed in a gut-derived, ventral-facing light organ. This symbiosis allows the squid to camouflage against predators while the bacteria gain essential nutrients. Despite decades of research on this symbiosis, the squid's response to temperature stress has not yet been fully elucidated. We conducted a multi-organ transcriptomic analysis by rearing squid at 30 , 27.5 , and 23 , rendering them colonized or aposymbiotic, and sequencing their light organ and gill transcriptomes 24 hours post-hatching. Our RNAseq analysis revealed significant differential expression of stress pathways in both tissues at elevated temperatures, particularly those linked to lysosomal and mitochondrial function, with these effects being enhanced in symbiotic squid. A key finding is that heat stress was still exacerbated by symbiosis in non-symbiotic respiratory organs, indicating that normally beneficial symbionts may incur a new, animal-wide cost in the face of this stressor. Our future work will use visualization and quantification to validate these stress pathways, including mitophagy, cathepsin activity, and protein oxidation. This research will enhance our understanding of how climate change impacts host responses in both symbiotic and non-symbiotic contexts.

Phylogenetics and polyploidy of Central African night frogs

David Blackburn, Kaitlin Allen, Mark-Oliver Rödel, Walter Tapondjou N.

Night Frogs in the genus Astylosternus and their sister taxon Trichobatrachus (Hairy Frogs) are widespread throughout the forests of West and Central Africa. This genus consists of 12 species that vary in body size, habitat, and elevational range, and includes one species that is known to be polyploid based on cytogenetic data. To date, no complete species-level phylogeny has been conducted, though past phylogenetic studies have revealed

extreme heterozygosity in the nuclear loci suggesting that polyploidy may be widespread in the genus. In this study we aim to (1) resolve the relationship between Astylosternus and Trichobatrachus, (2) resolve phylogenetic relationships within Astylosternus using whole mitochondrial genomes to assess species boundaries, cryptic diversity, and taxonomy, (3) and (3) assess the frequency of polyploidy in the genus by screening for heterozygosity in these nuclear-coding loci. Astylosternus, which is widely distributed across a variety of forest types and elevational gradients, represents a unique system for the study of the geographic, climatic, and temporal factors influencing polyploidization in anurans.

Born of a storm: First trimester intrauterine exposure to hurricane Florence shapes birth outcomes

Alexandra Blair, Michaela Howells, Jessica Reich, Lenis Chen-Edinboro

The shift in global climate has resulted in an increase in the frequency and severity of climatic disasters. These disasters negatively impact prenatal stress that may trigger adverse pregnancy outcomes. However, it is unclear if the severity of these outcomes are influenced by the stage of fetal development when the disaster occurs. This study compares birth outcomes by trimester for those pregnant during Hurricane Florence and those in the same community one and two years prior. Participants (n = 7,240) gave birth in New Hanover County, NC, a coastal community heavily impacted by the hurricane. The hospital-recorded data was analyzed using multiple logistic regression to determine the effects of period (hurricane or pre-hurricane), trimester, and their respective interactions on birth outcomes, controlling for key demographic variables (e.g., maternal age, marital status). Neonates in their first trimester of development during Hurricane Florence had elevated odds of preterm birth, lower birth weight, and lower APGAR scores compared to prior years. This work indicates that prenatal stress driven by climate disasters can shape the bodies of those in utero. Additionally, it highlights the importance of the uterus as the first environment and adds to the literature on the developmental origins of health. This study emphasizes the importance of targeted support for pregnant people during and after climate-related disasters for those in their first trimester.

Odors can shift mosquito color preference even in stimuli of equal brightness

Adam Blake, Gregor Belušič, Jeff Riffell

Mosquitos have a wide behavioral repertoire including floral foraging, vertebrate hosts seeking, and oviposition, all of which depend on vision. It has been proposed that odor is an important cue to prime the mosquito visual system to respond to different visual cues in different behavioral contexts. However, the mechanisms and effects of such olfactory coupling remain undetermined. In previous work with Aedes aegypti, we used wind tunnel bioassays to demonstrate that behavioral responses of mosquitoes to visual cues in the presence of CO2 can be explained through achromatic differences in brightness. Intracellular recordings from the outer photoreceptors (R1-6) revealed green and UV sensitivity thereby accounting for the observed visual responses induced by CO2. Next, in order to investigate olfactory gating of visual behaviors, we presented color choices between stimuli with matching perceptual brightness. In these experiments, we found that the addition of odor to CO2 shifted the color preference of mosquitos. This result suggested input from the central photoreceptors which are thought to play a role in color vision. Our photoreceptor recordings show peak sensitivities in the UV, green, or show a dual peak in the blue and green. We then used these spectral sensitivities to model the response of the photoreceptor to stimuli to detail possible neural mechanisms for this discrimination. Taken together these results suggest mosquitoes are capable of color discrimination.

Inclusive biology curriculum can reduce student beliefs in bioessentialist fallacies

Charlie Blake, Onyebuchi Ewa, Emily Eckles

Several topics that are usually covered in high school biology or introductory undergraduate courses, such as genetic inheritance, sex determination and development, and reproductive life cycles, are often taught with outdated material that is influenced by sociocultural bias and does not reflect the scientific knowledge of today. Outmoded biology materials can perpetuate alienating gender stereotypes, feed pseudoscientific thinking, and contribute to the underrepresentation of girls and LGBTQ people is STEM. Working with experienced inclusive science educators, we developed and classroom tested inclusive curriculum materials for life science courses. We preformed mixed-method research on the impact of updated inclusive curriculum content on student attitudes based on pre- and postsurveys using previously validated scales and follow-up interviews. Our findings from pre-surveys show that students who are LGBTQ or have an LGBTQ family member come in with ideas about the biology of sex that are significantly different than their straight peers--which emphasizes the importance of presenting scientifically accurate material that avoids alienating already marginalized students. Further, our findings indicate students who participated in our inclusive biology curriculum significantly increased their attitudes of affirmation for gender and sex diversity and reduced their bioessentialist thinking.

Heavy metal load in deer mice and western jumping mice tissues from the Anaconda Superfund Site

Laura Blumensaadt, Emma Roloff, Matt Young, Zachary Cheviron

Copper mining and smelting were some of the largest and most influential industries in western Montana from the late 19th to the late 20th century. The extensive scale and duration of these practices has led to the widespread release of contaminants, particularly heavy metals and metalloids, across the surrounding landscape. This contamination is the basis for the creation of one of the largest complexes of EPA Superfund Sites within the United States. Wild terrestrial mammals are underrepresented in heavy metal contaminant studies, though they may be exposed to contaminants through multiple routes: diet, ingestion of and physical contact with soil, and placental transfer from mother to offspring. Over two summers (2024, 2025), we collected liver and blood samples from the two most common rodent species on the Anaconda Superfund Site: Peromyscus maniculatus and Zapus princeps. Using ICP-MS, we measured the levels of several essential and nonessential metals in both tissue types from individuals living in a range of contamination levels. This data provides insight into the transfer of heavy metals from environment to individual, both short- and long-term, and will complement ongoing genomic analyses of these populations to better understand the evolutionary impact of pollution.

It's getting hot in here: the influence of experimentally elevated temperature on parental behavior

Rachel Bockrath, Samuel Lane, Hailey Wimberly, Britt Heidinger

Avian parents must balance their offspring's thermal and energetic needs with their own need for self-maintenance. Changes in environmental conditions, such as temperature, may also require parents to shift their care-giving behaviors. As global average temperatures increase, avian parent's abilities to mediate these demands will become increasingly important. Here we ask: how does nest temperature influence avian parental care behavior? We experimentally elevated the nest temperature of house sparrow (Passer domesticus) nests by approximately 4oC for 8 days during the nestling's primary growth period throughout the entire breeding season for two years. We recorded four-hour videos documenting parental behavior during the middle of the treatment, when nestlings are transitioning to become fully endothermic. Videos were later scored based on an ethogram and analyzed using linear mixed models. We predict that since females have brood patches that allow them to evaluate offspring temperature, females on heated nests will reduce their time spent brooding, and difference in brooding time will increase during the warmer late season. Although several studies have investigated the connection between temperature and parental care in birds, most focus on natural variation in ambient temperature. We looked at the behavioral differences of both males and females as both provide parental care to the offspring. By employing an experimental manipulation we are better able to investigate a causal relationship between nest temperature and parental behaviors.

Morphological modularity in *Anolis* lizards

Brooke Bodensteiner, Edward Burress

Adaptive radiation is often characterized by rapid species and/or phenotypic diversification into distinct ecological niches. One such radiation is the species rich group of Anolis lizards found across the Greater Antillean Islands. These lizards have independently evolved into various morphological specialist, deemed "ecomorphs", which exploit distinct microhabitat structural supports, such as twigs and tree trunks. However, little is known about the patterns of covariation among morphological traits and the rates of trait evolution through the lens of trait modularity and integration. A key prediction of the modular evolvability hypothesis is that traits in more modular clades will demonstrate greater variation attributable to their independence. Determining the level of trait modularity, amongst morphological traits, and the rate of evolution of those modules can allow us to glean insights relating to how trait diversification proceeded during the adaptive radiation of Anolis lizards.

Approximate SLIP model reveals bird-like running in Tyrannosaurus rex

Adrian Boeye

As the largest terrestrial apex predator, the speed of Tyrannosaurus rex has seen extensive study, although gait kinematics remain a unique opportunity for research. Here, a novel Spring-Loaded Inverted Pendulum model tuned for T. rex is created, producing a dynamic model. Adjustments were made to body mass, a modelled oscillating tail, approximations of the in/outswing of the leg during the stride, as well as muscle mass distribution. Results indicate slow to intermediate speeds of 6-8 m/s for T. rex specimens >8 tonnes. These gaits represent true running with an airborne phase, with estimated speeds that support the hypothesis of an active predatory lifestyle for T. rex. Gait characteristics include a low relative stride length around two times standing hip height (~7 meters), elevated stride frequency, low ground reaction forces between 1.5-1.8 body weights, and overall avian-like gait. This avian-like locomotion extends to locomotory aspects thought to be exclusively present in all birds, including low relative stride lengths, elevated stride frequencies, smooth gait transitions, and low contact forces, all of which are elements characteristic of avian locomotion. These results provoke questions about the origins and development of avian running. This study represents an accurate model of T. rex via the assumptions and metrics, further elucidating our understanding of its speed and predatory ecology, as well as the evolution of dinosaurs and birds.

A thermal gradient in genome size influenced adaptation to freezing in polar fishes

Samuel Bogan, Muh-Ching Yee, Sean Place, Joanna Kelley

Expansions of repetitive elements (REs) can enlarge genomes and facilitate structural variation. For example, non-allelic homologous recombination (NAHR) between REs causes chromosomal inversion, duplication, and deletion. Studying Zoarcoidei, a globally-distributed suborder of fishes with antifreeze proteins (AFPs) inhabiting the Arctic and Southern Oceans, we observe a strong thermal gradient in genome size driven by RE content. We assembled haplotype-phased Zoarcoidei genomes and performed time-calibrated evolutionary genomic analyses to test three hypotheses: (i) RE expansions occurred during the invasion of polar oceans, (ii) RE expansions in polar lineages increased rates of structural variation and NAHR, (iii) NAHR between polar REs shaped the structural variation and evolution of AFPs. Increases in Zoarcoidei genome size were driven by RE expansions concurrent with invasions of polar oceans. Large, repetitive polar genomes exhibited significantly greater inversion, duplication, and deletion between haplotypes, demonstrating a thermal gradient in structural variation. AFP tandem arrays were enriched for REs that dated to the invasion of polar oceans. AFP array haplotypes exhibited duplication and deletion driven by NAHR between REs. Finally, we found that a derived AFP gene with improved antifreeze function evolved at least twice in Antarctic Zoarcodei through independent origins and RE-mediated tandem duplications of the AFP ice binding domain. These findings suggest that thermal environments may have constrained the architecture of Zoarcoidei genomes, subsequently influencing repeated adaptation to freezing.

Wing silvering enhances mate attraction in a butterfly

Carol Boggs, Daniel Chappell, Chloe Keck, Madison Mengel, Sydney Wilson, Jenna Rechsteiner, Erica Fleishman, Daniel Speiser

Both pigmentation and structural modifications of scales affect lepidopteran wing color. In Speyeria mormonia, structurally modified silver scales on the ventral wings significantly brighten the color of the overlying orange pigmented scales on the dorsal wings. We tested whether silvering affects male detection of females in the wild through changes in the dorsal wing appearance. We constructed decoys matching reflectance spectra from the orange dorsal wings, underlain by either silver ("silvered") or orange pigmented scales ("orange") on the ventral wings. Males approached "silvered" decoys significantly more often than "orange" decoys in a silvered population (S. m. eurynome) and in a population without silver scales (S. m. artonis). However, in butterflies, the ventral silvering occurs in spots. We ran a follow-up experiment, in which spots of "silvered" orange on "orange" decoys were more attractive to males, provided they were bracketed in black, as they are in butterflies. Our results highlight a potential selective pressure favoring silvering in this species, which may rely on common elements of the male visual system, since males responded in the same way in populations with and without wing silvering. Our results suggest that patterning, pigmentation and structural modifications of scales evolve synchronously across the two wing surfaces.

Structure-function linkages in the cranial and appendicular skeleton of North American carnivorans

Emily Bogner, Anissa Savani, Evelyn Tanzil, Jack Tseng

The field of vertebrate functional morphology often focuses on structure-function analyses of specific skeletal elements; only rarely are different regions of the skeletal system studied simultaneously. Therefore, structure-function covariation between the cranial and appendicular skeleton is not well understood and may evolve under independent factors. To test this hypothesis, we utilized 3D geometric morphometrics and linear ratios to quantify the structure-function relationship between the cranial and appendicular skeleton in terrestrial North American carnivorans; a clade that includes all locomotor types, diets, and body size ranges of the order. Our results show decoupled structure-function relationships in the cranial and appendicular skeletal morphologies. The cranium structure-function relationship reflects phylogeny, while mandibular morphology is linked to diet. The morphology of the forelimb bones are linked to body size and locomotion, whereas the hindlimb bones reflect phylogeny. Additionally, canids and ursids have little morphological overlap with any other families, while mephitids almost always share a morphospace with mustelids, and procyonids with felids. Single-element based morphospaces showed highest similarity between carnivoran families in the distal elements of each limb (radius, ulna, tibia), while there was less overlap in the proximal elements (humerus and femur), and the least amount of overlap among family groups was observed in the cranial skeleton. These results suggest that developmental origins may also play a role in morphological shape in addition to phylogeny, locomotion, and diet.

Chambered nautilus: quantifying ontogenetic seashell variance

Lexi Bohman, Kathleen Ritterbush

Chambered Nautilus cephalopods are often called "living fossils" because the basic architecture of their seashell has persisted recognizably over hundreds of millions of years, surviving multiple mass extinctions and climate events. Nautilus conchs record an individual's changes in shape through growth and injury, providing a storybook of the organism's life. We use conch specimens from museum collections to look for ontogenetic patterns in geometry and injury frequency. We use structured-light scanning to create sub-mm resolution 3D surface models of Nautilus shells, then use logarithmic spiral analyses to detect shifts in growth parameters. We discuss ontogenetic trends in injury frequency by tracking sublethal shell repair locations across individual specimens. We speculate intervals of size-dependent shifts in growth geometry. Future work applying these approaches to specimens collected across the

past two hundred years may help test for shifts in Nautilus ecological interactions and growth rates over the historic timescales and create baselines for comparison of fossil taxa.

The curious neuroanatomical organization of the snapping shrimp *Alpheus heterochaelis*

Jacob Bolin, Rebekah Hansen, Alexandra Kingston

Snapping shrimp are known for their enlarged snapping claw capable of producing cavitation bubbles and their orbital hood, an extension of carapace that protects the eyes and brain from cavitation-induced shock waves. A particular curiosity of members of the Alpheidae family is their loss of eye stalks. In most other decapods, the eye stalks house the optic neuropils, brain regions that process and communicate visual information from the eyes to the central brain. In alpheid shrimp, the optic neuropils have migrated into the protocerebrum, while the eyes sit directly atop the brain. This unique neural organization has led to many unanswered questions about their neuroanatomy, and few neuroanatomical descriptions of alpheid shrimp are available. In this study, we describe the neuroanatomy of Alpheus heterochaelis using immunohistochemistry and microCT to create 2D and 3D brain maps. As expected, we find the lamina, medulla, and lobula in the protocerebrum, organized beneath the eyes. Using our maps as examples of typical brains, we are investigating neurotrauma in A. heterochaelis after exposure to shock waves. Moving forward, we will examine the expression of the damage-associated proteins and markers of neurogenesis to learn how shock wave exposure affects different regions of the brain, with a special focus on damage in the eyes and optic neuropils and how it compares to damage in the rest of the central brain.

The stepwise assembly of light sensitive cells from ancestral components

Kennedy Bolstad, Leslie Babonis

Light sensitive cells are important for coordinating diverse animal behaviours, from larval motility to reproductive synchronicity. Opsins, the light sensitive proteins characteristic of photosensitive cells, provide a direct link between the environment (i.e., light regime) and intracellular signaling (i.e., phototransduction). While opsins are specific to animals, several phototransduction components, such as CNG ion channels, arose in unicellular eukaryotes suggesting that opsin-mediated phototransduction evolved by co-option of an ancestral cell with an alternate sensory modality. To understand how opsins became integrated into these ancestral cells, we characterized the role of opsins and a CNG channel during the development of light sensitivity in the larvae of Nematostella vectensis. To characterize CNG4 expressing cells, we generated a transgenic reporter line using the promoter of CNG4 to drive the expression of a fluorescent protein that shows two morphologically distinct cell types, sensory and ganglion cells. Using in situ hybridization and immunolocalization we show that the co-expression of opsins and CNG4 in sensory cells is limited to early larval stages, suggesting that only a subset of these sensory cells are photosensitive. Pharmacological inhibition of CNG channels blocks larval photoactivity, confirming that photosensitive cells use CNG channels to mediate behaviour. Future comparisons of the expression profiles of both sensory cell types (photosensitive and alternative sensory) with the CNG4-expressing ganglion cells will provide insight into the assembly of animal photosensitive cells.

Endosymbiotic apicomplexans of marine holobionts: microbial parasites in a warming ocean

Anthony Bonacolta, Linmei Li, Javier del Campo, Patrick Keeling

Apicomplexans are a large group of parasitic protists that cause devastating human diseases such as malaria. They are obligate intracellular parasites that have an interesting evolutionary history, having evolved from a free-living, phototrophic ancestor. Despite the extensive research interest in this group, novel apicomplexans with important ecological roles are still being discovered, particularly from the marine environment. These often-overlooked apicomplexans infect a myriad of marine organisms and recent research on this clade has expanded our knowledge of parasite evolution and symbiosis in the ocean. Corallicolids, for instance, have reshaped our understanding of plastid evolution and have also been shown to play a role in coral thermal tolerance. Closely related are the ichthyocolids, blood parasites of fish that were mostly overlooked and misclassified until a phylogenomic investigation showed they are sister to the corallicolids, and incredibly widespread across sampled fish diversity. Furthermore, Apostichocystis gudetama, first described in 2025, is a coccidian parasite that infects the ovaries of sea cucumbers, where it disrupts spawning cues in hatchery-reared individuals. Given the pace of recent discoveries within this lineage, developing a cohesive framework for studying endosymbiotic apicomplexans is critical. Such an approach will illuminate their hidden biodiversity, clarify their impacts on host health and fitness, and provide the knowledge needed to predict how these parasites and their hosts will respond to accelerating climate change.

Life cycle complexity, metamorphosis, and the evolution of animal forms

Ronald Bonett, Anne-Claire Fabre

Metamorphosis is prevalent across animals, but how this dynamic process impacts the evolution of traits remains unclear. Current predictions posit that metamorphosing traits promote adaptive diversification by parsing a life cycle into independently evolving functional stages, whereas non-metamorphosing traits are evolutionarily constrained by adaptive compromises of different environments. Here we highlight often overlooked aspects of how the evolution of life cycle complexity and metamorphosis can significantly affect trait evolution. Specifically, we discuss how developmental mechanisms underlying metamorphosis can also limit phenotypic outcomes, perhaps explaining the persistence of some stereotypical animal forms over deep timescales. Life cycle simplification from abbreviating development prior to metamorphosis can break these constraints, unleashing the potential for the evolution of aberrant forms.

Neurotoxins in Nemerteans: An ELISA exploration for the presence of Tetrodotoxin

Chayse Bono, Rebecca Varney, Megan Schwartz

Nemerteans are a phylum of understudied animals that use a specialized organ, the proboscis, to subdue and paralyze their animal prey. Although a few protein venoms have been characterized from some species, several nemerteans are reported to contain tetrodotoxin (TTX), a potent neurotoxin likely acquired from environmental or microbial sources. Previous studies suggest that TTX is concentrated in the epidermis and proboscis, implicating it in both defense and prey capture. In this study we used a TTX ELISA to test the epidermis and proboscis of several nemertean species obtained from habitats near Friday Harbor Laboratories, WA, USA. Our survey demonstrated that TTX presence and concentration varied among species and tissue types, with some individuals showing detectable toxin in both epidermis and proboscis, while others did not have a detectable level of TTX. These results provide further evidence that nemerteans employ multiple strategies for prey capture and defense and highlight interspecific variability in toxin association. This work supports the value of TTX screening across nemertean diversity and a foundation for linking feeding biology with biochemical data.

Why a batoid's shape determines its locomotion style

Bart Boom, John Michael Racy, Megan Vandenberg, Tadd Truscott, Adam Summers, Ed Habtour

Batoids (skates and rays) are found from the Arctic to tropical rivers; shallow water and deep oceans; and marine and freshwater. These dorso-ventrally compressed relatives of sharks usually propel themselves with enlarged pectoral fins which have a variety of shapes and many swimming styles. The motions have a range of wavenumbers (λ), from oscillating (e.g. Manta λ=0.4) to undulating (e.g. River stingray λ=1.4). There is a correlation between the swimming style and body shape, however no physical explanation has been identified. To understand why different pectoral shapes in batoids generate different undulatory behavior, we used vibrational testing to identify mode shapes of different fin morphologies. Modeshapes show the amplitude,

number, and location of nodes–stationary points– and antinodes–points of greatest deflection. By understanding how a fin moves when periodically excited we can determine if batoids exploit this to generate fin motions. Using six models spanning the pectoral fin morphologies and wavenumbers found in nature, we found the first three mode shapes describe pectoral fin undulation. We propose that batoids excite their fins at specific frequencies to generate motions with wavenumbers found in nature. These insights into how batoids use fluid-structure resonance will guide the design of tunable artificial fins for efficient propulsion.

Sexual selection and its associated trade-offs in the leaf footed cactus bug

James Boothroyd, Phil Hahn, Christine Miller

Sexual selection is responsible for an astonishing array of extreme phenotypes. Competition within males often favors large males with weapons, who can monopolize territory or mates. Selection does not end there; males must also be selected by a female. Once selected, they must produce adequate sperm to fertilize a female's eggs when males are subject to sperm competition; when females mate multiply. It is poorly understood how all these selection act in sum across these episodes. Further, traits beneficial at each stage are costly, and thus expected to trade-off, yet, we no shockingly little about how reproductive trade-offs manifest. Here, I set out to address these gaps in knowledge using phenotypic manipulation to address trade-offs, and investigations of selection across all episodes of sexual selection, using the leaf footed cactus bug. I found that testes size increased stepwise with the loss of one, then two, weapons, suggesting a direct trade-off in tissue development. I also found dispersal may be enhanced for those missing hind legs, because the substantial weight lost may increase dispersal potential. Investigating sexual selection, I found that although mate choice and male-male competition favored larger individuals, postcopulatory selection appeared to dilute the effect of sexual selection overall. This work highlights the importance of looking at organisms holistically; how energy is investigated across many traits, and how selection acts on those traits collectively.

Latitudinal patterns of capsule size and spine dimensions in the Eastern mud snail

Jamiya Borden, Robert Podolsky

Like most gastropods, the Eastern mud snail, Ilyanassa obsoleta, encloses its fertilized eggs in a set of capsules and attaches them to substrates like algae and shells, where early development takes place. The small capsules, which are larger in volume than the collection of eggs in order to accommodate embryo growth, are adorned with numerous flat surfaces and spines. The species is distributed along the eastern coast of the U.S., and over that latitudinal range experiences a broad range of temperatures and other environmental conditions. The goal of this project is to examine changes in the size and spination patterns of capsules across this latitudinal range. In the laboratory we harvested egg capsules from snails from 12 populations spanning most of the species range from Florida to Maine. We digitized 24 landmarks for each capsule and are measuring capsule and spine dimensions. We are assessing patterns of variation in capsule size, capsule shape, and spine lengths across populations in order to develop hypotheses for the possible function of spines related to defense and gas exchange. Tests of these hypotheses will be part of our examination of the effects of latitude on life history traits in the Eastern mud snail.

Species diversity of ribbon worms (Nemertea) in Timor-Leste.

Phoebe Borkus, Svetlana Maslakova, Gustav Paulay

Timor-Leste is a country occupying the eastern part of the island of Timor, located in the Coral Triangle — the most biodiverse marine region in the world. Coral reefs of Timor are among the healthiest in the world, making them an important target of biodiversity surveys. While high marine diversity has been noted for fish and corals, it is not well documented for other taxa. We carried out the first targeted survey of nemerteans on Timor in February-March 2025, collecting 167 individuals. We documented 56 species, 52 of which are undescribed. This increases the number of nemertean species previously reported from Timor by an order of magnitude. Most (53) species were triple-documented with live photographs, vouchers, and DNA barcodes. We collected adult stages by mass sampling and ""sweating"" coral rubble, and larval stages from the plankton. No species overlap was observed between the larval and adult faunas. Species found in their planktonic larval stage contributed 23% of the total diversity. While larval sequences did not match any of the locally collected adults, three species matched adults found in other parts of the world's ocean (Japan, Hawaii, Moorea), and two larvae previously collected in the Caribbean Sea and Eastern Tropical Pacific. Our results highlight the importance of biodiversity surveys, especially in the most biodiverse and least studied parts of the world, and of sampling multiple life history stages.

Influence of beach topography on nesting sea turtles

Sally Bornhorst, Jake Lasala

A variety of environmental factors, including vegetation coverage, ambient lighting, and beach topography, can impact sea turtle nesting behavior. In 2024, hurricanes dramatically reshaped Florida's Gulf Coast, impacting the overall slope of the beaches. In addition, homeowners pushed sand back onto the beach, creating artificial berms. Sarasota County, Florida hosts the largest aggregation of loggerheads (Caretta caretta) in the Gulf and a rapidly growing green sea turtle (Chelonia mydas) population. This study aimed to determine if these beach changes impacted their nesting behavior in 2025. Slope measurements were taken directly adjacent to turtle crawls using a clinometer, and the average angle of the slope was recorded (n = 185). Measurements were recorded from the waterline to the nest location or the apex of the false crawl and total crawl length was calculated. Generalized linear models showed that the steepest slope encountered, but not the overall average slope had the greatest impact on nesting success. Species also differed - loggerheads would tackle large slopes and greens avoided them; crawl distance impacted success between species. These results suggest that large scale slope changes had less of an impact than smaller scale topographic features in nest site selection. Severe storms are becoming more common and understanding how topography impacts nesting behavior is critical to conserving these species in the future

Differing roles of sensory modalities on mass behavior in zebrafish

William Botta, Simon Garnier, Kristen Severi

Mass behavior, the rapid adoption of similar behavior by individuals within a group, is a common strategy for group cohesion in many species such as schooling fish and flocking birds. It is influenced by various factors including sensory processes allowing for detection and adoption of behavior; previous studies suggest that improved detection of conspecifics and their behavior through sensory means increases the likelihood of behavior spreading through a group. We tested this by manipulating visual and lateral line cues in zebrafish larvae and observing the impact on their spontaneous collective circling behavior exhibited when in dense groups. Larvae with functioning or ablated lateral lines were filmed in custom circular arenas exposed to constant light or darkness. Contrary to the prediction that improved perception of conspecifics should allow for increased spread of behavior, the absence of visual cues were associated with more collective circling events, not less. However, ablation of the lateral line prevented collective circling completely both in the light as well as in the dark. These results suggest a more complex interplay between these different sensory systems and the adoption of behavior, wherein some senses are required for the behavior to occur while others modulate its intensity.

The potential role for a host halide peroxidase in the sanctioning of non-cooperative symbionts.

Camille Boucaud, Elizabeth Heath-Heckman

Beneficial host-microbe associations require investment from both partners, raising the question: why do mutualistic associations not eventually transition to pathogenic through the rise of "cheating" symbionts? One answer may lie in hosts' ability to enforce symbiont investment, also called "sanctioning". The squid-Vibrio mutualism offers an ideal model to study this dynamic. In this

association, the bioluminescent bacterium Vibrio fischeri colonizes a specialized organ in the Hawaiian bobtail squid, facilitating predator avoidance via counterillumination. As light production is metabolically costly, non-luminous "cheaters" could hypothetically out-compete luminescent strains, and do so in culture. Previous studies using light-deficient mutants (Δlux), showed a population decline at 48 hours post-colonization, suggesting that the host sanctions non-luminescent symbionts. However, the molecular underpinnings of this phenomenon remain unclear. One potential candidate is halide peroxidase, an oxidizing enzyme highly abundant in symbiont-housing tissues. We hypothesize that halide peroxidase selectively sanctions cheaters by producing toxic aldehydes when luciferase reaction is absent. Performing immunocytochemistry, we identified halide peroxidase in the light organ appendages for Δlux mutants while it localized in the deeper crypts for the wild type, suggesting phenotype-specific host responses. Ongoing experiments will focus on halide peroxidase temporal expression and localization during single and co-colonization. Finally, chemical inhibition and RNAi knockdown will address its functional implications in symbiosis. Together, these findings will provide insights into how host control symbiont cooperation for a balanced partnership.

Resolving cephalopod phylogeny

Madison Boucher, Leann Biancani, Rachel Schwartz

Decapodiformes (which includes squid, cuttlefish, and their relatives) represent a highly diverse group of cephalopods, yet their evolutionary history remains partially unresolved. To address these inconsistencies, we constructed and analyzed phylogenies for selected taxa using DNA sequence data from 27 species obtained from the European Nucleotide Archive. The results strongly support a close relationship between Myopsida and Oegopsida. Xipholeptos notoides (Idiosepiidae) was also recovered as sister to Euprymna scolopes (Sepiolidae), indicating a closer relationship than previously suggested. These results align with some previous molecular findings but differ from other recent phylogenomic analyses. Refining the placement of Idiosepiidae and Sepiolidae helps clarify the early diversification of bobtail squids and their relatives. Understanding these relationships has important implications for understanding the evolution of cephalopod traits, including vision, camouflage, and reproductive biology. In a broader context, this study highlights the challenges and value of utilizing genome-scale data to address long-standing questions within diverse marine lineages.

Responsiveness of embryos to transient temperatures: Timing matters.

Rachel Bowden, Clinton Warren, Madison Wilken, Ryan Paitz

Transient shifts in temperature have the potential to influence many facets of an organism's biology and, as such, appropriate responses are often critical to their fitness. These responses may be transient (e.g., physiological, behavioral) or involve long-term to permanent changes (e.g., developmental, morphological). Given that many organisms experience transient temperatures in nature, variation in the timing of trait responses to temperature change, or what we refer to as "thermal responsiveness", is likely to have important implications to a species' ecology and adaptive capacity. When considering egg-laying vertebrates, variation in physiological responses to temperature are especially important during embryonic development when behavioral thermoregulation is highly limited. Our lab is specifically interested in the responsiveness of genes underlying two distinct phenotypic responses in developing red-eared slider turtles: (1) heat-shock response and (2) sex-determination pathways. Target genes for the former include the inducible heat-shock proteins (HSPs) which safeguard cellular proteostasis, and for the latter, those tied to each of the opposing temperature-dependent pathways which drive the permanent development of ovaries or testes. Using qPCR, we have begun to characterize the responsiveness of these various genes during critical periods of development in response to transient heat and/or cold and the long-term phenotypic consequences of this variation. Our studies have revealed that differences in ontogeny, thermal history, and duration of exposure are important sources of variation in thermal responsiveness.

The effects of early life gentle touch deprivation on touch sensitivity in Peromyscus californicus

Jared Boyce, Priya Joshi, Mia Owens, Haley Lebiecki, Peyton Luman, Stephanie Jabrial, Jada Cannon, Ravikiran Raju, Catherine Marler

Gentle touch is the first mammalian sensory experience after birth, promoting healthy infant attachment to the parent(s) and neurodevelopment. Studies in humans and rodents suggest that C-Low Threshold Mechanoreceptors in the dorsal root ganglia detect gentle touch. Children separated from their caregivers experience reduced pleasantness to gentle touch, and up to 42% of maltreated children exhibit hypersensitivity to gentle touch (tactile defensiveness). Tactile defensiveness also affects approximately 10% of the population and is a symptom of neurodevelopmental and psychiatric diseases like autism spectrum disorders, anxiety, attachment disorders, and borderline personality disorder. Despite the critical role of gentle touch early in life, the underlying molecular mechanisms have yet to be fully elucidated.Using the biparental rodent species, Peromyscus californicus, we will induce an early environment of touch deprivation with maternal, paternal, and biparental separation. We developed a Tactile Defensiveness Assay and adapted a clinically validated evaluation tool to quantify behaviors in response to gentle touch. Together, we seek to determine whether pups separated from their parents exhibit tactile defensiveness in response to gentle touch. Preliminary results suggest that i) pups in any separation condition exhibit greater sensitivity to gentle touch, and that ii) pups separated from both parents display severe tactile defensiveness at both P10 and P17. This research suggests that early life touch deprivation disrupts the development of the somatosensory system, leading to tactile defensiveness.

Testosterone increases the prevalence of helminth and coccidian parasites in wild brown anoles

Zohair Boz Al Asaal, Myles Davoll, Ashlyn Crain, Tyler Wittman, Robert Cox

The immunocompetence handicap hypothesis predicts that testosterone imposes a trade-off between enhanced secondary sexual traits and suppressed immunity. As such, increases in testosterone could alter the ability of an individual to resist or defend against parasites. We used a novel method of hormone manipulation via custom gel-forming injection to experimentally elevate testosterone levels (relative to a size-matched control group receiving only the gel-forming vehicle) in wild male brown anole lizards (Anolis sagrei). We tested for treatment effects of exogenous testosterone on the prevalence (presence or absence) and load (total count) of both helminth and coccidian parasites assayed from fecal egg counts. Our manipulation elevated circulating testosterone levels for approximately 1 month, at which time males treated with testosterone had a higher prevalence of both helminth and coccidian parasites, relative to controls. However, within infected males, testosterone had a weak and nonsignificant effect on the load of coccidian parasites and no effect on the load of helminth parasites. Our results suggest that effects of testosterone on parasitism in this species may be mediated more strongly by the risk of parasite infection than by the burden of parasitism following infection.

Mother knows best: influence of maternal cues on embryonic development in the Atlantic fiddler crab

Caitlin BrabbleRose, Paola López-Duarte

In many crustacean species, fertilized eggs are attached to abdominal appendages, and embryos develop attached to the female throughout incubation. In the Atlantic fiddler crab (Leptuca pugilator), embryo attachment is hypothesized to be necessary for survival, synchronous development, and successful larval hatching. Larval release is timed with tidal and lunar cycles, typically during nocturnal ebb tides at full and new moons, to maximize seaward export of larvae. While synchronized hatching is critical for larval dispersal, the role of maternal cues in regulating development and hatching remain unknown. We isolated embryos from the female's chemical and physical cues to test whether isolated embryos can develop synchronously with attached embryos and successfully initiate hatching. Embryos were removed at different developmental stages (early, mid, and late-stage) and exposed to chemical cue mimics previously identified in related crab species. Preliminary

results indicate that embryos develop synchronously in the absence of the female-associated cues, suggesting that maternal cues are not required for developmental synchrony. Isolated embryos that receive no female-associated cues, however, fail to successfully hatch, suggesting the necessity of maternal signals to initiate the hatching program. Experiments are underway to test whether chemical cue mimics (α-amylase, trypsin, & lysozyme) can induce hatching in isolated embryos. In L. pugilator, embryonic development appears to progress independently of maternal cues, but they are likely essential for the synchronization of larval release.

Effects of human disturbance on highly pathogenic avian influenza presence in urban habitats

Amber Brace, Elizabeth Walker, Ann Williams

Environmental alterations impact wildlife and cause physiological changes in animals that inhabit or pass through altered landscapes. Studies have demonstrated the negative effects of urbanization on physiological processes such as immune function in multiple taxa, including birds. Immune dysregulation in wild animals often occurs in response to the stressors experienced in disturbed habitats, causing increased parasitism in these organisms and the environment. As humans rapidly alter landscapes to accommodate growing populations, changes in land use ultimately result in increased contact between humans and wildlife, increasing opportunities for parasite transmission. Birds are of particular importance in such situations, as many species carry zoonotic parasites, such as highly pathogenic avian influenza (HPAI), and are often in proximity to humans.

The ongoing global HPAI outbreak has resulted in documented cases in wild and domestic birds and mammals. Indeed, recent findings of environmental transmission on dairy farms raise concerns for enhanced zoonotic pathways. Many bird species can asymptomatically carry HPAI and spread it through saliva and feces, underscoring the importance of monitoring wild birds in human-disturbed landscapes to understand future spillover risk. Here, we have collected fecal samples from camera-equipped bird feeders across levels of anthropogenic disturbance in Tampa Bay, identified resident and migratory species, and screened for the presence of HPAI. This research will help elucidate how human-altered habitats influence avian influenza dynamics and inform future mitigation efforts.

Harnessing the power of eDNA reference libraries for biodiversity and phylogenomic inferences

Heather Bracken-Grissom

Correct taxonomic identification is critical for all ocean exploration and research. In recent years, environmental DNA (eDNA) has shown increasing potential to complement biodiversity studies; however, misidentifications due to insufficient databases and a lack of properly identified material, are quite common. The development of a carefully-curated and properly-vouchered genetic reference library is a crucial first step toward the goal of a Digital Ocean. Current efforts have leveraged two of the largest and longest mesopelagic time-series projects in oceanographic history to build a comprehensive reference eDNA library across the Pacific and Atlantic basins. We are currently generating 100s of mitochondrial genomes (mitogenomes or mtgenomes) from crustaceans, fish and cephalopods, all of which have been curated in zoological collections and identified by taxonomic experts. In addition to advancing eDNA methods, these data can be harnessed for a variety of biodiversity and phylogenomic studies. Here, I will describe several examples of how mtgenomes and genome skimming data can contribute to other efforts, from phylogenetic “anchor trees” for new and cryptic species discovery to tracing the evolution of bioluminescence across the shrimp Tree of Life. While we work toward breaking the barriers that have limited the use of eDNA, it is also possible to repurpose this data to advance ecological and evolutionary studies.

One system, two tasks: hyolingual mechanics of eating and drinking in bearded dragons

Amelia Brady, Dylan Anderson, Nikole Schneider, Hannah Shideler, Helaina Callis, Ani Smith, Maressa Kennedy, Harlow Smith, Cate Pradhan, Thomas Stroud, Elska Kaczmarek, Armita Manafzadeh, Paul Gignac, Christopher Anderson, Christopher Mayerl

The survival of most amniotes depends on their ability to consume both food and water effectively. Both behaviors rely on the hyolingual system, but fundamentally differ in their mechanical demands. While feeding requires animals to acquire, process, and transport food to the back of the mouth to be swallowed, processing does not occur during drinking, suggesting that some amount of neuromotor flexibility must be present in order to adequately perform both behaviors. Despite these differences, we have minimal insight into how amniotes modulate hyolingual function to accomplish both feeding and drinking. We used bearded dragons (Pogona vitticeps) as a systemic model to evaluate how amniotes adjust their hyolingual mechanics during feeding compared to drinking. We synchronously recorded marker-based X-ray Reconstruction of Moving Morphology (XROMM) and electromyography (EMG) data as bearded dragons fed on roaches compared with drinking. We found that in general, drinking kinematics were similar to those of food transport, but differed markedly from food processing, especially in long axis rotation of the jaw. Furthermore, EMG activity and the position of the hyoid varied between drinking and feeding behaviors across the entire sequence. Together, these data demonstrate that variation in the mechanics of feeding and drinking likely represent a continuum, suggesting that achievable modulation of the hyolingual system can be seen through both behavioral and functional plasticity.

Pair coordination influences incubation length and reproductive success in a ground nesting seabird

Kendall Brainin, Liam Taylor, Patricia Jones

Organisms with obligate biparental care establish reproductive partnerships to ensure the survival of their offspring. They must decide how to allocate finite resources between short-term reproductive success and long-term survival, while responding to the same tradeoff decisions being made by their partner. Leach’s Storm-Petrels (Procellariiformes: Hydrobatidae: Hydrobates leucorhous) are burrowing seabirds with biparental care that incubate a single-egg clutch and forage for food throughout the Gulf of Maine. We monitored the incubation schedules of 47 active burrows on Kent Island, New Brunswick, Canada in 2025 using a burrow scale monitor consisting of a weigh bridge and RFID antennas to track the weights of individuals birds as they arrived for an incubation bout or departed for a foraging bout. We examined how sex, foraging success, and partner coordination affected the length of incubation and hatch success. Incubation length was affected by foraging success and partner coordination but not by sex. Coordination between pairs across the reproductive season is an understudied component of seabird life-history decisions yet has a major impact on reproductive outcomes and hatch success.

Reconsidering paradigms: Energetics and homeostasis in tropical hibernation

Ana Breit, Julie McKinney, Erin Ehmke

Hibernation at cold temperatures offers energetic savings but limits homeostatic regulation. Warmer hibernation temperatures may not offer the same energetic benefits but allow for a greater degree of gene expression and protein synthesis not obtainable at lower temperatures, potentially allowing greater homeostatic control but at the cost of energetic savings. In the tropics, hibernators may forgo the need for energetically-expensive interbout arousals and instead passively rewarm with their environment, saving valuable fat stores but still allowing for regular interbout arousals. We hypothesized that hibernation at fluctuating daily temperatures warm enough to facilitate passive rewarming may offer greater energy savings than constant cool temperatures necessitating energetically-expensive interbout arousals. To test this hypothesis, we study fat-tailed dwarf lemurs (Cheirogaleus medius), tropical primates able to undergo months-long hibernation at temperatures ranging from 12C to 32C. We are the first research group to have manipulated hibernation in

a primate at both cool and fluctuating temperatures, allowing us to compare the energetic costs of interbout arousals and the overall hibernation season. Lemurs hibernating in fluctuating temperatures (12C - 32C) displayed greater thermolability ($p < 0.05$) and energetic savings ($p < 0.05$) than those hibernating at relatively stable, lower temperatures (18C-22C). Our research in a hibernating primate will help identify the optimal hibernation conditions for human synthetic hibernation, balancing the tradeoffs between energy conservation and homeostatic control.

Love Bites: Comparative characterization of spine morphology in snake hemipenes

Patricia Brennan, Summer Sit, Rachel Keeffe

Genital spines are common and diverse in animals, but their morphology has not been characterized. Puncture performance of snake hemipene spines varies across their diverse shape, but data on their overall morphological diversity is lacking. We characterized the morphology of spines based on microCT scans of adult hemipenes of 14 species (Colubrids, Vipers and Elapids), and examined newborn and juveniles of six species to determine changes in morphology and calcification across ontogeny. Calcified spines were segmented using 3DSlicer software. We extracted smoothed volume and surface data for each spine, and calculated sphericity. The ontogenetic series showed variation in calcification where newborns did not have calcification in three species, but did in the other three. All juveniles, except in Nerodia sipedon, had calcified spines. Adult spines were just as variable. In N. rhombifer, similarly sized adults had highly variable spine numbers and sizes , while in C. viridis spines were similar. Across species, spine number varied ten-fold (117-1234), and largest spine volume varied 100-fold (0.067-12.675mm3). The spine sphericity index also varied, with some having narrow values (0.6-0.9), and others more variable ranges (0.1-0.9). Spine distribution on the hemipene surface also varied across species, but was conserved within species. Our findings emphasize the staggering diversity of spine morphology in snakes including differences in the ontogeny of their development that may relate to a diversity of functions beyond puncture.

Strengths, challenges, and experiences of neurodivergent faculty in academia

Noah Bressman, Heidi Fritz, Christina Bradley, Hannah Carlson, Ulrike Muller

Recently, there has been increasing attention to neurodiversity in academia, with focus on supporting neurodivergent (ND) students. However, ND faculty are often overlooked in neurodiversity research, leading to a lack of support. In this study, we quantitatively and qualitatively surveyed ND faculty (n=58) about their experiences in academia to learn more about their perceived strengths and weaknesses, coping strategies, and advice for other ND academics and neurotypical (NT) peers. Overall, ND faculty are burned out, with 94.2%, 75.0%, 57.7% of responders at or above the clinical thresholds for high-level burnout regarding cynicism, exhaustion, and accomplishment dimensions, respectively. They also strongly feel they have to do more emotional labor than NT peers. Additionally, most ND faculty feel their conditions confer both strengths (72%) and weaknesses (92.9%) compared to NT peers, but also feel that the strengths generally outweigh the weaknesses. Common strengths included creativity, problem solving, empathy, hyperfocus, and attention to detail. Common weaknesses included poor mental health, time management, rejection-sensitive dysphoria, overthinking/perfectionism, and social issues. While many responders indicated they have not found successful coping strategies or support, advice to others included building support networks, finding ND peers and mentors, leaning into ND strengths, practicing self-love, and leaving unsupportive institutions and/or academia altogether. Neurodivergent faculty also wanted to emphasize to NT peers the need for specificity and directness regarding critique, expectations, and communication.

CBG in comparative endocrinology: Misconceptions, issues, directions forward

Creagh Breuner

Corticosteroid binding globulin (CBG) is a large glycoprotein found in plasma and tissues. Plasma CBG limits access of plasma glucocorticoids (GCs) to tissues. Comparative data continue to arise pointing to interesting patterns of free (unbound to CBG) vs total GCs, and clinical studies continue to demonstrate a role for free plasma GCs. However, comparative views towards CBG remain hesitant. First, our methods to date measuring free hormone are based on useful but relatively archaic methodology developed in the last century. Additionally, these methods require tritiated steroids, which are now prohibitively expensive. Secondly, free hormone has not been measured directly, needing to be estimated from total hormone, CBG capacity, and affinity of hormone for CBG. And lastly, reviewers have confounded plasma and tissue CBG; there is clear evidence in biomedical studies that CBG localized to tissues can affect glucocorticoid movement into cells, and alter cellular function. Plasma CBG, however, is made in the liver and secreted into the bloodstream—independently of CBG made in specific tissues. Given these complications, it has been suggested that we shouldn't be measuring CBG or free hormone at all. Here I am going to cover some of the recent evidence for CBG and free hormone playing a role in glucocorticoid physiology, cover the caveats of former methods, and suggest ways forward to bring measures of free hormone into our toolboxes.

Weathering parenthood: Effects of temperature and precipitation on reproduction in western bluebirds

Valerie Brewer, Felipe Barreto, Jamie Cornelius, Suzanne Austin

Weather events may alter the behavior of animals. In birds, weather (e.g., temperature, precipitation) can affect reproductive success directly via its influence on resource availability or indirectly by altering the efficiency of reproductive behaviors like chick provisioning. Additionally, extra-pair paternity, or the production of young outside of the mate-pair, is an alternative reproductive behavior that can be impacted though behavioral changes in response to weather. We explored the impacts of weather on reproduction in western bluebirds (Sialia mexicana) using several long-term datasets. We also investigated how weather affects the presence of extra-pair offspring. The results of this study will contribute to the understanding of the impacts of weather and climate change on avian reproduction and will highlight environmental factors that potentially influence variation in paternity in birds.

Insights into early tetrapod terrestrial locomotion from digit use in polydactyl alligators

Trevor Brewington, Richard Blob, Roshna Wunderlich, Masaya Iijima, Victor Munteanu, Savannah Swisher, Amanda Kellerhals

Several of the earliest taxa of tetrapod vertebrates exhibited polydactyl hands and feet, with seven or eight digits rather than the typical five or fewer seen in extant lineages. How such digit arrangements might have been used during terrestrial locomotion is unclear, given the dearth of living models in which their performance can be studied today and limited evidence from fossil trackways. However, polydactyly occasionally appears in natural populations of American alligators (Alligator mississippiensis), animals with body plans that broadly resemble those of early tetrapods. To test how polydactyly like that seen in early tetrapods might have functioned on land, we used high-speed video and an EMED-ST pressure mat to measure the limb kinematics and foot pressures of three polydactyl alligators (~1.5 m in length) during walking. Our data did not indicate significant pressures from supernumerary digits in many cases, but a few trials showed their use in some instances. This indicates that polydactyly might not contribute substantially to terrestrial propulsion, providing context for the evolutionary loss of these structures as tetrapods became more terrestrial and potentially helping to explain the lack of examples of polydactyly in fossil trackways. Our results also imply that extra digit usage does not impede terrestrial locomotion. Thus, polydactyl digits might not be strongly selected against, potentially enabling the reappearance of this trait in extant populations.

Biomechanics of batoid tails: defensive weapon or balance beam

John Brierley, Jason Ramsay

Batoids, such as stingrays and skates typically swim using enlarged pectoral fins rather than a tail and caudal fin, yet they have very prominent tails that differ in morphology and use. Most stingrays have a tail with venomous barb that is used for defense by flexing the tail above the body to thrust the barb at attackers. Skate tails lack a barb, have two dorsal fins at the caudal end, and have been observed flexing the tail laterally into turns while using their modified pelvic fins to punt along the seafloor. Here we compare the anatomical and mechanical features of the tail vertebrae and musculature in Atlantic stingrays, Hypanus sabinus, and little skates, Leucoraja erinacea, to identify traits that may facilitate different tail uses in these species. Results reveal vertebral geometries in the tail that promote increased dorsoventral stiffness in L. erinacea, and multidirectional flexibility in H. sabinus. Also, tail muscle is more evenly distributed around the tail axis, and concentrated proximal to the barb in H. sabinus. In L. erinacea it is more laterally concentrated and evenly distributed along the tail length. Our data suggests that the anatomy of the tail in H. sabinus supports its use as an omnidirectional defensive tool, while that of L. erinacea may allow it to potentially work as a counterbalance when punting and turning on the benthos.

How geography, oxygen, and thermal history shape upper thermal limits in aquatic insects

Stephanie Bristow, Alisha Shah

Increasing average temperatures and the frequency of heatwaves pose significant risks for ectotherms, whose physiology is closely tied to environmental temperature. Therefore, identifying the drivers of their upper thermal limits (UTLs) is critical for predicting their vulnerability under climate change. Most syntheses of thermal limits focus on terrestrial and marine ectotherms, with freshwater insects largely excluded despite their abundance and unique traits. This knowledge gap is further complicated by methodological inconsistency: thermal limits are sensitive to experimental design, which varies substantially across studies. As a result, there is little consensus on the factors shaping aquatic insect UTLs. Here, we test the relationships between aquatic insect UTLs and maximum habitat temperatures, breathing modes, and experimental acclimation. Using a dataset of 78 sources and phylogenetic generalized linear mixed models (PGLMMs), we assessed patterns of UTL variation while accounting for methodological and phylogenetic effects. We found that UTLs increase with maximum habitat temperature, supporting the climate extremes hypothesis (CEH). Species and life stages relying on atmospheric oxygen also had consistently higher UTLs, supporting the oxygen- and capacity-limited thermal tolerance (OCLTT) hypothesis and emphasizing the role of oxygen availability in shaping thermal limits. Additionally, acclimation temperature and duration interactively affected UTLs. Overall, our findings underscore the vulnerability of tropical species while providing new evidence that species dependent on aquatic respiration exhibit some of the narrowest estimates of heat tolerance, even in temperate regions.

The genetic underpinnings of cell type diversity in the dorsal pallium of amniotes

Samuel Broadbent, Donald Morgan, EJ Huang, Amy Balanoff

Remarkable morphological disparity differentiates the dorsal pallium (DP) of mammals, birds, and non-avian reptiles. Nevertheless, recent studies of gene expression have identified a number of highly conserved genes that purportedly define a conserved set of cell types within the DP of crown amniotes. While much attention has focused on the spatial distribution of these cell types, considerably less is known about the evolutionary histories of the genes that establish DP cell type identities. Consequently, a gap remains between our understanding of DP cell type diversity and the genetic mechanisms underlying it. To elucidate the regulatory mechanisms behind phenomena such as cell type conservation, diversification, neofunctionalization, and dosage effects in the amniote DP, we performed a comprehensive phylogenetic analysis of prominent cell type-specific markers across a diverse amniote dataset. By reconciling these gene trees with a time-calibrated species tree, we reveal how historical events – such as speciation, gene duplication, and gene loss – have shaped DP neuron diversity in crown amniotes. Analyses of coevolutionary patterns across genes within territory-specific regulatory networks further shed light on putative homologies between DP territories across species. Collectively, these results help to elucidate the genetic and evolutionary bases of DP cell type diversity across amniotes.

Musculoskeletal dynamics of the rodent feeding system

Robert Brocklehurst, Dan Bartlett, Brandon Reder, Nicolai Konow

Feeding is a fundamental task performed by the craniofacial musculoskeletal system. Our understanding of mammalian feeding mechanics is principally based on anatomical models of muscle action, validated using electromyography data. Fewer studies have focused on muscle force production or contractile properties in vivo. To characterize the actions of the craniofacial muscles during feeding, we used a combination of XROMM (X-ray reconstruction of moving morphology), fluoromicrometry and electromyography, to capture skeletal kinematics along with muscle strain and activation in rats (Rattus norvegicus). Animals were presented with a range of foods to elicit different force responses, and harder foods were associated with higher muscle strains in both biting and chewing. Our results support the functional separation of the jaw adductor muscles, e.g., strains were greatest in the temporalis during the fast-close phase of chewing, whereas the superficial master showed greater strains during slow-close (the power-stroke). We find evidence of antagonist action, with the anterior digastric (a jaw opener) actively lengthening during jaw closure to stabilize the system against perturbations when food items fracture. We also observe patterns of aponeurosis and fiber length change in the superficial masseter consistent with elastic energy storage and release. Our work provides deep insights into the musculoskeletal dynamics of the mammalian feeding system, and highlights biomechanical phenomena well known from locomotion – antagonism and elastic action – applied to feeding.

BCEENET supports student learning through CUREs using digitized natural history collections data

Cecily Bronson, Jean-Louis Bru, Jack Carlin, Noah Courtney, Sonja Cwik, Adania Flemming, Kristen Genet, Jeremy Hsu, Matt Johnson, Carly Jordan, Janice Krumm, Lisa Limeri, Kathryn Weglarz

Supporting the development and implementation of Course-based Undergraduate Research Experiences (CUREs) in ecology and evolution is an important step in supporting equity in undergraduate research opportunities. Incorporating research directly into undergraduate coursework has been shown to reduce barriers to participation, such as time and financial limitations students may experience. Biological Collections in Ecology and Evolution Network (BCEENET) is a community of collections professionals, undergraduate educators, researchers, and data experts committed to increasing equity in undergraduate research experiences through CUREs. Here, we present four inclusive CUREs created by the BCEENET community using digitized natural history collections data, a unique and growing resource that can help to expand opportunities for research in ecology and evolution. BCEENET CUREs have been implemented at 53 institutions, including 12 community colleges and 18 minority serving institutions, in online, hybrid, and in-person formats, engaging over 6,000 undergraduates in research experiences. We also discuss preliminary assessment results, support and resources for new BCEENET CURE implementers, and share opportunities to collaborate in assessment activities.

Legs, angle, traction: a new angle on dragonfly larval predation

Christofer Brothers, Sophia Phillips, Katya Tapia, Stacey Combes

Dragonfly larvae are predatory, aquatic insects equipped with a unique morphological adaptation - the labial mask, which extends rapidly during predatory strikes to grasp and pull prey towards the dragonfly's jaws. Recent studies focus on strikes in which the prey is positioned directly in front of the nymph, however many dragonflies, especially sit-and-wait predators in the family Libellulidae, successfully attack prey over a range of angular positions, extending to more than 90 degrees from their body axis while standing atop

various surfaces, including rough, slippery, and loose substrates. Previous observations suggest that predation success may vary with substrate roughness, as the tarsi (feet) can slide on smoother surfaces, especially during angled strikes. Here, we filmed larvae of the flame skimmer (Libellula saturata) interacting with freely swimming prey (Daphnia magna) atop both smooth and rough substrates. We overlaid video frames of labial strikes immediately before and at maximal labial extension to quantify the angle of each labial strike relative to the nymph's body axis. We determined whether strikes were successful and calculated success rate as a function of strike angle, distance, and substrate. We found no overall difference in success rates on slippery vs. rough substrates - but the average angle of strikes on slippery substrates was lower than on rough substrates, suggesting that the zone of potential prey capture may be reduced on slippery surfaces.

Effects of warming temperatures on the hibernating heart proteome

Catrina Brown, Jane Khudyakov, Gilbecca Rae Smith, Frank Van Breukelen, Vivi Huynh

During hibernation, animals cycle through states of torpor and short periods of arousal. During torpor, most mammals drop their Tb toward ambient temperature to conserve energy. This leads to a reduction in enzymatic activity and protein turnover. To investigate the importance of low Tb in maintaining tissue function during hibernation, we compared the heart proteomes of golden-mantled ground squirrels (Callospermophilus lateralis) that were torpid with Tb of 4oC, 12oC, 20oC, 25oC, and 30oC and those that were summer active. We isolated proteins from the samples, sequenced them using LC-MS/MS, and compared protein abundances between Tb groups. In total, we identified 1061 proteins in the ground squirrel heart proteome, of which 132 differed in abundance between Tb groups. Compared to animals hibernating at 4oC, warm hibernators had higher abundance of proteins involved in protein and lipid metabolism and cardiac muscle contraction. In comparison to summer active animals, warm hibernators had higher abundance of proteins functioning in inflammation, glycolysis, and gluconeogenesis. In contrast, few proteins differed in abundance between summer active animals and cold hibernators, suggesting that hibernation at warm temperatures may impact homeostasis. These data raise questions about how rising temperatures may impact hibernating species and provide insights on how the cardiac proteome may respond.

Comparing canine tooth morphology across domesticated dog breeds

Henry Hobbs Brown, Nicholas Hebdon, Kelly Diamond

Humans have bred dogs for many purposes, such as hunting, sport, work-related tasks, and companionship. This artificial selection has resulted in different breeding group classifications, defined by the desired functions of different breeds. In carnivorous mammals, the canine tooth is used for gripping prey; we decided to focus on the canine because it is one of the largest and most recognizable teeth in dogs. Our goal for this study was to determine if the shape of the canine tooth is correlated with the breeding group and the skull size. To test this prediction, we used the right canine tooth from 33 canids, including 32 dog breeds and 1 wolf. We compared canine tooth shape, using pseudolandmarks, and relative canine tooth size (tooth length: skull length), across 8 groups and 7 size classes. We did not find any significant differences in canine tooth shape among our breeding groups or breed sizes. Canids in the wild and working groups had proportionally larger teeth than the other breeding groups and medium-large breeds had proportionally smaller teeth than the other size groups. These results suggest that domestication has a similar effect on most breed's canine tooth morphology, as our wild canid showed the largest morphological differences from any domesticated breed.

Cadaver-based 3D kinematics of the canine hip-joint to inform *in vivo* dynamics

Ike Brown, David Lee

Comparative biomechanics includes non-model species that are highly specialized and also moderately large samples of non-model species comprising a phylogenetic analysis. Given that analytical musculoskeletal models have been established for only a few taxa, there is impetus for methods that provide high-precision kinematic data without invasive procedures such as marker implantation. This cadaver-based study of hip-joint biomechanics explores the kinematic range of the canine hip-joint in six degrees of freedom (6-DOF). We used three-dimensional biplanar x-ray motional analyses to characterize motion of the femur with respect to the pelvis during limb retraction 1) in a parasagittal plane and 2) with shear force to exaggerate hip abduction. We repeated these conditions after cranio-dorsal transection of the hip-joint capsule and compared kinematics in 6-DOF across these four conditions. As predicted, subluxation, which is diagnostic of canine hip dysplasia and osteoarthritis, increased with transection of the joint capsule. This work supports the feasibility of using cadaver-based kinematics to assess range of motion in 6-DOF and to inform in vivo dynamics of a specific joint or kinematic chain. Ongoing work using machine learning to develop marker-less tracking based on cadaver training data holds potential to enable less-invasive studies of exotic species, as well as to expand phylogenetic studies requiring data from many species of a particular clade.

Selenium effects on telomere length in the Black Hills American dipper population

Emma Brownlow, Jessica Graham

In the Black Hills of South Dakota, there is an endemic population of American dippers (Cinclus mexicanus) that has been under great duress. Due to the decline, South Dakota Game, Fish, and Parks have labeled the dipper as a species of greatest conservation need. Heavy mining in the areas surrounding Spearfish Creek has led us to believe that there are high levels of Selenium in the water. Studies suggest that excess Selenium can reduce sperm quality and quantity in males by damaging telomeres, which could contribute to previously documented decreases in hatching rate or other sublethal effects at the cellular level. Telomeres, the non-coding DNA sequences that protect chromosome ends, play an integral role in the life cycle of cells within an individual. Individuals with short telomeres have a notable drop in lifetime reproductive success, resulting in lower overall fitness. To determine the cause of the rapid decline in the Black Hills American dipper population, we examined the telomere length of individuals captured along watersheds in the Black Hills. We hypothesized that individuals exposed to higher Selenium concentrations have shorter telomeres, resulting in lower reproductive success. As bioindicators for stream health, the American dipper plays an integral role in understanding how pollution may be affecting water quality and, therefore, human health.

Utilizing large language models in upper division science courses

George Brusch

AI is increasingly integrated into various careers today, enhancing productivity and decision-making across industries such as healthcare, finance, and customer service. In biological sciences careers, AI is revolutionizing research and development by enabling advanced data analysis, accelerating drug discovery, and improving genomic sequencing, thereby enhancing our understanding of complex biological systems and facilitating personalized medicine. As AI becomes more prevalent in educational settings to prepare graduates for careers, it is crucial to understand how students perceive and respond to these technologies. I conducted two semester long case-studies on how to potentially use AI as a tool to help students understand scientific literature. I also had students participate in weekly discussion sessions about the use of AI at school, in their lives, and in their future careers. Finally, I collected anonymous data about their experiences with AI at CSUSM and their expectations for the future. Overall, I found that AI-generated summaries can be an effective tool to help students comprehend scientific research articles. I also found that

students are generally excited about using AI in the classroom and are confident that they will need to use it in their future careers. While only preliminary, these results provide data suggesting that the use of AI is an effective tool for educators to help students meet course and degree learning objectives.

Less than lethal approaches to understanding bumblebee responses to landscape scale change

Caleb Bryan

Insects, in particular pollinators, are declining in both biomass and biodiversity globally. This poses major threats to terrestrial ecosystems and global food security. Bumblebees are generalist pollinators that are common across many temperate regions and are critical for crop production in many systems. Current work monitoring bumblebees often relies on lethal sampling of insects, which limits the potential of understanding how the insects move through and utilize the landscape. In the past few years less than lethal approaches have been more commonly adopted. Here we show a variety of these approaches and how they have been successfully used to understand bumblebee forager responses to landscape scale changes.

Slippery fish: identifying the elusive male specific region of the Poecilia reticulata Y chromosome

Meridia Jane Bryant, Matthew Taves, Ben Sandkam

Sex chromosomes are remarkably diverse across species, and is thought to be in part due to the movement of genes to the sex chromosomes to resolve sexual conflict. Guppies, Poecilia reticulata, are classic models for sexual conflict and male-specific genes, yet their X and Y chromosomes are nearly identical. To identify unique Y genes, we generated crosses between populations from Trinidad and mainland South America (Suriname). We then de novo assembled fully-phased chromosome-scale genomes by trio-binning PacBio HiFi reads. Using sex-specific k-mers, M:F coverage ratio, and FST methods, we narrowed the male-specific region of the Suriname Y to a 9.9 Mb region (~25% of the chromosome). While this region contains only 52 of the 981 genes found on the Y chromosome, 19 are not present on the X chromosome, consistent with genes under sexual conflict being moved from autosomes to the Y. Interestingly, these Y-genes include TCF4, a transcription factor with sex specific expression in the gonads of mice. Additionally, TE content was far higher on the Y than the autosomes, with expansion of the Helitron, Gypsy, and hAT families. TEs may be acting to transfer genes to the Y as they replicate themself across the genome. Our work is consistent with the accumulation of male-specific genes on the Y, and provides clues to the male-determining mechanism by identifying male-specific genes.

Male lamprey Ichthyomyzon fossor invest up to half their body mass in testes

Tyler Buchinger, Weiming Li

Gonad investment varies dramatically within and across taxa. In general, females invest more in gamete production than males (i.e., higher gonadosomatic index; GSI; the proportion of body mass devoted to gonads). Broadcast spawning males in sessile or weakly mobile species can invest as much as 50% or more in testes, whereas male GSI in highly mobile species rarely exceeds 15%. Here, we report an exception to these trends — the lamprey Ichthyomyzon fossor. Lampreys including I. fossor are highly mobile jawless fish that spawn in nests built on gravel bars in streams. We found that male I. fossor invested up to 46% of their body mass in testes and, on average, nearly twice what females invested in ovaries (male GSI = 35.3 ± 1.57%, female GSI = 19.08 ± 0.65%, mean ± se). This testes investment was unique compared to 1) Lethenteron appendix (male GSI = 4.6 ± 0.4%), a nonparasitic stream-resident lamprey with the same communal mating behavior as I. fossor, 2) I. unicuspis (male GSI = 15.2 ± 0.9%), a close relative of I. fossor that differs only in being parasitic and migratory, and 3) Petromyzon marinus (male GSI = 1.35 ± 0.17%), a parasitic migratory species that differs by having a polygynous mating system. We propose that lampreys are a useful model to study the evolution of gonad investment.

Determining the timeframe of microbiome shifts in a bryozoan through reciprocal transplants.

Savannah Buckner, Kent Hatch, Jose Moscoso

Microbiomes are made up of symbiotic microorganisms residing in a host organism including viruses, bacteria, and fungi. Changes in the environment can result in microbiome variation. Preliminary studies suggest that the microbiomes of translocated Schizoporella variabilis colonies resemble those of local conspecifics while maintaining some microbes from their site of origin, suggesting a strong influence of the environment on microbiome composition which can overwhelm host controls on microbiome assembly. This study aims to determine the timeframe of changes in microbiomes of S. variabilis using reciprocal translocation and weekly sampling of individual microbiomes. We used reciprocal transplants of S. variabilis colonies at SUNY Maritime College in Bronx, NY and Captree State Park in Oak Beach, NY. Settlement plates from each location, including the cross-site transplanted plates containing S. variabilis colonies were collected at the moment of translocation and weekly thereon for seven additional weeks. ; Five colonies from each site x origin were excised from settlement plate samples from each week. S. variabilis were identified using synapomorphies for the species as described by Winston and Hayward (2012). We characterized microbial communities through sequencing of 16S rDNA gene amplicon libraries, and analysis using the DADA2 workflow.

How does a compromised immune system affect reproductive tradeoffs in leaf-footed bugs?

Lillian Burbulis, Lauren Cirino, Autumn Pembelton

Animals have finite resources and must carefully partition them into life history traits resulting in tradeoffs. Thus, energy is allocated in a hierarchical fashion. In some cases, resources are allocated to traits associated with somatic maintenance over reproduction because these traits are metabolically expensive - the metabolic investment hypothesis. Alternatively, energy might be allocated to reproduction at the cost of somatic maintenance to enhance fitness as stated by the terminal investment hypothesis. One example of somatic maintenance is an immune response, which supports the overall upkeep of the body and is metabolically expensive. We tested these hypotheses using leaf-footed cactus bugs (Narnia femorata). When no other metabolically expensive process occurs, leaf-footed bugs can partition resources that were originally being used for the growth and upkeep of hindleg weapons (i.e., autotomy) to testes size (a reproductive tradeoff). However there is limited information on how energy is partitioned when other constraining factors exist. Our aim is to examine the effects of energy allocation when another metabolically costly trait is presented (i.e., immune response). We placed late-stage juveniles into four treatments: autotomy only, autotomy/immunocompromised, immunocompromised only, and a control. We measured testes size to determine reproductive fitness. Here we discuss the possible somatic-reproductive tradeoff findings. Examining the complex nature of resource allocation will help us understand the reproductive capacity of a population and predict population dynamics.

A new vulnerability metric outperforms existing methods for assessing species' climate vulnerability

Isabella Burger, Eric Riddell

Estimating vulnerability is imperative for developing targeted management protocols for species most at risk of extinction. Climate change vulnerability is often measured by adding or multiplying the three components that constitute vulnerability – exposure, sensitivity, and response. However, adding or multiplying these metrics may poorly reflect how organisms experience and respond to environmental change. In contrast, the weighted climate vulnerability index (CCVIw) incorporates the subcomponents such that the importance of a species' sensitivity depends on the degree of exposure and a species' response depends on their exposure and sensitivity, better reflecting the true relationship between components. Here, we used the change in relative abundance of 134 butterfly species and the change in occupancy of 133 bird species to compare the ability for the three metrics (additive, multiplicative, and weighted) to accurately predict vulnerability. We found that the CCVIw had a significant relationship with changes in relative abundance and

changes in occupancy across butterflies and birds, respectively, with species ranked as more vulnerable having a greater decrease in abundance/occupancy. Alternatively, the additive and multiplicative indices had no relationship with these changes, suggesting that these estimates of vulnerability do not reflect natural trends in population structure. Thus, the CCVIw more accurately predicts vulnerability compared to traditional estimates by accounting for the dependencies between the three subcomponents, allowing for a better understanding of the mechanisms that shape climate vulnerability.

Climate manipulation alters the role of pollinators in floral microbiome assembly of two wildflowers

Emily Burgess, Moria Robinson

Microbiomes are important mediators of stress, and climate change presents several key avenues that may disrupt host/microbiome interactions. In plants, floral microbiomes may be especially critical because of their potential to impact plant reproduction. Shifts in floral phenology are well-documented consequences of climate change that may expose flowers to different microbial species pools, abiotic stressors, and key biotic interactions. For example, pollinators play an important role in microbial dispersal, and disruption of plant-pollinator interactions can result in unique trajectories of floral microbiome assembly. In 2024, snowmelt timing and air temperature were manipulated in a subalpine Rocky Mountain meadow (Rich Co., UT) to assess the effects of climate on floral phenology, microbiome assembly, focusing on two native wildflower species: Claytonia lanceolata (Montiaceae) and Delphinium nuttallianum (Ranunculaceae). Simultaneously, a pollinator limitation treatment was applied to assess the role of plant-pollinator interactions in floral microbiome assembly processes. Bacteria and fungi were cultured from individual flowers to assess microbial abundance. Phenology advanced for both plant species under climate manipulation. For bacteria in Claytonia and both bacteria and fungi in Delphinium, pollinator limitation reduced microbial abundance when climate was unmanipulated. However, this effect was weakened or reversed under nearly all altered climate treatments. This suggests that climate change may alter the roles of pollinators as microbial vectors between flowers, with potentially important ramifications for the assembly of floral microbiomes.

Smad3-mediated TGF-β gene regulation of symbiosis and heat stress in Aiptasia using ChIP-seq

Olivia Burleigh, Virginia Weis, Mascha Dix, Manuel Aranda Lastra, Maria Ruggeri

Reef-building corals and other cnidarians rely on a crucial symbiosis with dinoflagellates (Symbiodiniaceae) to thrive in their environments. In a healthy symbiosis, the host can obtain up to 90% of its energy from its symbionts. With climate change driving more frequent and severe bleaching events, the host is left starved and stressed under elevated temperatures. Increasing evidence suggests that the host's immune system plays a central role in the establishment, maintenance, and breakdown of this relationship. Transforming growth factor beta (TGF-β) is a highly conserved cytokine involved in innate immune signaling. Prior work has shown that TGF-β promotes symbiont tolerance in cnidarians, while its inhibition increases heat-induced bleaching. Although many bleaching-related processes have been studied, it remains unclear how these pathways are integrated and regulated by the immune system, particularly through TGF-β/Smad-dependent signaling. To address this gap, I aimed to identify binding sites of the Smad3 transcription factor during the early heat-stress response in symbiotic and aposymbiotic sea anemones (Exaiptasia diaphana). I performed chromatin immunoprecipitation sequencing (ChIP-seq) for Smad3 alongside RNA-seq. This represents the first application of transcription factor ChIP-seq in a symbiotic cnidarian, providing a novel framework for investigating host transcriptional regulation. Results indicate that Smad3 binding differences are more strongly associated with symbiotic state than temperature, suggesting TGF-β/Smad signaling is central to host–symbiont regulation under both ambient and heat-stress conditions.

Artificial light at night has life stage-specific effects on walnut husk fly biological rhythms

Jenna Burns, Breanna Beard, Sophia Anner, Dae-Sung Hwangbo, Alycia Lackey

Life has evolved under predictable patterns of bright day (up to 100,000+lx) and dark night (approximately 0lx). Artificial Light at Night (ALAN) (up to 100+lx) disrupts biological rhythms across taxa, which often leads to fitness consequences. We tested for effects of ALAN on biological rhythms and fitness in the walnut husk fly (Rhagoletis juglandis), which regulates its biological rhythms using temperature and light cues. To test for effects of ALAN at multiple life stages, we placed pupal flies into one of two environmental chambers, which had standard 14:10 light:dark hours but differed in the level of light they received at nighttime: ALAN (80 lux) or Control (0 lux). As the flies eclosed as adults, half stayed in their original chamber, and half were switched to the other chamber, yielding four treatment groups: ALAN pupa—ALAN adult, Control pupa—ALAN adult, ALAN pupa—Control adult, and Control pupa—Control adult. To test ALAN's effect on biological rhythms, we measured circannual rhythms (days to eclosion) and circadian rhythms (percent sleep). To test for fitness effects, we measured lifespan, body size, and female egg load. We found that ALAN disrupts eclosion timing as well as sleep patterns, with distinct effects at pupal and adult stages. I will discuss the direction of this work towards testing for evolutionary consequences of ALAN.

Light duration on nocturnal insect accumulation

Mia Buruato, Jesus Ronquillo, Jose Gonzalez, Anna Levene, Brett Seymoure

Artificial light at night is a leading cause for insect declines. Although artificial light at night disrupts insects' circadian rhythms, development, vision, predator-prey interactions and numerous other biological phenomena – perhaps the biggest issue is the flight to light behavior that many insects exhibit. Insects that fly to lights at night are estimated to have 33% mortality within 8 hours! Fortunately, research exists on underlying mechanisms that result in insect light attraction. Unfortunately, research into best practices to reduce insect light attraction is lagging. Here, we test if turning lights off intermittently throughout the night reduces the number of insects that are found at a light. We also test if intermittently turning white lights to red lights throughout the night reduces insect attraction. We ran light experiments at two sites: Dallas, TX and El Paso, TX during the summer of 2025. We found that lights with a 15 minute on and 5-minute off schedule attracted the fewest number of insects, whereas lights with a 45 minute and 15-minute off schedule attracted similar amounts of insects to a continuous light. Additionally, we found that switching lights from white to red for 15 minutes every hour did not reduce the number of insects attracted. This research demonstrates that altering the duration of lighting can help reduce the flight to light behavior of insects, albeit, with many caveats.

Effects of rearing temperature on heat-exchanger morphological development in Atlantic bluefin tuna

Jeannette Bush, Kathy Dickson, Alejandro Buentello, Kristy Forsgren

Atlantic bluefin tuna (Thunnus thynnus) exhibit regional endothermy, retaining metabolic heat in specific regions via counter-current heat exchangers (= retia), enabling specific tissue temperatures to remain elevated above ambient water temperature. To investigate the development of retia, juvenile tuna were hatchery-raised under two different temperature regimes. Indices of heat exchanger efficiency, including the length and number of paired blood vessels in red muscle retia and the cross-sectional area of visceral retia, were analyzed in relation to fish fork length (FL) and acute tissue temperature across a developmental size range (23.5 cm to 37.5 cm FL). The minimum size for red muscle endothermy (acute muscle temperature elevated > 3ºC) was 32 cm FL. Red muscle retia length increased with FL (Pearson's r=0.78, N=26, P < 0 .0001), and the rate of increase differed significantly between temperature treatments (ANCOVA, F(1,22)=4.62, P=0.043). In contrast, the number of paired vessels in the rete did not correlate with FL (r=0.16, N=24, P=0.46) or differ significantly with rearing temperature (F(1,19)=1.52, P=0.23). Visceral endothermy was not detected in the size range of juveniles studied. The cross-sectional area of

visceral retia correlated with tissue temperature elevation (r= 0.51, P= 0.02) but did not differ significantly between temperature treatments (F(1,16)=1.2, P=0.29). These findings suggest that water temperature may influence aspects of rete development and heat-exchange efficiency, potentially affecting the onset of regional endothermy in Atlantic bluefin tuna.

House sparrow nestlings reach larger sizes when exposed to higher levels of wildfire smoke

Mike Butler, Brooke Weiss, Olivia Asher, Jeffery Kittilson, Britt Heidinger

Large wildfires are becoming increasingly common across North America, and plumes of smoke can travel for hundreds of kilometers. While smoke has clear negative effects on organismal physiology, the effects on animal behavior can be quite varied. With increased activity in some species, but decreased activity in others, a wide variety of patterns can manifest within ecosystems, particularly with respect to locating or capturing food items. We conducted an in situ experiment when large Canadian wildfires resulted in increased levels of smoke-based particulate matter in eastern Pennsylvania in summer 2023. During this time, we collected data on house sparrow (Passer domesticus) nestling growth and development, and then tested for correlations between nestling phenotype and environmental conditions. We found that nestlings that were exposed to higher levels of smoke had larger body masses, longer tarsus bones, and longer wings when they were near the end of the nestling period. However, circulating levels of glucose and protein, as well as telomere length, were not affected. While the opportunistic nature of this study did not allow for testing the mechanisms driving this pattern, variation in insect activity could have made it easier for provisioning parents to either detect or capture insects to feed to their young. Additionally, reduced activity from competing songbird species might allow provisioning parents to acquire more insects to feed to their developing young.

Pressure effects on deep-sea fishes' protein structure

Amanda Byer, Samantha Canter, Rowan Considine, Katie Le, Jacob Daane, Mackenzie Gerringer

Moving from the surface to the deepest sea (nearly 11,000 m), hydrostatic pressure increases from 1 atm to around 1,100 atm, affecting all life and activity. Despite this pressure increase, fishes have evolved to use similar proteins as those found in fishes at surface pressures. In vitro experiments on proteins from sea-surface organisms show high-pressure stress often deleteriously affects protein structure, and thus function. Therefore, we hypothesized that structural changes in these deep-sea fish proteins allow these fishes to survive at high pressures. Using a handful of enzymes as case studies, this work examined pressure effects on enzyme structures in fishes from the order Perciformes, including the snailfish (Liparidae), eelpout (Zoarcidae), and lumpsucker (Cyclopteridae) families. Employing sequences from both known genes and genes identified by DNA analysis of recently collected fishes, we heterologously expressed these genes in Escherichia coli and developed novel protocols for purifying these proteins. We monitored protein conformational changes under a range of pressures (0 – 350 MPa) in solution, to minimize artifacts, using high-pressure small-angle X-ray scattering (HP-SAXS) at the Cornell High Energy Synchrotron Source (CHESS). Examining pressure effects on protein structures in deep-sea fishes not only deepens our understanding of the chemistry and biophysics of protein stability and function, but also of life in extreme environments, of potential temperature-driven fish relocation effects, and of biomedical implications.

Detecting bone pneumatized by diverticula in extant and extinct archosaurs using bone thickness

Paul Byrne, David Bottjer, Nathan Smith

Birds exhibit numerous non-ventilatory diverticula branching off the lungs and air sacs, directly pneumatizing skeletal tissues and extending around organs and joints. Despite similar patterns of pneumatization in non-avian dinosaurs, determining the presence of these pulmonary diverticula in fossils is challenging due to the rarity of soft-tissue preservation. Because the pneumatization of bone has direct effects on cortical and trabecular thickness (i.e., thinner and thicker, respectively), we assess whether the ratio between cortical and trabecular bone thickness (Ch.Th.:Tb.Th.) can reliably identify pneumatized bone. We tested this by creating volume fraction scalar maps to measure Ch.Th.:Tb.Th. using a µCT dataset of 13 extant birds, 4 extant reptiles, 8 extant mammals, and 4 extinct archosauromorphs. Six vertical sections of bone were serially measured through the caudal cervical and cranial dorsal vertebrae from each sample to ensure regional variations in thickness would not bias the results. We find that pneumatized bone exhibits a Ch.Th.:Tb.Th. of ≤2.05, while non-pneumatized bone exhibits higher values (i.e., ≤5.86). For our fossil samples, histologic sectioning was paired with µCT data to ground truth our volumetric models. No fossil samples displayed pneumosteum, nor did they exhibit Ch.Th.:Tb.Th. values lower than 2.05. Interestingly, we find relatively low Cb.Th.:Tb.Th. values in extant crocodilians (i.e., 1.8, 2.8) and an extinct shuvosaurid pseudosuchian (i.e., 2.27). Despite having non-pneumatic vertebrae, this may suggest that crocodilian-line archosaurs have trabecular and cortical bone morphology more closely resembling birds than mammals and other reptiles.

The amazing amphibious appendages of aerial-aquatic insects

Margaret Byron, Spandana Bharadwaj, Nitis Chantarawong, Jean-Paul Edwards, Snigdha Shiuly Tikader

Amphibious locomotion is relatively common in the animal kingdom, but difficult to achieve effectively in bioinspired design—due in part to insufficient mechanistic understanding of transitions between aquatic, aerial, and terrestrial environments. This is particularly true at the air-water interface, which is governed not only by aero- and hydrodynamics but also interfacial tension and associated phenomena. In this talk, we will examine the biomechanics of swimming and flying across several orders of aquatic insects, including backswimmers (Notonectidae), water boatmen (Corixidae), and diving beetles (Dytiscidae). We will explore specialized adaptations, such as superhydrophobic wings and shape-morphing limbs, that enable multimodality in these insects. We will also discuss the role of the microscale setae on the metathoracic legs, which simultaneously facilitate their dual functions as 1) non-leaky paddles during swimming and 2) springboards from the air-water interface during take-off. High-speed videography enables visualization of the (non-breaking) deformation of the surface as the setae-laden legs push down to provide a vertical reaction force, launching the insects into the air. With this information, we can quantify the interfacial forces produced during takeoff; when coupled with observed body kinematics, we can infer the respective roles of aerodynamics, hydrodynamics, and interfacial tension. Our results can not only inform the development of bioinspired vehicles, but provide valuable insight on convergent behaviors observed across taxa that enable multimodal locomotion across the air-water interface.

Variation in *Bombus impatiens* foraging habits across space and time

Alex Bzdafka

Differences in flower phenology and community composition lead to variation in floral resources over time and space. Such differences affect both the composition and quantity of pollen collected by generalist bees; the manner in which this occurs is often not well understood. To address this question, we collected pollen from Bombus impatiens throughout the foraging season across 3 field sites in, Statesboro Georgia, each with varying levels of invasion and human influence, all to understand how generalist bees respond to variation in floral resource availability. Pollen was identified using light and scanning electron microscopy, allowing us to compare foraging habits over time and among sites. We visualized the differences in pollen collection communities with non-metric multidimensional analysis (NMDS) yielding 4 distinct communities. We also found that pollen collection richness was highly variable over time. Despite this, we found similar composition of pollen collected among sites, largely due to strong preferences for certain species even if they were not observed in close proximity to a given site.

Investigating lunar phobia: Does moonlight influence foraging activity and mortality in wild mice?

Angelina Cabarle, Jonah Koenig, Tracy Burkhard, Madison Johnson

Animals balance fitness tradeoffs across activities; for example, while foraging is necessary for sustenance, it often increases predation risk. In small nocturnal rodents, lunar phobia—aversion to moonlight—is widely interpreted as an anti-predator behavior: activity should be suppressed under bright conditions to minimize visual detection by predators. While activity suppression has been reported in various rodents, these data are difficult to interpret: common methods provide coarse proxies for activity, indirect assessments of predator risk, or rely on artificial conditions such as enclosures. Alternative hypotheses remain largely unexplored, and no study has directly linked rodent activity, mortality, and lunar conditions, leaving the adaptive significance of activity suppression under moonlight unclear.

Here, we quantify activity patterns and predation risk under different lunar conditions in Western deer mice (Peromyscus sonoriensis) in the Pacific Northwest. First, we assessed activity across lunar phases using live-trap and camera-trap transects. Surprisingly, preliminary results suggest that mouse activity may increase with greater lunar illumination, contrary to current knowledge. Second, we used a clay model predation experiment to measure predation-related mortality across lunar phases. Clay models were placed along transects, and tooth and claw impressions were used to assess predation events. This approach allows us to quantify predator attacks and estimate the strength of selection on activity suppression. Together, these studies provide a more comprehensive understanding of how animals balance risk and reward.

Body composition and body fat distribution in relation to genetic variation and sex in athletic mice

Haley Cabrera, Natalie Whitehead, Natalie Trutalli, Theodore Garland

The relationship between lean mass, fat mass, and overall body composition may seem straightforward but is in fact very complex. Each component is potentially influenced by multiple factors, including age, sex, genetics, chronic levels of physical activity, and lifestyle. In particular, physical activity contributes substantially to daily energy expenditure, and even acute changes in activity levels can generate energy imbalances that alter patterns of fat storage and lean tissue maintenance, independent of food availability. Long-term selection experiments provide a powerful framework to examine how traits evolve under defined types of selection and to assess correlated responses across physiological and behavioral systems. The High Runner (HR) mouse selection experiment is a well-established model of 109 generations, in which four replicate lines have been bred for increased voluntary wheel-running behavior, and four non-selected lines are maintained as controls (C). This system has yielded extensive insight into the consequences of selection on behavior, physiology, and morphology. In the present study, we investigated fat distribution in both sexes and tested for differences among the replicate lines. We obtained whole-body composition (lean and fat mass) using non-invasive EchoMRI, then we dissected and weighed the hearts, kidneys, and visceral and reproductive fat pads. Our findings contribute to a broader understanding of how selection on a behavioral trait can shape physiological systems related to energy balance and storage. NSF IOS-2038528 and USDA CA-REEOB-5205-H.

How adhesion influences locomotor performance of geckos on surfaces of varying roughness

Zachary Cadima, Marina Vollin, Amber Wright, Tim Higham

To actively capture prey and evade predation on inclined surfaces, arboreal animals must attach firmly to the surface in order to avoid slipping and/or falling. Although there are several mechanisms for enhancing contact with a surface, anoles and geckos are two groups of vertebrates that utilize adhesion. Adhesion works best on smooth surfaces that maximize the contact area between their setae and the surface. Therefore, adhesive strength decreases with increasing surface roughness. However, almost nothing is known about how adhesive strength is related to locomotor performance. Using the day gecko (Phelsuma laticauda), collected in Hawaii, we examined the relationships between frictional adhesion and both maximum running velocity and acceleration across surfaces of varying roughness. We used high-speed videography to obtain locomotor performance and a force transducer to measure adhesive strength. We predicted that adhesive force would decrease with increasing surface roughness, and that locomotor performance would follow this pattern. As predicted, adhesive force decreased significantly with increasing surface roughness. It was expected that reduced adhesive force under these conditions increases the likelihood of foot slippage during locomotion, thereby limiting the effective transmission of propulsive forces and resulting in lower acceleration. However, surface roughness had varying impacts on locomotor performance. Our results suggest that substrate texture plays a critical role in adhesive performance, but the translation of adhesive performance to organismal performance is less clear.

Differential hippocampus RNA expression in high runner mice

Marcell Cadney, Theodore Garland

The development and evolution of complex traits, such as behavior, may be under epigenetic control. Experimental evolution can be a useful technique for understanding the molecular basis of many complex traits by using animal models to replicate evolutionary forces in controlled laboratory environments for many years. We used a novel mouse model of mice selectively bred for high voluntary wheel running behavior for over 100 generations across 30 years. As a result of selection, replicate High Runner (HR) mouse lines run 2.5-3-fold more revolutions on wheels than Control (C) lines. The goal of this study was to identify the expression profile of the hippocampus, which may have evolved to promote physical activity in the HR lines. Ten mice from each replicate HR and C line (n = 80) were sampled from generation 100 of the selection experiment. Here, we present a modern application of next-generation RNA-seq technology on this long-running selection experiment, providing greater read depth and sensitivity across the full range of the transcriptome. In a linear mixed model using line nested within linetype, analyses of expression between HR and C mice identified 48 genes after correcting for multiple comparisons. Gene Set Enrichment Analysis (GSEA) identified a small number of enriched GO terms. Finally, cross-referencing these genes with a number of databases, including GEO Accession, revealing few or no matches.

The effect of embryonic corticosterone exposure on oxidative damage and telomeres

Madelena Cagnina, Delaney Pascual, Kayla Lichtner, Sarah Chapman, Tori Chace, Nicole Joseph, Jack Dziubek, Benjamin Haussmann, Ryan Paitz, Mark Haussmann

Exposure to maternal glucocorticoids during development can have marked effects on embryonic physiology. Previous studies in avian species report significant effects of prenatal corticosterone exposure, including increased levels of oxidative damage and reduction in telomere length. During oxidative stress, radical oxygen species can accumulate and target DNA, resulting in oxidative damage. However, telomeres help protect DNA, and their degradation can be used as an indicator of cellular health and thereby organismal health and lifespan. This study investigates how embryonic exposure to corticosterone affects oxidative damage and telomere length in developing domestic chicken embryos (Gallus domesticus). On embryonic day 0, all eggs were injected with either a sesame oil vehicle or corticosterone. Blood samples were collected on embryonic day 18 to measure erythrocyte DNA oxidative damage (8-OHdG) using HPLC-LC MS/MS and telomere length using the telomere restriction fragment assay. We found that the embryos prenatally exposed to corticosterone had decreased levels of oxidative damage, and we will discuss how this finding relates to telomere length. Contrary to previous studies, this result suggests that the physiological response to prenatal corticosterone exposure may be more complex than previously understood, and we will discuss how this contributes to our understanding of physiological programming during development.

Distinct human-linked factors drive similar range size patterns in non-indigenous & cryptic species

Abigail Cahill, Frédérique Viard

Cryptic species (CS; reproductively isolated yet morphologically indistinguishable units), are common among marine animals. Whether a nominal species contains CS is affected by historical factors, with important consequences in ecology and conservation. For example, CS can affect species' perceived range size: nominal species containing CS have larger ranges than those without CS. Nonindigenous species (NIS; species translocated outside their native ranges by human activities) should also, by definition, have larger ranges than indigenous species. Since many NIS also contain CS, nominal species with large ranges might be NIS, CS or both. In particular, the cumulative effect of the two processes is unclear: if nominal species containing CS are more likely to be introduced, this might explain the observed larger ranges in CS. To separate the effects of CS and NIS, we used a previously-compiled database of 978 nominal marine metazoan species containing CS, along with publicly-available data regarding NIS status. By comparing species' latitudinal and longitudinal ranges, we show that the effect on range size of containing CS is equivalent to that of being NIS: that is, incorrect species taxonomy is equivalent to anthropogenic transport. Interestingly, the effects can also act additively: being CS+NIS sometimes leads to even larger ranges, particularly in some classes. Our work reinforces the importance of correct taxonomic identification, while accounting for human-induced actions, when studying global patterns of biodiversity.

Role of sphingosine kinase in *Exaiptasia diaphana*

Jun Cai, Virginia Weis, Angela Poole, Sheila Kitchen

Climate change has accelerated coral bleaching and the destruction of coral reefs, threatening the survival of these crucial hotspots of ecological, cultural, and economic services for millions worldwide. Despite the threat of increased bleaching events, many aspects of the cellular mechanisms of coral-algal symbiosis remain under-studied. A greater understanding of these fundamental aspects of coral biology is essential for predicting how corals respond to ongoing environmental change and developing successful conservation strategies. Sphingolipids are important lipid signalers in many cellular processes related to host-microbe interactions. We investigated the functional role of the sphingolipid pathway during symbiosis establishment in *Exaiptasia diaphana* (commonly known as Aiptasia), a model system for coral-algal symbiosis studies. We combined RNAi-mediated gene knockdown and chemical inhibition of sphingosine kinase (SPHK) to study sphingolipid regulation during symbiont uptake. We tested effects in symbiotic animals and those undergoing re-colonization and quantified symbiont density in host tissues with epifluorescent microscopy. Our results showed that RNAi successfully knocked down gene expression in symbiotic animals and SPHK inhibition significantly reduced algal colonization in re-colonizing animals. These results indicate that SPHK activity and sphingolipid signaling are essential for successful symbiont estabilshment, highlighting their important role in regulating coral-algal symbiosis.

Collective motion in a sea of chaos: understanding how fish navigate through turbulence

Michael Calicchia, Yangfan Zhang, Yu Pan, George Lauder, Rui Ni

For decades, researchers have sought to understand how fishes efficiently perceive and respond to the surrounding flow, particularly in turbulent conditions, where the stochastic, multiscale dynamics complicate navigation and often increase the cost of transport. Adding another layer of complexity is that not all turbulent flows are the same, and different types of turbulence may elicit distinct behavioral responses. In this study, we performed a series of experiments exposing groups of Giant Danios (Devario aequipinnatus) to turbulence of varying intensity and homogeneity. Depending on the experiment, turbulence was generated either by a passive grid or a jet array system. The schooling dynamics, trajectories, and kinematics of the fish were recorded using high-resolution cameras, while the turbulence characteristics and in certain studies the fish wakes were measured using 2D Particle Image Velocimetry (PIV). We then analyzed how the fish responded to the different types of turbulence and the strategies they adopted to navigate these complex environments. Finally, we explored the extent to which schooling serves as a mechanism for coping with the surrounding turbulence.

Implications of nipple size on aerodigestive physiology in premature infant pigs

Helaina Callis, Elska Kaczmarek, Ani Smith, Harlow Smith, Cate Pradhan, Maressa Kennedy, Hannah Shideler, Dylan Anderson, Thomas Stroud, Christopher Mayerl

Infant mammals must coordinate swallowing and breathing because the pathways for food and air cross at the back of the mouth. Yet, this coordination can be impacted by several factors, including nipple properties and gestational age at birth. Researchers typically measure respiration using a plethysmograph band placed around the ribcage, which may be impacted by movement and assumes that airflow at the thorax reflects airflow at the oropharynx. A spirometer measures airflow at the oropharynx and may be less sensitive to movement artifacts. We measured breathing using both a spirometer and plethysmograph to evaluate their detection of respiratory function, including the impact of nipple size on aerodigestive function. We raised premature infant pigs on a standard or small nipple, and filmed them using high-speed biplanar videofluoroscopy when feeding on both nipple types while synchronously measuring breathing. We found that the spirometer detected differences in respiratory volumes based on nipple type, with infants taking deeper breaths on the nipple they were raised on, whereas the plethysmograph didn't. There were significant differences in the detection of swallow-breath coordination between the two measures of respiration. These data demonstrate that the type of nipple an infant is raised on, and fed on, impacts respiratory function and swallow-breathe coordination. Furthermore, the methods used to evaluate respiration impact how coordination is measured, which has implications for understanding aerodigestive physiology.

Extreme Sugar Diets Rewire Glucose Regulation in Nectar-Feeding Bats

Jasmin Camacho, Valentina I. Peña Gonzalez, Andrea Bernal, Selene Swanson, Nicolas Rohner

Neotropical nectar-feeding bats hover while feeding from flowers, linking extreme locomotor demands with exceptional dietary sugar intake. While the biomechanics and bioenergetics of bat flight and feeding are well studied, the physiological and molecular basis of adaptation to an extreme sugar-rich diet remains poorly understood. Nectar-feeding bats are known to sustain extreme postprandial hyperglycemia, with blood glucose levels exceeding 750 mg/dL. Using in vivo endocrine and metabolite measurements together with in vivo and ex vivo skeletal muscle analyses, we show that nectar-feeding bats produce functionally mature insulin yet fail to lower circulating glucose levels. In skeletal muscle, GLUT4 expression is preserved, but insulin fails to activate AKT, resulting in reduced glucose uptake. Instead, muscle tissue exhibits enrichment of AMPK- and pentose phosphate–associated pathways, consistent with metabolic flexibility and redox buffering. Functional assays in nectar bat muscle cells confirm redirected insulin signaling toward ERK pathways while maintaining oxidative energy production. Together, these results reveal a noncanonical insulin signaling program that underlies adaptation to extreme sugar intake, enabling the dietary and locomotor specializations of nectar-feeding bats.

Assessing visual system morphology in social snapping shrimp

Kristina Camia, Claire Bailey, Phillip Barden

Sponge-dwelling snapping shrimp from the genus Synalpheus contain almost a quarter of all eusocial origins in animals. Like many insects and other crustaceans, Synalpheus shrimp perceive their environment using compound eyes composed of multiple optic units working cooperatively to develop an image of their surroundings. The structure of this system is subject to specialization based on various ecological factors, such as habitat depth or intraspecific relationships. Gross morphology of compound eyes can be used to estimate visual

acuity and resolution. For example, a larger eye containing a large number of facets is associated with greater acuity. To determine if complex social organization or greater depth along the water column results in a constraint in visual acuity, I will quantify Synalpheus eye morphology in eusocial and non eusocial species collected from reefs at varying depths. This project will uncover how the sensory ecology of snapping shrimp is impacted by obligate group living and environmental conditions.

How variation in parental care affects nestling quality in barn swallows (*Hirundo rustica*)

Madeleine Campbell, Mira Allen, Sarah Verner, Omar Morosse, Iris Levin, Toshi Tsunekage

In altricial species, offspring depend entirely on their parents during early maturation, meaning parental investment can profoundly affect juvenile health, growth, and development. However, parents often face trade-offs between current offspring care and future reproductive success, leading to variation in parental care within populations. In this study, we examined how differential parental care influences nestling growth and development in North American barn swallows (Hirundo rustica erythrogaster) breeding in a large colony. We monitored nests for the entire breeding season to track brood progression and recorded videos to observe parental care, specifically brooding time, feeding rate, and nest maintenance, twice during the nestling period. To assess nestling condition, we took morphometric measurements, collected developing breast feathers, and measured baseline corticosterone levels. Growth rate was calculated by changes in wing length and mass between days 5 and 12 of life. We predict that increased parental care will correspond with higher nestling quality, as indicated by larger body size, denser feather barbs, lower corticosterone levels, and faster growth rates. Our study thus grants insight into behavioral plasticity in avian parental investment and the associated consequences for offspring development.

Split by plumage: phylogenetic analysis of conspicuous plumage evolution in herons

Russell Campbell, David Kikuchi, Kathryn Everson

Avian plumage is under strong selective pressures, producing remarkable diversity in form and function. Among the many phenotypes produced, uniform white plumage is especially intriguing. Despite the reduced structural strength of melanin-free feathers, this phenotype has evolved repeatedly across birds, suggesting important but unresolved selective advantages. Herons (Ardeidae) provide an ideal system to explore this puzzle: the white phenotype occurs across genera, alongside dark-plumaged relatives, and even within polymorphic species where both morphs coexist. To investigate the evolutionary drivers of this pattern, we reconstructed ancestral states and tested for correlations between plumage color and ecological or behavioral traits. This comparative framework allows us to identify candidate selective pressures like habitat preference, foraging ecology, and social signaling that may explain the repeated origins and persistence of white plumage. By linking macroevolutionary patterns to ecological pressures, we have identified traits that warrant further empirical testing and the selective contexts in which white plumage is maintained.

Structural responses of fish enzymes to high hydrostatic pressure

Samantha Canter, Rowan Considine, Amanda Byer, Jacob Daane, Katie Le, Mackenzie Gerringer

The deep sea constitutes 70% of Earths habitable space yet remains one of the least understood ecosystems. At the deepest depths of 11,000 m, hydrostatic pressure can reach up to 110 MPa, posing physiological challenges for deep-sea organisms. To understand the effects of high pressure on protein folding and function, we investigated the enzymes malate dehydrogenase (MDH) and lactate dehydrogenase (LDH), which are essential for cell metabolism. We studied these enzymes from fishes across a range of habitat depths, including the hadal snailfish, Pseudoliparis swirei, and shallow-living lumpsucker, Cyclopterus lumpus. We cultured Escherichia coli cells containing plasmids with the genes for these target enzymes, induced protein expression, and purified the target enzyme through cell lysis and affinity purification. Enzyme purity, yield, and activity were determined through SDS-PAGE, Bradford assays, and enzyme assays, respectively. High-pressure small-angle X-ray scattering (HP-BioSAXS) at the Cornell High Energy Synchrotron Source allowed real-time monitoring of protein conformational changes in solution across a pressure range of 0 to 300 MPa. Proteins showed structural responses to increased hydrostatic pressure, and these responses were both species and temperature dependent. Studies of protein stability in deep-sea fishes inform understanding of life in extreme environments, potential impacts of climate-driven bathymetric range shifts, and provide insights for biotechnological applications.

Argentine ants display large speed fluctuations during steady-walking

Yakun Cao, Andrew Chacon, Agasthya Valluri, Nick Gravish

Small terrestrial animals navigate complex environments where rapid adjustments in speed and direction may be essential. Previous studies have categorized the variation in locomotion behaviors across scale, such as intermittent stopping/starting, directional changes, and gait variation across strides. However, we have observed that even within a stride small animals such as ants display large fluctuations in speed during steady gaits, in addition to multi-stride speed changes through turning and stopping. Here we explore the connection between intra-step speed variation and multi-step locomotion behavior. We measured the intra-step speed fluctuations of Argentine ants (Linepithema humile) walking and turning. To induce high-speed locomotion we used air-puffs to stimulate an alarm response. Our results (n = 2021 steps) showed that, on average, ants experienced a speed variation equal to 59.9% of their maximum instantaneous speed with a minimum value of 23.4%. This is higher than the 11% reported for birds and lizards in a previous study. Furthermore, greater speed variation was significantly correlated with increased average speed; faster walking displayed larger speed fluctuations within a stride. Upon antenna contact with obstacles, ants could reduce their velocity component perpendicular to the wall to nearly zero in one step. Our study demonstrates that intra-step speed fluctuations in Argentine ants are substantial and cannot be neglected, highlighting the need for further investigation into intra-step variability in small animals.

Effect of skull sexual dimorphism on biting performance

Furkan Cardakli, Chris Law, Narimane Chatar

Although sexual dimorphism is observed in many species across vertebrates, the functional implications of this phenomenon remain poorly studied. Here, we examined the effects of skull dimorphism on biting performance in two mustelids, the fisher (Pekania pennanti) and American marten (Martes americana). Despite inhabiting similar geographic ranges and consuming similar diets, fishers exhibit significant skull dimorphism while martens do not. Thus, we first tested the hypothesis that male fisher skulls, with their more robust morphology, exhibit lower stress than female fisher skulls when biting. In martens, we tested the hypothesis that there is no difference in stress between male and female martens due to the lack of skull dimorphism. We quantified the von Mises stress on the skull as a proxy for biting performance. Higher stress indicates areas likely to fracture, signifying lower biting performance. To model the stress caused by jaw adductor muscles, we employed muscle-induced finite element analysis (FEA). We then tested differences in stresses on the skull between the species and sexes. Our results in fishers show males having lower cranial stress but similar mandibular stress compared to females, suggesting males and females exhibit stress in different areas of the skull when biting. In martens, the results are alike albeit with a smaller difference in cranial stress, indicating that non-significant sexual dimorphism can still contribute to slight functional differences.

Testing the antagonistic pleiotropy hypothesis for the evolution of trade-offs

Vincent Careau, Alastair Wilson, Matthew Wolak, Theodore Garland

Given the central role of trade-offs in evolutionary theory, there has been surprisingly little examination of how quickly they emerge under selection. Theory predicts that selection should fix/purge alleles with unconditionally beneficial/deleterious effects on two or more fitness components, and the remaining standing variance for fitness should mostly consist of segregating alleles that exhibit antagonistic pleiotropy. The resulting trade-off should be quantifiable as a negative genetic correlation (rA) between fitness components. We used data from a long-term artificial selection experiment with house mice, where the selected trait (distance run) is a direct product of average running speed and duration, mimics the scenario where fitness components multiply to yield fitness. While the rA between running speed and duration remained positive in the four non-selected control lines, in the four selected lines the rA quickly declined within 7 generations and subsequently remained at rA~0-0.2 throughout 71 generations. The absence of trade-off within selected lines could be explained by a large mutational target for running speed and duration. However, after ~40 generations, the selected lines started to drift along the trade-off function, which resulted in a negative among-line correlation between running speed and duration. Hence, the combined action of selection, mutation, and drift can mask the predicted quantitative genetic signature of trade-offs within populations, while generating negative correlations that are readily detected across populations.

MHC-II diversity and *Mycoplasma* infection in the endangered Florida Scrub Jay

Andrew Carlson, Maryam Ghoojaei, Anna Savage, Eric Hoffman, David Breininger, Anna Forsman

Identifying the drivers of disease susceptibility, resistance, and tolerance in wildlife populations is a central challenge in conservation biology. Understanding these factors requires an integrative approach that connects various disciplines including ecology, immunology, and genomics. Such studies are particularly important for endangered species, like the Florida Scrub Jay (FSJ; Alphecoma coerulescens), where habitat fragmentation has resulted in isolated populations with reduced genetic diversity.

In this study, we investigated the relationship between allelic diversity at the Major Histocompatibility Complex class II locus (MHC-II) and the incidence and intensity of Mycoplasma gallisepticum (MG) infection in FSJs sampled in Brevard County, Florida. In addition to qPCR screening for current infection, we used ELISA to quantify MG-specific antibody (Ab) concentrations in plasma to identify previously exposed individuals that have subsequently recovered and retained immunological memory (MG-/Ab+). The combination of qPCR and ELISA allows us to differentiate between four disease states in relation to MG: naive (MG-/Ab-), early-stage infection (MG+/Ab-), mature infection (MG+/Ab+), and recovered from previous infection (MG-/Ab+). We tested for differences in allelic composition between naive and recovered birds that may suggest genetic underpinnings of MG resistance. Immune status of birds in all four categories was further assessed through differential white blood cell counts to characterize immune activity with infection. These insights into host-pathogen dynamics will help inform ongoing FSJ conservation strategies.

Total evidence phylogeny and geometric morphometrics of deep sea tubeshoulders (Platytroctidae)

Emily Carr, Carter Lang, Rene Martin, John Sparks

Tubeshoulders (Platytroctidae) are a family of deep-sea fishes with a novel shoulder organ capable of emitting bioluminescent goo. Tubeshoulders exhibit a large variation in body shape across the 40 species and 13 genera. However, few studies have investigated the morphological disparity across this family, which lack a comprehensive phylogeny. The first and only molecular phylogeny of Platytroctidae uses a single gene and consists of 14 species across nine genera. In this study, our goal is to create a comprehensive total evidence phylogeny of Platytroctidae, using over 50 morphological characters from 37 species and five genes. We then conduct a geometric morphometric analysis on 30 of the 40 species of tubeshoulders, including both juvenile and adult specimens. Using our newly constructed tree, we then investigate trends of morphological variation across the family. We find significant variation in body shape among genera (e.g., Platytroctes), as well as over ontogeny.

The intensity of honey bee recruitment to natural pollen sources

Morgan Carr-Markell, Madeline James, Peculiar Emmanuel-King, Erian Stewart

Honey bee colonies target their foraging efforts on the most profitable nectar sources using a unique signal called a waggle dance. Individual foragers assess resources and decide how much time and energy to spend on recruiting other bees. Pollen serves as their main source of protein, fat, vitamins, and minerals, but we know far less about what factors influence the intensity of recruitment to pollen sources than to nectar sources. In this study, we investigated the natural range of recruitment intensities to pollen sources and the influence of distance, plant source, and amount of pollen collected. We placed two colonies in plexiglass-walled hives and video recorded the behavior of 97 dancing pollen foragers. When the dancer deposited her pollen loads in a beeswax cell, we opened a door in the plexiglass, marked the forager with paint, and collected the pollen loads. We determined: the number of waggle runs performed (recruitment intensity), plant source (DNA barcoding), distance traveled (waggle run duration), and size of the pollen loads (estimated using area in ImageJ). Recruitment intensity ranged from 1 to 298 waggle runs per dance. Although distance, plant source, and pollen load size did not show significant effects on recruitment intensity, there was a trend toward an effect of distance. We discuss the implications of these results and suggest experiments to better understand honey bee foragers' decisions.

Garter snakes that vary in chemical prey preference use different aquatic prey capture tactics

Elsie Cecilia Carrillo, Rita Mehta

Garter snakes are semi-aquatic obligate carnivores with diverse dietary breadths and behavioral adaptations for foraging at the water's edge. In this study, we tested the chemosensory prey preference and aquatic prey capture ability in two garter snake species, the Lake Chapala garter snake (Thamnophis eques obscurus) and checkered garter snake (T. marcianus). Using number of tongue flicks, number of attacks, and attack latency as proxy for interest in terrestrial and aquatic prey extracts presented, we verified dietary preferences reported in the literature describing T. e. obscurus as an obligate forager and T. marcianus as a facultative aquatic forager. We then categorized strike mode and quantified several metrics describing prey capture efficiency at two treatment depths: number of strikes, prey capture latency, prey transport time, total time spent foraging underwater and gape angle at two different depth treatments. Our prey preference tests revealed that T. e. obscurus had a stronger preference for aquatic prey and at the shallower depth used mostly forward strikes, was more accurate at striking live mosquito fish, and was faster at prey capture. Increased depth resulted in longer foraging times and prey capture latency, larger gape angles in both species, and T. marcianus using forward strike modes. Our work provides insight into the adaptability of naïve individuals garter snakes in aquatic prey capture contexts.

Patterns and thermoregulatory impacts of catastrophic molt in male northern elephant seals

Halley Carson, Rachel Survilas, Emily Robinson, Heather Liwanag

Many animals undergo molt (shedding of skin, hair, feathers, or shell) to facilitate growth and development. This process is often passive and in small amounts. However, northern elephant seals (Mirounga angustirostris, NES) exhibit an unusual physiological phenomenon known as a "catastrophic molt," which involves the shedding of both hair and cornified epidermis over a short period of time. Although NES are well studied, there is surprisingly little information about their annual molt. In this project, we documented the molt pattern and surface temperatures of subadult and adult male NES during the catastrophic molt. To do this, we performed visual observations and collected

infrared thermal images of molting male NES at the Piedras Blancas rookery across two molting seasons. We created a molt code to describe the predictable pattern of male molt we observed. Seals consistently began molt on the head and flippers, followed by their chest shield and dorsum, and completed with the ventrum. We also found that freshly molted body regions were associated with areas of increased surface temperature, suggesting that these seals may increase blood flow to the skin to facilitate the molting process. This is the first study to document the pattern and thermal consequences of the catastrophic molt in male NES. Future work will compare these results to the molt in other NES age classes.

Mechanosensory cells in “extreme” ion strength environments

Karen Carvajal, Yuriy Bobkov, Brendan Gibbs, Elias Lunsford, Joseph Ryan, Leonardo Ibarra-Castro

Apical surfaces of sensory cells are often exposed to nurturing microenvironments that provide optimal conditions for sensory transduction. The apical surfaces of cochlear and vestibular mechanosensory cells are surrounded by endolymph containing [K^+]~150mM and [Ca^{2+} +Mg^{2+}] ≈11mM; [Na^+]≈500mM; [Ca^{2+} +Mg^{2+}]≈65mM) or extremely low ionic strength conditions ([K^+]≈50μM; [Na^+]≈50-100μM; [Ca^{2+} +Mg^{2+}] < 1 00μM). Accordingly, sensory systems must be equipped to function and maintain excitability across ionic environments that differ by 3–4 orders of magnitude. To elucidate how mechanosensory systems adapt to different ionic environments, we have collected transcriptomic and functional datasets from freshwater (Danio rerio) and saltwater (Lutjanus campechanus) species. Our results provide evidence that anion efflux can drive HC activation in freshwater species in a manner similar to vertebrate chemosensory neurons, through calcium-activated chloride channels. We sequenced individual HCs and identified consistent expression of important channel-coding genes including a calcium-activated chloride channel. We have also identified differences in structural organization of neuromasts and gene expression profiles between freshwater and saltwater species. Together, these data open a new dimension to our understanding mechanosensory transduction in variable ionic environments.

Regulation of begging behavior due to food supplementation in urban and rural house wrens

Ivan Celso Carvalho Provinciato, Jenny Ouyang, Ava Ciaccia

Urbanization irreversibly alters landscapes, contributing to avian population declines, especially for species that depend on native insects to feed altricial young. Nestlings communicate their needs with parents through visual cues—begging behavior—regulated partly by corticosterone. Begging can signal need (hungrier nestlings beg more and receive more food) or quality (individuals in better condition beg more and receive more food). These strategies are species-specific and shaped by ambient food availability. Although corticosterone levels are known to be affected by resource availability, whether this variation affects begging remains unclear. Using house wrens (Troglodytes musculus) breeding along an urbanization gradient, I tested whether offspring alter begging behavior depending on their rearing environment. I hypothesized that in resource-limited urban habitats, offspring beg to signal quality rather than need. I manipulated food availability along an urbanization gradient (by supplementing nests with mealworms) and quantified nestling condition and behavior. Preliminary results show food supplementation reduces total begging time, and nestlings in poorer condition beg more, regardless of urbanization, indicating begging reflects need. I will discuss how corticosterone levels affect begging across environments and whether baseline differences between populations predict behavioral shifts under altered food supply. These findings clarify mechanisms underlying begging behavior and link ecological variation with individual phenotypes, advancing our understanding of how urbanization reshapes parent–offspring communication in insectivorous birds.

A morphological innovation enables a several-fold expansion of the ecological niche

Jerome Casas, Thomas Steinmann

Maneuvering on fast running waters is an energy demanding task, making this niche hard to access. The propelling fan of the waterstrider Rhagovelia is an evolutionary innovation that enhances the maneuverability in these environments. This structure consisting of 20 lamellate branches, each with thinner secondary branches, offers a unique model to understand the tenuous link between morphological innovations and adaptation to new ecological environments. We characterized the kinematics of fan and body of Rhagovelia during the propulsion phase. A simplified mechanical model that replicates the movement of the fan is used in both experiments and fluid dynamic computations.

Using Particle Image Velocimetry, we measured the flow velocity field around it and determined the magnitude of forces using a load cell. Finally, we used computational fluid dynamics to resolve the flow around a numerical fan replicate of similar morphology. The computations, once validated by their comparison with experimental results using similitude principles, allowed us to determine the nature of the forces acting on the fan. A large part of the fan’s resistive force is due to viscous shear stress. The 75 % porosity lamellate fan functions as a leaky paddle, while producing 80 % of the hydrodynamic drag force of an equivalent membrane oar. The thrust enables the strider to colonize most streams, expanding its niche by a factor of four to five.

Teaching the biological variation of sex, gender and reproduction in biology to support all students

Aramati Casper, Antonio Duran, Yoon Ha Choi, Sarah Eddy

Biology is often taught from an oversimplified perspective, which frames science as an unbiased practice and often centers cisgender and heterosexual norms. However, science is a social practice that can never be unbiased and there is vast variation in biology of sex topics (sex; gender; reproduction; sexual, romantic and related orientations [hereafter orientation] and sexual behavior). We hypothesize that how these topics are taught may influence if biology courses are supportive or exclusionary of queer students and students of all genders, orientations, and races. We identified nine instructors at five Hispanic Serving Institutions (HSIs) who taught in a range of ways about biology of sex and science practices. We chose HSIs because of their purported focus on supporting students with minoritized identities. We surveyed students in these classes to identify how students’ identity characteristics and instructor teaching approaches predict students’ sense of belonging and STEM identity. Queer students in classes framing science as a social practice and centering biological diversity felt more recognized by others and rated their own competency higher than those in “status quo” courses. This shift may be caused by how centering biological variation can validate queer identities from the perspective of non-queer peers and counter the unfounded invocation of biology in cisheteronormative social narratives, supporting queer students in their social experiences, academic identity and opportunities, and in the larger socio-cultural climate.

Do complex sexual systems affect unexpected eastern hemlock survival with hemlock woolly adelgids?

Aramati Casper, Syzylvia Newman, Jodyel Rivera, Sarah Steely

Sexual systems are often considered in evolutionary and developmental biology, but less frequently in ecology. Yet, they can shape organismal interactions and energy flow within ecosystems. An example of this dynamic is the relationship between eastern hemlock (Tsuga canadensis) and the introduced hemlock woolly adelgid (Adelgies tsuga; HWA). Studies of the impact of HWA on hemlock ecosystems are plentiful, but work considering how the lifecycles of both species influence these interactions is lacking. The HWA has a non-obligate metagenetic lifecycle, in which asexual and sexual generations alternate. In North America, all reproduction is asexual because there is no suitable host for the sexual generation. The fact that sexual adults die without feeding or reproducing limits the HWA population, lessens their impact, and slows their evolution; a suitable host for the sexual generation would release these constraints. In a long-term study of hemlock-HWA interactions in

Massachusetts, started in 2002, I found unexpectedly high numbers of healthy hemlocks in 2025. I hypothesize potential reasons for their unexpected health and discuss how analysis of hemlock–HWA dynamics through a lens including the sexual systems of both species is important to identify unfounded assumptions and the potential for shifting dynamics if the sexual HWA found a suitable host or if eastern HWA evolved to skip the sexual generation, as they have in western North America.

From *'completely erasure'* to *'there is a place for us here'*: Teaching accurate and socially just sex-related biology content.

Aramati Casper

In this workshop, participants will explore the narratives about sex-related topics that 56 trans, non-binary, gender non-conforming, and intersex life science majors from across the U.S. shared support and harm them. Participants will use this knowledge as a foundation to discuss and develop inclusive teaching practices and pedagogical strategies. These strategies will center the inter- and intra-species biological diversity of sex, gender, reproduction, sexual behavior, and sexual, romantic, and related orientations, and employ education and science communication practices developed to teach topics where students likely hold existing knowledge that conflicts with current scientific knowledge.

We will first explore the experience of trans, non-binary, gender non-conforming, and intersex students with sex-related content in biology through case study activities. Then, we will discuss a variety of inclusive teaching practices from across the field of biological sciences and the educational and science communication theory that supports them. Finally, participants will have an opportunity to work together to begin to develop inclusive and biologically-accurate pedagogies for sex-related topics. These will consist of actionable items to implement in their own courses, including tools to facilitate teaching and discussing these topics in the current polarized sociopolitical climate. Deeply aligned with the "Sex Across Origins" symposium, this workshop will encourage participants to introduce current, cutting-edge conversations into the science classroom.

Synthesizing sex/es across scales and lineages: Using a plant-centric lens

Aramati Casper

Life cycles, modes of reproduction, sexes, and unitary/modular organization are relevant across evolutionary, developmental, and ecological contexts. However, vertebrate-centric norms relating to these topics limit our conceptualization of and communication about these processes, across biological scales. In this talk I consider (i) how centering plants, fungi, and algae can shift our perspectives in a range of biological contexts, and (ii) some ways that concepts developed to describe the biology of plants could be useful more broadly. For example, centering plants, fungi, and algae would frame sessile organisms that use mediated gamete transport (e.g., pollination) as normative. Recent marine algae research has revealed that gamete transportation via invertebrates may have evolved >500 million years ago, indicating that mediated gamete transport is older than previously thought and may have multiple evolutionary origins. This re-centering would change current debates surrounding if plants have mate choice, since it would normalize the occurrence of multi-species interactions in reproduction. In broadly useful concepts from botany, quantitative gender can describe phenotypic gender, an individual's relative production of eggs and sperm, and functional gender, an individual's relative reproduction via each gamete type. This could be applied to any anisogamous organism and be broadly useful for hermaphrodites. Through these and other examples I will highlight ways including plants, algae, and fungi can help broaden dialogues that are commonly vertebrate-centric.

Intra-individual morphological variation in a carnivorous plant and functional implications

Vianey Castillo, Ulrike Muller, Otto Berg

Bladderworts (Utricularia) are a genus of carnivorous plants, named after their tiny underwater suction traps. Many aquatic species form long, free-floating strands with a growing and a senescing end and tens to hundreds of traps. This project focuses on two species, one species with monomorphic traps (U. gibba, habitus: branching or single strand), and one with dimorphic traps (U. australis, habitus: single or branching strand with series of leaf nodes). We measured trap size to test whether trap size is bimodal versus unimodal in monomorphic versus bimorphic species. We also logged the position of traps along the strand and within the node (U. australis only) to examine if trap size correlates with trap position within the plant. We observed a bimodal size distribution of traps in U. australis and a unimodal size distribution U. gibba, confirming the characterization of two species as di- and monomorphic, respectively. In U. australis, position correlates with trap size: within a given node, larger traps are located closer to the main stem; along the strand, the number of large traps decreases toward the senescing end of the strand. Our findings have implications for trap function: Size-dependent positioning within each node suggests prey specialization; size-dependent position along the strand suggests size-dependent senescence - larger traps have higher metabolic demands, leading to more damage from metabolic byproducts.

FGFRL1 regulates neuroectoderm and endomesoderm patterning during axial formation in sea urchins.

Jillian Cate, Ryan Range, Jennifer Fenner

Fibroblast growth factor (FGF) signaling is a major signaling pathway present in all metazoans. It plays a role in a wide range of developmental processes, including anterior-posterior (AP) patterning, where it may interact with Wnt signaling. FGF signals through receptor tyrosine kinase (RTK) receptors (FGFRs). Fgf-FGFR activity can illicit powerful cellular responses that must be regulated tightly to prevent developmental abnormalities and cancer. One putative regulator is fgfrl-1, a paralog of FGF receptors that lacks an intracellular kinase domain. fgfrl-1 has been implicated in human cancers, and orthologs of it have been identified in most deuterostomes. In this study, we investigate the role of fgfrl-1 in deuterostome development using the sea urchin as a model. Spatiotemporal analysis using hybridization chain reaction fluorescent in situ hybridization (HCR-FISH) showed that fgfrl-1 transcripts are expressed along the early sea urchin AP axis in similar patterns as the ligand fgfa and receptor fgfr1. Fgfrl-1 functional knockdowns showed disruption of early AP patterning of the anterior neuroectoderm territory, and embryos had gastrulation and skeletal defects. Expansion of anterior neuroectoderm suggests that FGF signaling could play a role in AP patterning, a process previously thought to be determined primarily by Wnt in the urchin. Our results further elucidate the complexities of early body axis patterning shared among sea urchins and other deuterostomes, including vertebrates.

Gene expression variation across caste, tissue, and genetic lineages in a social wasp

Michael Catto, Sarah Orr, Brendan Hunt, Michael Goodisman

Division of labor in social insects emerges through interactions among castes, tissues, and genetic diversity within colonies. Yet, the extent to which these factors shape gene expression in social insects remains unclear. In this study, we examine transcriptomic variation in the yellowjacket Vespula maculifrons to test how caste identity, tissue specialization, and patriline differences contribute to patterns of gene regulation.

Our analyses reveal distinct signatures of expression associated with caste and tissue, and also point to contributions from within-colony genetic lineages. These results provide new perspectives on the molecular foundations of division of labor and illustrate how both social and genetic structure influence transcriptomic diversity in eusocial systems.

Integrative taxonomy reveals cryptic diversity within genus *Meningodora* (Decapoda: Acanthephyridae)

Angela Ceballos, Stormie Collins, Nia Brotherton, Heather Bracken-Grissom

The genus Meningodora Smith, 1882 (Decapoda: Acanthephyridae), a group of deep-pelagic shrimps, remains understudied in the Gulf of Mexico, a region recognized for its richness in crustacean diversity and high levels of endemism. All but 1 species of Meningodora were originally described as Notostomus A. Milne-Edwards, 1881 and the systematic placement of Meningodora has long been taxonomically problematic due to morphological similarities between the two groups. Phenotypic variability in defining morphological characters have led to taxonomic inconsistencies in species-level identifications, prompting concerns about non-monophyly in recent genetic studies. As part of ongoing efforts to clarify species boundaries and evolutionary relationships within species of Meningodora, our research aims to takes an integrative approach, combining detailed morphological assessments with molecular analyses using the mitochondrial (16S, COI) and nuclear (PEPCK) gene regions. This analysis tentatively recognizes the identification of six distinct species, Meningodora vesca, M. mollis, M. longisulca, M. marptocheles, M. compsa, and M. miccyla, and several novel clades. A total of 95 preserved specimens were examined for morphological analysis focusing on diagnostic characters across multiple body regions including rostral shape and armature, positioning of the branchiostegal spine and lateral carinae. This study highlights the importance of integrating morphology and molecular data in reevaluating and resolving complex taxonomic groups while contributing to a deeper understanding of species morphological diversity within Meningodora.

Pursuit and avoidance behavior of hawks in natural, cluttered environments

Henry Cerbone, Miguel Ángel Muñoz-Bañón, Maurice Fallon, Graham Taylor

Birds of prey navigate highly cluttered habitats where visual guidance must balance obstacle avoidance with goal-directed pursuit. Although previous studies have characterized pursuit in open and lab-controlled environments, less is known about how gaze strategies and guidance models adapt to natural clutter. To address this, we outfitted four (n=4) Harris's hawks (Parabuteo unicinctus) with lightweight head-mounted cameras and IMUs to capture the available visual information during flight. Birds were flown repeatedly at two experimental sites: one sparsely wooded, the other densely cluttered. A falconry lure was released unpredictably from the left or right, requiring the hawks to pursue targets while avoiding trees. Surrounding forest structure was reconstructed through high-resolution terrestrial laser scanning (Leica RTC360) and neural radiance field (NeRF) models, enabling 3D replay of each flight within photogrammetrically accurate virtual environments. Using onboard video, we quantify both gaze allocation, binocular fixation points and shifts, and flight behavior including steering adjustments, reaction times, and obstacle clearance margins. Synthetic trajectories allow comparison and testing of observed strategies against previous work and theoretical modeling. We also show the ability to localize the bird within our neural radiance field model using only onboard video data. This work provides new insight into how raptors integrate visual guidance, embodied constraints, and environmental complexity to successfully pursue targets in cluttered habitats.

Radiance field reconstructions for studying perception and ecology,

Henry Cerbone

Understanding animal perception and behavior in complex environments requires tools that can faithfully reconstruct what organisms actually see during ecologically relevant tasks. Traditional approaches to studying perception have relied on simplified laboratory settings or sparse environmental reconstructions, limiting their ability to capture the full visual scene. Recent advances in radiance field methods, such as neural radiance fields (NeRFs) and GaussianSplatting, offer new frameworks for studying animal ecology and guidance behavior. Using as little as 20-odd images collected from a scene of interest, researchers can now reconstruct three-dimensional environments with photogrammetric accuracy while also generating novel visual perspectives from an animal's point of view. These reconstructions enable detailed analyses of gaze allocation, obstacle geometry, and optic flow, linking environmental structure to behavioral decisions. We illustrate this approach with Harris's hawks flying pursuit trajectories in cluttered forested habitats, where head-mounted cameras and inertial sensors capture gaze and motion data synchronized with NeRF reconstructions of the flight path. This methodology provides both ecological realism and experimental control, bridging the gap between controlled laboratory assays and naturalistic field studies. Beyond raptors, radiance field reconstructions hold promise for studying how diverse animals—from pollinators to primates—interact with their visual environments. These models can also be combined with recent work on visual models to reconstruct biologically relevant views. As a perspective, we argue that radiance field methods constitute a powerful and generalizable toolkit for advancing the study of perception, guidance, and ecology in natural settings.

Communication blueprints: Sensory specialization and signal diversity in Morpho butterflies

Uroš Cerkvenik, Marko Ilić, Gregor Belušič

Morpho butterflies are known for their vivid wing coloration, likely involved in predator avoidance and mate recognition. Color varies widely (from blue to brown and white) among sympatric species with distinct circadian activity and inhabiting different forest strata. This raises questions of whether and how visual systems facilitate species-specific communication across ecological niches. To investigate how ecological factors shape signal production and perception, we studied several Morpho species coexisting in French Guiana that differ in flight height (canopy vs. understory) and circadian activity. Using a custom insect ophthalmoscope, intracellular electrophysiology, and behavioral assays, we examined how retinal specializations align with signaling strategies. All species have UV-, blue-, green, and red-sensitive photoreceptors, but vary in additional ommatidial types, polarization sensitivity, and dorsoventral retinal organization. Combining retinal data with wing reflectance spectra, we identified three signal–receiver strategies: (1) saturated-chromatic, with sharp spectral peaks and low polarization signal and sensitivity, (2) mixed-mode, with broad reflectance and moderate polarization signal and sensitivity, and (3) polarization-enhanced, combining broadband reflectance with high polarization signal and sensitivity. Behavioral assays in M. helenor suggest polarization of light increases signal salience. Additional behavioral tests are planned for other species to assess the generality of these results. These findings emphasize the role of matched sensory filters in visual communication and support the sensory drive hypothesis as a potential mechanism driving ecological diversification in signaling systems.

Nature's steerable needles: structure and mechanics of a parasitic wasp ovipositor

Uroš Cerkvenik, Johan van Leeuwen, Robin Heinen, Sander Gussekloo

Parasitic wasps are a remarkably diverse and successful insect group, largely due to their parasitoid lifestyle. They lay their eggs in hosts hidden in various substrates, using an often long and slender ovipositor. This is a tube constructed from three interconnected elements that slide along each other with a tongue-and-groove mechanism that prevents separation. During penetration pushing on one element while pulling on the others, diminishes the net force required for insertion and avoids buckling. Offsetting these elements also provides a degree of control over probing direction, as it leads to bending of the ovipositor's distal end. Both insertion and bending are substrate dependent and are greatly affected by the substrate reaction forces. Although the general mechanisms of insertion and bending are understood, the interplay between substrate properties and ovipositor morphology is not. The ovipositor's external features, internal morphology, and material properties vary across species and are thought to be adapted to particular hosts and substrates. However, a systematic analysis of these features and associated substrates is missing, partly due to the difficulty in assessing their mechanical properties. Nevertheless, comparing ovipositor morphology to probing substrates indicates that the robustness of the element interconnections and the ovipositor

outer walls increases with substrate toughness, which provides insights into the insertion and bending mechanics, evolutionary pressures acting on parasitoids wasps, and could inspire new bio-inspired tools.

Morphology of chemosensory sensilla in the model butterfly species, *Bicyclus anynana*

Anna Cerveny, Erica Westerman, Gregory Pask

Insects rely on olfactory organs as their primary sensory mechanism that informs behavior essential for survival. The antenna is the main sensory organ that houses various sensilla, which can provide vital information for identifying different chemical and environmental cues. Bicylus anynana is an established model organism for chemical ecology and sexual selection, with males producing pheromones critical to female choice. B. anynana uses antennal sensilla for olfaction, tarsal sensilla for contact chemoreception, and ovipositor sensilla for egg-laying behaviors. Here, we compared the morphology of chemosensory sensilla on the antennae, ovipositor, and tarsi. Three types of sensilla found on B. anynana antennae in both male and female butterflies were characterized using scanning electron microscopy (SEM) to identify potential sex-specific differences in the morphology across the sensilla. We conducted whole-antenna imaging to map the distribution of sensilla types on the dorsal and ventral sides and compared morphological differences in three different mutant lines of butterflies. These images provide a morphological basis for future work in investigating B. anynana chemoreception.

Parental feeding patterns and offspring corticosterone levels during chick-rearing in a seabird

Tori Chace, Kayla Lichtner, Sarah Chapman, Axel Uribe, Samuel Neirink, Liam Taylor, Robert Mauck, Patricia Jones, Mark Haussmann

During reproduction, pelagic seabirds must balance energy allocated to foraging flights and parental care. Leach's storm-petrels (Hydrobates leucorhous) address this challenge through biparental care, which results in unpredictable fasting and feeding periods for the chick. This natural variation in fed and fast states affects chick physiology. Corticosterone (CORT), a hormone involved in hunger, satiety, and metabolic regulation, may both reflect and mediate changes in a chick's physiological state. We previously found that chicks who were fed more often and more consistently by their parents had larger decreases in baseline CORT over the 20 day study period, while meal size had no significant effect despite high variation among chicks. Here, we further investigated these connections by monitoring chicks all the way from hatching to fledging. Burrow entrance scales allowed us to obtain robust data on feeding frequency, volume, and timing. Plasma samples collected weekly over the chick rearing period were used to measure baseline CORT levels, which were subsequently quantified using an enzyme-linked immunosorbent assay. We will discuss how variation in both fed and fasted periods affect nestling baseline CORT levels across development. This work reveals how parental energy allocation affects baseline CORT in storm-petrel chicks. Understanding the relationship between parental investment and chick physiology offers valuable insights into how early-life investment may ultimately affect a chick's long-term fitness.

Exploring the impact of antioxidant-rich diets on healthspan using Drosophila melanogaster

Moumita Chakraborty, Mark Phillips

Antioxidants have been studied for over a decade due to their reported benefits in increasing longevity and overall health span. Using the Drosophila model system, researchers have also extensively studied the strength of these effects and the mechanisms that underlie them. However, these studies are typically done in isogenic lines and are not representative of the variation we observe in natural populations. In this study, we aim to test the effects of two antioxidant diet supplements, apple and pomegranate, on a large outbred Drosophila melanogaster population. By doing this, we hope to obtain a more accurate estimate of their general efficacy and how their effects vary with genetic background. Specifically, we measure lifespan, reproductive output, and neurological function to assess the impact of these supplements on health span. Initial results from four replicates showed that the mean lifespan of male flies fed pomegranate supplement (PmM) was extended by 3.15%, whereas, the apple-fed male flies (ApM) slightly decreased compared to the control treatment. Overall, male flies depicted a higher lifespan among all treatments compared to male and female flies. We are continuing the mortality and fecundity assay in four additional replicates, which will provide a comprehensive estimate. Using metabolomic and transcriptomic data, we also aim to characterize the mechanisms underlying their effect and quantify their impact on "biological age".

Snow fleas' glandular landings and meniscus climbing

Elio Challita, Richard Viveiros, Robert Wood, Victor Ortega-Jimenez

Snow springtails ("snow fleas", Collembola) are able to execute ballistic jumps on snow, without deforming their bodies, then land controllably using a sticky anal gland that anchors to dry or wet surfaces. This mechanism lets them quickly stabilize, escape holes and depressions, and reset for subsequent jumps. Additionally, these arthropods can transition from water to land by climbing the meniscus, using lateral capillary forces generated by their jumping organ, mouth and body. Here we report the kinematics of springtail jumps and their gland-assisted landings on both horizontal and vertical surfaces. A bio-inspired microrobot was developed equipped with a gland-like adhesive mechanism, enabling repeatable jump-landing cycles and effective escape from holes across varied surfaces. The robot uses a shape-memory-alloy (SMA) actuator for takeoff and integrates an adhesive pad within an otherwise superhydrophobic shell to enable rapid, localized gland-style anchoring. We quantify landing success rate, adhesion onset time, and rebound suppression as functions of body posture, pad adhesion, and approach velocity. Finally, we demonstrate meniscus climbing using our robot by tuning surface-tension gradients through active body deformation. Together, the biological kinematics and robotic validation outline a physics-grounded pathway to reliable, repeatable jumping on snow and multimodal locomotion across the air–water interface.

Bioactivity of stingray venom

Kally Chamberlain, Catherine Walsh, Carl Luer

Venom-derived peptides from many different species have been shown to inhibit cancer progression through multiple mechanisms by targeting ion channels, integrins, G protein-coupled receptors, and membrane molecules. Galectin, a type of glycoprotein, has been previously found in stingray venoms and also demonstrates cancer growth inhibitory activity. This study evaluated the anticancer potential of venom-derived peptides from the Atlantic stingray (Hypanus sabinus) and spotted eagle ray (Aetobatus narinari). Venom samples were collected from dorsal and ventral regions of the spine, as well as from mucus, to investigate spatial variation in potential bioactive compounds. Cytotoxic activity was assessed using MTT assays on Jurkat E6-1 leukemia cells, and Western blotting was employed to detect galectin-like proteins. Venom from the ventral spine of the spotted eagle ray exhibited the strongest antiproliferative activity, whereas the Atlantic stingray showed consistent cytotoxicity from both dorsal and ventral venom. Mucus samples, only collected from the Atlantic stingray, exhibited minimal activity. Using mammalian antibodies, galectin antibody reactivity was observed in both eagle ray and Atlantic stingray venom samples, but carbohydrate affinity purification with specificity for galectins showed limited galectin-1 binding, suggesting other bioactive components may be responsible for cytotoxicity. These findings highlight the potential of ray venom as a source of novel anticancer peptides and support further investigation into non-galectin candidates.

Black is the new orange: examining elytral variation in *Nicrophorus defodiens*

Keaton Chamberlin, Ahvi Potticary

Color variation plays important roles in organismal life history. In ectotherms, darker coloration is often considered adaptive at higher latitudes for thermoregulation, though the opposite pattern has also been observed, raising questions about what ecological factors drive color variation across species. One possibility is that temperature shapes coloration, such that colder climates

select for darker organisms. Alternatively, local adaptation to ultraviolet (UV) radiation may drive coloration, with higher UV exposure at selecting for darker organisms. We investigated the relationship between coloration and latitude using variation in elytral patterning in burying beetles. Nicrophorus spp. are black beetles exhibiting extensive orange patterning, or maculations, on their elytra, particularly along the Pacific coast of North America. To quantify latitudinal maculations, we used iNaturalist images of N. defodiens from four populations: low, mid, and high coastal groups, aswell as an upper Midwest group at a latitude comparable to the high coastal site. Images were processed with Fiji to calculate the proportion of maculation area. Southern beetles had reduced maculations, where beetles at southern latitudes were significantly darker. These findings suggest maculation patterns reflect local adaptation to environmental conditions across N. defodiens. Future work will test whether these trends extend to other sympatric Nicrophorus species to assess the generality of the pattern.

Correlation-based insights into fish collective behavior

Alyssa Chan, Ashley Hayward, Haotian Hang, Nathan Swanson, Ashley Peterson, Hanliang Guo, Christopher Martinez, Matthew McHenry, Eva Kanso

Schooling fish often self-organize into a variety of collective patterns, and many mathematical models have been developed to understand the emergence of these large-scale dynamics. However, these patterns are not consistent across all biological schools, and the mechanisms underlying these interspecies differences are not well identified. In this work, we analyzed the schooling behavior of three tetra species - Black neons, Pristellas, and Buenos Aires - to distinguish and classify their collective behavioral signatures. Our findings show that simple group-level kinematics and correlation-based metrics can differentiate species and provide parameters to infer individual-level behavioral rules from large scale schooling behaviors.

Metabolite analysis of benthic microbial crust of Hawaiian anchialine ponds

Sneha Chandak, Justin Havird, Mariangel Correa Orellana, Cassidy Hawk, Brina Sedio

To determine the ecological niche of microbial communities, most studies focus on quantifying the species composition but rarely analyse the metabolites being produced. By searching for commonalities in metabolites, we can determine whether communities with variable species composition are filling similar ecological roles. Anchialine ponds are formed by lava flows creating small shoreline water bodies with subterrestrial tunnels connected to fresh and salt water. Their formation leads to highly variable salinity, temperature, dissolved oxygen, and chemical profiles. Previous work has found significant endemism in the microbial composition of Hawaiian anchialine ponds. We characterized the metabolic compounds within the benthic sediments of anchialine ponds across Hawaii. By characterizing these metabolites, we may better understand the ecological function of microbial communities and their differences across ecological conditions. We worked with benthic samples of algal mats taken from Hawaii during 2020-2024. We analyzed 70 samples ranging across 23 different ponds to see differences across ponds and through time as the mats develop. Using mass spectrometry, we have identified several unique compounds across the ponds. With this data, we intend to search for significant differences in makeup of ponds and correlate it with the environmental conditions at the pond, including salinity, temperature, and the presence of shrimp in the water. This analysis can inform the ecological niche being fulfilled by algal mats and how to better protect these ponds.

Using a mechanical model of Utricularia traps to test how size affects suction feeding flows

Nari Chang, Otto Berg, Ulrike Muller

The carnivorous plant Utricularia is the fastest and smallest suction feeder. Fluid dynamics principles impose a strict lower size limit for suction feeding, yet bladderworts operate exclusively near this limit. The diameter and shape of the trap entrance varies widely across bladderwort species, from long to short (aspect ratio) and straight to flared (contraction ratio). Entrance morphology has been shown to affect suction flow in fish and man-made structures operating far from the lower size limit. This study uses a dynamically scaled mechanical model of a bladderwort trap to examine how suction flow is affected by trap size (entrance diameter) and shape (length of the funnel). To examine size effects, we varied Reynolds number Re (5 to 800; bladderworts: 300-800) and funnel aspect ratio (ratio of funnel diameter to funnel length (0.6 to 16). Consistent with predictions of computational fluid dynamics models, we found that decreasing size changes the shape of the suction flow field and drastically decreases peak flow speed, while decreasing the aspect ratio of the funnel has only a small effect on flow speed and the shape of the flow field. In the future, we will examine the effect of contraction ratio (ratio of the diameters of the outer and inner opening of the funnel) and the influence of model prey on suction flow over the same range of Reynolds numbers.

The zebrafish anal fin as a model to explore sensorimotor circuits

Weipang Chang, Melina Hale, Eden Anne Bauer

The ability to react to changes in the environment relies on the coordinated activation of sensorimotor circuits in the spinal cord. The zebrafish (Danio rerio) provides a powerful vertebrate model for dissecting these mechanisms because its nervous system is experimentally accessible and shares fundamental neurobiological features with other vertebrates.

Here, we take advantage of the zebrafish spinal cord to investigate both sensory and motor pathways innervating the anal fin, a median fin essential for postural control and maneuvering. Retrograde labeling of sensory nerves identified dorsal root ganglion (DRG) neurons projecting to the anal fin and revealed organizational features within the ganglion. Patch-clamp recordings demonstrated two classes of DRG neurons—adapting and non-adapting—that differed in size, rheobase, input resistance, and spatial distribution. Extracellular recordings further showed slowly adapting DRG activity in response to fin mechano-stimulation. In parallel, retrograde labeling of motor neurons from fin muscles revealed corresponding somata, which exhibited reliable excitability and action potential under both current- and voltage-clamp conditions.

Together, these findings establish the zebrafish anal fin as a tractable preparation for studying sensory afferents and motor efferents within the same system. Ongoing work incorporating detailed innervation maps, behavioral assays after fin excision, and spinal cord anatomy will not only deepen our understanding of these circuits but also enable exploration of how sensory and motor elements connect and interact to regulate locomotor control.

Genetic and environmental variation of immune function shape life cycle dynamics of Trichuris muris

David Chang van Oordt, Oyebola Oyesola, Daniel Metz, Seokyoon Chang, P'ng Loke, Clayton Cressler, Andrea Graham

Genes and the environment are well known mediators of the immune response, and their interaction can shape a host's ability to harbor an infection. However, the downstream effects of host immunity on parasite fecundity and transmission are not well understood despite extensive study of the immune mechanisms required to fight said parasitic infections. Infections by Trichuris muris, an intestinal nematode, in resistant laboratory mice show that high infective doses are cleared but low doses are not. Given this observation, we use dose-response experiments to understand how dose, environment and host genetics interact to shape the response to T. muris and how immune phenotypes can predict infection dynamics. To do this, we gave varying doses of T. muris eggs to resistant and susceptible mice maintained in either conventional laboratory or "rewilded" settings. Rewilded mice were housed in outdoor enclosures providing more natural living conditions. We characterized pre- and post-infection immune phenotypes, quantified worm burden at different time points, and measured egg shedding in fecal pellets. We show that egg shedding is only achieved at low dose regardless of genotype, and that pre-infection lymphocyte numbers are the best predictors of worm burden: more lymphocytes in blood predicts lower worm burdens. Overall, we show that parasite ecology depends on the current state of a dynamic immune system and that we can infer parasite dynamics from host immune observations.

Investigating variations in host immunity and symbiosis across the range of A. poculata

Isabella Changsut, Koty Sharp, Chloe Poenisch, Lauren Fuess

Reef-building corals are key ecosystem engineers that create a rich habitat, home to immense biodiversity. However, these habitats are threatened by disease outbreaks and other effects of global climate change such as marine heatwaves. For this reason, understanding the diversity and dynamics of coral-associated symbiotic relationships, particularly in the context of immunity and disease is of paramount importance. Previous work has established Astrangia poculata, a cosmopolitan facultatively symbiotic temperate coral, as a useful experimental system for studying symbiosis-immune interplay in cnidarians. Prior studies, based on a single A. poculata population in Fort Wetherill, RI, have consistently demonstrated a positive association between symbiont density in immunity. To explore variation in symbiosis-immune interplay across Astrangia's natural range, we evaluated host gene expression across four different populations (Rhode Island, Virginia, Florida, and Texas) of Astrangia poculata. This study is the first of its kind to include samples of Astrangia from its southern populations, including some populations that had not been confirmed for several years. Our results highlight variation across populations, and potential variability in symbiosis-immune interplay across these regions. This work lays a strong foundation for continued use of Astrangia as a powerful system for studying coral immunity and endosymbiosis.

Feeding performance of Louisiana poeciliid fishes exposed to residential wastewater effluent

Jonathan Chapman, Emily Kane

Mosquitoes are a primary transmitter of vector-borne disease, and their larvae can thrive within shallow pools of stagnant water. Rainwater drainage ditches are a common sight in many communities, and in Louisiana, they are dually used as outlets for onsite residential wastewater discharge in neighborhoods disassociated from municipal sewage treatment. However, when discharge systems malfunction, the water becomes uninhabitable to mosquito predators, allowing mosquitoes to thrive. This research examines the feeding performance of mosquitofish (Gambusia affinis), sailfin mollies (Poecilia latipinna), and least killifish (Heterandria formosa), the primary larval mosquito predators found within ditch communities. Individuals were captured within neighborhoods with ditches exposed to raw effluent (exposed) and those that use municipal water systems (control). Fish were exposed to one of five concentrations of effluent water (0%, 15%, 30%, 45%, and 90%) and fed live mosquito larvae. Larvae clearance rate was monitored over 60 minutes. No differences were found among concentrations nor exposure type, likely due to a wet spring that diluted the septic water. However, mosquitofish were consistently the most proficient predators of mosquito larvae among the 3 species. Our research suggests that the introduction of mosquitofish would be the most efficient method of biocontrol to reduce mosquito populations in effluent-exposed areas of Louisiana and elsewhere.

Early-life telomere dynamics: Linking nestling growth and parental feeding in Leach's storm-petrel

Sarah Chapman, Kayla Lichtner, Axel Uribe, Tori Chace, Liam Taylor, Samuel Neirink, Robert Mauck, Patricia Jones, Mark Haussmann

During development, environmental conditions can have profound and lasting effects on an individual's telomere dynamics. Telomeres, the protective structures at the end of eukaryotic chromosomes, have been used to understand how life history strategies affect patterns of senescence. Many studies show that telomere loss is greatest during rapid juvenile growth, while other studies show telomere lengthening during some developmental periods. Previous work in our lab found that Leach's storm-petrel nestlings (Hydrobates leucorhous) with the fastest wing growth showed the most attrition in telomere length, whereas body mass had no effect on telomere length. However, few studies have extensively examined telomere dynamics throughout postnatal development itself, particularly in species with slow life histories. Here, we investigated natural variation in growth and telomere length in Leach's storm-petrel nestlings by collecting daily body mass, weekly wing length, and weekly blood samples for telomere analysis throughout the 66-day nestling period. Erythrocyte telomere length was measured using the telomere restriction fragment assay. We will discuss the relationships between parental provisioning and nestling morphometrics to better understand the plasticity of early-life telomere length. To gain further ecological insight, future research should explore how environmental factors during development and parental investment shape telomere dynamics and other patterns of physiological programming.

Marine mammal bone: A unique tissue for hormones and beyond

Patrick Charapata, Casey Clark, Kerri Smith, Lara Horstmann, Emily Sperou, Brooke Morris, Nicole Misarti

Climate change has drastically altered ecosystems world-wide, making pre-modern era (< 1950 CE) animal population data essential for establishing accurate baselines with modern data. Bone is a mineralized tissue composed of organic and inorganic materials that contain ecological, physiological, and genetic data. Zooarchaeologists and archaeologists have developed extensive research disciplines using bones to study animal population changes over extensive time periods, yet the application of these approaches to study marine mammal species is still relatively new. Here, we present a practical beginner's guide for marine mammal (and other vertebrate) biologists, who are interested in using bone as a tool to perform retrospective studies on animal physiology, ecology, genetics, and conservation. Specifically, we give a broad overview of bone biology, and the different analytes preserved in different bone components. We provide a blueprint of best practices and methods for destructive sampling and maximizing analyte data from small bone sample sizes, while also noting key caveats. We provide two case studies that highlight the use of bone to collect ecological, physiological, and biometric data for marine mammal species. Finally, we provide a conceptual framework that helps researchers identify the best methods for investigating their research question(s) of interest. We suggest bone is a critical tissue to address questions related to how adaptable marine mammal populations are to their rapidly changing environments in the post-industrial era.

Larval behavior contradicts poleward range expansion in mangrove tree crabs

Corie Charpentier, Savannah Goodwin, Justin Madrigal, Gabriela Molina, Madison Niederriter

As our climate warms, the geographic range of tropical species expands poleward. For example, mangrove tree crabs (Aratus pisonii) now reside in salt marshes that are hundreds of kilometers northward of their historic mangrove habitats. However, the behavioral mechanism for A. pisonii expansion is unknown. We hypothesized that this expansion was facilitated by dispersal of planktonic larval stages; larvae may expedite dispersal by ascending to "ride" outgoing tidal currents at the surface. We collected A. pisonii from a mangrove habitat in Mosquito Lagoon, FL, USA and evaluated swimming behaviors that would impact larval depth and thereby dispersal, including endogenous tidal rhythms and responses to gravity and light. We observed endogenous tidal rhythms in early-stage larvae, who descended at the time of outgoing tides, contrary to our prediction. Late-stage larvae were negatively geotactic and negatively phototactic, ascending in the dark and descending in response to downwelling light. These combined responses to gravity and light point to diel vertical migration, which improves avoidance of visual predators through descent to darker waters during the day. Overall, the observed behaviors are surprisingly aligned with estuarine retention and persistence, rather than offshore dispersal. These larvae may favor retention in Mosquito Lagoon, which maintains relatively high salinities required for larval survival. Future work should assess whether A. pisonii from brackish estuaries exhibit behaviors that would expedite dispersal and range expansion.

How honeybees self-assemble into stable, adaptive structures

Danielle Chase, Orit Peleg

When a honeybee colony reproduces by fission, a queen and several thousand worker bees take flight from the original nest and coalesce into a dense cluster suspended from a surface in nature (e.g., a tree branch). This cluster serves as a temporary home for several hours to days, during which the swarm actively buffers environmental perturbations by adjusting its global morphology. I will discuss the collective mechanics of swarm formation and how the resulting architecture supports both mechanical stability and adaptive responses to dynamic environmental conditions.

The effects of web geometry on spider sensitivity and habituation to auditory stimuli

Danielle Chase, Deepa Rajan, Melanie Romina Ramos Requejo, Cindy Lita Pariachi Laura, James Clinton, Saad Bhamla

Many spiders use their webs to detect vibrations from ensnared prey. Slingshot spiders (family Theridiosomatidae) take an active approach by constructing conical webs that they tension and release to intercept airborne prey before it contacts the web. They likely detect prey using vibrations transmitted via their setae, their web, or a combination of both. Here, we test habituation in slingshot spiders in situ in the Peruvian Amazon rainforest by measuring their response to repeated auditory stimuli. We also test whether the geometry of the web could enhance vibration detection by comparing responses to auditory stimuli in slingshot spiders with conical webs versus those with simple three-strand webs. Because each response requires the web to be re-tensioned, this system highlights a distinctive form of behavioral plasticity in which responsiveness is coupled to the active tuning of an external sensory structure.

From innovation to constraint: experimental insights into the evolution of mammalian teeth

Narimane Chatar, Melvin Vankelst, Alejandro Pérez Ramos, Tahlia Pollock, Davide Tamagnini, Margot Michaud, Levi Raskin, Jack Tseng

The tribosphenic molar is a dual-function structure that enabled both slicing and crushing in a single tooth. It represents a defining feature of mammalian dentition and underpins the evolution of heterodonty, yet the trade-off between these antagonistic functions remains poorly understood. Carnivorans are one of the most diverse mammalian orders and exhibit an exceptional dietary breadth, making them key to explore functional trade-offs. heir carnassial teeth can either resemble the tribosphenic condition (retaining both slicing and crushing capabilities) or specialize in a single function, making them an ideal system for investigating evolutionary transformations. Using the lower carnassial as a case study, we combined high-density 3D geometric morphometrics on 250 extinct and extant species with about 300 physical slicing and crushing experiments. Performance landscapes reveal that slicing efficiency is tightly constrained to a narrow range of morphologies, whereas crushing performance is more flexible. Despite the adaptive significance of both functions and the theoretical advantages of combining them, only two species (both extant feliforms) evolved truly optimized dual-function carnassials. These results suggest that the deep-rooted morphofunctional limitations of the tribosphenic architecture canalized subsequent evolutionary innovations toward divergent specializations rather than the maintenance of dual functionality in predators. More broadly, our findings illustrate how a key innovation can also act as a constraint during macroevolution.

Functional organization of haltere axon terminals and neck muscles in flying Drosophila

Payel Chatterjee, Serene Dhawan, Emily Behnke, Bradley Dickerson

Animals stabilize and redirect gaze during locomotion to minimize motion blur and extract relevant visual information. Flying insects primarily rely on head motion to stabilize gaze as they have limited ability to move their eyes relative to their heads. In flies, these reflexes are mediated by vision and mechanosensory input from the halteres, multifunctional mechanosensory organs that in part function as gyroscopic sensors. Although it is well-established that the halteres synapse onto the neck muscle motor neurons, how haltere feedback is modulated to achieve both stabilization and redirection is less clear. Using 2-photon calcium imaging in tethered Drosophila melanogaster, we investigated the functional organization of the haltere axon terminals in the brain during flight. A pixel-by-pixel correlation and clustering analysis revealed that the haltere tract can be functionally divided into two clusters differing in their probability density distributions. Further, connectomics analysis revealed that the neck motor neurons receive inputs from specific haltere morphological clusters, similar to previous analyses on the connection between the haltere and the wing motor system. Calcium imaging from two dorsal neck muscles revealed that their functional classification is consistent with the haltere functional division. Thus, gaze stabilization and redirection movements of the head are mediated in parallel with the wings by distinct haltere subtypes.

Hormonal control of plumage dimorphism in Anna's hummingbird

Soumyadeep Chatterjee, Chris Clark

Sexual dimorphism is hormonally controlled in birds. Differential effects of different hormones cause differences in morphology that lead to sexual dimorphism. Feather morphology in chickens is controlled by both thyroid as well as sex hormones. Chickens and ducks show estrogen-controlled, male-default plumage where increased estrogen or thyroid hormone levels results in the female phenotype. Passerines show a testosterone/luteinizing hormone-controlled, female-default plumage where higher levels of these hormones cause plumage to become male-like. Phylogenetically, hummingbirds lie in between these two systems. We studied hormonal control of feather morphology in Anna's hummingbirds. Specifically, the effects of oral administration of (i) T4, a thyroid hormone; (ii) Methimazole, a thyroid antagonist and (iii) estrogen. Feathers from the throat, crown, back and tail were plucked and treatment administered. Newly growing feathers were monitored until fully grown and their morphology studied. Pilot data from a male and a female showed that there is a feminizing effect of thyroid hormone on male iridescent plumage. Administering thyroid hormone also stimulated heavy molt in the female bird but not in the male. Preliminary data showed hummingbirds likely have male-default plumage. This means that hummingbirds are more chicken-like in their hormonal control of dimorphism. The switch to female-default plumage and testosterone-controlled dimorphism, such as in Passerines, likely occurred after hummingbirds diverged during avian evolution.

Use of sunlight differs between sympatric garter snakes in montane riparian forests

Ethan Chatwood, David Tevs

Microhabitat selection by small ectotherms often involves trade-offs between accommodating the thermoregulatory needs of the organism and minimizing predation. Sunny microhabitats are often used as basking sites by small ectotherms. However, sunlight may also increase chromatic contrast between the animal and its substrate, thereby increasing visibility to potential predators. To counter this increased exposure, small ectotherms may develop means to remain hidden in sunny areas or achieve suitable body temperatures while in shaded areas. We collected data on substrate temperature, light conditions, observation time, and behavior (active vs stationary) between two sympatric garter snake species with contrasting dorsal colorations (Thamnophis elegans and Thamnophis sirtalis) in western Montana (USA). We observed the darker T. sirtalis more frequently in shaded areas and later in the day than the lighter T. elegans. However, substrate temperature at time of observation did not differ between the two species. We suspect T. elegans' lighter coloration allows them to utilize sunny areas earlier in the day while decreasing interactions with T. sirtalis and remaining concealed to predators. In contrast, dark coloration on T. sirtalis may result in greater chromatic contrast with its substrate during sunny conditions. Consequently, T. sirtalis activity may be constrained to times of day when shaded areas provide both a means of crypsis and adequate thermoregulation.

Sinus Inspection — Using surface microtexture to diagnose cranial pneumaticity

Ani Chaudhary, Brian Beatty, Emma Schachner, Andrew Moore

Skeletal pneumaticity—invasion of bone by a highly efficient respiratory system—is a hallmark of archosaur evolution. However, diagnosing postcranial pneumaticity in fossils remains difficult, particularly when foramina leading to expansive internal chambers are absent. We test whether bone surfaces adjacent to pneumatizing diverticula (PD) exhibit consistent microtextures, enabling reliable identification of pneumaticity in such cases.

We compare four cranial regions with distinct tissue interfaces: (1) paranasal sinuses, unequivocally pneumatic, (2) attachment sites for mandibular adductor muscles (adductor fossa; mandibular ramus), (3) cartilaginous occipital condyles, and (4) outer cranial table. In total, we collected >100 high-resolution optical profiler scans across three genera with divergent respiratory anatomies: Larus, Crocodylus, and Homo. Preliminary results reveal that sinus surfaces exhibit heterogeneous microtextures—calloused, stretched, and warped morphologies, as well as pitted, cavernous zones—consistent with remodeling variability documented on the external cranial table.

Each scan yields >60 topographic variables. To assess their diagnostic potential, we apply linear discriminant and canonical variates analyses using leave-one-out cross-validation to calibrate accuracy. Clear group separation confirms that diagnostic microtextures in PD-adjacent bone reflect conserved cellular processes across amniotes.

Applying this framework to fossils requires quantifying taphonomic and preparatory impacts on microtexture. We are also dissecting postcranial material to image unequivocal pneumatic spaces and expand a comparative dataset. These efforts underpin establishing a microtexture-based method for detecting pneumaticity in fossils, advancing our understanding of archosaur respiratory evolution.

Mechanosensory lateral line diversity in sharks and rays

Julia Chaumel Cerda, George Lauder

The lateral line is a mechanosensory system widespread among aquatic vertebrates, enabling detection of water disturbances from abiotic (e.g., waves, currents) and biotic (e.g., prey, predators, conspecifics) sources. Elasmobranchs (sharks and rays) are known for their sophisticated sensory systems, including electroreception and mechanoreception. However, despite longstanding recognition, the morphology and interspecific variation of their lateral line system remain poorly understood. Here, we characterize the 3D morphology and histological structure of the lateral line system across multiple elasmobranch species, including sharks, skates, and rays. Sharks, both pelagic and benthic, exhibit a conserved morphology: a canal connected to the environment via short, unbranched tubules similar to that of bony fishes. In contrast, batoids show greater diversity. Pelagic rays (e.g., manta, eagle, cownose rays) possess a canal extending along the tail, connected to a highly branched network of tubules opening to the skin. This arrangement likely functions as a low-pass filter, enhancing sensitivity to low-frequency, high-amplitude stimuli. Skates and benthic rays (e.g., Dasyatis spp.) exhibit simpler lateral lines with minimal branching, suggesting limited signal filtering. Deep-sea rays (e.g., leaf-nose skate) display multiple lateral line canals on each body side, likely improving detection in low-light environments. These findings reveal that lateral line morphology in elasmobranchs is closely linked to habitat and ecological function, revealing previously unrecognized diversity in this sensory system across elasmobranchs.

Structural evolution of Apis mellifera queen cells by X-ray microtomography

Nikhilesh Chawla, Brock Harpur, Nicole Balog, Krispn Given

The hexagonal honeycomb structure of honey bees has been described for centuries. This highly efficient structure serves every purpose in the hive, from resource storage to worker and drone rearing. The only bee not raised in these hexagonal cells is the queen bee. Queens develop in highly specialized, single-use cells that are continually extended to accommodate the growing queen. These cups are described by their “morel” texture, a poorly understood feature whose function is not well-known. X-ray microcomputed tomography (XCT) was utilized to study the internal and external microstructural features of queen cells over time. Apis mellifera larva were grafted into plastic queen rearing cells and placed into cell builder hives. One cell was removed from a hive every 12 hours from grafting to emergence and subjected to XCT scanning. It was interesting to note that, in addition to changes in cell length, fraction of wax, and thickness, the degree of texturing, shaping, and building of quasi-cells was observed. Various parameters were used to describe the evolution of the wax cell and developing queen, including total wax volume, thickness, and porosity, which will be discussed in detail.

Protozoan grazing impacts Vibrio fischeri symbiotic fitness in the Southern dumpling squid

Daravuth Cheam, Michele Nishiguchi, Valentina Pallida, Eshaine Sun

Environmentally transmitted bacteria can be impacted by multiple biological factors (such as protozoan predation) before the onset of symbioses. The southern dumpling squid Euprymna tasmanica and its bacterial symbiont Vibrio fischeri is an ideal model to examine whether biotic factors such as protozoan grazing selects for key features important for symbiont competency. Sepiolid squids were colonized by both ancestral and evolved V. fischeri strains whose biofilms had been predated on for >60 generations. We used dual-RNA transcriptomics to determine whether protozoan predation had an effect on gene expression in both host and symbiont during colonization. Differences in gene expression patterns were found between ancestral and evolved strains that were subject to grazing, as well as the type of predator and strain used. Our results demonstrate specific genes that regulate symbiotic competency are subject to selection by external processes such as protozoan grazing prior to symbioses. This information provides insight as to how biotic factors shape microbial evolution and subsequently effect the degree to which beneficial associations are subject to extrinsic factors outside of the symbiosis.

The Aerodynamic Implications of Bird Tail

Die Chen, Qiu Huihe, Wei Shyy

The tail plays a crucial role in avian flight by contributing to both aerodynamic stability and maneuverability. Understanding its aerodynamic function is essential for advancing bio-inspired flight technologies. In this study, the vortex dynamics induced by tail motion in Agapornis roseicollis during short-range free flights were investigated. Time-resolved Particle Image Velocimetry (PIV) was employed to capture spanwise wake structures of the tail, while tail kinematics were simultaneously recorded using a multi-camera Direct Linear Transformation (DLT) system.

Our results first examine the relationship between wing motion and tail wake vortices, revealing notable interactions between the body and the tail. Body angles play a key role in shaping the tail wake, where appropriate orientations can effectively suppress flow separation in the tail region. Moreover, the results highlight the pronounced impact of tail attack angle on wake vortices. Throughout the flight, the tail angle exhibits continuous variation, reflecting its dynamic involvement in flight control. The dynamic motion of the tail plays an indispensable role in the maneuverability and flight stability of birds. A wake vortex model is identified in this study: the kinematic characteristics of the tail can lead to the formation of reversed counterrotating vortex pairs (RCVPs).

These findings underscore the critical aerodynamic role of dynamic tail control in avian flight, highlighting its dual function in modulating stability and contributing to aerodynamic force production.

Evolution of sexual systems and sex-allocation strategies in plants: dioecy and gender diphasy

Kai-Hsiu Chen, John Pannell

Flowering plants are extremely diverse in their sexual systems and sex-allocation strategies. Understanding the evolution and adaptive significance of different strategies requires measurements of both male and female reproductive success, as well as the quantification of components of selection. In this talk, I will present our research on two species with distinct sexual systems and sex-allocation strategies. First, in wind-pollinated Mercurialis annua

(Euphorbiaceae), the positive dependency of the selfing rate on male allocation results in disruptive selection on sex allocation when inbreeding depression is high, favoring unisexual male and female individuals (dioecy). This finding may help to account for the strong correlation between dioecy and wind-pollination in flowering plants. Second, in the perennial plant Pulsatilla alpina (Ranunculaceae), small individuals shift between male and hermaphrodite phases among seasons ('gender-diphasy'). By projecting floral reproductive success onto a landscape of male and female allocations, we find fitness peaks that correspond to the sex-allocation strategy actually adopted by the species, with the production of both unisexual male and bisexual flowers. Our studies contribute to the understanding of sexual-system evolution by estimating the shape of the relationship between fitness and sex allocation, both in terms of male and female components separately as well as in terms of their joint effects on a two-dimensional fitness landscape.

The role of sex in structuring aggression, rank, and hierarchy structure in monk parakeets

Yuchen Chen, Sara Lipshutz, Elizabeth Hobson

In gregarious species, aggressive interactions are often necessary for forming social rank and dominance hierarchies. Following the assumption that females and males compete under different selection pressures, many studies examine aggression and dominance in each sex separately. However, social selection pressures may influence the sexes similarly, and more work is needed to directly examine the role of sex in aggression and dominance. To address this, we compared aggression levels, occurrences of conflicts, and dominance hierarchies in captive mixed-sex groups of highly social monk parakeets (Myiopsitta monachus). We examined interactions at the individual, dyadic, and group levels in 6 10-bird groups. We asked whether sex predicted aggressiveness, choice of targets, and social rank. We found no evidence that one sex was more aggressive than the other. We also found that the sex of the bird did not significantly predict the rank that they achieved in the group; females and males were equally likely to be high ranked. The only sex-based difference we found was that males were significantly more aggressive towards other males compared to mixed-sex or female-female dyads. Overall, we found that sex had limited impacts on aggression and rank in these groups. Our study provides new insights into social aggression and dominance in monk parakeets by examining both sexes and highlights the importance of studying sex similarities and differences within complex social environments.

Cicada-wing inspired nanotopography exhibits enhanced bactericidal activity under shear flow

Yutao Chen, Marianne Alleyne, Nenad Miljkovic, Donghyeon Yoo, Alex Shuppara, Joseph Sanfilippo

We investigated the antibacterial performance of bioinspired nanostructured surfaces under varying flow conditions. Our previous work demonstrated that nanopillars on cicada wing surfaces achieve high bactericidal efficiency through purely mechanical forces upon bacterial contact with the surface. Building on this, we engineered cicada-wing-inspired surfaces and evaluated their bactericidal efficiency under controlled shear flow, providing a more realistic model of physiological environments.

Nanostructured polystyrene samples, inspired by nanopillars on cicada wing surfaces, were fabricated via nanoimprinting using anodized aluminum oxide molds. To assess the role of flow, we prepared polystyrene samples with three different nanostructure heights but identical diameters. These samples were mounted in custom-built microfluidic channels, where bacteria were introduced at flow rates of 3ul/min, 7ul/min, and 10ul/min for one hour. Bacterial attachment and behavior were monitored microscopically at 5-minute intervals, and departure rates, trajectories, and orientations were compared against smooth control surfaces. Bactericidal activity was quantified using confocal microscopy to measure cell death at 60min. Overall, comparisons across nanostructure heights and flow conditions revealed higher death rates of bacteria on surfaces with shorter nanopillars and under stronger flow.

By incorporating flow conditions, this study provides a more physiologically relevant assessment of the bactericidal performance of natural and engineered nanostructures, ensuring relevance to the environment encountered by organisms, as well as implications for the guided design of medical devices and implants that employ bioinspired surfaces.

Mapping functional connectivity in the pigeon brain with wide-field optical imaging

Kathryn Chenard, Annie Bice, Seana Bice, Joseph Culver, Paula Gerliz, Xavier Helluy, Onur Güntürkün, Jason Trobaugh, Mehdi Behroozi, Carlos Botero

A primary goal in neuroscience is to understand how complex cognitive abilities arise from the brain's patterns of anatomical and functional connectivity. Adapting optical imaging technology to avian models can overcome many limitations imposed by fMRI, which currently restrict the number of species used to study functional connectivity. We assess the potential of optical imaging technology to measure resting state functional connectivity in birds, utilizing pigeons as an avian model. Using optical intrinsic signal imaging, a widefield optical imaging (WOI) method, we imaged resting state functional connectivity in scalp-retracted anesthetized pigeons. We then used iterative parcellation and hierarchical clustering to create functional connectivity maps of correlation between parcels at two spatial scales. We recorded a second independent dataset of ten pigeons using GE-EPI fMRI and applied the same methods to compare functional connectivity patterns between the two datasets. We successfully partitioned signal activity into clusters of parcels which exhibit symmetry between hemispheres, and which align well with known anatomical regions of the dorsal surface of the pigeon brain. Moreover, functional connectivity matrices reveal positive correlations with parcels located in their homotopic cluster. Cluster partitions and functional connectivity maps display similar patterns across and within individuals. Finally, WOI imaging results were comparable to fMRI. Overall, our results indicate that optical imaging technology is a viable and cost-effective alternative for imaging resting state functional connectivity in birds.

Convergent anatomical mechanisms of harmonic filtering in bat echolocation

Vaibhav Chhaya, Tim Smith, Abigail Curtis, Thomas Eiting, Wu-Jung Lee, Sharlene Santana

The evolution of multifunctional anatomical structures is governed by a complex interplay of selective pressures. Used for feeding, smelling, breathing, and echolocating, the bat rostrum (snout) is a compelling system to study complex form-function interactions. While external rostrum shape is driven by dietary and sensory needs, the internal structure and functional role of the rostrum's nasal passages remain understudied in bats. Here, we examine whether nasal passage morphology reflects the sensory demands of different echolocation modes in bats – oral, nasal or non-echolocating. Using 3D models of bat skulls in phylogenetic comparative analyses, we first test the relationship between echolocation mode and the morphology of nasal turbinals–structures involved in olfaction, respiratory conditioning, and possibly sound filtering. We find that nasal-emitting bat species show convergent reduction in turbinal complexity (relative surface area) and the presence of accessory paranasal spaces in their nasal cavities when compared to oral-emitting and non-echolocating species. Next, we use acoustic finite element analysis to investigate whether the specialized nasal morphology of nasal emitters enhances echolocation performance. We find that the nasal passage morphology of nasal emitters facilitates the suppression of the fundamental harmonic in echolocation calls, a spectral feature that could improve prey detection, tracking, and ranging in cluttered environments. These findings suggest that nasal sound emission may impose a performance trade-off between echolocation and the olfactory/respiratory functions of the rostrum.

Walking Drosophila flexibly recruit leg muscles to generate similar movements

Raveena Chhibber, Elliott Abe, Lili Karashchuk, Chris Dallmann, Bingni Brunton, John Tuthill

Movements arise from activation of motor neurons and their corresponding muscle fibers. Muscle activation often has nonlinear relationships with movement: different patterns of motor neuron activity can produce similar movements.

Drosophila are well-suited for studying how muscles generate movement, as their genetic tractability allows measurement and perturbation of behavior. Previously, measuring the temporal dynamics of leg muscles has been challenging. Here, we analyze calcium activity from antagonistic muscles controlling the coxa during walking.

We find that antagonistic muscles often show an anti-phase relationship, with peak activity between either swing or stance. However, we also observe that phase relationships between muscles can vary widely while generating similar kinematics. While the swing muscle is consistently recruited before swing, the stance muscle is activated in-phase, non-phasically, or antiphase. We hypothesized that swing muscle activation is fixed relative to the step cycle, whereas the stance muscle may be flexibly activated to fine-tune force-production.

To understand each muscle's contribution to walking, we leverage a biomechanically realistic fly body in virtual physics engine MuJoCo. We fit a Hill-type muscle model using work loop data for the fly jump muscle to estimate the possible underlying forces. We hypothesize that the stance muscle's flexible timing may reflect different functional roles in the walking cycle. We are now measuring the activity of the remaining three muscles at the joint to understand flexible neural control.

Birds that don't exist: tracing the evolutionary constraints on bird morphology

Stephanie Chia, Anshuman Swain, Nathaniel Josephs, Lizhen Lin, William Fagan

Understanding why some viable body forms are missing from living species can reveal how ecological and evolutionary forces shape biodiversity. We investigate this question in the Passeroidea, a large group of songbirds, by analyzing their morphological trait space using topological data analysis and ancestral state reconstruction. We identified a long-standing morphological gap—corresponding to an average-sized passerine with a relatively thin beak—that has remained unoccupied throughout the passeroid diversification, despite being densely surrounded by extant species.

To explain this persistent gap, we evaluated hypotheses including extinction, neutral diversification, intrinsic constraints, niche absence, and competitive exclusion. The gap shows no evidence of occupation by extinct or ancestral species, and does not match expectations under neutral models. However, similar morphologies occur in other bird lineages, suggesting the missing forms are physically and ecologically viable. Our results support competitive exclusion as the most plausible explanation: territorial niche-specialists from outside the Passeroidea likely colonized key habitats earlier, preventing later-arriving passeroids from evolving into that trait space.

This study illustrates how historical contingency and species interactions can leave lasting imprints on trait evolution. More broadly, it introduces a new and generalizable framework for investigating macroevolutionary patterns in high-dimensional trait space.

Sensitivity analysis of coupled Hopf oscillator dynamics for flipper-driven robot locomotion control

Nnamdi Chikere, Alexander Dowling, Yasemin Ozkan-Aydin

While sea turtle hatchlings possess flippers for efficient aquatic propulsion, these limbs must also manage traversal of loose terrestrial substrates during their journey from nest to ocean. Hatchling's ability to generate rapid, coordinated flipper-driven strokes on yielding terrain has inspired robotic systems designed to operate in deformable environments. Central Pattern Generators (CPGs), modeled after the neural circuits that produce rhythmic motion in animals, provide a framework for coordinating these cyclic limb movements. Identifying the CPG parameters that influence locomotor performance is essential for developing adaptive and energy-efficient gait controllers. In this study, we present a parameter-sensitivity analysis of a Hopf-oscillator Central Pattern Generator (CPG) that drives a sea-turtle-inspired robot in a MuJoCo environment. We performed systematic sweeps of key CPG parameters, including stance and swing frequencies, amplitude gains, and coupling strength, quantifying their effects on forward speed, mechanical energy expenditure, and cost of transport. The results demonstrate that stance frequency is a dominant determinant of forward propulsion, with speed increasing up to approximately 1.0-1.1Hz before saturating. Foreflipper amplitude is crucial, producing a twofold increase in speed, while hindflipper and hip amplitudes primarily influence stability and energy consumption. Furthermore, the coupling strength strongly modulates the quality of flipper coordination. These findings identify the key CPG parameters governing robust flipper-based locomotion on yielding terrain, providing critical insight for optimization and adaptive control strategies in bio-inspired robotics.

Flipper morphology and gaits shape turning performance in a sea turtle-inspired robot

Nnamdi Chikere, Frank Fish, Yasemin Ozkan-Aydin

Navigating complex, heterogeneous coastal environments is a fundamental challenge for sea turtle hatchlings, where the ability to execute effective, robust turning maneuvers represents a critical determinant of survival. To investigate how morphology and gait influence the maneuverability of hatchlings, we developed a robotic model and evaluated its turning ability across compliant foam, dry granular sand, and four distinct rocky substrates. We systematically investigated five distinct gait types: all-flippers-together, front-only, back-only, diagonal, and single-flipper, using both rigid and soft flipper configurations. The all-flippers gait produced the best turning performance, with peaks of 50.31 ± 1.19 /cycle and 22.50 ± 1.20 /s on foam and 55.49 ± 0.32 /cycle and 22.48 ± 0.16 /s on sand, though performance declined at higher stride frequencies. The front-flippers gait was also effective, achieving 47.79 ± 3.15 /cycle and 23.90 ± 1.57 /s on foam and maintaining moderate turning (15 /s) on sand and rocks. Back flippers were useful on flat terrain (32.99 ± 1.13 /cycle, 24.04 ± 1.85 /s) but lost efficiency on uneven ground. Diagonal and single-flipper gaits provided limited performance (< 4 /s) on sand and rocks. These findings show that full-body and front-based actuation strategies enable reliable turning across varied terrain, while reduced-contact gaits are less effective but may conserve energy. This work provides new insight into hatchling locomotion and informs the design of bioinspired robots for navigating complex and variable environments.

Repeatability of the endocrine stress response over 5 years in an *Octodon degus* cohort

Ava Choi, Alejandro Sanchez, Oliver Clackson, Kaja Arusha, Ava Craig, Tate Garcia, Annalise Di Cicco, Carolyn Bauer

Glucocorticoids, such as cortisol, are the major mediators of the endocrine stress response. Cortisol levels have been assumed to be repeatable in individual animals, however, this assumption has only been tested over short periods of time and never over the entire lifespan of most species. In this study, we used a social rodent species (Octodon degus) under controlled laboratory conditions to test the hypothesis that the endocrine stress response will change with age but remain repeatable within a cohort of males and females over their lifetime. To test this, we took blood samples to assess baseline cortisol levels, stress-induced cortisol levels, and cortisol negative feedback strength at ten different timepoints between 1-58 months of age. We found that cortisol levels significantly changed with age, with degus having their highest average stress-induced cortisol levels and weakest negative feedback at 58 months of age. In terms of repeatability, we found that negative feedback strength, but not baseline and stress-induced cortisol levels, was significantly repeatable over time within our degu cohort. Our results suggest that cortisol negative feedback strength is the most repeatable component of the degu's stress profile and that an individual's baseline and stress-induced cortisol level at one time point are not representative of all past and future time points, opposing assumed repeatability of the endocrine stress response.

Hydrodynamics of water-hopping behavior of mudskippers

Daehyun Choi, Ian Bergerson, Kai Lauren Yung, Kenny Zhang, Saad Bhamla

Mudskippers exhibit remarkable water-hopping behavior by skipping on the water surface without full submergence, extending their pectoral fins to generate lift during splashing and flapping their caudal fins for water exit. This is the first comprehensive study combining field observation, physical modeling, and robotic validation to understand this peculiar locomotion mechanism. Field observations using low-cost and accurate stereo-imaging revealed that water-hopping mudskippers achieve speeds up to 2.5 m/s with 40% higher agility compared to other water-skipping animals. Physical modeling using computational fluid dynamics and water tank experiments identified optimal pectoral fin geometry with aspect ratios and specific angle of attack profiles for maximum dynamic stability. Our bio-inspired robotic prototype demonstrated that water-hopping behavior enables amphibious vehicles to achieve higher energy efficiency improvement above the critical operational velocity. These findings provide the first biological evidence for energetic benefits of water-hopping locomotion and suggest innovative design principles for future amphibious vehicles with potential applications in rescue operations and environmental monitoring.

Linking developmental stage to locomotor strategy: swimming in centipedes

Baxi Chong

Recent studies have highlighted the diverse swimming behaviors of centipedes, revealing two distinct modes. In one, centipedes swim within a fluid body, relying on body undulation for self-propulsion. In contrast, at the air–water interface, some centipedes employ a unique strategy: they propagate body waves from tail to head, with reaction forces generated by their splayed legs enabling forward motion. Intriguingly, these locomotor strategies appear to align with developmental differences. Epimorphic centipedes, born with their full set of limbs, typically swim within fluids, whereas anamorphic centipedes, which hatch with only 8–10 legs and add legs throughout their lifetime, are typically surface swimmers. This suggests that early juvenile morphology may play a critical role in shaping locomotor strategies. To test this hypothesis, we examined two juvenile species: Scolopendra subspinipes (epimorphic; N = 10; 38 legs; 50.76 ± 0.1 mm; 301.8 ± 12.3 mg) and Thereuopoda longicornis (anamorphic; N = 3; 8–10 legs; 4.87 ± 0.1 mm; 2.9 ± 0.3 mg). Preliminary observations show that S. subspinipes already exhibits strong swimming abilities resembling its adult forms, while T. longicornis struggles to swim effectively. To further investigate, we developed a Dynamic Resistive Force Theory (DRFT) model that integrates empirically measured force relations across the swimmer's body. Simulations suggest that effective surface swimming emerges once centipedes possess approximately 16 legs, supporting the role of developmental morphology in shaping locomotor capacity.

3D reconstruction and description of material composition of Haemaphysalis longicornis mouthparts

Kaylin Chong, Alexandre Casadei-Ferreira, Adrian Richter, Sebastian Büsse, Evan Economo

Ticks are vectors of many important human and animal diseases. They are hematophagous arthropods that require a blood meal to acquire the nutrients for development and for egg production. Given their unique feeding strategy, ticks have highly specialised piercing and sucking mouthparts that aid in both penetration and anchorage to the host. Historically, much work has been done to characterise their mouthpart anatomy primarily through dissections and histology. With advances in imaging techniques, more recent work has explored stages of the tick feeding process including salivation, suction as well as penetration. However, most of this work has been focused on the species of Ixodes, due to their medical importance, and a comprehensive overview of the mouthpart internal and external anatomy is still lacking. In this study, we focus on another medically and agriculturally important tick, Haemaphysalis longicornis, a tick native to East Asia, that now has spread globally. Using micro-CT scan generated data, we document mouthpart and head anatomy of this species for the first time and provide an up-to-date review of these features across ticks. We also explore the chelicerae in more depth, looking at their material composition and the mechanisms driving their slicing movement. We highlight how a morphological perspective is crucial to understanding tick mouthparts and their function in blood feeding.

Holding on tight: how tick mouthpart structure enables attachment to diverse tissue structures

Kaylin Chong, Rachel Zoll, Mady Corrigan, Elio Challita, Robert Wood

Hard ticks (Ixodidae) are hematophagous arthropods that have mouthparts specialized for penetration and attachment to a range of vertebrate hosts. Bloodfeeding is important for these ticks to acquire the nutrients required for a range of physiological tasks including moulting, spermatogenesis and egg laying. However despite the shared function, there is much morphological diversity in mouthpart structure across different ticks. In this study, we focus on the hypostome, a spiky ventral mouthpart protrusion, that becomes embedded in the host tissue during bloodfeeding. We aim to explore how varying the shape of the hypostome as well as the qualities of the denticles found on its surface can affect the ability to remain stuck in tissue. Using 3D models of female tick heads generated from micro-CT scanning, we first examine the morphologies of ticks known to not only have different hypostome structures but also feed on different hosts and quantify the removal force across a range of tissue structures. We then vary the parameters related to the shape of the hypostome and denticles found on the surface. Through this, we hope to gain insight to the characteristics of the hypostome that are important for sticking into different tissue structures. Understanding how the morphology affects tissue puncture mechanics holds potential for informing the design of tissue anchoring mechanisms.

Shining a light on the developmental origin of novelties: examining proleg development in sawflies

Elizabeth Chou, Yuichiro Suzuki

Evolutionary novelties are novel body structures that are neither homologous to any body parts in the organism's ancestral lineage nor serially homologous to any other body part of the same organism. Abdominal appendages in immature insects, called prolegs, are present across diverse orders of insects but appear to be absent in a shared common ancestor. Whether these prolegs are serially homologous or evolved as independent novel structures remains an important but unresolved question. Using the introduced pine sawfly Diprion similis as our model organism, we investigated the mRNA expression of several relevant developmental genes that are involved in limb development, followed by pupal RNA interference-mediated knockdown of these genes to examine phenotypic changes. I will present in situ hybridization chain reaction (HCR) data on the expression of these key developmental genes in D. similis embryos. Through this work, the evolutionary origin of abdominal appendages will be discussed.

Overwhelmed by choice – consequences of choice overload in gray treefrogs

Trina Chou, Kim Hoke, Jessie Tanner, Mark Bee

Choice overload is the phenomenon where increasing the presented number of options in a decision-making task may lead to individuals reaching their cognitive limits, resulting in worse decision outcomes. While comprehensively studied in human economic decision-making, choice overload has yet to be understood in animal contexts. Here, we take advantage of a previously published dataset on gray treefrogs (Hyla chrysoscelis) presented with 2, 4, or 8 simulated male alternatives to understand how numerous options in mating contexts may lead to choice overload. Additionally we explore the consequences this might have for male and female fitness. Female treefrogs routinely make decisions about who to mate with during the breeding season, listening to the advertisement calls of dozens of males in any given night. In our analysis, we found that females display symptoms of choice overload in the 4- and 8- choice contexts, taking longer to make decisions and being more likely defer their decision. As the number of presented options increased, outcomes worsened for females, that is, they selected males that

were objectively worse than the best quality males in the set. Additionally, we found that males had to have signals of higher quality to be selected. Our work demonstrates how sexual selection imposed by mate choice may be weakened when more options are provided and prompts further investigation of choice overload in non-human contexts.

Active stretch dynamics of muscle-tendon units

Hanna Chow, Miles Valencia, Katelyn Manross, Richard Casler, Kiisa Nishikawa, Manny Azizi

The presence of a compliant, in-series tendon has been shown to limit the magnitude and velocity stretch applied to muscle fascicles when a muscle-tendon unit (MTU) is lengthened. This attenuating effect can alter the force output of muscle fascicles and potentially protect muscle fibers from muscle damage. Here we explore how the time-varying viscoelastic properties of muscles and tendons influence the flow of mechanical energy in the MTU. To investigate the impact of stretch applied to a fully active MTU, we used an in situ muscle-tendon preparation of the rat medial gastrocnemius where sonomicrometry was used to measure muscle fascicle length and an ergometer was used to measure MTU lengths. Muscles were maximally activated at various lengths around 30% of their optimal length. After reaching a steady-state force, a 5% stretch was applied to the MTU. Preliminary results support previous findings that show less stretch is applied directly to muscle fascicles when operating with an in-series tendon. Additionally, we observed that following the imposed stretch, while the MTU remained active and held at constant length, the stress-relaxation of the MTU led to a gradual, delayed stretch of the muscle fascicles. This result suggests that the viscoelastic properties of the MTU have direct influence on muscle fascicle length trajectories which may be significant during latch-mediated behaviors with prolonged periods of loading. Supported by NSF DBI 2319710.

FGF receptor trafficking during cell division in human cells

Thanisha Chowdhury, Christina Cota, Bradley Davidson

Growth factor receptors regulate cellular growth and differentiation. Mutant growth factor receptors have been linked to cancer and are targets for cancer treatment. During mitotic entry, the plasma membrane is internalized into endosomes to facilitate cell rounding while during mitotic exit, the membrane is recycled back to the surface to promote division. In our lab we study the trafficking of Fibroblast Growth Factor Receptors (FGFR) in the invertebrate Ciona robusta and our published work indicates that FGF receptors are internalized along with the associated membrane during mitotic entry, and then stored through inhibition of endosome degradation and recycling pathways. We are investigating whether this model of receptor internalization and storage applies to human cells by examining the localization of FGFR-GFP fusion proteins in HeLa cancer cell lines. Transfected FGFR-GFP HeLa cells were synchronized in interphase using CDK-1 inhibitors, and then released for 30 minutes to allow them to enter into mitosis prior to fixation and staining. Our initial analysis indicates that the intensity of FGFR-GFP staining along the plasma membrane decreased during mitotic entry, supporting hypothesized receptor internalization during this period. We also observed that vesicle size decreased during mitotic entry. Future studies will focus on imaging FGFR-GFP cells during the remaining stages of mitosis in order to fully characterize receptor trafficking.

Time calibrated phylogenomic analysis of cyclostome divergence, diversity and biogeography

Evan Christensen, Douglas Fudge, David Plachetzki

The superclass Cyclostomata—hagfishes and lampreys—represents the only surviving lineage of jawless vertebrates (agnathans), offering a unique window into early vertebrate diversification. Once regarded as paraphyletic, cyclostomes are now supported as a monophyletic clade by molecular evidence. Yet, despite their evolutionary significance, a comprehensive phylogenomic analysis of the group has been lacking. Here, we present a comprehensive time-calibrated phylogeny of cyclostomes, using mitochondrial markers from 113 species, with additional genome and transcriptome data from 30 of those species, encompassing all publicly available phylogenetic markers for cyclostomes. Our analyses provide robust support for cyclostome monophyly and date the hagfish–lamprey split to the early Paleozoic. Although this divergence between hagfish and lamprey is ancient, diversification within both lineages is comparatively recent, beginning in the Mesozoic. By integrating mitochondrial and genomic data, we resolve several interspecific and intergeneric relationships and establish a comparative phylogenetic framework that spans all sequenced cyclostome species. We leverage this framework to investigate the biogeographic correlates of cyclostome diversity.

Spots tell stories: discovering the relationship between wing spots in Pieris rapae butterflies

Lauren Chudner, Natalie Wagner, Kiyra Bergstrom, Saige Pompura

Pieris rapae butterflies are characterized by distinct wing melanization patterns that exhibit sexual dimorphism and phenotypic plasticity. On anterior forewings, both sexes can display apex wing melanization and an M3 spot, and the presence of a Cu2 spot uniquely distinguishes females. Current literature suggests that wing melanization plays a key role in sexual selection, communication, and thermoregulation, and may have additional unknown functions. In female Pieris rapae butterflies, we hypothesized that the Cu2 and M3 spot areas may have a positive relationship if they are controlled by similar genetic or developmental mechanisms underlying melanization expression. Using museum specimens from the online database iDigBio, the Cu2 and M3 wing spot areas of 70 female butterflies from Europe and North America were measured. A bivariate linear regression analysis in JMP revealed a positive relationship between the Cu2 and M3 spot areas in Pieris rapae females, and findings suggest a statistically significant biological association between the Cu2 and M3 spot areas (Left Wing: $R^2 = 0.588$, $p < 0.0001$; Right Wing: $R^2 = 0.560$, $p < 0.0001$). Future research may expand on the findings of this project by continuing to learn about the relationship between Pieris rapae wing spots, especially in the contexts of genetic expression for melanization, butterfly behaviors, evolutionary adaptive strategies, and metabolic mechanisms.

The effect of the chorus on close-range courtship interactions of túngara frogs

Olivia Chung, Marcos Gridi-Papp

Male túngara frogs (Engystomops pustulosus) form large choruses but they are known to clasp any individual within close-range. Yet, during breeding trials in which females were placed within close-range of the male without any acoustic stimulus, the male consistently chose to call instead of clasping. The discrepancy between clasping observed in the field and calling during the previous trials could have been due to the lack of a chorus to stimulate the female. Male calls have been reported to trigger egg laying in females which may explain why the males called in the lab trials. We hypothesized that chorus playback would stimulate the female resulting in the male foregoing calling to clasp. We tested six chorus playback stimuli during close-range breeding trials. We found no significant effects of chorus presence, constancy, call rate, or call complexity on male calling, indicating that the chorus does not replace calling. Oviposition, however, was significantly more likely when pairs were exposed to a fast-complex chorus compared to either simple, slow or no chorus. The chorus may therefore only stimulate the female or it may stimulate the male to call more which would in turn stimulate the female.

Cetacean airway branching geometry is optimized for low resistance at the expense of dead-space volu

Robert Cieri, Merryn Tawhai, Marina Piscitelli-Doshkov, Robert Shadwick

The pulmonary systems of Cetaceans are the largest in evolutionary history and tell a fascinating story about adaptation to marine life. Cetacean lungs may be challenged by extreme body size, the repeated collapse and reinflation of lungs due to external pressure during diving, and unusually short breaths and high tidal volumes. Using morphological analysis of pulmonary airways segmented from computed tomography scans of inflated lungs from 13 species, we show that airway morphology differs from terrestrial mammals but also varies among cetacean species. In branching networks, the decrease in channel diameter at bifurcations is an important determinant of the relative number and size of airways at each generation and thus forms a trade-off

between flow resistance and dead space volume. The diameter of airways in cetaceans reduces less rapidly compared to terrestrial mammals, facilitating lower resistance but also resulting in an higher anatomical dead space. Further, we show that the Strouhal diameter ratio, another index of how rapidly airway diameter decreases along branching generations, differs among cetacean species. Higher ratios, indicating a greater degree of diameter reduction, are associated with deep-diving, and lower ratios are associated with fast ventilation. This suggests that changes in airway tree geometry represent a trade-off between the need to store lung gas in the greater airways during diving may be a more important selective pressure than maximizing flow rates.

Functional allometry of sexually selected traits in red milkweed beetles

Lauren Cirino, Kirsten Lindemann, Travis Hagey, Rafael Rodriguez

The allometry of sexually selected traits is highly variable. Some traits scale steeply, some shallowly, and others scale proportionately to body size. One explanation for this variability is trait function. Sexually selected traits should scale differently according to the function that they perform – the functional allometry hypothesis. Here, we investigate the functional allometry hypothesis in red milkweed beetles, Tetraopes tetrophthalmus (Coleoptera: Cerambycidae), a species that possess multifunctional sexually selected traits. Males use their mandibles to eat and as weapons to fight rivals. Their antennae act as sensory organs and as tactile signals during copulatory courtship. We measured these sexually selected traits along with body size in both males and females. We also measured thorax and leg size, traits presumably not under sexual selection, as control traits. We found that tactile signal traits used in courtship were negatively allometric, while weapons, traits supporting the weapon, and control traits were isometric. Although male mandible weapons were isometric, we found that female mandibles were negatively allometric. Finally, weapon shape was also examined as this trait is important to fighting outcomes. We found that male mandible weapons have a rugose medial curve with a midpoint ledge that female mandibles lack. These results support the functional allometry hypothesis for variation in trait allometry. We discuss how interactions between the functions that these traits perform may influence the evolution of morphology.

Peptide-induced spawning and long-term larval culture of the sea cucumber *Apostichopus californicus*

Xochitl Clare, Billie J. Swalla, Jacqueline Padilla-Gamino

Experimental studies of non-model marine invertebrates is often limited by difficulties in inducing spawning and rearing larvae. The giant sea cucumber Apostichopus californicus, an ecologically and commercially important species in the Pacific Northwest, has lacked reliable laboratory culture methods for developmental cellular and experimental studies. Here, we report one of the first successful long-term larval rearing of A. californicus using peptide-induced spawning at the University of Washington Friday Harbor Laboratories (FHL) in summer 2025. Adults injected with the neuropeptide NGIWY released gametes within one hour, and fertilization yielded rapid synchronous embryonic development through cleavage, blastula, and gastrula stages. Larvae were cultured on microalgae (Rhodomonas and Dunaliella) and successfully reached the pentacula stage with five tentacles. Developmental variation, including doliolid morphologies, suggesting potential influences of density, temperature, or stirring on larval outcomes. Using only four adults for this study's broodstock, our results establish A. californicus as a tractable model for experimental studies in developmental and reproductive biology. By providing a reliable method to raise sea cucumber larvae through key developmental milestones, this study lays the foundation for both fundamental research in developmental and reproductive biology and applied conservation of an important fisheries species.

Morphologies of the jawless feeding apparatuses in hagfishes and metamorphosed lampreys

Andrew Clark, Theodore Uyeno, Paul Gignac

Hagfishes and metamorphosed lampreys possess jawless feeding apparatuses (JFAs) composed of keratinous teeth mounted onto cartilaginous dental plates (DPs) that cyclically protract and retract to procure food. Previous gross dissection and histological data fail to trace individual muscle fascicle bundles through their three-dimensional (3-D) trajectories, limiting our understanding of structure-function relationships within jawless feeding systems. Using diffusible iodine-based contrast-enhanced CT (diceCT), we assessed JFA morphologies in three hagfish species and one lamprey. Segmentations of dentition, cartilage, and retractor muscle fascicles corroborate previous data, confirming that hagfish JFAs are larger and predominantly muscular, while lamprey JFAs are mostly cartilaginous and operate with smaller muscles. Reconstructions of fascicles in hagfishes yield highly-detailed 3-D orientations of complex, densely-packaged arrangements of longitudinal, semicircular, and transverse muscle fibers, which allow us to better visualize the hydrostatic support from activated musculature. These intricate muscle orientations are conserved across species, possibly suggesting similar feeding muscle activity patterns. Lamprey retractor muscles bear simpler 3-D arrangements of longitudinal and circular fibers. Like hagfishes, lamprey DP movement is supported by basal plate cartilages (BPs), however, lamprey BPs are extremely narrow, have ligamentous DP connections, and taper into needle-shaped posteriors completely enveloped within circular muscles. Activated circular muscles likely protract BPs which, via ligaments, would induce DP retraction. This out-of-phase BP-DP movement resembles a simple reverse-motion linkage system uncharacteristic to BP-DP movements in hagfishes.

Stiff competition: morphology and mechanics of lamniform shark vertebrae

Aubrey Clark, Genna Felder, Jamie Knaub, Madisan Biordi, Isabella Fernandez, Michelle Passerotti, Marianne Porter

During swimming, the shark vertebral column is cyclically loaded by side-to-side tailbeats, a crucial component of thrust production. As the column bends, it experiences repeated forces of combined loading that vary along the length of the body, and with swimming speed and mode. In response to disproportionate forces along the column, vertebral mechanical properties may not be consistent in all body regions. In sharks, vertebral morphology is known to vary in the arrangement and amount of mineralized cartilage. Members of the order Lamniformes (mackerel sharks) share similar vertebral architecture, with radiating mineral structures called lamellae. However, these species can differ in swim mode and speed. Here, we compared the relationship between the vertebral mechanical properties and morphology of five lamniform shark species (N=3 families; 21 individuals). We hypothesized that vertebrae in the posterior body region would be toughest and stiffest, and have more lamellae, to facilitate thrust production. Using an Instron material tester, we quantified mechanical properties for three body regions (anterior, middle, posterior) under three compression loading regimes to represent a wide variety of swimming forces. We calculated stiffness (MPa, resistance to compression and deformation) and toughness (MPa, ability to absorb energy) from stress-strain curves. We quantified lamellae using micro-CT scans. A greater understanding of the relationship between vertebral column form and function can provide insights into the mechanical underpinnings of aquatic movement.

Powerful photons for probing phyla: Synchrotron-based micro-CT imaging in organismal biology

Elizabeth Clark, Dula Parkinson

Three-dimensional imaging has revolutionized organismal biology through visualizations of intricate structural relationships, functional mechanisms, and dynamic processes previously inaccessible with other experimental techniques. Synchrotron-based micro-CT imaging remains securely at the forefront of imaging capabilities in terms of acquisition speed and resolution. The Advanced Light Source (ALS) at Lawrence Berkeley National Laboratory offers cutting-edge synchrotron-based micro-CT capabilities that deliver sub-micron-level resolution, high-speed data acquisition, and a range of sample

environments for broad experimental applications. Our facility uniquely integrates AI-powered acquisition and analysis tools that dramatically reduce processing time and enhance data accessibility. We demonstrate this transformative power by showcasing recent research collaborations across taxa, from the hydrodynamics of bird feathers to three-dimensional neural architecture in bee brains, exemplifying how our capabilities are redefining experimental possibilities across diverse biological systems. We invite organismal biologists to explore how synchrotron-based micro-CT could transform their research questions and welcome discussions about collaborative opportunities that will push the boundaries of discovery in the field.

FathomVerse: Ocean exploration for the masses

Emily Clark, Kakani Katija, Joost Daniels, Giovanna Sainz, Lilli Carlsen, Laura Chrobak, Kevin Barnard, Ellemieke Berings

In order to fully explore and protect our ocean, we need to increase our capacity for biological observations; massive disparities in effort between visual data collection and annotation make it prohibitively challenging to process this information. State-of-the-art machine learning approaches cannot solve this problem alone, and building an integrated community of educators, scientists, and enthusiasts is key. Previously, we introduced FathomVerse, a mobile game designed to inspire a new wave of ocean explorers by teaching casual gamers about ocean life while improving machine learning models and expanding annotated datasets. Here, we share how we refined consensus protocols to turn more than 20 million player annotations into high-quality scientific observations and developed improved machine learning models. We also dive into changes made for V2 of the game, which launched in April 2025, making the game more engaging and adding localization tasks for players. This demonstrates leaps in progress towards more complete coverage of annotations for each image, both by player-contributed localizations as well as rapidly improving detection models. Finally, we introduce a completely new ID app where anyone can use the same machine learning models we use to analyze their own images and contribute by sharing their observations. Through FathomVerse and FathomVerse ID, we engage global audiences, increasing public awareness and inspiring empathy for ocean life, while allowing them to contribute to science in meaningful ways.

Same bacteria, different responses: host genotype drives variation in *Nematostella*

Justin Clark, Quinton Krueger, Adam Reitzel

Animals harbor diverse microbial communities composed of mutualists, commensals, and pathogens. We investigated whether the sea anemone Nematostella vectensis can (1) distinguish among bacterial species and (2) mount genotype-specific responses. Using individuals from three Atlantic coast populations, we examined transcriptomic responses to two related marine bacteria: the pathogen Vibrio coralliilyticus and the commensal Vibrio diabolicus . We compared gene expression between anemone genotypes (differential expression, WGCNA, and GO-enrichment analyses) to compare and contrast how anemones with different genetic backgrounds responded. V. coralliilyticus induced stronger responses in Florida and North Carolina populations, consistent with its role as a pathogen in diverse invertebrates. Surprisingly, V. diabolicus elicited a comparable response in Nova Scotia anemones, despite its presumed commensal role. These results suggest that host genotype strongly shapes responses to microbes, offering insight into the drivers of microbiome variation in broadly distributed animals.

Investigating the genetic architecture of sex determination (SD) in *Cassiopea xamachana*

Mikayla Clark, Myles Wagner, Marie Strader

Mechanisms of sex determination (SD) vary tremendously across the tree of life. Broadly, SD is grouped into three categories: genetic (GSD), environmental (ESD), and complex—systems with both genetic and environmental components. Despite being an early-branching lineage that offers insights into the evolution of reproductive systems, cnidarian SD remains minimally characterized across the phyla. In this study, the genetic basis of SD was investigated in the upside-down jellyfish, Cassiopea xamachana, using whole-genome sequencing of 183 wild individuals. Chromosome-level coverage analysis revealed no evidence of heteromorphic sex chromosomes (e.g., XY or ZW), however, a finer scale sliding-window approach identified eight genomic bins across five chromosomes that exhibited a significant sex-specific skew (>2X) in coverage. A genome-wide association study further identified ~100 candidate sex-linked SNPs across nine chromosomes. These results provide preliminary evidence for a polygenic system of GSD in Cassiopea, although a complex system incorporating environmental cues cannot yet be ruled out. Validation of sex-specific markers will enable molecular sexing of sexually immature individuals, including polyp lines routinely used in research. This study is the first genome-scale investigation of SD in a rhizostomean jellyfish (Order Rhizostomeae) and underscores the complexity and evolutionary diversity of sexual systems in early metazoans.

Salinity tolerance and local adaptation in *Culex quinquefasciatus*

Amel Clifford, Noah Rose

Culex quinquefasciatus is a member of the globally distributed mosquito species complex Culex pipiens, and a key vector of West Nile virus and St. Louis encephalitis in the Americas. It is broadly distributed in tropical and subtropical regions of the globe and is known to thrive in a variety of natural breeding sites. Our research focuses on three populations of Cx. quinquefasciatus found in San Diego County, CA, with larval habitats ranging from ocean-fed salt marsh ponds to small, creek-fed freshwater pools. The physical and chemical properties of these pools are highly variable across sites, meaning each population is exposed to different environmental pressures at the larval stages. Our initial surveys revealed clear differences between the salinities of each breeding site, building out our hypothesis: individuals from populations with breeding sites in high salinity habitats are more fit in medium and high salinity conditions than individuals from populations that only have breeding sites in low salinity habitats. Salinity tolerance experiments were performed to test this hypothesis and to look for signs of local adaptation in sampled populations. Early results show differential survival and wing size between populations at medium (>5ppt) and high (>10ppt) trial salinities, but more work is required to determine a signature of local adaptation.

Variation in foot bone morphology with swimming behavior in waterfowl

Glenna Clifton, Nathaly Galindo, Lili Gudgel, Makarios Macris

All waterfowl have 3 webbed toes, yet swimming ability varies dramatically—from mostly terrestrial screamers to surface swimming mallards to deep diving mergansers. This behavioral variation relates to differences in the motion, timing, and forces of foot paddling. In addition to these kinematic differences, waterfowl vary in hindlimb skeletal and muscle anatomy, with diving species possessing relatively shorter femurs and tibiotarsi. Yet, the skeletal anatomy of the foot has never been analyzed broadly across waterfowl. In this study, we aim to relate foot anatomy to swimming performance. We CT-scanned a complete foot from 102 waterfowl (Anseriformes) species, representing both phylogenetic and behavioral diversity. These CT scans were analyzed to compare the lengths of each phalanx and the ratio of full digit lengths. The cross-sectional area of the tarsometatarsus was also calculated along its axial length to estimate bending properties. To account for phylogenetic relatedness and detect associations of foot morphology with swimming behavior, these traits were analyzed using a multivariate OU model applied to the OpenTree avian phylogeny. While the digits are longer in aquatic, predatory waterfowl, preliminary results suggest a relatively weak influence of swimming behavior on digit length ratios. We expect there may be shifts in the splay (adduction) of digits, which will be estimated by analyzing the distal condyles of the tarsometatarsus.

Video analysis and robophysical modeling of slingshot spider's ultrafast web actuation

James Clinton, Nethra Ashok, Daniel Herrera Vicioso, Danielle Chase, Saad Bhamla, Elliot Hawkes

Slingshot spiders construct conical, elastic webs, anchored by a single tension line. They draw in the tension line with their legs, storing energy in their webs, then release to shoot their webs rapidly forward for prey capture. Slingshot spiders use a form of actuation known as latch-mediated spring actuation (LaMSA), where energy is slowly loaded into a spring (the web), secured with a latch (the legs), and released for ultrafast movements. They also make use of work multiplication, using multiple strokes of an actuator to load a spring, which is rare in biological systems. LaMSA and work multiplication have been successfully used in many engineering applications, including high-power jumping, launching, and striking. However, slingshot spiders stand out from other LaMSA systems in the unique morphology of their web-springs and their ability to actuate in controlled increments, as opposed to the typical binary actuation of most systems. In order to more deeply understand these unique aspects of the slingshot spider, we collected field data, created a mathematical model, and developed a robophysical model. We present high-speed video collected in the Peruvian Amazon. We also present modeling of this system, including potential strategies for 3D trajectory control. Finally, we present early prototypes of a slingshot spider inspired robot, with a web shaped spring and multiple release mechanisms, enabling study of web geometries and control strategies.

Vitamin D regulation in the anoxia tolerance of Austrofundulus limnaeus.

Patrick Clouser, Amie Romney, Jason Podrabsky

Austrofundulus limnaeus, is found in ephemeral ponds in Venezuela. When their ponds evaporate all hatched members of the species perish. Austrofundulus limnaeus has developed strategies to face these harsh environmental extremes. A. limnaeus utilizes developmental dormancy (diapause) and extreme stress tolerance, especially to lack of oxygen (anoxia). To better understand the genetic pathways involved in this anoxia tolerance, RNAseq was performed on WS 36 embryos with 5 experimental conditions: normoxic controls, 2 anoxic conditions, and 2 recovery conditions. Differential expression and gene ontology analysis was performed. Anoxia exposure increased transcripts for vitamin D receptor (VDR), and CYP24A1, an enzyme that deactivates the active form of vitamin D3 (calcitriol). Anoxia decreased transcripts of CYP2R1, an enzyme needed to convert vitamin D3 into its active form. Thus, it appears that down-regulation of the vitamin D3 signaling pathway is associated with entrance into anoxia. I hypothesize that maintenance of active vitamin D3 signaling through the introduction of exogenous calcitriol will disrupt the anoxia tolerance of WS36 embryos. To test this hypothesis, I will treat WS36 embryos with calcitriol and compare anoxic survival with controls. This study is the first to evaluate vitamin D3 signaling in the regulation of stress tolerance associated with metabolic dormancy. Dormancy and stress tolerance are often associated, but there are few studies that can mechanistically link these two important strategies for seasonal survival.

Effects of urbanization, water quality, and habitat complexity on amphibian antipredator behavior

Kaya Clove, Jessie Powell, Caitlin Gabor

Detecting and avoiding predation is a fundamental challenge for all organisms. Like many prey animals, amphibians rely on antipredator behaviors such as reducing activity and seeking refuge, which are often mediated by the detection of chemical cues. Anthropogenic activity and urbanization may disrupt prey organisms' ability to detect and respond to threats of predation. Urban stream syndrome degrades water quality through increased temperatures and pollution, which may mask chemical cues and impair chemoreception in aquatic organisms. For this study, we tested the hypothesis that environmental conditions associated with urbanization influence antipredator behavior in Incilius nebulifer tadpoles. We recorded the behavior of tadpoles (n=30) collected from six different sites across central Texas that vary in urbanization, water quality, and habitat complexity. We measured baseline activity by recording the time each tadpole spent moving, not moving, and hiding over a five-minute period, then introduced a chemical Lepomis cyanellus predator cue and repeated the process for another five minutes. We predicted that tadpoles from more urbanized environments will exhibit a reduced antipredator response due to sensory impairment, and that those from complex habitats will show an increase in refuge use. This field-based study will better our understanding of how multiple environmental gradients interact to influence predator-prey dynamics and ultimately contribute to amphibian declines.

The specific functions of the sternal and coxal gills in the ecotoxicological model, *Hyalella azteca*

Jamie Cochran, Andrea Durant

Hyalella azteca is a species complex of epibenthic amphipods inhabiting freshwater systems throughout the Americas. Due to its ecological significance and the relative ease of maintaining laboratory colonies, it has become the predominant freshwater crustacean used in ecotoxicological studies throughout North America. Numerous studies have been conducted to understand whole-organism responses of H. azteca to a suite of contaminants, but little is known about the basic osmoregulatory, respiratory and acid-base physiology which often underpin toxicological thresholds. Notably, H. azteca has two different gill types- coxal gills and sternal gills. These two gill types are morphologically distinct, with differing expression of key ion pumps and ultrastructure of epithelial cells. The typical ion-transport epithelia of coxal gills suggests it plays a stronger role in ion transport, compared to sternal gills which may be better suited to acid-base regulation or oxygen transport. Here, we test this hypothesis by measuring real-time ion (Na+, NH4+) and oxygen fluxes at each gill with pharmacological inhibitors to characterize the specific functions to systemic ion and water homeostasis and oxygen uptake. We also report the differential expression of principal genes for ion absorption (carbonic anhydrase, Na+/K+/Cl−-cotransporter) and oxygen sensing. As this two-gill phenotype is an uncommon feature among amphipods, this research also aims to use a comparative structure/function approach across different gill plans of amphipods occupying different salinity and pelagic zone niches.

Lumpsucker armor as a model for regeneration and maintenance

Karly Cohen, Tracy Popowics

Organisms recover from injury through wound healing, repair, or regeneration. Dermal odontodes – including scales, spines, and tubercles – are developmentally homologous to teeth but operate under different functional and environmental pressures, making them an ideal system for testing how odontogenic pathways diverge. The armor of the Pacific spiny lumpsucker (Eumicrotremus orbis) consists of tooth-like cones that must withstand constant abrasion in subtidal habitats. We combined histology, developmental staging, and gene expression to trace the growth of lumpsucker odontodes. We found that initial placodes are temporally restricted and go through waves of rapid growth. Adult armor forms through a signaling cascade in which each placode serves as a base for the next cone, producing the signature spiral. To explore the limits of this plasticity, we conducted damage and growth experiments that mimic wound-healing. Comparing extrinsic (injury-induced) and intrinsic (developmentally programmed) pathways revealed distinct responses that begin to define how armor is maintained. Because lumpsuckers are effectively covered in teeth, they pose a central evolutionary question: are dermal odontodes constrained by the same developmental cycles as oral dentitions, or do they represent a more flexible system? Our findings suggest that lumpsuckers not only illuminate the evolution of regenerative capacity in fishes, but also provide a tractable model for studying dental regeneration and skeletal maintenance, with implications extending from evolutionary biology to clinical contexts of tissue repair.

Effects of ocean acidification on the energetics and larval development of a coastal fish

Thea Cole, Darren Johnson, Alexis Lundquist

Ocean acidification (OA) can cause a variety of detrimental effects on the physiology and ecology of larval fishes. Despite a preponderance of negative effects, studies of how OA influences mortality and growth have produced mixed results. These patterns emphasize the need for more comprehensive studies that examine mechanisms linking OA stress to endpoints such as growth and mortality. We tested the effects of OA on energy intake, as measured by feeding rate, and energy expenditure, as measured by respiration, then compared these results to growth and development of larvae of a coastal fish, the California Grunion. We found that feeding rates significantly decrease under increasing levels of pCO2. Coupled with minor effects on metabolic rate, these results suggest an energy deficit under higher levels of CO2 stress. Paradoxically, we also found strong evidence of faster growth in both mass and length when developing under OA conditions. To explore the consequences of these results, we examined development via allometric analysis of organ growth. We found that the relative growth of the eyes, stomachs, and tails of larvae were significantly slowed when larvae developed under high pCO2 conditions. Together, these results suggest that ocean acidification conditions can give rise to both less energy overall and a greater allocation of resources towards somatic growth. The effects of these shifts are likely to have cascading effects on recruitment success.

Stunning secretions: incapacitating effects of ctenophore mucus across species and prey

Sean Colin, John Costello, Bradford Gemmell

Ctenophores are often dominant predators in open ocean ecosystems globally and feed on a diverse assemblage of prey. The conventional description of ctenophore predation is that ctenophores use adhesives present in colloblasts and mucus to capture their prey. Recently, we have found that, Mnemiopsis leidyi, a voracious predator found in coastal ecosystems uses neurotoxins to incapacitate their prey. Here, we compare the effects of mucus from five species of oceanic ctenophores on crustacean prey to examine the broad application of neurotoxins among ctenophore taxa. Further, we quantified the effects of ctenophore mucus on a diverse array of prey taxa ranging from crustaceans to molluscs to chordates. We found that the mucus of all the ctenophores examine are able to incapacitate crustacean prey. Further, we show that the toxins in ctenophore mucus acts indiscriminately, incapacitating a broad range of prey taxa. The use of generalist neurotoxins by ctenophores helps explain the trophic success of this predator.

Glowing shrimp laser eyes: a microCT approach to investigate ocular light organs

Stormie Collins, Ruchao Qian, Jamie Theobald, Lorian Schweikert, Heather Bracken-Grissom

Many animals in the deep-sea use bioluminescence to survive, serving roles that include communication, camouflage, and defense. In midwater decapod shrimps, it is not uncommon for an animal to possess dermal light organs called photophores that are distributed across the body, with a concentration of photophores on the animal's ventral surface. Previous studies have shown that photophores conceal the body against downwelling light via counterillumination, aiding to obscure the animals from predators below as they migrate through different light environments. It is therefore curious that some midwater shrimps exhibit photophores bordering the dorsolateral cornea, seemingly oriented toward the eye. Given that these shrimps have superposition reflecting eyes, it is possible that these photophores may illuminate the mirrors within each facet, perhaps concealing the silhouette of the eye. However, in doing so, this illumination could functionally blind the animal, presenting a potential tradeoff between camouflage and sight. To investigate this phenomenon, we performed micro-CT scanning of the eyes of three species with distinct photophore types. This approach is being used to characterize ocular photophore morphologies and enable ray-tracing analyses to model how light organ illumination interacts with ocular mirrors. These findings will help reveal the functional use of bioluminescence in shrimps and expand our current knowledge of integrative sensory systems in midwater shrimps.

Terminal investment and energy allocation tradeoffs in amphibians: Biases, gaps, and future steps

Zuania Colón-Piñeiro, Ana Longo

To optimize fitness, immunity competes for energy with reproduction, leading to trade-offs that may exacerbate under suboptimal conditions like food scarcity and pathogen pressure. The terminal investment hypothesis (TIH) suggests that reproduction should increase under disease-induced mortality risk; yet empirical support for reduced immune investment remains inconsistent. We conducted a meta-analysis integrating data from interdisciplinary approaches to synthesize evidence for (and against) TIH in amphibians, focusing on compensatory adaptations to pathogen infections. Our data revealed highly variable reproductive responses to infections instead of clear evidence for TIH. With data for less than 0.5% of frog and salamander species, and none for caecilians, the gap highlights the layered absence of data across biological and ecological scales, from specific traits and reproductive modes to evolutionary histories and geographic distributions, hindering our understanding of lethal and sub-lethal effects contributing to amphibian declines and extinctions. Complex dynamics require holistic approaches to detect hidden patterns from multiple interactions. Our meta-analysis offers a roadmap for future research: prioritizing neglected taxa (e.g., caecilians) and reproductive modes (e.g., direct-development, live-bearing, or paedomorphic), incorporating multi-trait and longitudinal data, and leveraging tools like OMICS and causal inference frameworks to better understand the adaptive significance of reproductive responses to infection. An integrative approach is essential for linking sub-lethal pathogen effects to long-term fitness and species persistence, with implications for evolutionary ecology and conservation strategies.

Evolutionary and ecological signal of the squamate reptile microbiome

Timothy Colston, Brice Noonan, Frederico França, Colin Jackson

There is growing evidence that the microbiomes of animal hosts not only aid essential physiological and immune functions, but are heritable and impact host evolution. Much of this evidence in vertebrates is limited to mammalian studies which represent only a fraction of vertebrate diversity, and these studies are often on captive rather than wild mammals. We use the largest non-mammalian vertebrate gut-microbiome sampling to date and targeted amplicon sequencing to characterize the microbiome of squamate reptiles, the largest terrestrial vertebrate clade, and test whether the microbiome contains ecological or evolutionary signal. Our results show that squamate reptiles possess a core bacterial microbiome dominated by Proteobacteria and Fimicutes, similar to that of avian reptiles (birds), rather than terrestrial mammals. This core microbiome is significantly different between lizards and snakes, evidence of phylogenetic constraints, while within each group the microbiome community structure is a reflection of host ecology, particularly foraging mode. The microbiome of squamates is both constrained by phylogeny and shaped by host ecology, and this pattern is likely ubiquitous across vertebrate groups.

Impacts of acute and chronic iron oxide nanoparticle exposure on house sparrow antipredator behavior

Eden Comer, Kelly Ronald, Shae Johnston, Olivia Sprys-Tellner, Peyton Hallemann, Chisom Okogbue, Jacob Bergstrom, John Wenderski, Liam Hanlon, Natalia Gonzalez-Pech

The growing human population has caused a significant increase in urbanization over the past 50 years. This increase has led to detrimental environmental effects and is correlated with an estimated 29% decrease in North American bird populations. Previously studied causes for this decrease include habitat loss, agricultural chemical use, and domestic cat predation. However, air pollution remains a potential but understudied mechanism of avian decline. The

solid portion of air pollution includes nanoparticles that are small enough to enter the bloodstream through the blood-gas barrier and the brain through the blood-brain barrier. Nanoparticles have potential to alter behavior by altering neural anatomy and physiology. We exposed house sparrows to iron oxide nanoparticles (IONPs) to simulate air pollution, as IONPs are a main component of atmospheric particulate matter. We predicted that house sparrows exposed to aerosolized IONPs would show less antipredator responses (e.g. scanning and fleeing) and less exploration of their environment compared to control animals. Preliminary results show that time to return to foraging depends on both sex and acute IONP exposure. We anticipate greater behavioral impacts in animals exposed to IONP chronically rather than acutely. Results will help us understand the effects of IONPs on avian species and provide a potential explanation for their recent decline. House sparrows, in particular, may serve as a sentinel species for other downstream consequences of urbanization.

Cnidarian striated muscle evolution revealed through scRNAseq of the hydrozoan *Podocoryna*

Michael Connelly, Matthew Travert, Marina Stoilova, Abdel Elkahloun, Paulyn Cartwright, Andy Baxevanis

The hydrozoan Podocoryna americana possesses a complex life cycle that features both sessile colonial polyp and free-living medusa (jellyfish) life stages, each with distinct morphological and functional characteristics. To determine the molecular basis of life stage-specific traits, such as striated swimming muscles in the adult medusa stage, we performed a comprehensive single-cell transcriptomic analysis of dissected Podocoryna polyps, reproductive (budding) polyps with developing medusae, and liberated adult medusae. Downstream analysis identified distinct cell types – including pluripotent stem cells, neurons, digestive gland cells, epithelial cells, and both smooth and striated muscle cells – each having different gene expression profiles across life stages. Striated swimming muscle cells were uniquely present in the medusa, expressing homologs of the myosin heavy chain, myosin regulatory light chain, tropomyosin, and tropomodulin proteins.The myogenic transcription factors Msx and Otx were also found to be expressed. Gene expression trajectory analysis resolved the development of striated muscle cells from multipotent progenitor cells in budding polyps, highlighting the sequential expression of myogenic transcription factors and muscle structural proteins during muscle cell development. Phylogenetic analysis of muscle cell marker genes revealed independent origins and lineage-specific gene duplications of hydrozoan muscle structural proteins relative to their bilaterian homologs, indicating that striated muscle cell types evolved independently in cnidarians and bilaterians. Together, these results reveal the molecular basis of striated muscle development in early animal evolution and create new opportunities to characterize the function, differentiation trajectories, and regenerative potential of muscle cells across all animals.

Effects of student demographics on self-identity as a scientist in course-based research modules

Patrice Connors, Laurie Dizney, Jennifer Duggan, Liesl Erb, Johanna Varner, Lorelei Patrick, Elizabeth Flaherty, Christopher Yahnke, Hayley Lanier

Course-based Undergraduate Research Experiences (CUREs) are an ideal teaching method to share the benefits of authentic research experiences to a larger, more diverse population of students. We created a national network of field-based, mammalogy focused CURE modules investigating the behavioral ecology of squirrels, called Squirrel-Net. Previously, we found that Squirrel-Net improves student self-identity as scientists. Here, we describe the demographic parameters of Squirrel-Net students and their impact on students' likelihood to self-identify as scientists. Students from almost 60 institutions spanning 90 courses responded to surveys before and after participating in a Squirrel-Net CURE between 2019-2022. Student demographics included gender, ethnicity, identification as Hispanic, and first-generation status. Student respondents for pre- and post-CURE surveys (N = 2382) were very demographically similar, with students most often identifying as female, white, non-Hispanic, and non-first-generation. We analyzed demographic parameters as predictors of self-identity as scientists with paired response data (N=466) using GLMs in R. Females and non-first-generation students were more likely to identify as scientists after participating in Squirrel-Net. Females were also more likely to change their response in a positive direction than males, and first-generation students were less likely to change their response than non-first-generation students. Our analyses provide a demographic snapshot of Squirrel-Net students, highlight the importance of expanding and diversifying the network, and confirm the benefits and pedagogical effectiveness of Squirrel-Net for undergraduate students.

Stress, survival and facultative sex: A symphony of syndromes in eukaryotic microbes

George Constable

The selection for sexual reproduction is often viewed through the lens of macroorganisms, with a particular focus on the population genetic advantages and disadvantages of recombination during meiosis. In microorganisms, which are particularly relevant for understanding the early evolution of sex, this picture is complicated by the deployment of alternate reproductive and survival strategies. This talk will begin with a survey of some of the unusual reproductive behaviours of some model eukaryotic microbes, including the green alga Chlamydomonas reinhardtii, the fungus Saccharomyces cerevisiae and the amoeba Dictyostelium discoideum. We will then discuss some recent theoretical results in this area [1-3]. The focus will be in particular on the rarity of bouts of sexual reproduction in unicellular eukaryotes and the importance of ecological and physiological factors for understanding the preponderance of stress-induced sexual reproduction in these species.

[1] Liu, X., Pitchford, J.W., & Constable, G.W.A. (2025). Cell size and selection for stress-induced cell fusion in unicellular eukaryotes. PLoS Computational Biology

[2] Liu, X., Pitchford, J.W., & Constable, G.W.A (2025). Parthenogenesis, sexual conflict, and selection on fertilization rates in switching environments. Theoretical Population Biology.

[3] Constable, G.W.A, & Kokko, H. (2018). The rate of facultative sex governs the number of expected mating types in isogamous species. Nature Ecology & Evolution

Are red carotenoids present in the mitochondria of a red songbird?

Amberlee Cook, Matthew Toomey, Yufeng Zhang, Sara Patton, Geoffrey Hill

In many birds, red carotenoid coloration signals individual quality, but the mechanisms linking redness to performance are uncertain. One hypothesis is that production of red ketocarotenoids is linked to mitochondrial function. In support of this, previous research found high concentrations of ketocarotenoids in the hepatic mitochondria of molting male House Finches. However, it was recently discovered that unlike many songbirds with red carotenoid coloration, House Finches do not use CYP2J19 and BDH1L to produce red feathers; they use undescribed enzymes. We hypothesized that birds such as the Northern Cardinal, which use CYP2J19 and BDH1L enzymes, may not have the same dependencies on mitochondrial function as House Finches. To test if carotenoid storage in mitochondria occurs in birds using the CYP2J19/BDH1L pathway, we trapped molting male cardinals and House Finches. We isolated mitochondria from livers of both species and measured carotenoids. Analyses were repeated during a non-molt period to determine if mitochondrial carotenoids are tied to feather pigmentation. We predicted higher carotenoid levels in house finch mitochondria compared to cardinals, and higher levels during the molting season compared to non-molting season. We confirmed high levels of ketocarotenoids in the mitochondria of House Finches, but observed trace levels in cardinal mitochondria. These observations indicate that cardinals do not accumulate mitochondrial carotenoids, suggesting that the CYP2J19/BDH1L pathway may have different condition dependencies than House Finches.

Neural mechanisms underlying the evolution of vocal divergence in Xenopus frogs

Jackson Cook, Michael Okpoti, Carlton Roe, Charlotte Barkan

The evolution of behavior arises from divergence in the neural and muscular mechanisms that generate motor patterns. Vocalization is a stereotyped motor behavior essential to successful courtship in many species. Males of extant species in the Xenopus genus produce an advertisement call to attract conspecific females. The Xenopus phylogeny consists of ~30 described species, each with a unique advertisement call. X. laevis and X. petersii are two closely related species whose advertisement calls consist of fast and slow trains of sound pulses. While call rates are similar between species (fast and slow trills are ~60 and 30 pulses s-1, respectively), call duration and period differ. What neural mechanisms underlie these distinct vocal patterns? We previously described a vocal central pattern generator in the parabrachial nucleus that autonomously encode species-specific call duration and period. To further understand the neural mechanisms underlying the divergent evolution of vocal behaviors, we are investigating this vocal hindbrain circuit in X. laevis-X.petersii F2 hybrids. In a fictively calling preparation, in which compound action potential (CAP) patterns resemble sound pulse patterns of advertisement calls, we use extracellular local field potential recordings to study the premotor pattern generating circuit. Our results will allow us to distinguish whether duration and period are likely to be regulated by shared or distinct mechanisms in both parental species, providing insight into neural mechanisms of behavioral evolution.

The scaling of metabolic rate through ontogeny in two viviparous chameleon species

Etti Cooper, Krystal Tolley, Graham Alexander, Christopher Anderson

Metabolic rate (MR) is a metric summarizing an organism's energy expenditure over a given period. While many factors influence MR, body size is a primary determinant. Therefore, considerable research has focused on the interspecific allometric scaling relationship between MR and body mass among adult animals. However, much less is known about the intraspecific relationship between MR and body mass in neonates and juveniles, which is an important distinction given that growth represents a significant energetic cost that is not present in adults. Additionally, little work has investigated the metabolic differences between juveniles from the same clutch, although body size can vary between littermates and often impacts neonate performance. This study examined the scaling relationships of resting metabolic rate (RMR) through ontogeny among four clutches (8 –10 individual per clutch) in two species of viviparous dwarf chameleons: Bradypodion ventrale (1 clutch) and two populations of B. melanocephalum (3 clutches). Following birth, we measured (and continue to measure for some clutches) RMR using stop-flow respirometry in postabsorptive animals over their first eight months. There was significant variation in growth rate and metabolic scaling between species and among littermates: scaling exponents ranged from 0.62 to 0.95 in B. ventrale and from 0.89 to 2.00 in B. melanocephalum. This work will help to characterize the most energetically costly stages of growth, providing valuable insights into growth patterns among species and populations.

The genetic determinants of performance and survival in high elevation deer mice

Keely Corder, Ryan Mahar, Rena Schweizer, Schuyler Liphardt, Kaitlin McHugh, Nathan Senner, Zachary Cheviron

Understanding the genetic basis of performance and survival in wild populations is crucial for not only understanding how organisms have adapted to challenging environments in the past, but also for predicting their capacity to adapt to change in the future. Montane environments provide a laboratory to explore the connections between genotype, phenotype, and fitness because they impose severe physiological challenges which necessitate physiological adaptations to ensure survival. Here, we integrated population genomic, phenotypic, and demographic data to investigate the genetic basis of individual variation in survival and performance in a high-elevation population of deer mice (Peromyscus maniculatus). We identified dozens of loci associated with survival, and hundreds associated with aerobic performance trait and blood oxygen carrying capacity. Survival-associated loci included genes with a wide array of functions, however, these survival associated loci showed little overlap with those associated with aerobic performance and blood O2 carrying capacity, suggesting that genetic variants that underlie performance variation in this population are generally not associated with contemporary variation in survival. Mark-recapture data corroborated this pattern; none of the aerobic performance phenotypes influenced survival over the study period, but both hematocrit and hemoglobin concentration were significantly, and negatively associated with survival. Together, findings suggest a temporal disconnect in the genetic and phenotypic determinants of fitness, with different traits exhibiting distinct patterns of historical selection and contemporary fitness effects.

Effects of Nanoplastic Exposure in *Drosophila melanogaster*

Avis Corea Britton, Patricio Palomino, José Miguel Simões

Plastic pollution is a pervasive environmental threat, but research on its biological effects are limited. To more accurately model real-world exposure, this study investigated the effects of weathered polyethylene terephthalate (PET) nanoplastics (<0.2µm) on the fitness of Drosophila melanogaster. We hypothesized that nanoplastic exposure would negatively affect key biological functions, including survivability, reproductive fitness, and locomotion. Adult flies were exposed to nanoplastics in their food under both acute (a few days) and chronic (for several generations) conditions. We used two concentrations, a low dose (0.05 g/L) and a high dose (0.5 g/L), in addition to a control group (no plastic in food). Our results show that acute exposure to nanoplastics reduced adult survivability, oviposition, and egg hatchability in a dose-dependent manner. Additionally, in flies exposed chronically to this pollutant, we observed that locomotor function was impaired, as indicated by a decrease in their climbing performance. These findings suggest that nanoplastic exposure has a significant adverse impact on critical biological functions. This research serves as a foundational study for exploring the specific molecular and neurological pathways affected by nanoplastics, highlighting the importance of understanding the widespread environmental and behavioral impacts of these widespread contaminants.

Habitat ecology shapes the evolutionary performance surfaces of turtle shells

Katherine Corn, Roi Holzman, T. Linscott, Christopher Martin, Josef Uyeda

Trade-offs among mechanical functions are a ubiquitous feature of organismal systems. Most turtle shells experience a performance trade-off among two functions: crushing resistance, which requires a highly domed shell, and swimming, which typically relies on a dorsoventrally flattened shell to reduce drag. However, terrestrial turtles must also be able to self-right when they are flipped onto their backs, and how these three functions interact to shape the evolution of turtle shells remains challenging to decipher. We used existing performance landscapes describing the performance of different turtle shell shapes at self-righting, crushing resistance, and swimming, alongside shell shapes and habitat data for 218 species of aquatic and terrestrial turtles. We developed a phylogenetic model ('ripple') that estimates the contribution of performance surfaces to the history of turtle shell shape evolution. Our model allows variance in the base rate, steepness, and contribution of each performance task to the evolutionary performance landscape on which each habitat guild evolves. We recover major differences in the evolutionary performance surfaces experienced by aquatic and terrestrial turtles. Drag coefficient has the greatest contribution to the evolutionary performance landscape of both aquatic and terrestrial turtles, but terrestrial turtles experience a landscape with performance optima that reflect self-righting capacity and crushing resistance. Our method demonstrates the context dependence of mechanical trade-offs, where ecology alters both location of and strength of draw towards performance optima.

Behavioral and physiological responses of songbirds to wildfire smoke in dry pine forests

Jamie Cornelius, Kenneth Glynn, Dorothy Zahor, Ben Sonnenberg, Alex Jahn, Ella Rader

Wildfire smoke is a pervasive and invasive feature of many environments across the globe, yet little research exists on the impacts of wildfire smoke on the behavior and health of animals. It is likely that animals have coping strategies, but what those strategies are and how they minimize or exacerbate physiological consequences of smoke are poorly described. We caught songbirds in dry pine forests of central Oregon to assess physiological impacts of wildfire smoke by measuring body condition and collecting blood samples. We also fit American robins (Turdus migratorius) with Argos GPS tags to determine if migratory behavior was affected by smoke. We found that robins exposed to heavy smoke did not leave their breeding territory and that exposure to smoke particulate classified as unhealthy for humans (i.e., Air Quality Index of 151-200) correlated in multiple songbird species with higher circulating stress hormones, lower blood sugar levels, lower body condition and a more activated immune system. However, the strength of these relationships was also dependent on the species of bird. Insectivores may be more negatively impacted by wildfire smoke than are seed-eating or omnivorous birds, perhaps due to a difference in ability to alter foraging behavior to reduce exposure. We discuss these results in the context of behavioral flexibility and physiological constraints that may impact how songbirds cope with and are impacted by wildfire smoke.

Sex, food, and rock'n roll: Reproduction and energy homeostasis in a swordtail fish

Savvy Cornett, Yohana Perla-Vasquez, Kathryn Douglass, Aastha Bhatia, Maria Valenzuela, Molly Cummings, Hans Hofmann

Across vertebrates, multiple hypothalamic neuropeptide systems orchestrate the interplay between nutritional state and reproductive physiology, including melanocortin-4 receptor (MC4R) and the gonadotropin-releasing hormones (GnRHs), especially GnRH2. While the GnRHs collectively regulate reproduction, MC4R regulates energy homeostasis, and both coordinate puberty onset, the relationship between these pathways remains poorly understood. We investigated the physiological and behavioral effects of food deprivation in the Pánuco swordtail (Xiphophorus nigrensis), a poeciliid fish with alternative reproductive tactics: large males perform elaborate mating displays, while small males mate coercively. MC4R allelic and gene copy number variation determine at which body size fish mature, predicting their reproductive tactic. We compared mating behavior between fed and food-deprived pairs of swordtails (female with a small or large male; N=32 pairs) for either 2 or 10 days, using daily video recordings. To determine the effect of food deprivation on behavior, we quantified courtship, coercive, and responding mating behaviors as well as food-seeking behaviors. Compared to fed controls, unfed fish invest less time in mating behaviors, especially the large males. We use RNA Sequencing to assay the expression of candidate genes involved in GnRH and melanocortin signaling and to discover novel pathways in these processes. Ongoing analyses are revealing how these pathways interact to regulate reproduction in concert with nutritional status. Overall, our study elucidates the functional interactions between the reproductive axis and energy homeostasis.

Sorting cell populations reveals the cellular bleaching response in the coral Pocillopora damicornis

Brendan Cornwell, Stephen Palumbi

Coral reef ecosystems are fueled by the symbiotic partnership between the coral and intracellular single-celled algae. Heat waves cause coral cells to lose symbionts, resulting in coral bleaching. Previous work on gene expression of bleaching corals could not disentangle the response of symbiont-containing cells (usually < 1 0%) from the response of those without symbionts. We used Fluorescence Activated Cell Sorting (FACS) to separate symbiont-containing and host-only cells, allowing us to parse gene expression changes due to heat stress in these different cell types. We find that much of the transcription change attributed to coral bleaching occurs similarly in symbiont-containing and host-only cells, suggesting that these changes in gene expression are not uniquely associated with bleaching. For example, downregulation of nutrient transporters, which has been predicted to help the host sanction non-cooperative symbionts, also occurs in host-only cells. By contrast, in symbiont-containing cells we see unique up-regulation of genes within protein classes including oxidoreductases, mitochondrial and organellar membranes, respiration and electron transport and spliceosomal complexes. For example, within these gene classes, 12 of 15 chromoproteins, hypothesized to form a spectral shield for symbionts, are upregulated in symbiont-containing cells. Up-regulation during heat stress in symbiont-containing cells include genes for Wnt and Notch signaling, TNF receptors, cell migration, DNA repair and replication. These results help pinpoint mechanisms of coral bleaching by concentrating on cellular processes within symbiont-containing cells.

Pathways to immortality: proteomic insights from spontaneously replicating grunion cell lines

Meranda Corona, Johnathon Li, Dietmar Kueltz

Continuously replicating cell lines enable cost-effective, ethical studies of animal physiology. However, in many species, establishment requires genetic or pharmacological intervention. California grunion (Leuresthes tenuis) are an exception: cell lines derived from their embryos exhibit long-term proliferation without such treatments, offering a model for spontaneous immortalization.

We compared proteomic trajectories of two independently established L. tenuis embryonic cell lines using LC-MS/MS profiling. LtE-1 was sampled across passages P1–P12, while LtE-2 was profiled over a targeted window spanning the phenotypically defined immortalization point (P4–P7). Analyses were performed relative to P1 and P4 to capture culture establishment and immortalization-associated changes.

In LtE-1, early passages showed enrichment of stress response, adhesion, and cytoskeletal stabilization. Around P4, protein synthesis, nucleotide metabolism, and energy production peaked before stabilizing, followed by upregulation of proteostasis, autophagy, and cell cycle regulation at later passages. LtE-2 displayed similar enrichment patterns for these pathways but differed in the progression and magnitude of changes post-P4; enrichments persisted longer, and some signaling pathways diverged from LtE-1.

Thus, cross-line comparison revealed convergent enrichment of pathways post-P4, suggesting core molecular signatures of spontaneous immortalization. Divergence in certain immune-associated pathways also indicates that multiple regulatory routes can lead to immortalized states. These results establish L. tenuis cell lines as a tractable model for investigating spontaneous immortalization and long-term culture stability in non-model organisms. Supported by NSF MCB-2127516, IOS-2209383.

Is it all about Deerweed? Exploring the use of Deerweed by native bees in California

Jesse Cortez, Danielle Velazquez, Harmonie Lo, Robert Schroeter, Alicia Fox

At Allan Hancock College (AHC), we have been active participants in a native bee project (The BUZZ) surveying native bees on community college campuses (e.g. urban gardens) for the past 4 years. In 2024, Sedgwick Reserve, a U.C. Reserve was added to our project. We noted that 8 of 10 bee genera collected at our wild site at Sedgwick Reserve were found on Acmispon glaber, Common Deerweed, in 2024. In 2025, we catalogued bees collected on Deerweed at our study sites, as well as at other schools within the project. When looking at bees associated with Deerweed, it was primarily bee genera from the bee family Megachilidae. Additionally, the greatest number of bee genera at our wild habitat sites were from the family Megachilidae, while our urban garden sites skewed towards the family Apidae. As we continue to survey native bees at our college campuses as well as at Sedgwick Reserve, we plan to further examine the use of Deerweed by native bees. We are working with Sedgwick Reserve to grow and plant Deerweed in the gardens around their Field Station for 2026. We have also planted Deerweed at two of our native plant gardens at our main campus at AHC.

Mycoplasma gallisepticum inhibits succinate dehydrogenase to suppress host immune response

Soren Coulson, Reihane Eric, Chidambaram Ramanathan, Katherine Talbott, Francis Tillman, James Adelman, Yufeng Zhang

Many pathogens can increase their fitness by suppressing the host's immune response. One potential, though underexplored, cellular target for such suppression is the host mitochondria, which can modulate immune responses through succinate dehydrogenase (SDH). Several pathogens, including Mycoplasma species, have been shown to increase cellular accumulation of itaconate, a potent SDH inhibitor. Here we hypothesized that Mycoplasma gallisepticum (MG) suppresses host early immune responses by inhibiting SDH. We tested these hypotheses using a three day ocular inoculation of same dosages of live or heat-killed MG, and media control on house finches. We measured SDH-mediated oxygen consumption rate (OCR) of two sites of infection (trachea, eyelid conjunctiva) and immune cells (peripheral blood mononuclear cells (PBMCs)). To test the role of SDH during MG infection, we also administrated itaconate (SDH inhibitor; 800mg/kg) by intraperitoneal injections, alongside heat-killed MG inoculation. We found that eyelid OCRs increased with live MG, but was not affected by heat-killed MG, while trachea OCRs were unaffected by any inoculation. In contrast, PBMC OCRs increased with heat-killed MG, but did not change with live MG compared to media control. Following itaconate administration with heat-killed MG inoculation, OCRs were unchanged in trachea or eyelid, while PBMC OCRs were lower than with only heat-killed MG inoculation. Our findings partially support our hypothesis, suggesting that MG inhibits SDH in immune cells using a mechanism similar to itaconate.

The importance of social interactions and social learning in house sparrow neophobia

Victoria Coutts, Marquise Henry, Lauren O'Callaghan, Kathryn Stewart, Allison Morales, Elena Liebl, Blake Dusang, Manishq Goribidanur, Hermione Lam, Christine Lattin

House sparrows (Passer domesticus) are invasive worldwide and a successful human commensal. Part of sparrows' success in new and human-altered environments could be their strong social learning ability related to neophobia (novelty avoidance). Previously, we found neophobic house sparrows paired with less neophobic sparrows showed long-term social learning about novel objects placed near food. However, sparrows were caught in late fall, and there may be selection on sparrow populations for social learning ability that is diluted by recruitment of naïve fledglings into the population each year. Here, we repeated this social learning study with house sparrows caught in the late summer, when the number of fledglings in the population is high. Sparrows underwent 3 weeks of behavior trials: 1) solo trials to evaluate initial neophobia; 2) paired trials with mixed neophobic/non-neophobic pairs and similar neophobic/neophobic or non-neophobic/non-neophobic pairs; 3) solo trials after separating pairs. Sparrows with a less neophobic partner were more likely to feed during paired trials. However, contrary to previous results, sparrows with a more neophobic partner were not slower to feed during paired trials, and changes in more neophobic birds did not persist during final solo trials. These results show the importance of social interactions in determining how house sparrows respond to novelty, and suggest sparrows that are more likely to survive to later in the season have stronger social learning ability.

Machine learning identifies two novel hormonal states in intermolt blue crabs from the Carolinas

Joseph Covi, Lauren Ryan Booth, Blaine Farrell, Ernest Chang, Sharon Chang

The blue crab, Callinectes sapidus, is a prized economic and cultural resource on the eastern seaboard of the United States, but populations of this iconic species have been in decline for 30 years along the coastal Carolinas. There is no clear singular cause for this prolonged population decline. However, pollution is widely discussed as a contributing factor. Endocrine disruption by specific anthropogenic chemicals is documented by controlled laboratory studies on decapods, including C. sapidus. Detecting the impacts of endocrine disrupting chemicals (EDCs) in natural systems is far more challenging. This study was originally designed to provide a baseline for hemolymph ecdysteroid titers in wild-caught blue crabs along the coastal Carolinas. Hemolymph was drawn from >350 intermolt animals collected over two years at ten estuarine sites along 160 miles (257 km) of the Atlantic coast between the White Oak River, North Carolina, and the Santee River, South Carolina. Ecdysteroids were then quantified using an Enzyme Linked Immunosorbent Assay (ELISA). An analysis using machine learning supports the separation of intermolt animals into two distinct groups based on hemolymph ecdysteroid titers. These two distinct hormonal states in intermolt animals are apparent year-round, regardless of the sex of the animal or location of collection.

Reinforcing effects of intranasal oxytocin in familiar female California mice

Kelci Cox, Xin Zhao, Catherine Marler

In recent years, intranasal oxytocin (IN OXT) has gained attention for its potential therapeutic applications in neuropsychiatric disorders marked by social impairments. While studies have provided significant insights into the role of oxytocin (OT) in social behavior, less is known about the context-dependent nature of these effects, particularly how social or environmental factors may influence OT's impact. Using the conditioned place preference (CPP) paradigm in California mice, a monogamous species commonly used to study social bonding, we found that IN OXT induced a conditioned place preference in familiar female cage mates, but only when paired with a social stimulus. Building on these findings, the current study explored how IN OXT alters social preferences in familiar female California mice using the conditioned social preference (CSP) paradigm. We conditioned focal animals with their initially less-preferred cage mate in an initially unpreferred location. Following conditioning, IN OXT increased preference for the previously unpreferred cage mate, while preference for the unpreferred location increased only in the presence of either cage mate, regardless of treatment. IN OXT did not increase social proximity to the previously unpreferred cage mate. Overall, this study highlights the context-dependent role of oxytocin in reshaping social relationships among familiar peers.

Integrating mechanistic and evolutionary views on phenotypic integration through hormonal pleiotropy

Robert Cox, Tyler Wittman, Christopher Robinson

Organismal biologists have studied phenotypic integration from diverse perspectives that span molecular, cellular, physiological, and developmental mechanisms up through evolutionary patterns. Nonetheless, integration across these scales is rare, such that studies of mechanism can be difficult to link to evolutionary dynamics, and vice versa. Here, we integrate mechanistic and evolutionary perspectives on phenotypic integration through hormonal pleiotropy, which occurs when one hormone influences multiple phenotypes. We focus on trait covariances as unifying measures of phenotypic integration that can be quantified at multiple scales of biological organization and linked to evolutionary dynamics through associated measures of genetic covariance. Drawing from our work on steroid hormones in lizards, we illustrate experimental approaches for quantifying hormonal pleiotropy at transcriptomic and organismal scales. By combining these experimental approaches with quantitative genetic breeding designs, we illustrate how hormonal pleiotropy structures not only phenotypic integration, but also the underlying genetic variances and covariances that shape evolutionary responses to selection. We also illustrate how genetic variance in phenotypic responsiveness to a hormonal signal raises new questions about the cellular and molecular levels at which this genetic variance resides and the evolutionary lability of hormonal pleiotropy itself. We conclude by considering the potential role of ecological stressors in shaping evolutionary trajectories through endocrine pathways that alter phenotypic and genetic integration.

Keratinase digestion enhances hair glucocorticoid measurement in neotropical bats

Matthew Coyle, Thayse Benathar, Leonardo Trevelin, Valeria Tavares, C. Loren Buck

Understanding how environmental stressors influence physiological mechanisms is critical to predicting species responses to anthropogenic change. Neotropical bats are an excellent model for investigating the physiological impacts of environmental disturbance, as they are commonly found across gradients of habitat degradation. Many bat populations are severely at risk from habitat disturbances, in part due to their long lifespans, low reproductive rates, and roost fidelity. Carajás National Forest, Pará, Brazil, is home to the world's largest iron ore mine, with many bat species co-occurring in both mining-impacted and undisturbed forest habitats. To establish a foundation for exploring disturbance-endocrine relationships, we first identified cave sites at varying distances from mining activity (ranging from ~0.1-13km) and collected hair samples from five bat species (Anoura geoffroyi, Carollia perspicillata, Furipterus horrens, Lonchorhina aurita, and Natalus macrourus). Hair samples were subjected to an optimized keratinase digestion, building on methods developed for other keratinized tissues, and extracted using solid-phase extraction (SPE). Cortisol concentrations were quantified from the extracts using a competitive ELISA, with assay performance validated through parallelism and spike-and-recovery (i.e., accuracy) tests. We found that the keratinase digestion increased yield of glucocorticoid hormones by ~200% (±55%) when compared with a methanol extraction ($p < 0.001$). This approach advances the use of hair glucocorticoids as a minimally invasive biomarker of disturbance exposure, a valuable development given the pressing conservation threats and limited study of bats.

Quantitative genetic basis of juvenile dispersal in brown anole lizards

Ashlyn Crain, Tyler Wittman, Rachana Bhave, Heidi Seears, Aaron Reedy, Daniel Warner, Robert Cox

Although dispersal has often been considered a condition-dependent trait in vertebrates, growing evidence suggests that it also has a genetic basis. Quantifying this genetic basis through estimates of the heritability of dispersal is important for understanding whether and how this phenotype will evolve in response to selection. We used Bayesian animal models to estimate the additive genetic variance and narrow-sense heritability of two juvenile dispersal phenotypes (binary dispersal propensity and continuous dispersal distance) in an island population of brown anole lizards (Anolis sagrei). Dispersal propensity and dispersal distance each show significant heritability in both males and females when accounting for environmental and maternal effects. Despite males exhibiting significantly higher dispersal propensity and distance than females, we also find significant positive cross-sex genetic correlations for both dispersal phenotypes, indicating a shared genetic architecture. We discuss these results in the context of our corresponding estimates of natural selection on dispersal phenotypes and consider their implications for the adaptive evolution of dispersal.

On the fly: exploring *Drosophila* walking kinematics

Callie Crawford, Fang-Ju Lin

Fruit flies, Drosophila melanogaster, have long been studied for development, behavior, and sensory studies, due to their suitability as models of human diseases. Walking behavior in Drosophila melanogaster offers a system for exploring limb placement and coordination and how those locomotion factors are altered in models of neurological dysfunction. Here, we compare the walking kinematics in parental control (elav-Gal4) and Alzheimer's Disease model (AD) flies from 9 to 30 days post emergence. We focus on the gait patterns exhibited by these flies as they age while also including comparisons of walking speed and duration. We used videos of free-walking male flies and analyzed their movement patterns using deep learning-based software. Our findings contribute to the growing understanding of how motor behaviors are impacted by degenerative neurological disease over time.

Using CORT and telomeres to understand the diet-mediated effects of contaminants in tree swallows

Bridger Creel, Megan Fylling, Brian Balmer, Zachary Cheviron, Benjamin Colman, Creagh Breuner

Mining-contamination is a major ecological disturbance with disproportionate impacts on riparian ecosystems that host diverse breeding songbird populations. Traditionally, research has focused on how direct metal exposure from mine wastes reduces songbird fitness. Yet, prey limitation is increasingly recognized as a potentially equally important stressor in mining-contaminated habitats. Many riparian songbirds rely on emergent aquatic insects, which are nutritionally superior to terrestrial prey due to their high polyunsaturated fatty acid content. However, aquatic insects are especially vulnerable to mortality from metal toxicity during emergence. Thus, aquatic insect survival through emergence determines whether riparian birds primarily face direct metal exposure in prey or the loss of high-quality prey. To disentangle the importance of prey depletion versus metal exposure, we studied tree swallows (Tachycineta bicolor), a model aerial insectivore reliant on emergent aquatic insects, along a gradient of mining-contamination in the Upper Clark Fork River Superfund site. We measured proportion aquatic diet (δ13C/ δ15N), blood metal concentrations (ICP-MS), relative telomere length (RTL), and plasma corticosterone (CORT) in mothers and nestlings in addition to reproductive output. Nestling RTL and CORT integrate the effects of metal toxicity, nutritional stress, and maternal physiology and early-life changes can have lasting effects on survival and reproduction. By linking reproduction and biomarker responses to diet and metal accumulation, we provide new insight into how mining-contamination alters ecological subsidies and songbird physiology and fitness.

Great minds of the great blue: comparative brain volumetrics in filter-feeding ocean giants

Alejandro Crespo, Lauren Simonitis, Aubree Jones

Manta rays (Mobula spp.) and whale sharks (Rhincodon typus) are large, pelagic, filter-feeding elasmobranchs (Myliobatiformes and Orectolobiformes). However, these species have contrasting social behavior: manta rays have been observed forming stable social communities, while whale sharks generally exhibit solitary behavior, and conspecific associations are rare, and manta rays frequently utilize coastal reef habitats and lagoon nurseries, while whale sharks blend shallow surface feeding with regular deep dives during the day. Therefore, these species are of interest for comparative neuroecology study via comparative volumetric analysis of the brain. In this study, we investigated whether key sensory regions of the brain displayed notable differences using contrast-enhanced microcomputed tomography (microCT) scans to measure volumes of the telencephalon and cerebellum, normalized for total brain size. We predict that there will be differences in these regions, indicating the relative investment of each species' visual and motor coordination centers. Differences in these brain regions would suggest neurological specializations for the ecological strategies of each species. This study expands our understanding of neuroanatomical diversity among large-bodied elasmobranchs and provides baseline morphology for future interspecific comparisons of elasmobranch neuroecology.

Sustained effects of developmental conditions on physiology and body size in an Australian lizard

Ondi Crino, Kristoffer Wild, Christopher Friesen, Dalton Leibold, Naomi Levan, Amelia Peardon, Pablo Recio, Karine Salin, Dan Noble

Developing animals are increasingly exposed to elevated temperatures as global temperatures increase because of climate change. Vertebrates can be affected by elevated temperatures during development directly, and indirectly through maternal effects (e.g., exposure to prenatal glucocorticoid hormones). We tested interactions between incubation temperature and prenatal corticosterone exposure in the delicate skink (Lampropholis delicata). We treated eggs with high or low doses of corticosterone and incubated eggs at 23°C (cool) or 28°C (warm). We measured the effects of these treatments on development time, body size and survival from hatching to adulthood and on adult hormone levels and mitochondrial respiration. We found no evidence for interactive effects of incubation temperature and prenatal corticosterone exposure

on phenotype. However, incubation temperature and corticosterone treatment each independently decreased body size at hatching and these effects were sustained into the juvenile period and adulthood. Lizards exposed to low doses of corticosterone during development had elevated levels of baseline corticosterone as adults. Additionally, lizards incubated at cool temperatures had higher levels of baseline corticosterone and more efficient mitochondria as adults compared with lizards incubated at warm temperatures. Our results show that developmental conditions can have sustained effects on morphological and physiological traits in oviparous lizards but suggest that incubation temperature and prenatal corticosterone do not have interactive effects.

War of the *Rubus*: functional morphology of passive puncture in the Allegheny blackberry

Stephanie Crofts, Jennifer Martinez Paz

Contrary to many puncture systems in biology, plant puncture is passive; requiring energy input from the puncture target rather than the organism with the puncture tool. Despite this, there is a huge diversity of plant puncture tools and functions. Plant puncture tools may be derived from shoots, leaves, or epidermis tissue, and can vary wildly in size and location on the plant itself. To begin to explore this system, we studied the puncture mechanics of the Allegheny blackberry (Rubus allegheniensis). Blackberries have a biennial life history: with the first year (primocane) focusing on stem growth, and flowers and fruit being produced in the second year (floricane). Stems in both years have prickles, derived from the epidermis, as defensive structures. Given the possibly different functional pressures experienced by primocanes and floricanes, we explored prickle morphology, density, and puncture mechanics along the length of a stem, as well as the material properties of the stem itself. We observed differences in stem bending and density of prickles between the two life-stages, but less variation in puncture mechanics.

Crayfish and their hidden tenants: the direct and indirect effects of symbionts on crayfish behavior

Tara Cronin

Symbiotic relationships are ubiquitous throughout all ecosystems, serving as a backbone to life itself. Regardless if parasitic, mutualistic or commensal, these relationships may directly and indirectly impact the various aspects of the biology of the organisms involved, including the behavior of the host species. Freshwater crayfish of the genus Cambarus often engage in multiple symbiotic relationships, the most prominent being that with branchiobdellid worms. Crayfish-branchiobdellid symbiosis is viewed as a mutualistic cleaning relationship, with branchiobdellid worms cleaning fouling material from the gills and exoskeleton; however, this relationship is known to also be parasitic under certain conditions, with branchiobdellids consuming gill tissue resulting in melanized scars on the crayfishes gills. Using unique regulatory grooming behaviors, crayfish can control the load of branchiobdellids they host allowing them to balance the benefits and costs of the relationship. In this study, we examine the direct and indirect effects of branchiobdellids on crayfish behavior through simple one-hour behavioral trials. We analyzed each trial using BORIS to examine the frequency and duration of grooming and locomotion behavior, in addition to performing microdissections to determine symbiont abundance and the amount of gill scarring on each crayfish. Regression analyses indicated gill scarring had significant impacts on crayfish behavior, and a path analyses indicated branchiobdellid abundance was negatively related to grooming behavior, whereas gill scarring was positively related.

Unlearning the norms: a journey through transition, diagnosis, and doctoral study

Tara Cronin

Using the qualitative research methodology of autoethnography, this study explores my experiences as a transgender women navigating disability diagnoses, and social and medical transition while in a PhD program. This study was conducted to help educate others on the unique challenges and struggles that transgender individuals and those with disabilities may experience in higher education, especially in the current political climate within the United States. Through implementing the methodology of autoethnography, I was able to reflect on my experiences in a structured academic medium, allowing for the sharing of firsthand experiences while acknowledging potential biases as well as linking the experiences to existing literature and current events. The results of this study intend to spread awareness, as well as to spark conversations on equitable practices in higher education.

Species-specific inhibition of facial development by progesterone in cichlid fish embryos

Katie Cross, Kara Powder

Regulation of hormones like progesterone is at the epicenter of the body's main biological functions. Embryonic development is often sensitive to external hormone exposure, but we do not fully understand why some species are resistant to effects while others are more sensitive. We sought to understand the impact of progesterone exposure on facial development using cichlid fishes and how that may differ across species with distinct genetic backgrounds. Embryos were exposed to progesterone throughout facial development, from the migration of precursor cells to when the facial skeleton is established as cartilage. Geometric morphometric shape analyses demonstrated that Pseudotropheus livingstonii were resistant to progesterone exposure ($p=0.505$ and $p=0.155$ compared to untreated and vehicle-exposed siblings, respectively). In contrast, development in Aulonocara baenschi was sensitive to progesterone. Specifically, embryos showed overall developmental delays such as stunted formation of facial cartilages. Interestingly, these embryonic species-specific effects of a sex hormone mimic the pattern of sexual dimorphism observed in adults, with Pseudotropheus livingstonii exhibiting lesser dimorphism and Aulonocara baenschi showing distinct facial morphologies between females and males. These results suggest that progesterone can act as an external inhibitor of embryonic development, and future research can identify the genetic basis of species-specific sensitivities. Work supported by the Clemson Creative Inquiry program and NIH P20GM121342.

Island entanglement: integrating perspectives on Bodhi tree introduction on the Hawaiian Islands

Jazlee Crowley, Beth Davis, Dana Howe, Dee Denver

The global migration of the sacred Bodhi tree (Ficus religiosa) alongside Buddhism has occurred for over two millennia. We study the impact of this potentially invasive tree across the Hawaiian Islands, as well as the relationship between the Bodhi tree and local Buddhist communities. Our goal is to investigate the tree's rate of spread in Hawai'i, as well as potential ecological damage and further naturalization. We surveyed one island, Kaua'i, for Bodhi tree seedling spread across three years; two additional islands (O'ahu and the Big Island) were surveyed for one year. Offspring location and patterns of spatial variation, specifically radial distance from reproducing adult trees, were analyzed in ArcGIS. In 2025 surveys, we found 115 offspring on Kaua'i, 39 on the Big Island, and notably 521 on O'ahu. Across three years, the reproductive rate of each adult tree on Kaua'i varied by location. On Kaua'i and the Big Island the distance between offspring and adult tree was contained within a 0.3 km radius. However, on O'ahu offspring spread up to 2.5 km away from the nearest adult tree. Additionally, cooperative cross-cultural knowledge cultivation with Hawaiian locals was integrated into the project's design and was imperative to our outcomes. Whilst creating an integrative approach to biological fieldwork, we have described the current state of Bodhi tree introduction and entanglement in island ecosystem and culture.

Evolution of the outer ear from an ancestral gill program

Gage Crump, Mathi Thiruppathy, Andrew Gillis

The outer ear is a mammalian innovation whose evolutionary origins have remained a mystery. It develops through outgrowth of neural crest-derived cells and contains a unique type of elastic cartilage. We find that the gill filaments of fishes share a common developmental program and an elastic cartilage subtype with the outer ear. Comparative single-nuclei multiomic analyses of the human fetal outer ear and zebrafish gills reveals common gene expression and enrichment of transcription factor binding motifs (e.g. DLX) in differentially accessible regions (DARs) of chromatin. This conserved gene

regulatory architecture is reflected by specific transgenic activity of human outer ear enhancers in zebrafish gills, and reciprocal activity of zebrafish gill enhancers in the mouse outer ear. Both human outer ear and zebrafish gill enhancers also drive transgenic activity in the gill filter system of frogs, showing retention of this program in tetrapod gills. Remarkably, single-cell multiomics reveals that a DLX-mediated gill program may be conserved in the book gills of the Atlantic horseshoe crab, which are supported by tissue resembling elastic cartilage. Supporting homology with vertebrate gills, a horseshoe crab book gill-specific distalless enhancer drives specific expression in zebrafish gills. These findings suggest the mammalian outer ear arose from reutilization of an ancestral gill program and show the power of cross-species enhancer testing to reveal cryptic homology across vast evolutionarily timescales.

Nest site fidelity estimates for sea turtle populations on Florida's Gulf Coast

Jacob Cummings, Jake Lasala

Throughout their lives, sea turtles will repeatedly return to their natal region to nest, a behavior known as nest site fidelity. Nest site fidelity ranges can vary across individuals, and nesting populations. By exploring fidelity on a local scale, we can determine how clutch risk is divided over space and the true geographical extents of a population. Sarasota County, Florida hosts the largest nesting aggregation of the loggerhead (Caretta caretta) in the Gulf and the green sea turtle (Chelonia mydas) nesting population is rapidly growing. This area has been monitored for 40+ years by the Sea Turtle Conservation and Research Program at Mote Marine Laboratory. In this study, we use 22 years of capture-mark-recapture (CMR) data collected with GPS points to calculate nest site fidelity as the maximum distance between a turtle's two most distant verified nests. Loggerheads and green sea turtle individuals show relatively high fidelity to their nesting sites, though these values are also likely underestimated. Additionally, we found no statistically significant change in nest site fidelity across the study period for either species, nor between neophyte and remigrant populations. Future research should collaborate with other local monitoring programs to include a larger geographic range of nesting beaches within this analysis, resulting in improved estimates of nest site fidelity. This information can be used to better inform conservation managers for these species.

Embrace the darkness: negative phototactic behaviors in brittle stars

John David Curlis, Benjamin Foglesong

An animal's ability to conceal itself from predators is often the primary determinant of its survival. Even in species that lack eye structures, sensory systems have evolved to allow organisms to determine whether they are likely to be hidden or exposed. Brittle stars (Echinodermata: Ophiuroidea) can detect light via putative photoreceptors distributed across the body. While several species have been shown to rapidly move away from sources of light toward darker spaces (negative phototaxis), the factors that influence such movements are complex and poorly understood. In this study, we conducted a series of behavioral experiments to characterize phototaxis in two species of brittle stars, Ophiocoma echinata and Ophioderma appressa, from San Salvador Island in the Bahamas. We found that both species exhibit strong shade-seeking behaviors that appear to be independent of individual body size, time of day, or the physical structure of shelter. We also found that, when presented with shaded refuges in opposing directions, brittle stars of both species show no directional preference unless a greater number of arms detect shade from one direction versus the other. Lastly, we found that differing wavelengths and/or intensities of light can greatly impact the degree of response for both species. Taken together, our results provide valuable insights into brittle star phototaxis and highlight the profound role that light environments can play in the evolution of animal behaviors.

Vertebral bending in chameleons across the arboreal spectrum

Michael Curran, Christopher Anderson

The form and number of vertebrae found in organisms can vary greatly across lineages, impacting locomotor strategies. These vertebral features may constrain organisms to a particular environment based on their ability to perform across those substrates. For example, arboreal primates possess several vertebral modifications in the thoracolumbar and lumbar regions, resulting in a greater range of motion during protraction for safer excursions. Previous research has mainly focused on arboreal mammals, however chameleons (family Chamaeleonidae) provide an opportunity to investigate vertebral specializations in arboreal squamates. Chameleons inhabit a wide range of arboreal environments with specializations to arboreality including prehensile appendages, increased vertebral counts and regionalization of their axial skeleton. We segmented trunk vertebrae from micro-computed tomography (µCT) scans of 22 terrestrial and arboreal chameleons. Coordinate systems were formed for the axial, lateral and sagittal rotations, and anatomical landmarks were placed on each joint at the centrum and zygapophyseal. Automated digital bending experiments (AutoBend) calculated the osteological range of motion (oROM) by manipulating articulated vertebrae to endure multiple constraints on motion and flexibility. We then calculated centrum strain and zygapophyseal strain to understand the oROM in each intervertebral joint. These comparisons across the arboreal spectrum provide insight into how arboreality shapes morphology and performance in their respective environment. In particular, these data test whether regionalization of vertebral mobility observed in arboreal taxa are common across species.

Local sediment chemistry shapes microbiome assembly in horseshoe crab eggs

Nathaniel Curtis, Jose Moscoso, Kent Hatch

During spawning events, horseshoe crabs (Limulus polyphemus) deposit their eggs into intertidal sediments. As the eggs incubate, poor sediment chemistry (e.g., hypoxia and elevated sulfide concentrations) can lead to reduced hatch rates. Given that microbial communities regulate these redox conditions, the egg-associated microbiome may play an important role in determining developmental success. However, little is known about horseshoe crab egg microbiomes in situ. Here, we used 16S rRNA sequencing to investigate egg- and sand-associated microbiomes at Zach's Bay, Long Island, NY, with two objectives: (1) to assess whether egg-associated microbial communities differ when eggs are laid in anoxic versus oxic sand, and (2) to establish a baseline characterization of egg-associated microbiomes in the field for comparison with laboratory samples. Eggs hosted low-diversity subsets of the surrounding sediment communities, with those deposited in anoxic sands exhibiting slightly higher species richness. Differential abundance analyses revealed that egg microbiomes consistently favored anaerobic lineages, and eggs collected from anoxic sediments had the highest abundances of sulfate-reducing and fermentative taxa. Most populations detected in egg microbiomes (89%) overlapped with the surrounding sediment, indicating that eggs assemble their communities primarily from adjacent sand. Collectively, these findings demonstrate that egg-associated microbial communities are shaped by the local nest microclimate. This work provides foundational data for ongoing investigations into how microbial communities influence horseshoe crab egg ecology under varying environmental conditions.

Diet of invasive rudd in Conesus Lake, New York from stomach contents analysis

Louis D'Ambro, Jacob Calus, Ledis Coronna, Angelina Batista, Griffin Meyer, Ryan Bohen, Mackenzie Gerringer

Invasive species can be a major driver of ecological change, often disrupting food webs and altering ecosystems through their interactions with native species. One such invasive species, the European rudd, Scardinius erythrophthalmus (Family Leuciscidae, Order Cypriniformes) was introduced to Conesus Lake in the Finger Lakes region of upstate New York in the 1980s. To understand the impact of this species on the local aquatic ecosystem, we investigated the rudds' diet through stomach contents analysis. From our

analysis of forty-six stomachs, we found a wide variety of prey items, including algae, plant matter, invertebrate crustaceans, and macrophytes. Most of the stomach contents in these rudd were either branched or filamentous algae, suggesting that algae play a significant role in the rudd's diet. We also observed the plastics and other debris in multiple stomachs, highlighting an additional human-induced stressor on this ecosystem. Future analyses will compare diet across location in the lake, fish life stage, and season, in addition to obtaining finer resolution taxonomic identification through DNA sequencing of stomach contents. These findings on the diet and ecological impact of rudd can help inform better management plans for understanding and mitigating the impacts of this invasive species in Conesus Lake.

Presence and prevalence of microplastics in smallmouth bass in the St. Joseph and Elkhart Rivers

Sofia Dahl-Santoro, Katrina Whitlow

Microplastic presence in tissues has become increasingly relevant in research in the 21st century. From findings in human breast milk, testes, and brains, microplastics are a growing concern with many medical and ecological implications. This study aims to assess the extent of microplastic contamination in freshwater fish, beginning with smallmouth bass (Micropterus dolomieu) in the St. Joseph and Elkhart Rivers. Tissue samples (fillet, GI tract, and liver) were dissolved in a 10% potassium hydroxide (KOH) solution to break down organic material. Specimens were analyzed for fiber, film, and shard contaminants. Visual identification confirmed the presence of plastic particles, including both translucent shards and fibers, in digestive tissues, suggesting ingestion of environmental debris. Variation in microplastic load was observed among individual fish, indicating differences in exposure that may be linked to habitat, diet, or environmental conditions in different parts of the rivers. While these results are preliminary and based on a limited sample size, the consistent detection of microplastics indicates the need for expanded sampling, standardized particle identification, and assessment of potential ecological implications associated with microplastic contamination between these waterways.

Does size matter? The impacts of sperm size and male condition on media-dependent sperm performance

Lula Dalupang, Tenniyah Jennings, Andrea Jivanny Hernandez Ramirez, Ariel Kahrl

The process of fertilization involves complex interactions between sperm and eggs. Fluid released alongside eggs and/or compounds released from eggs can drastically change sperm motility and velocity as well as capacitating sperm to prepare for fertilization. Previous research on anurans shows that egg water has the ability to capacitate sperm, however how sperm respond to swimming in pond water vs egg water has not been observed. Our first aim is to quantify this relationship in Green Frogs. We tracked sperm with the use of Sperm Class Analyzer (SCA), recording sperm velocity, and measuring sperm longevity as the proportions of motile sperm at timepoints 0, 30, 60, 90, and 120 minutes in pond water and egg water. Additionally, whether sperm morphology or male physical traits, such as condition, play into sperm performance in either media has not been explored. Here we predict that 1) sperm will survive longer and swim faster in egg water, 2) that morphology will influence sperm performance, and 3) males in better condition have increased sperm performance. Studying these relationships will identify the characteristics of anuran sperm that contribute to successful external fertilization.

In situ vocalizations of sea turtles on Florida'a Gulf coast

Grace Dandeneau, Beth Brady, Jake Lasala

Unique vocalizations have been observed in both freshwater and marine turtles in captivity and in the wild. Some species begin vocalizations while within the egg as embryos, and hatchlings can vocalize prior to emerging from the nest. In other reptiles and birds, within-nest vocalizations have been linked to synchronized behaviors. Vocalizations may serve to coordinate group emergence for sea turtle hatchlings, thereby reducing individual effort and increasing survival. However, sea turtle vocal repertoire differs between species and has predominantly been studied in controlled settings - less is known about in situ behavior. This project aimed to classify and categorize the vocalizations of the loggerhead (Caretta caretta) and green sea turtle (Chelonia mydas) across three seasons (2023-2025) on a dense nesting beach on Florida's Gulf coastline. Recordings were taken leading to nest emergence and calls were categorized and analyzed. Nests were excavated, three days following emergence and contents were quantified. Hatchling emergence was modeled in relation to specific sounds and behavior. Calls were analyzed in relation to hatching events, and nest success was compared to corresponding acoustic data. The findings suggest that vocalization patterns may provide a non-invasive method for monitoring nests and predicting hatchling emergence.

Lightfield imaging captures biological fluid interactions at a range of scales and depths

Joost Daniels, Paul Roberts, Kakani Katija

For marine organisms, interactions with their surrounding fluid is at the core of all aspects of life, from larval dispersal to respiration and prey capture. In order to perform quantitative studies of this interface of biology and physics, numerous imaging techniques have been developed for both in-vitro and in-situ applications. Common techniques to provide accurate measurements in a three-dimensional environment include structured light (e.g., laser sheets), and stereo imaging. These solutions quickly become cumbersome in-situ, especially with the size requirements of diver-operated systems and autonomous vehicles. Plenoptic (light field) imaging can offer 3D measurements with a single camera at a range of scales, holding promise both in system packaging and ease of application, because there is no need to align the subject with a narrow imaging plane. Recently, we presented detailed measurements of octopus kinematics with a light field system on a remotely operated vehicle. We also developed diver-operated plenoptic system to study biological fluid interactions for a range of hard- and soft-bodied animals. Here, we provide early results and implications for predator/prey interactions, gas exchange, and fluid flow for reef-building organisms, and discuss the complications of analyzing the dense data collected. This imaging technique opens up new avenues in diver-operated fluid measurements and capture of 3-dimensional surface dynamics at sub-meter scales that are relevant for the marine science community at large.

The expensive tissue hypothesis revisited: encephalization and dietary quality across Primata

Cassidy Davis, Timothy Ryan

A rich expanse of work exists exploring the ecological characteristics of species who have evolved larger brains relative to their sister taxa, linking encephalization to specific social, dietary, and life history traits. These studies, which examine why a larger brain would be selectively beneficial, are complimented by investigations of how organisms can metabolically support this increase of energetically costly brain tissue. One prevailing theory known as the expensive tissue hypothesis posits that to sustain a larger brain, the size of the similarly expensive gastrointestinal tract will decrease in compensation. This inverse relationship has been demonstrated interspecifically in birds, fish, and anurans, but studies in various taxonomic levels of primates have yielded mixed results. To further clarify this relationship within primates, I present the largest comparative primate sample of endocranial volumes to date, with representatives from each of the sixteen primate families. Using a field-standard proxy of dietary quality for gut size, I examine the correlation between brain size and dietary quality using a series of phylogenetically-corrected multiple regression models. My results corroborate earlier findings in Platyrrhine primates, suggesting no significant correlation between dietary quality and encephalization when taking phylogenetic effects and body size into account. Future analyses should look to identify whether pre-processing of food prior to ingestion explains variation among closely related species with differing amounts of encephalization.

Methylene blue enhancement of neuro-regeneration and blastema cellular density in Dugesia tigrina

Clara Davis, Thomas Pirtle

Methylene blue is a synthetic compound with a range of clinical applications, including surgical staining, treatment for cyanide poisoning, and as a cure for the blood condition methemoglobinemia. However, current research suggests that methylene blue has further clinical potential to influence neurotransmission by interacting with signaling pathways as a redox-cycling substrate for various reducing and oxidizing substances. This attribute, along with the molecule's small molecular weight, polarity, and ability to act as an electron carrier in mitochondrial electron transport chains, means methylene blue has the possibility to act as a cognitive enhancer. We chose to test this chemical on Dugesia tigrina, or planarians, which are small, complex, flatworms. They are powerful model organisms for observing tissue and neural regeneration and are able to quickly and completely regrow their body parts. Here we quantify the effects that different concentrations of methylene blue have on planarian neuro-regeneration by monitoring the reappearance of eyespots and imaging nuclear density within the regenerated blastema. We hypothesized that headless planarians exposed to methylene blue will regenerate their heads faster than those in only planarian water, and that planarians treated with higher concentrations of methylene blue will have higher nuclear density. Our results thus far indicate that methylene blue shortens eyespot regeneration and increases cell density within the blastema of treated planarians.

Polybrominated diphenyl ethers (PBDEs) and their physiological effects on reproductive gartersnakes

Isabella Davis, Jen Terry, Susannah French, Lori Neuman-Lee

Polybrominated diphenyl ethers (PBDEs) are organobromine compounds used as fire-retardants. These toxic chemicals are persistent and bioaccumulate in the environment. While effects of PBDEs on wildlife health remain understudied, there are known deleterious effects from PBDEs on organisms. In addition to toxic effects of the chemical, exposure may elicit a chronic stress response which can initiate physiological energetic tradeoffs among processes. Reproduction and immune function are highly energetically expensive physiological processes that may be deprioritized during energetic limitation due to chronic stress. To examine the physiological consequences of PBDE exposure compared to a non-toxic novel chronic stressor, female gartersnakes were maintained throughout their reproductive period and exposed to one of the following treatments: PBDE oral treatment, daily physical handling, and a non-handling/non-PBDE exposure (control). Reproduction effort was quantified by measuring sex steroids (progesterone, estradiol, and testosterone) using radioimmunoassays. Immune function was assessed using bacterial killing assays and the stress response was measured by challenging snakes to an acute stressor and measuring baseline and acute stress concentrations of corticosterone. We were able to develop hormone and immune profiles across the reproductive season for each treatment group to understand the influences of exogenous chemicals and chronic stress on reptile physiology.

Does self-modification of lipopolysaccharides influence host colonization in the squid-vibrio system

Kyle Davis, Elizabeth Heath-Heckman, Bethany Rader

Communication between hosts and their symbionts is important for processes like host development and symbiont retention. In the squid-vibrio system, the Hawaiian Bobtail Squid (Euprymna scolopes) has a specialized light organ that houses its bacterial symbiont Vibrio fischeri. V. fischeri products, such as lipopolysaccharides (LPS), potentiate several symbiotic phenotypes, including the apoptosis of ciliated epithelial cells outside of the light organ. Dephosphorylation of the lipid A portion of V. fischeri LPS by alkaline phosphatases produced by the squid has been found to promote bacterial persistence, but it is unknown if this phenomenon is also regulated by V. fischeri. To address this gap in knowledge, we identified lpxF in V. fischeri, which also dephosphorylates lipid A and asked if its deletion would impact bacterial colonization. To test this hypothesis, we inoculated juvenile squid with the Δ lpxF mutant V. fischeri for 24 hrs and then performed competition assays between the mutant and WT V. fischeri in the host. We found that while the mutant could colonize the squid, the relative competition index between it and WT was 0, suggesting that the WT V. fischeri has a significant competitive advantage over the mutant at 24 hrs. These data suggest that both host and symbiont dephosphorylation of lipid A is important for symbiosis initiation and persistence. Future experiments will determine how both mechanisms co-exist in the light organ.

Hindfoot shape during swimming of salt marsh harvest mice and coexisting rodents of the Suisun Marsh

Zachary Davis, Arianna Ramirez, Diego Sustaita

The salt marsh harvest mouse (Reithrodontomys raviventris) is an endangered species endemic to the San Francisco Bay Estuary, and as such must tolerate tidal and/or managed flooding events. We study its swimming capabilities in comparison to those of coexisting species, the western harvest mouse and the house mouse, to understand how it is adapted to this ecosystem. These species are all hindfoot-propelled swimmers, and here we compare differences in hindfoot shape during paddling. Mice were filmed while swimming from posterior views using GoPro cameras positioned in the water. Frames were selected at the point the hindfoot was most planar to the camera during the middle of the power phase of each of 3 successive paddle strokes for each swim trial. Ten landmark points were selected on each image, which formed the basis for interdigital and foot angle measurements derived from the Procrustes aligned x-y landmark coordinates, and a geometric morphometric analysis of shape variation. We found that house mice tend to spread their digits out more while swimming, whereas the two harvest mouse species maintain relatively narrow toe configurations. We tentatively surmise that these differences in paddle shape are influenced by phylogenetic differences but could also have important functional implications for swimming efficiency.

Measuring selection on testosterone in a wild lizard population

Myles Davoll, Robert Cox, Tyler Wittman, Ashlyn Crain

In male vertebrates, testosterone is hypothesized to underlie the life-history tradeoff between survival and reproduction. Indeed, testosterone has been correlated with components of male reproduction by way of accentuating courtship behavior, territorial aggression, and the development of primary and secondary sexual characters while simultaneously suppressing components of survival such as somatic maintenance and immune function. Despite the wealth of information surrounding the action of testosterone and its role in the expression of traits correlated with fitness, there remains a need for studies that simultaneously link natural variation in testosterone to both survival and reproductive success in the wild. To test whether testosterone structures the tradeoff between reproduction and survival, we measured standing variation in circulating testosterone levels of adult males at three points during the reproductive season, then estimated survival (using mark-recapture) and reproductive success (using genetically assigned parentage) in a wild population of brown anole lizards (Anolis sagrei). We predict that variation in testosterone will be positively correlated with reproductive success and negatively correlated with survival.

Comparing the effect of looming silhouette detail on escape response in fish with different ecology

Liv Dawes, Nadalee Jones, Steve Heim, Miki Nara, John Steffensen, Jacob Johansen, Paolo Domenici

When startled, fish perform an escape response to flee from predators. Looming, a technique to visually stimulate a fish, has been extensively studied; however, studies have focused on a simplified loom that approximates the silhouette of an approaching predator as an expanding disk. We hypothesize that more detailed silhouettes of species-specific predators may have different effects on fish of different ecology. To this end, we look at the effect of adding flapping fins to the loom, simulating a seal attack, which adds both spatial and temporal detail to the loom. We used this to startle two different species of fish: staghorn sculpin (Leptocottus armatus), a benthic and cryptic species,

and shiner perch (Cymatogaster aggregata), a benthopelagic species active in the water column, both of which are commonly preyed upon by harbor seals. To clarify the effect of a finned predator, four loom treatments were used: a black disk without fins (control), a black disk with unmoving fins, a black disk with flapping fins, and a pair of flapping fins with no disk (control). We compare the effect of adding the flapping fins to the looming silhouette on response distance (timing), response strength, kinematics, and response rate.

Effects of anthropogenic landscape change on the behavior of camouflaged animals

Joao Vitor de Alcantara Viana, Rafael Duarte

Camouflage is one of the most widespread visual adaptations in nature, allowing prey and predators to conceal themselves and thereby alter the likelihood of predation. For camouflage to be effective, multiple intrinsic factors (e.g., coloration, morphological adaptations) and extrinsic factors (e.g., background coloration, light environment, and the visual capabilities of the observer) must interact to ensure effective concealment. Anthropogenic changes in the landscape can disrupt several aspects of these mechanisms. Examples include alterations in background coloration caused by human-induced fires, habitat deforestation, pollution, artificial light at night, increased water turbidity, and even noise, which can interfere with organisms' ability to change color. Despite these diverse impacts, human-induced effects on camouflage remain poorly studied. In this review, we provide a comprehensive synthesis of the literature to examine how anthropogenic changes affect camouflage effectiveness in nature, how these changes interact with the mechanisms involved, and the potential consequences for species conservation. Finally, we emphasize the need to address anthropogenic change not only at the species level but also in relation to one of the most widespread functional traits in nature: coloration, given its central role in behavioral ecology and its vulnerability to ongoing environmental change.

Comparative genomics of clownfish-hosting sea anemones

Aurélien De Jode, Anna Marcionetti, Nicolas Salamin, Benjamin Titus

Among all mutualistic symbioses, none are more recognizable than the association between clownfishes (Subfamily Amphiprioninae) and their giant host sea anemones (Anthozoa: Actiniaria). Distributed on tropical coral reefs throughout the Indian and Pacific Oceans, 28 clownfish species have rapidly radiated to form obligate mutualistic relationships with 10 nominal species of venomous sea anemones. Chromosome-level reference genomes are now available for all 28 clownfish species, and comparative analyses are revealing the first candidate genes likely associated with clownfishes' ability to remain protected from toxic sea anemone hosts. However, our evolutionary understanding of the symbiosis is limited because most research and genomic resources have focused on clownfishes. Interestingly, unlike the 28 described clownfish species which form a monophyletic clade, the 10 clownfish hosting sea anemones belong to three distinct lineages within the sea anemone superfamily Actinioidea that have evolved symbiosis with clownfishes independently. Using a recently assembled high quality reference genome for Stichodactyla haddoni and Illumina WGS for other species of the Stichodacylina clade, we provide the first comparative genomic analysis between clownfish-hosting and closely related non-hosting species. We identified 20,487 orthogroups (OG), among which 3,231 were present in every species in a single copy. Using 378 OGs that showed similar topology to the species tree, we detected positive selection on branches leading to host species in more than 30 genes.

Remodeling of hypothalamic signaling systems supports a seasonal switch to anorexia in hibernators

Cole Deal, Kathryn Wilsterman, Cory Williams

Ground squirrels exhibit endogenously programmed circannual rhythms of body mass and appetite. These rhythms are characterized by increased feeding and rapid fattening in the fall, before hibernation onset, upon which animals are aphagic for up to 8 months. The physiological and neuroendocrine control mechanisms that govern this metabolic transition are largely unknown. Here, we show that prior to hibernation, there are progressive decreases in appetite, resting metabolic rate, and overnight body temperatures – during this interval, fattening slows, and body mass eventually plateaus and decreases. RNA-sequencing of hypothalamic micropunches revealed that the switch to hypophagia occurred in concert with reductions in retinoic acid and thyroid hormone signaling, confirming their role in mediating seasonal metabolic shifts. Further, the transition to hypophagia was characterized by a decrease in the sensory capacity of tanycyte cells along the third ventricle of the hypothalamus. The expression of genes downregulated in hypophagic animals were enriched for processes related to cilia assembly and G-protein-coupled receptor signaling. These results suggest declines in appetite and weight prior to hibernation may stem from a loss of cilia, which act as metabolic scaffolds on tanycyte cells. These results enhance our understanding of the conserved biological processes involved in seasonality across the animal kingdom.

Characterization of ctenophore feeding flow fields in the presence of microplastics

Cassandra DeBlois, Marcus Raposo, Elizabeth Shepard, Anabela Maia

Ctenophores are an often-overlooked gelatinous zooplankton in Narragansett Bay but are vital to food web dynamics, zooplankton populations, and carbon transport. The species Mnemiopsis leidyi is abundant in the Bay and has been increasing in seasonality and abundance over the years. Microplastics have also been increasing in concentration across the globe's oceans and can have a variety of effects on the local ecosystem, including invertebrates. This study intends to investigate the effects of microplastics on M. leidyi feeding including flow fields via particle image velocimetry (PIV). Additionally, we also performed a kinematic analysis of feeding trials collected with high-speed video under normal light conditions. PIV with 76-93 µm silver coated ceramic beads were used to show control flow fields while the experimental treatment contained 73-95 µm polyethylene spheres (PE) at a concentration of 0.0222 g/L. We hypothesized that comb jelly feeding currents will show decreased flow speed as their digestive system fills with non-edible particles that cannot properly be digested. Preliminary results suggest that feeding currents are not altered in the presence of polystyrene beads and that comb jellies are able to ingest both ceramic and polystyrene beads accidentally while feeding on Artemia. While many vertebrates face digestion complication when consuming pollutants, comb jellies do not have mechanical interruptions to their feeding and will continue to survive as microplastic concentrations in the ocean increase.

Post-hurricane vegetation coverage impacts on sea turtle nesting behavior

Gemma DeCarolis, Melissa Macksey, Jake Lasala

When choosing a nest site, sea turtles prefer a dark background. Dune vegetation is important in shielding the beach from light, as well as supporting dune structure. Hurricanes overlap with sea turtle nesting season and can wash out and destroy nests and dune vegetation. Hurricane Helene and Hurricane Milton struck the Sarasota/Tampa Bay area in the fall of 2024, drastically changing the layout of vegetation on sea turtle nesting beaches. This study analyzed how decreases in vegetation impacted loggerhead (Caretta caretta) and green sea turtle (Chelonia mydas) nesting behavior. Nesting data from the Sea Turtle Conservation and Research Program at Mote Marine Laboratory and aerial imagery from Sarasota County were used to analyze nesting success and percent vegetation coverage, respectively. There was a significant decrease in vegetation coverage from 2024 to 2025, but this decrease did not significantly affect the nesting success of sea turtles. However, nesting sea turtles crawled further up the beach on average in 2025, revealing that spatial patterns of nesting on these beaches changed, following percent vegetation decrease. This loss of vegetation has also dramatically increased the numbers of disorientation events between the two years (~3x) and could impact future conservation efforts. These topics will be discussed.

The light-mediated contractile response of the sea anemone, *Nematostella vectensis*

Tiana DeGrande, Indira Cummings, Camilla Sharkey, Kyle McCulloch

The sea anemone, Nematostella vectensis, does not have elaborated visual organs, but it still possesses the ability to react to different wavelengths of light. In response to rapid environmental changes, including changes in light, the anemone's tentacles are quickly pulled into the body, possibly as a response to danger from predation. To better understand both the salient light stimuli and how the contractile response proceeds, we determined how adult sea anemones react to red, yellow, green, blue, violet, and ultraviolet lights. Each anemone was kept in the dark with infrared illumination, and then the respective light was turned on, and behavior was recorded with an infrared camera. The recorded behavior was then analyzed using ImageJ, and body movement was tracked with DeepLabCut. Using DeepLabCut output, we analyzed response rate per color, lag time, speed, and angle of contraction along the body axis, and other parameters. We report differences in response rate depending on the wavelength of light and characterize the timing and motion of contractile response under all colors tested. Together, our results add to the picture that despite no eyes or brain, anthozoans like Nematostella are still capable of precise light-mediated behavior and coordinated whole-body responses. Future studies will determine the genes required for contractile response and whether these are similar or different under different colors.

Comparative analysis of hypobranchial muscle architecture and mechanics in suction feeding sharks

Marie Del Vicario, John Brierley, Jason Ramsay

Unlike many fishes, cartilaginous fishes lack the skeletal connections and coordination of movements that functionally engage the trunk musculature to augment power production during suction generation. Thus, cartilaginous fishes rely solely on head musculature for the behavior. These muscles should have a relatively small power output compared to the combination of head and trunk muscles used by bony fishes, yet they are capable of the same or higher levels of performance. Here we aim to describe and quantify muscle-tendon architecture and leverage in representatives from three divergent groups of suction feeding sharks to reveal features that may facilitate high powered suction. We used DiceCT reconstructions to quantify muscle features and measure 3D moment arms of the hypobranchial muscles of Chiloscyllium plagiosum (high-powered suction feeder), Squalus acanthias (feeding generalist) and Mustelus canis (durophagous species). While the general morphology of the primary hyoid-depressing muscles is similar across species, moment arms differ significantly. In C. plagiosum, this moment arm starts at near-zero, a feature resulting from the alignment of the muscles with the articulations hyoid and drastically increases at early degrees of hyoid depression. This supports previously proposed catch mechanism hypotheses. The primary jaw-opening muscles exhibited an opposite relationship. Muscle moment arms were consistent, but the muscle architecture of C. plagiosum resulted in a higher potential for force output.

Bioluminescence and environmental light drive visual evolution in deep-sea shrimp

Danielle DeLeo, Heather Bracken-Grissom

Light functions as the universal language in the deep sea (>200 m), either dimly illuminating the water column or emitted as bioluminescence. Because of its central role in behavior, fitness, and life history, light is a powerful driver of sensory evolution. In pelagic environments, vertically migrating animals encounter dramatic shifts in illumination across depth, creating selective pressures that may shape their ability to distinguish ambient light from bioluminescent signals.

We applied a phylotranscriptomic framework to characterize visual proteins (opsins) in bioluminescent deep-sea shrimp (n=11) from the Superfamily Oplophoroidea, a group with diverse migration strategies and bioluminescent modes (photophores and secretions). Opsin diversity was highest in species migrating into shallower waters, where light regimes are more variable. We also identified evidence of adaptive evolution in photophore-bearing species that employ dual bioluminescent modes. Notably, a mid-wavelength sensitive opsin (MWS2) shows signatures of positive selection, suggesting an important role in discriminating between light sources.

Our results indicate that diversification of MWS2 is closely tied to photophore evolution and may represent a key innovation contributing to the ecological and evolutionary success of Oplophoroidea. These findings demonstrate how the interplay of environmental light and bioluminescence has repeatedly shaped visual adaptation in deep-sea shrimp, offering broader insight into the selective forces structuring sensory systems in one of the ocean's largest and most light-limited ecosystems.

Natural variation in nematocyst length and density in colonies of *Anthopleura elegantissima*

Itzel Delgado Lopez, Caitlin Plowman, Eva Harvey, Rowan McLachlan, Nathan Kirk

The sea anemone Anthopleura elegantissima reproduces asexually to form clonal colonies that are abundant in the intertidal zone along the Western United States. These colonies engage in intraspecific competition for space using specialized structures called acrorhagi that are laden with nematocysts, single-use organelles, which can inject neurotoxin into conspecific anemones. Although we know the result of these aggressive interactions is the retreat of one or both combatants, less is known about what traits predict the outcome and which colonies will ultimately prevail. Here we examined variation in nematocyst length and density in acrorhagi of multiple clones from colonies on the Oregon coast hypothesizing that increased weaponry could contribute to the success of certain clones: some of the clones have grown in population size over the last 3 years and some have decreased. Nematocyst length was determined from acrorhagi squashes and ranged from 62.8 +/-10.0 um to 80.3+/-9.9 across the clones; There were significant differences among the colonies and nematocyst length inversely correlated with changes in colony size indicating possible tradeoffs in increased investment in nematocysts. To determine the density, part of the body column containing the acrorhagi was dissected out and prepared for histological sectioning. Preliminary results show a significant difference in the densities between 2 of the colonies with densities reaching 3067 +/-1362 nematocysts/1mm2 in 5 um sections in the uninflated acrorhagi.

Neuromuscular control of wing morphing in response to upward gusts during gliding flight in doves

Rémy Delplanche, Bret Tobalske, Kathryn Greil, Daniel Inman

Real-world airflows are complex, and perturbations have likely served as selective pressures upon flying organisms. Preflexes, in which external forces are initially absorbed by viscoelastic properties of muscle, are hypothesized to play an important role in maintaining locomotor stability. To provide a novel test of this "preflex hypothesis" in flying vertebrates, we trained Barbary doves (Streptopelia risorii, n=6) to glide in a wind tunnel operating at an airspeed of 10m/s while experiencing simulated upward gusts. These gusts, 1m/s in magnitude, were generated using 2 airfoils mounted at the front of the flight chamber which could deflect air into the birds from below. We used high-speed video recordings to measure the 3D kinematics of wing morphing, while sonomicrometry and electromyography were used to measure the strain and neuromotor recruitment of select wing muscles during gust rejection. Our results were consistent with the preflex hypothesis: in response to upward gusts, wing elevation initially increased without a concurrent change in pectoralis motor unit recruitment. After a delay, pectoralis activation increased, thereby modulating wing elevation. Motor unit recruitment in the distal wing muscles did not modulate during the gust response despite changes in distal wing kinematics, revealing a proximo-distal gradient in wing neuromechanical control during perturbations.

Quantifying sensory microstructure and modeling olfactory morphology in blacktip sharks

Nicole Demaras, Aubrey Clark, Marianne Porter, Tricia Meredith, Lauren Simonitis

Sharks detect odorants as water flows into their incurrent nares, through the olfactory rosette, and out the excurrent nares. Olfactory rosettes consist of lamellae— plates of tissue covered in sensory and non-sensory epithelium. Lamellar structure varies by position along the rosette and may correlate with water flow. Since previous studies focus on elongated or truncated olfactory rosettes, we investigated the intermediately shaped blacktip shark (Carcharhinus limbatus) rosette. We hypothesized that blacktip shark lamellar microstructures vary by location. Using scanning electron microscopy (SEM), we found that lamellar sensory surface area remained consistent across lateral and central regions of the rosette (90-95%), but decreased in medial lamellae (80-90%). Lamellae on both medial and lateral ends also exhibited fewer secondary folds. We also used contrast-enhanced microCT scans to generate 3D reconstructions of the rosette, which inform the creation of simplified CAD models. These will be used to vary rosette parameters (i.e. fineness ratio, lamellar number, curvature) and investigate hydrodynamic patterns within the rosette through CFD. We aim to tie rosette hydrodynamics to variations in sensory morphology. These 3D reconstructions also allow us to correct our 2D surface area measurements to account for 3D structures (like secondary folds). Together, SEM and 3D modeling connect lamellar structural variation to flow within the rosette, enhancing our understanding of optimization in this sensory organ and overall olfactory morphology of sharks.

Reproductive responses to salinity stress in the intertidal crab, *Petrolisthes cinctipes*

Asia DeMarre, Brian Tsukimura

The rocky intertidal zone is an ecosystem subject to a wide range of abiotic stressors, such as temperature, pH, and salinity, which are intensified by climate change. The El Niño Southern Oscillation (ENSO) influences salinity fluctuations in rocky intertidal zones through increased precipitation and freshwater runoff. These changes in salinity pose physiological challenges on the reproductive fitness of intertidal species such as the anomuran crab, Petrolisthes cinctipes. This study examined the effects of climate-driven salinity changes on reproduction in P. cinctipes during fall, winter, and spring. Crabs were exposed to salinity levels of 25, 30, 35 ppt at a constant temperature of 12 °C for seven days. Hemolymph vitellogenin (Vg) levels and gonadosomatic index (GSI) were measured as biomarkers of reproductive investment. Results showed that GSI did not differ among salinities in fall or winter ($p > 0.05$), but in spring, GSI was significantly higher at 25 ppt than at 35 ppt ($p > 0.029$). Percent changes in Vg revealed reduced upregulation of yolk protein post-treatment at 25 ppt relative to 35 ppt ($p > 0.0341$), demonstrating that low salinity negatively impacts reproductive capacity. Overall, these findings indicate that P. cinctipes reproductive investment is sensitive to both osmotic stress and seasonal timing, highlighting the potential impacts of climate driven salinity fluctuations on intertidal species fitness.

STEM communication training through a cognitive science lens

Elise Demeter, Jill Huerta, Adam Reitzel, Aura Young

STEM researchers need to communicate their work effectively to policymakers, journalists, business leaders, the public, and fellow scientists. While graduates develop deep expertise in their disciplines, many complete their degree program without the training to present their work clearly, accessibly, and with cultural sensitivity for diverse audiences. Currently, communication training in graduate STEM programs remains limited, especially at public, non-flagship institutions. To fill this gap, we designed, implemented and evaluated an asynchronous, online training program composed of six modules developed by science communication experts and practitioners. Each module includes content in various mediums, discussion boards, and targeted short assignments to lead to the production of a final capstone project for students to practice communicating research through written and visual products designed for nonacademic audiences. This talk will describe the structure of these modules, the effectiveness of each based on student self-assessments and external reviewers of products, the impact of exposure to cognitive science theories on student performance in the training, and the opportunities for dissemination to other institutions. Complete curricular materials (objectives, lectures, assignments, rubrics, etc.) are freely available for easy implementation at other institutions using a learning management system. Supported by NSF Award #2325453

Communicating in noise: behavioral plasticity and its limits in a rapidly changing world

Elizabeth Derryberry, Graham Derryberry, Ruth Simberloff, Amy Luo, David Luther, Michael Blum, Jennifer Phillips

Anthropogenic change is altering environments at unprecedented rates, yet behavioral plasticity can buffer populations against such rapid perturbations. The COVID-19 pandemic, sometimes termed the Anthropause, created a rare quasi-experimental opportunity to examine how animals adjust their behavior in response to shifting anthropogenic noise. We previously showed that songbirds in the San Francisco Bay Area rapidly adjusted song traits during the statewide Spring 2020 shutdown, producing lower-amplitude, wider-bandwidth songs that enhanced communication efficiency, but that responses to the return of noise were non-parallel, with some song traits reverting and others persisting. Extending this work, we find that the degree and pace of reversion to pre-pandemic soundscapes varied across sites, and that changes in singing behavior closely tracked these local trajectories. Ongoing analyses are investigating how such context-dependent dynamics interact with individual variation in signal plasticity, and how altered songs influence communication efficacy in social contexts. Together, these findings highlight both the resilience and the limits of behavioral plasticity in avian communication: while behaviors can shift rapidly when anthropogenic pressures are relaxed, their reversal may lag or vary across ecological and social contexts. Such context-specific differences underscore the importance of linking local environmental trajectories to behavioral outcomes to understand how populations cope with—and sometimes fail to keep pace with—anthropogenic change.

Honey bees and native pollinators occupy distinct climatic niches in a spring-blooming crop

Nicole DesJardins, James Crall

Insect-mediated pollination is critical to our food supply. However, pollinators are threatened by stressors such as extreme weather and climate change. The production of some fruit crops, particularly those that bloom in the unstable weather of spring, is currently limited by a lack of pollinators. We assessed how climatic preferences varied among the taxa involved in apple pollination, with the goal of determining how resilient these pollination services will be to climate change. To monitor pollinator foraging activity in the field, we used AutoPollS, a computer vision-powered camera trap. AutoPollS were placed in apple orchards during bloom along with weather-monitoring equipment. The units took photos of insects as they visited flowers, and offline analysis identified the insects to genus. Comparing activity among wild bees, honey bees, and flies, we found that wild bees had the narrowest climatic niche, only foraging at the warmest temperatures and in sunny conditions. Honey bees also preferred warmer temperatures, but showed more tolerance for sub-optimal conditions than wild bees. Flies were the most tolerant of sub-optimal conditions, such as lower temperatures, lower light, and higher humidities. These results show that different types of pollinators occupy distinct climatic niches, providing a mechanistic understanding of niche complementarity in apple pollination. Ensuring the presence of a diversity of pollinators will help spring-blooming crops be resilient to climate change. Supported by NSF PRFB DBI-2305941.

Physiological metrics during migratory transitions in a facultative migrant, the red crossbill

Jalyn Devereaux, Heather Watts, Jessica Karr, Jamie Cornelius

Many passerines have evolved annual schedules that optimize fitness by partitioning phases of breeding, migration, and overwintering. Some show high degrees of flexibility in timing but the mechanisms for how they physiologically coordinate transitions are poorly described. The Red Crossbill, Loxia curvirostra, is a songbird with flexible timing of migration and breeding. Here, we describe hormone levels, blood metabolites and body condition during the circannual spring nomadic migratory period and the fall irruptive period in a captive colony of crossbills housed in rooftop aviaries and in free-living birds, respectively. We found that captive crossbills increase baseline corticosterone levels, fat, and mass as the spring migration period approaches in semi-natural outdoor conditions. Interestingly, males maintained spermatogenic-sized testes across the spring but produced low baseline levels of testosterone – which may differ from obligate migrants. During the fall irruptive migratory period all reproductive metrics declined as molt intensified to completion in free-living birds. Baseline and induced corticosterone increased after molt completion, and mass declined across the season. Significantly fewer crossbills were present at the study site later in winter, indicating that this population likely migrated away from the study site. We discuss these physiological and morphological shifts in crossbills and what they suggest about migratory flexibility, which is important given that increasingly unpredictable climate conditions are expected to push species to adapt more facultative migration strategies.

Basal metabolic rate and glucocorticoid levels are not correlated in the rodent *Octodon degus*

Annalise Di Cicco, Sarah Heissenberger, Daniela Rivera, Carolyn Bauer

When encountering a stressor, an animal's glucocorticoid levels and metabolic rate both substantially increase. Glucocorticoids regulate the allocation and utilization of carbohydrates and increased metabolic rate can be indicative of an increased use of glucose. While several studies have found positive correlations between metabolic rate and glucocorticoid levels within various species, these studies generally include both pre- and post-stressor timepoints in their analyses. We hypothesized that this positive correlation between metabolic rate and glucocorticoid levels is also present under non-stressed, baseline conditions. Using 34 adult Octodon degus, a non-traditional rodent model, we conducted flow-through respirometry to assess basal metabolic rate. We also took blood samples to measure baseline cortisol levels, stress-induced cortisol levels, and cortisol negative feedback efficacy. Contrary to our hypothesis, we did not find a significant correlation between basal metabolic rate and cortisol measures. These results suggest that an animal's basal metabolic rate is not predictive of its endocrine stress profile and that during stressors, glucocorticoids and metabolic rate may increase independent of one another.

Comparative analysis of escape responses in goby fishes from around the world

Kelly Diamond, Raphaël Lagarde, Takashi Maie, Amanda Palecek-McClung, Dominique Ponton, Shrika Ravichandran, Heiko Schoenfuss, Jeffrey Walker, Richard Blob

Animal form and function are influenced by both the current ecology and the past evolutionary history of species. In this study, we evaluate how multiple factors may influence the performance of fast-start escape responses in eleven species of amphidromous waterfall-climbing gobiid fishes from five localities around the world. We tested how age category, ecology, waterfall-climbing style, and evolutionary history influence escape performance in these fishes. In six of the seven species for which we had data from both adults and juveniles, juveniles responded more frequently than adults, as expected. Individuals from the same locality had more similar escape response metrics than individuals from different localities, regardless of their evolutionary relatedness. None of our metrics showed significant patterns related to climbing style by itself; however, our measures of body bending and maximum escape velocity were influenced by the interaction between climbing style and locality. These patterns persisted when we controlled for phylogenetic relationships, providing evidence for the shaping of escape performance by local conditions. Through these analyses, we demonstrate how waterfall-climbing goby fishes provide a system that is well suited for studying the drivers of phenotypic diversity, in which direct measurements of biomechanical performance can enhance perspectives generated from morphological comparisons.

A kinematic web: The twirling bolas of the moth-catching spider, Cladomelea akermani

Candido Diaz, Ashkaan Fahimipour, John Roff, John Long

Spiders of the family Araneidea use webs to capture aerial prey. The structure of webs varies dramatically by species, with the most extreme being the single thread with a glue droplet, the bolas that gives bolas spiders their name. To attract aerial prey within striking distance, bolas spiders release pheromones that lure male moths; in Cladomelea akermani, the moths are lured into a kinematic web, a temporal trap-net of a glue droplet twirled through space below the spider. The time-evolving trajectory of the glue droplet is under the control of the spider, and our goal is to ascertain the likely control mechanism. Using three-dimensional video of this behavior, taken in the field in South Africa, we analyze the moments of the spider's body and limbs and the resulting movement of the glue droplets and the approaching moth. We compare a variety of possible control mechanisms, based on treating the trajectory of the droplet as being produced by a simple pair of coupled sinusoidal oscillators or by a driven pendulum acting as a chaotic attractor. Our ultimate goal is to understand how the spider increases the probability of prey capture when the moth is close. The project is supported by NSF award number IOS-2031962.

Thermal and symbiotic regulation of pedal lacerate development in *Exaiptasia diaphana*

Yoshigei Diaz Hernandez, Noor Denolf, Jun Cai, Virginia Weis

Climate change is a large contributor to coral bleaching—a phenomenon where corals expel their symbiotic algae and, as a result, can have high rates of mortality. Bleaching can be catastrophic to coral reef ecosystems and threatens their valuable ecological, cultural, and economic services. Observations made on a cellular level provide a clear measure of coral health and can guide effective conservation strategies. In this study, we examined the effects of increased temperature on host development and the maintenance of symbiosis in the symbiotic sea anemone Exaiptasia diaphana, a model system for coral-algal symbiosis. Experiments were performed on symbiotic, aposymbiotic, and newly inoculated asexual buds. Measures of host health and growth were quantified, including tentacle count, pedal disk size, and mortality rate. In addition, using immunofluorescence microscopy, we visualized rates of host cell proliferation and apoptosis (programmed cell death). Our results showed a significant impact of symbiotic state and temperature on mortality and developmental rate. Our imaging data showed differential patterns of cells undergoing proliferation and apoptosis depending on the treatment type. These results highlight the importance of environmental conditions in host developmental rate and the complex cellular mechanics of this symbiosis.

Feather pigmentation as a signal of cognitive traits in male swamp sparrows

Danae Diaz Wong, Steve Nowicki, Sonke Johnsen, Katherine Henson

Cognitive traits can influence fitness, yet they are rarely observable to potential mates. Plumage signals may provide indirect cues, particularly, pheomelanin-based coloration as its synthesis draws on resources (e.g., cysteine) also required for central nervous system (CNS) development. Individuals are expected to prioritize cysteine for CNS function, with excess availability reflected in secondary traits. We tested whether pheomelanin-based cap coloration predicts cognitive ability in male swamp sparrows (Melospiza georgiana). Cap patch coloration was measured through spectral reflectance (400–800 nm) using redness indices, and size by measuring the pigmented patch area. Males were then tested on a battery of cognitive tasks. We evaluated associations between coloration metrics and performance on each task, as well as correlations across tasks. Males with larger pigmented

patches performed better on a novel foraging task but worse on a detour-reaching task. Performance on a color association task correlated positively with performance on a color reversal task, but no other cross-task correlations were detected. These results suggest that pheomelanin-based coloration is associated with specific cognitive abilities and may signal certain abilities. Our findings highlight the potential for feather pigmentation to serve as an honest indicator of cognitive traits while emphasizing a domain specific variation in performance across cognitive tasks.

Salinization effects on predator-prey interactions between dragonfly nymphs and two tadpole species

Ava DiBattista, Allison Welch

Freshwater salinization caused by increased storm surges, climate change, sea level rise, and anthropogenic factors poses a threat to coastal freshwater habitats. Changes in salinity may affect predator-prey interactions when salinity tolerance is not uniform among species. Dragonfly nymphs (predator) tend to be more tolerant of salinization compared to amphibian tadpoles (prey). While most amphibians cannot tolerate high salinities, tolerance varies among species. We tested the effects of increased salinity on interactions between dragonfly nymphs (Erythemis simplicicollis) and two tadpole species that differ in salinity tolerance: green treefrogs (Hyla cinerea) and a ranid (Lithobates sp.). After several days of salinity exposure, ranid tadpoles showed reduced activity relative to freshwater controls, as well as reduced survival in 24-hour predation trials. By contrast, the more salinity-tolerant H. cinerea tadpoles were unaffected by salinity, with no difference in either activity or vulnerability to predation. The reduced activity of ranids in the elevated salinity treatment may explain their vulnerability to predation, as they may be unable to evade predation. Salinization of these species' freshwater habitats may result in a community shift to green treefrog as the ranid species is more vulnerable and susceptible to predation. The results clarify how freshwater salinization affects predator-prey interactions in coastal habitats.

Microplastic studies: using penguin samples to exemplify the complexity of the task

Brianna DiMaggio, Andrew White, Jada Ormsbee, Gabriel Rodrigues, Sara O'Brien, Brian Walker

Microplastics (MPs) are becoming a serious concern for life on this planet. In humans, negative effects of these particles are beginning to be documented, but a more complete and precise understanding of how MPs impact all life on earth is imperative. As such, analytical procedures must be improved among myriad different stages from plastic creation, to ultimate deposition in their micro form in both abiotic and biotic destinations, as well as the subsequent effects of their presence in those destinations. Here we present exploratory data quantifying the levels of MPs in five species of captive penguins from two aquariums in the eastern USA. Our data show MP contamination being widespread across all penguin species examined, although significant variation exists both within and between species. Next, our intent is to use these data to examine how MP studies are an exercise in variability....due to such things as potential contamination at every stage of analysis, actual procedural differences in sample collection and handling, laboratory processing of samples, method of identification of potential MPs, and accuracy of results obtained. To be able to precisely determine the differential effects of MPs in the environment and its inhabitants, we must be able to accurately quantify their presence, identity and consequences of their presence. We argue that the tools and techniques to do such remain variable, at best.

Evaluation of depth perception in terrestrial and arboreal lizards

Sydney DiPietro, Eleanor Prosser, Victor Munteanu, Richard Blob

The visual perception system of arboreal (tree-dwelling) animals helps them investigate their habitats and perceive hazards, such as drop-offs, in efforts to limit the risk of falling. In this experiment, we observed the willingness of four species of lizards (representing arboreal and terrestrial ecomorphs) to navigate various drops in environmental height. We placed lizards in a custom-built apparatus that simulated a natural drop ranging between 0 to 30 cm. We filmed trials in aerial view and assessed the willingness of each lizard to traverse over the threshold, the duration of traversal, and which area of the threshold that traversal occurred (traversal path). Preliminary data indicate that arboreal lizards had a higher incidence of refusing to traverse drops compared to terrestrial lizards. Furthermore, when assessing the successful traversals, there were significant duration differences between species, but durations did not differ across different drop heights. There were also differences in traversal direction between species. The difference in the tendency to refuse traversal suggests that arboreal animals may take additional caution across substrates with height changes that terrestrial animals do not. Additionally, the traversal path may have helped to increase stability during traversal.

Tracking relationship formation in vampire bats

M. May Dixon , Raven Hartman, Guadalupe Garcia, Jorge López, Rachel Page, Gerald Carter

Social bonds are stable cooperative relationships that can play a critical role in animal wellbeing, survival, and reproductive success. However, less is known about how social bonds form. Experiments with vampire bats have 'jumpstarted' new social bonds by housing unfamiliar bats in 'forced proximity'. Here, we took an alternative approach that allowed us to measure (1) how movement and spatial exploration shapes social bonding, and (2) how social bonding affects existing social bonds. We housed three social groups of common vampire bats (n=22) in separate flight cages for two years. Next, we opened portals between these cages to allow bats to visit new spaces and meet outgroup bats. Before, during, and after this merging of groups, we tracked movement and rates of clustering, grooming, and food sharing among all bats using scan sampling, focal follows, on-bat proximity sensors, and 48 RFID antennas. We analyzed changes in social relationships using Bayesian Social Relations Models. Preliminary results show that 1) bats varied in their propensities to move into new areas which influenced rates of between-group contact; 2) RFID-based associations were strongly correlated with grooming and food sharing; and 3) ingroup bias in association declined quickly and stabilized, whereas ingroup biases in grooming and food sharing persisted longer. Our findings further explicate how spatial exploration might involve a trade-off between strengthening existing bonds and building new relationships.

Determining the expression patterns of ultraviolet sensitive opsins in *Gonodactylaceus falcatus*

Noah Doeden, Mireille Steck, Megan Porter

Opsins, a diverse group of proteins involved in light detection, are associated with vision but may also be tied to nonvisual functions such as circadian rhythms. These opsins may be expressed in other tissues, including the skin, brain, and nervous system. Stomatopod crustaceans, commonly referred to as mantis shrimp, are a taxonomic group notable for having exceptional opsin diversity. Select stomatopod species from Superfamily Gonodactyloidea possess at least three distinct opsins specialized for ultraviolet (UV) light detection, the greatest diversity found in UV-detecting animals. Three UV sensitive (UVS) opsins, uv1, uv2, and uv3, have been detected through transcriptomic analyses in both the larval and adult stages of Gonodactylaceus falcatus, an introduced stomatopod species found in Hawai'i. This is surprising as the larval and adult forms of G. falcatus occupy distinct environmental niches and possess drastically different eye types. To further investigate the diversity and localization of UV opsins in G. falcatus, we applied a combination of reverse transcription (RT) PCR and immunohistochemical (IHC) methods. Our study is the first to examine UVS opsin protein localization between life stages in any stomatopod. From our preliminary results, we observed the presence of uv1, uv2, and uv3 in both retinal and nervous tissues, implying a previously unexplored function of UV opsins beyond vision.

The effects of captivity on the bill coloration of male Northern Cardinals (Cardinalis cardinalis)

Carlie Dollar, Sara Patton, Rebecca Koch, Matthew Toomey, Yufeng Zhang, Geoffrey Hill

Carotenoid-based coloration is important for social signaling in many species of birds. In Northern Cardinals, Cardinalis cardinalis, males possess two distinct carotenoid-based signals, bright red plumage and orangish-red bills. The red keto-carotenoids necessary for both color ornaments cannot be synthesized de novo but are instead produced by metabolizing yellow carotenoids obtained from the diet. Feather coloration is produced in a narrow time window as feathers are grown during a cardinal's single annual molt. Once deposited in feathers, plumage pigmentation cannot be altered except by feather wear. In contrast, the carotenoid pigments that give rise to red bill coloration are produced and replenished continuously. Such static versus dynamic traits are predicted to show different responses to environmental perturbations. In this study, we captured Northern Cardinals and held them in cages to assess the effects of captivity on bill coloration, bill carotenoid content, and circulating carotenoids in the plasma. With these data, we aim to assess possible relationships between circulating carotenoids and carotenoid composition of the bill, whether bill color post captivity can be predicted by the bill color before being held in captivity, and differences in bill coloration between wild and captive birds.

Honey, I stuck the kids: an exploration of temporary adhesion in Ponerinae ant larvae

Sammie Dolloff, Sean O'Donnell, Alyssa Stark

Adhesion to various substrates is used by many animals and often critical to survival. Ponerinae, a large subfamily of ants (ca. 1,405 species), includes some species whose non-mobile larvae exhibit a unique adhesive strategy. Specifically, some larvae have adhesive tubercle or pad structures on their dorsal surface. These adhesive structures are posited to adhere the developing ants to the surface of the nest for easy feeding; however, descriptions of these structures are sparse and less is known of their mechanistic function. First, we classified these structures based on symmetry across the dorsal midline, presence of stalk, and number of distinct adhesive structures across all available Ponerinae species via direct observations, photos, diagrams, and descriptions of morphology in the literature. Then, we selected two genera (Hypoponera and Brachyponera) for SEM imaging to confirm distinct features of the adhesive structures. Next, to analyze the evolution of this trait, we looked at its distribution across the Ponerinae genera phylogeny using a presence/ absence analysis. Our results indicate that the presence of adhesive structures in certain genera is evolutionarily labile, winking in and out across the phylogeny. This may indicate a unique need for adhesive larvae in certain species based on habitat type or nest construction. Future work will include a biomechanical approach using force assays to quantify adhesive performance and a chemical analysis of the adhesive.

Climate drives selection for body shape in a high-elevation passerine

Beverly Domschot, Creagh Breuner, Jessica Malisch, Thomas Hahn, Thomas Riecke

Rapid morphological change is increasingly documented as a biological response to recent climate warming. Across bird communities, individuals are tending toward smaller bodies and proportionally longer wings as temperatures rise, suggesting climate-linked selection on body size and wing morphology. We tested this idea in a high-elevation songbird, the mountain white-crowned sparrow (Zonotrichia leucophrys oriantha), using a multi-decade capture-mark-recapture dataset (1996-2022). We fit Bayesian CJS survival models that integrated large-scale climate variability indexed by the El Niño Southern Oscillation (ENSO) with individual morphometrics (tarsus, keel & wing chord). Our models reveal climate-driven selection on wing morphology and body size: in warmer ENSO phases and years with positive temperature anomalies, survival increased with relatively longer wings at a given body size, while larger structural size showed neutral to negative associations with survival. Together, the results link a widely observed phenotypic trend of smaller bodies with longer wings to measurable fitness differences in relation to large-scale climate variability. By coupling individual morphology with ENSO dynamics in a survival framework, our study provides direct evidence that recent warming can reshape survival landscapes and thereby promote rapid morphological change in a montane passerine.

Picture pore-fect: Mapping shark electroreceptor pores using novel methods with 3D photogrammetry

Natalie Donato, David Edwards, Ethan Personius, Jessica Schulte, Taylor Chapple

Sharks can detect electric fields within their environment via their Ampullae of Lorenzini, subdermal clusters of sensory cells which manifest as gel-filled pores primarily across their head. The number and distribution of pores can vary based on the phylogeny, biology, and potentially life history stage of the shark, thus providing insights into species-specific behaviors and movements. Traditionally, the ampullary pore distribution is mapped on a flat plane by removing and illuminating the skin of a shark and tracing the pore positions. While effective, the process is time consuming and destructive, making it unsuitable for museum specimens and live individuals, so we developed a more efficient, entirely digitized method as an alternative. A 3D model is created using 3D photogrammetry, from which a "digital skin" (a 2D, 360-degree view of the head) is generated, allowing the ampullary pores to be efficiently and accurately mapped non-destructively. We then applied the method to select sharks of the Northeast Pacific, analyzing differences across and within species, and recording the ampullary pore maps of some species for the first time. The analysis provides further insight into the electrosensory system of sharks and demonstrates the effectiveness of a non-destructive method to map ampullary pores.

We are the data: lived experiences of neurodivergent professors in STEM

Cristine Donham, Petra Kranzfelder, Hillary Barron, Erik Menke

To date, there is a significant gap in the literature surrounding the experiences of neurodivergent instructors in higher education STEM. To address this, we explore the educational and professional experiences of four neurodivergent STEM professors in discipline-based education research (DBER) using a collaborative autoethnographic approach. Collaborative autoethnography engages a research team by pooling their lived experiences on selected sociocultural phenomena and collaboratively analyzing and interpreting them for commonalities and differences (Chang, Ngunjiri, and Hernandez 2013). This methodology involves the researchers pooling their lived experiences and collaboratively analyzing them for commonalities and differences. Taking from a range of data sources, such as autobiographical narratives, personal recollections, self-reflections, and free-form group discussions, we aim to gain a deeper understanding of how our educational training, interactions with colleagues, and the academic and professional environment have shaped, and been shaped by, our identities as neurodivergent people, STEM faculty, and education researchers. This talk will offer insights for faculty and practitioners on fostering more inclusive and equitable practices, with particular attention to qualitative methodologies that honor the perspectives and experiences of neurodivergent scholars and how that might influence the student experience.

Temperature-driven winter dormancy loss reshapes bacterial communities in *Astrangia poculata*

Anna Dormitzer, Mia Sarris, Megan Harrington, Ciaran Fitzpatrick, Alicia Schickle, Anya Brown, Sean Grace, Justin McAlister, Koty Sharp

The temperate coral, Astrangia poculata, provides a valuable study system for investigating organismal mechanisms for enduring environmental change. In the northern limits of its range along the eastern United States seaboard, A. poculata has historically demonstrated quiescence when water temperatures fall below 5 , serving as a survival adaptation during winter extremes. This dormancy period is associated with shifts in the holobiont's microbiome, with different suites of microbes governing the onset, maintenance,

and emergence from quiescence. However, as global sea temperatures increase due to human activity, A. poculata at our Rhode Island study site has responded by not entering its annual quiescent period. This absence has implications for the coral's energy stores; without a critical metabolic rest period, A. poculata may not have the capacity for maintaining normal growth and reproductive rates. In this study, we compare the microbiome of A. poculata from a season where colonies entered quiescence (2020-2021) to one where they did not (2023-2024). By sequencing the V4 region of the 16S rRNA gene, bacterial and archaeal microbiomes were assembled for the combined datasets. Differential abundance tests on these microbiomes will be used to elucidate which microbes are absent in non-quiescent samples, and how temporal abundance dynamics contribute to the observed physiological shift. The results of these analyses will be contextualized using water temperatures as a parameter that reflects ongoing environmental changes.

Sexual systems and reproductive strategies in mosses: evolutionary trade-offs and challenges

Wagner dos Santos

Mosses offer a unique perspective for understanding the evolution of plant reproduction, as their haplodiplontic life cycle and reliance on water for fertilization impose strong ecological and evolutionary constraints. Their reproductive biology is shaped by the alternation of generations, with a dominant gametophyte and a nutritionally dependent sporophyte. Within this framework, sexual systems (monoicy and dioicy) play a central role in shaping reproductive strategies, success, and persistence. Monoicous species may benefit from assured reproduction but risk inbreeding depression, while dioicous species promote genetic variability but face challenges of mate limitation and dispersal of motile gametes. Comparative studies suggest that these trade-offs contribute to the coexistence of both systems across habitats, from wet to seasonally dry environments. Reproductive outcomes, such as sex expression, sex ratios, and resource allocation to gametangia, further reflect the influence of sexual systems on fitness. Case studies from model species and diverse lineages illustrate how monoicy and dioicy interact with ecological conditions and evolutionary pressures, shaping the diversity of reproductive strategies in mosses. Understanding these dynamics is key to addressing broader questions in plant reproductive biology, including why different sexual systems persist, how reproductive trade-offs affect population structure, and how changing environments may shift reproductive success. Mosses, with their diversity and ecological significance, provide a valuable model for exploring the evolution of plant reproduction.

Shared and specific motor patterns underlying the diversity of flapping frequencies in flight

Benjamin Doshna, Leo Wood, Simon Sponberg

How does the nervous system adapt to produce different locomotor frequencies and flight styles in animals with similar muscle anatomy? Bombycoid moths, despite sharing highly conserved anatomy, exhibit a wide range of wingbeat frequencies (5–70 Hz) and different flight styles between hawkmoths and silkmoths. The scaling of muscle twitch kinetics suggests that moths cannot simply execute the same motor program at higher speeds, and variations in flapping frequency and flight style likely require different strategies for controlling unsteady turns. Therefore, we hypothesize that stable flight and turning rely on consistent motor patterns across the clade, with specific adaptations enabling maneuverability across different flight styles and frequencies.

We recorded comprehensive, spike resolved flight motor programs from 42 individuals across 16 species. We found shared patterns for turning such as bilateral timing asymmetries in downstroke and steering muscles that scaled with wingbeat frequency, so faster species generated larger torque from smaller asymmetries. We also identified family-specific patterns: silkmoths, with proportionally larger subalar muscles, activate them early in the downstroke, while hawkmoths activate them mid-downstroke and spend more time in that phase of the cycle. These shifts may contribute to the bobbing flight of silkmoths versus the hovering behavior of hawkmoths. This demonstrates both shared and specific coordination patterns within this clade, showing how conserved anatomy generates the diversity of flapping frequencies and flight styles in bombycoids.

From development to display: unraveling the sparkle trait in swordtail fish

Sashoya Dougan, Nadia Haghani, Paola Fascinetto-Zago, Molly Schumer

Coloration plays a fundamental role in the natural world, aiding in mate choice, defense, and communication. One striking type of coloration, iridescence, occurs when light interacts with reflective structures to create the appearance of color. Iridescence is widespread across taxa—including hummingbirds, morpho butterflies, and cephalopods—but its evolutionary drivers vary. This study investigates the development and environmental modulation of an iridescent trait called "sparkle" in the swordtail fish Xiphophorus evelynae.

To characterize the ontogeny of sparkle, we conducted weekly imaging of individuals from birth to eight weeks, documenting when, where, and how sparkle emerged. We further compared individuals reared in isolation versus social groups to assess whether the social environment influences sparkle development. Our analyses reveal consistent patterns in the timing and spatial progression of sparkle formation, with evidence that social context alters developmental trajectories.

These results highlight how environmental factors shape the emergence of ornamental traits and provide insight into the developmental dynamics underlying iridescent coloration in natural systems

House Sparrows as sentinels of antimicrobial resistance: a global ecological perspective

Nathan Dowling, Lynn Martin, Kailey McCain, Diego Santiago-Alarcon

Many putative reservoirs live in close proximity to humans and livestock. This proximity disposes such species to spillover risk, as most spillovers arise at least partly from opportunity. Although only a subset of pathogens infect multiple vertebrate species, all putative host species remain vulnerable to risks imposed by antimicrobial resistance (AMR), which spreads horizontally among bacterial pathogens. Here, we focus on House Sparrows (Passer domesticus) as indicators of AMR exposure to humans and livestock, asking how often and which AMRs they carry, as well as what conspicuous environmental factors predict prevalence among populations.

We hypothesized that (1) higher antibiotic use in healthcare and agriculture increases AMR prevalence, (2) House Sparrows near agricultural areas show higher prevalence, and (3) AMR prevalence decreases as country GDP increases. To test these predictions, we collected 205 House Sparrow gut samples from eight countries. We screened their DNA for nine resistance genes and used PCR with gel electrophoresis.

AMR prevalence in House Sparrows ranged from 29.2% to 66.7%. TetM (tetracycline resistance) appeared most frequently. GDP per capita best predicted prevalence, showing a negative association with TetM. Indexes of medical and agricultural antibiotic use, and proximity to agriculture and wastewater treatment plants, did not significantly predict prevalence. These findings suggest that stronger stewardship programs in higher-GDP countries help buffer the relationship between antibiotic use and AMR spillover into wildlife.

Teaching about the importance of allometric scaling in biology using comparative immunology

Cynthia Downs, Samantha Elliot

Immunology and allometric scaling are daunting topics for most students taking an undergraduate animal physiology course. Building upon research demonstrating that active learning improves retention and understanding of complex ideas, we developed a lesson about comparative immunology and allometric scaling for an upper-division Animal Physiology course. In this lesson, students explored how differences in body size affect both metabolic rates and immune cell concentrations. To ease the implementation for instructors, we build upon commonly used examples of why size matters, namely, a Science paper about a study that involved giving LSD to an elephant and scaling of metabolic rates. Students who completed this activity improved their scores on scaling questions included in a class exam by more than 29% over students who only received a lecture on the course material. Pre- and post-quizzes also demonstrate that the activity increased scores on questions about scaling and immune concepts. By requiring students to apply concepts

of allometric scaling, a fundamental concept in biology and physiology, to a system not typically considered in animal physiology courses, immunology, this activity enhanced students' understanding of that topic while introducing them to immune cell types. We believe this approach fills gaps within undergraduate physiology courses and improves understanding of topics central to animal physiology.

Exploring post-fire avian malaria dynamics in Mountain Chickadees (*Poecile gambeli*)

Aynsleigh Dragon, Linnea Schaefer, Zachary Cheviron

Avian communities are affected by wildfire through changes in movement, demographics, and stress. These factors may affect disease transmission and prevalence in post-fire wildlife communities, but empirical tests of these relationships are rare. Avian malaria is a common disease caused by a parasitic infection (Plasmodium sp.) and current projections predict an increase in prevalence of this disease. Avian malarial infection rates are high in certain species of the Paridae family, including the Mountain Chickadee (Poecile gambeli), whose range extends from California to Yukon. In 2021, the Dixie Fire burned over 900,000 acres in Northern California. Here, we explored the impacts of the Dixie Fire on the prevalence of avian malaria. We screened 114 Mountain Chickadee samples collected pre- (67 individuals) and post-fire (47 individuals). We used binary logistic regressions and Wilcoxon rank sum tests to identify relationships and potential predictors of avian malaria occurrence. We found that fire severity, elevation, and life stage are predictors of avian malaria infection. We also identified spatial (site) and temporal (pre-fire vs. post-fire) relationships to avian malaria presence. It is becoming increasingly important to explore disease dynamics in post-fire wildlife communities to understand risks associated with changing fire regimes.

Bumble bee diversity, abundance, and flower preferences across habitats in northern Indiana

Wiktoria Drapala, Stacy Sierra, Morgan Carr-Markell

Bumble bees are important pollinators of many plants, but some species are facing steep population declines. These declines stem partly from decreases in the diversity and abundance of flowers, which affect bumble bee nutrition. In this study, bumble bee abundance, diversity, and flower preferences were recorded across three habitat types in northeastern Indiana: forests, grasslands, and edges of managed lawns. There were four transects per habitat at each of two sites. Flower surveys documented the diversity and abundance of blooming plants. Bumblebee diversity surveys were conducted following a modified version of the Xerces Society's Bumblebee Atlas protocol. During these visits as many bumble bees as possible were caught during a one-hour period and briefly chilled on ice, recording the species, sex, and flower visited, and marking the bee with paint so that we did not recapture them. The surveys occurred during the summer and fall seasons of 2025. Five species were identified: two-spotted (Bombus bimaculatus), brown-belted (B. griseocollis), common eastern (B. impatiens), golden northern (B. fervidus), and lemon cuckoo bumble bees (B. citrinus). Bumblebee diversity was the highest in grassland transects, but the overall abundance of bumble bees was not significantly different across habitats. Bees significantly preferred common motherwort (Leonurus cardiaca), common milkweed (Asclepias syriaca), sweet clover (Melilotus sp.), and bee balm (Monarda fistulosa), which provides information for future bee-friendly planting projects.

Instructor thinking and context influence use of inclusive sex/gender curriculum in biology

Emily Driessen, Abbi Kivett, Aramati Casper, Joel Schneider, Sarah Eddy, Kelly Lane

Inaccurate sex/gender narratives have saturated the political landscape, resulting in legal restrictions for trans-spectrum and intersex folks. Biology educators can correct these false narratives to ensure both accurate scientific understanding and inclusion. To examine how and why biology instructors are reforming their sex/gender curriculum to be more accurate and inclusive, we interviewed a national sample of 22 undergraduate biology instructors about the sex/gender course materials they use, their thinking behind using these materials, and the contexts in which they teach. We noticed three themes: (1) subject area mediates perceived relevancy (i.e., the type of biology topics instructors' taught impacted the degree to which they felt accurate and inclusive sex/gender teaching strategies were applicable); (2) 'science' versus 'science adjacent' content (i.e., some instructors focused on teaching sex more accurately but then only either briefly differentiated between sex/gender or did not address gender at all because they felt gender is "not biology content"); and (3) concerns about assigning students to discuss these topics in groups (i.e., many of these instructors taught their entire courses using group work but worried that group discussions of these specific sex/gender topics would cause student discomfort). We can use these themes to develop targeted reform approaches that the biology education community will use in their own contexts.

Functional morphology and trophic impacts of gelatinous tentaculate ambush predators

Kevin Du Clos, Patricia Cosper, Kelly Sutherland

Tentaculate ambush predators (TAPs) are a functional group of gelatinous marine zooplankton, including siphonophores, cydippid ctenophores, and hydromedusae, that use static tentacle arrays to capture motile prey. TAPs are abundant in many marine ecosystems, and prey on a range of crustacean, fish, gelatinous zooplankton, and other prey. Estimating the predation impacts of TAPs is complicated, however, by difficulties associated with studying fragile gelatinous organisms, and prey capture events may be too infrequent for direct observations to be practical. The diversity of prey types and tentacle arrangements among TAPs suggests that prey capture structure morphology may be useful for categorizing predation strategies and possibly predicting predation impacts for species for which we have insufficient data. We are combining in situ and laboratory 3D tentacle reconstructions, gut content and feeding studies, and mechanistic prey capture models to explore the functional morphology of tentacle arrays and its contribution to predation impacts. We hope to better understand the roles that TAPs play in the important and understudied ""jelly web"".

Deconstructing body elongation in ray-finned fishes.

Summer Duba, Audrey Hales, David Collar

As the most diverse group of vertebrates on the planet, ray-finned fishes display striking variation in body shape, ranging along a continuum from deep-bodied or stout to extremely elongate and eel-like. Previous research has shown that body shape is associated with variation in habitat, swimming mode, and feeding behavior, but it is a complex phenotypic trait determined by multiple anatomical components. Evolutionary change in the cranial or vertebral skeleton can cause shifts in overall shape, and these anatomical characters may confer distinct functional consequences with ecological implications. For example, a greater number of vertebrae may increase flexibility and provide advantages in structured environments, whereas a longer head may affect feeding. In this study, we investigate variation in anatomy that underlies broad-scale diversity in body shape across ray-finned using measurements of body shape (as Elongation Ratio) and skeletal dimensions from a diverse comparative data set, spanning 2170 individuals from 680 species and 137 families. Fitting evolutionary models to these data and a phylogenetic tree reveals that body shape evolution is often associated with changes in the axial skeleton, but lineages vary in the degree of correlation between changes in the precaudal and caudal axial regions. This variation also shows links to differences in ecological circumstances, suggesting that body shape diversity is a product of diverse selective demands.

Functional trait variation and reverse phenology in tropical dry forest tree *Bonellia nervosa*

Ciara Duff, Bridget McBride, Gerardo Avalos

Tropical dry forest (TDF) resource pressures, including extreme seasonal variations in rainfall and sunlight, have produced a diversity of functional strategies in plant species. Bonellia nervosa is a TDF understory tree with reverse phenology, producing leaves, fruits, and flowers during the dry season when

other plants senesce. This unique strategy presents an opportunity to study intraspecific trait variation (ITV) of a TDF species to elucidate the mechanisms driving trait plasticity. We examined how plant size, reproductive stage, and canopy structure influence leaf trait variation in B. nervosa during the dry season. We measured physical and photochemical traits of 54 individuals: height, diameter, reproductive status, specific leaf area (SLA), leaf thickness, leaf water content, leaf stomatal density, and chlorophyll fluorescence as a proxy for photochemical efficiency. We used hemispherical photographs of the surrounding canopy of each individual to estimate canopy openness, leaf area index (LAI), and transmitted light. A principal component analysis and linear regression models revealed relationships between canopy structure variables and SLA, indicating leaf structural acclimation to microclimatic light conditions and the significance of environmental, rather than ontogenetic, factors driving ITV in B. nervosa. Our results support previous evidence that B. nervosa's phenological timing is driven by light conditions rather than water availability during the dry season, suggesting that reverse phenology in phreatophytic species is functionally decoupled from seasonal water stress.

Disentangling the roles of neural and peripheral androgen signaling in paternal care in birds

David Duffey, Josephina Fornara, Kim Rosvall

Androgens play an important role in regulating suites of traits, from reproductive physiology to parental behavior. Androgens affect these traits by binding to androgen receptors (ARs) expressed in neural and peripheral tissues. However, it remains unclear how independent versus coordinated androgenic signaling across tissues shapes the phenotype. We used pharmacological agents to strategically block ARs in free-living male tree swallows (Tachycineta bicolor) during the chick-rearing period, when males regularly provision offspring. We accomplished this using subcutaneous implants containing either flutamide (FLUT), which blocks ARs throughout the brain and body, or bicalutamide (BICAL), which cannot cross the blood-brain barrier and thus acts on ARs in the periphery but not the brain. We measured the effect of each treatment on the frequency of male provisioning visits in order to test three non-mutually exclusive hypotheses: (1) If paternal care is sensitive to androgen signaling in the brain, FLUT males should provision differently than BICAL and placebo males; (2) If paternal care depends on androgen signaling in the periphery, BICAL and FLUT males should provision differently than placebos; (3) If paternal care depends on coordinated androgen signaling between the brain and body, BICAL males should provision differently than FLUT and placebo males. Preliminary results support our final hypothesis, suggesting coordinated androgen signaling in the brain and body plays an important role in orchestrating the phenotype of paternal males.

Do gametes or adult communication coordinate reproductive output of the ctenophore *Mnemiopsis*?

Orianna Duh, Allison Edgar

Communication between conspecifics is a key part of the sexual reproduction of many organisms. Simultaneously hermaphroditic species that possess the ability to self-fertilize may communicate in order to coordinate a behavior called gamete trading that promotes outcrossing. This involves conspecifics alternating between producing male and female gametes while in each other's presence. Prior research suggests that Ctenophora may have some form of signaling that impacts their reproductive output. We further investigated this possibility by asking whether actual gamete exchange or transfer of smaller molecules through water exchange mediate this phenomenon. We spawned lobate Mnemiopsis leidyi in pairs in different treatment tanks that allowed for a range of interactions including: physical contact allowed, no contact but gamete trading allowed, no contact but water transfer allowed, and no interaction at all. As ctenophores are the sister group to all other animals, knowing more about their ability to communicate with conspecifics can provide insight into how communication evolved in early animals.

Assessing locomotion in early mammals: integrating comparative anatomy and ancestral reconstructions

Connor Dumas, Jonathan Nations, Lucas Weaver, David Grossnickle

Mammals and their extinct relatives display a wide range of locomotor strategies, including arboreality, which evolved repeatedly across their history. Yet the ancestral locomotor behaviors of the earliest mammals remains unclear, in part due to the scarcity of postcranial fossils for early mammals. Recent interpretations of new discoveries suggest arboreality may have been the ancestral condition for major lineages such as therians (placentals and marsupials). To evaluate this hypothesis, we analyzed appendicular skeletal features closely tied to locomotor behavior in extant mammals. We collected linear measurements from ~50 Mesozoic species and compared them against regression models derived from a dataset of ~285 extant mammal species. These models incorporate variables that reliably distinguish tree-dwelling from ground-dwelling taxa. Further, we incorporate ancestral state reconstructions, which combine morphometric data with phylogenetic models to estimate the probability of arboreal versus terrestrial habits across important phylogenetic nodes. By including fossil taxa within this comparative and phylogenetic context, these analyses evaluate alternative scenarios for the origins of major clades, testing whether groups such as crown Mammalia and Theria arose through "tree-down" (ancestrally arboreal) or "ground-up" (ancestrally terrestrial) evolutionary pathways. Our results provide less support than expected for arboreality in early groups, with Jurassic gliding haramiyidans as a notable exception. These findings challenge the view that arboreality was widespread or ancestral among early mammals.

Mapping feeding-strike related functional morphology across Syngnathoidei

Alexander DuToit, Graham Short, Cassandra Donatelli, Karly Cohen, Roi Holzman

Syngnathoidei, a diverse suborder of seahorses, pipefish, snipefish, shrimpfish, cornetfish, and trumpetfish, are specialized suction feeders capable of capturing small zooplankton with remarkable speed. These rapid feeding strikes are powered by elastic energy stored in the epaxial tendons, which is released during prey capture. In seahorses (genus Hippocampus), this system is further enhanced by an elongated sternohyoid tendon, creating a secondary spring that supplements the epaxial system. The effect of this increasing functional complexity on the wider mechanical linkage system remains unclear in this morphologically diverse clade. Here, we used µCT scan data to measure functionally relevant bone lengths across 30 species from 5 families. We then compared those lengths across a phylogeny to determine where certain features evolved. We found significant correlations between various functional measurements and identified a robust phylogenetic basis for the neurocranial lever ratio and urohyal length. The latter marks a transition from a one to two-spring system between pipefish and seahorses, as an elongated sternohyoideus tendon replaces the shortened urohyal bone. We also report ossification of the epaxial tendon in several closely related pipefishes, a feature that may constrain their ability to generate high-powered feeding strikes relative to other lineages.

Peristaltic motion of centipedes in confined spaces

Wesley Dyar, Malaika Taylor, Christopher Pierce, Daniel Soto, Daniel Goldman

Centipedes navigate diverse and complex environments by propagating limb-stepping waves as well as waves of body bending. Some centipedes exhibit peristaltic motion within their burrows, described by Manton (1965) as an earthworm-like extension and contraction of body segments. However, centipede peristalsis has not been studied systematically. We studied peristaltic motion in two species: Scolopendra subspinipes and Scolopendra polymorpha (body lengths: 80mm – 145mm, body width 6mm – 10mm, mass: 3g – 10.5g), by developing a simplified model of a burrow that allowed us to quantify the body kinematics. We created a rigid channel with a fixed 15mm height and a width that could be varied in 2mm increments between 8mm and 20mm and used a funnel to direct the centipedes into the channel. Multiple trials were performed at each channel width with individual centipedes from each

species (12 S. subspinipes and 5 S. polymorpha). We observed the behavior with a high-speed camera and tracked the kinematics via markers painted on each segment. As the width of the channel decreased, the centipedes switched from undulatory movement to peristalsis at a characteristic average body segment width to channel width ratio of approximately 0.5. We hypothesize that peristalsis enables locomotion in confined spaces which would otherwise restrict limbed locomotion. We will test this by creating a robophysical model in collaboration with Ground Control Robotics, Inc.

Discrimination and color vision in diurnal frogs

Ashley Dye, Lauren Shinn, Galina Aglyamova, Andrew Rubio, Adam Stuckert

Color is vital to animal communication, influencing mate attraction, territorial defense, and predator signaling. Yet we lack a clear understanding of how receivers' visual systems influence the evolution of color, leaving a critical gap in predicting how selection drives signal diversity. Color perception begins when light enters the retina and interacts with photoreceptors sensitive to specific wavelengths. Color discrimination arises from the spacing of photoreceptor sensitivities and neuronal opponency. Visual acuity, the ability to resolve objects or patterns, further shapes how organisms perceive their environment. Together, detection, discrimination, and acuity determine visual perception, which can be evaluated with visual models and behavioral experiments to infer the evolution of visual systems under different selective pressures. Aposematic poison frogs exhibit conspicuous coloration that deters predators and may be used by conspecifics to make choices about mating behaviors. We hypothesized that poison frogs utilize color in intraspecific interactions and should therefore exhibit discrimination between ecologically relevant colors. To test this, we used visual models based on measured photoreceptor sensitivities to predict color discrimination between morphs of Dendrobates auratus and Ranitomeya imitator. We assessed visual acuity and color discrimination with an optomotor response test. Our results suggest R. imitator can discriminate between morphs, whereas D. auratus shows limitations in discrimination. These findings provide insight into poison frog visual ecology and its role in the evolution of aposematic signals.

Climate change intensified temperature regimes impact amphibian growth and development

Shayna Earl, Alycia Lackey, Mikus Abolins-Abols

Anthropogenic climate change shifts natural temperature regimes, leading to extreme variations in seasonal temperatures. Across taxa, increases in temperature have been shown to cause earlier phenology, decreased body size, and increased mortality. While there is an established understanding of how increases in mean temperature might impact organisms, there is a gap in our understanding of the impacts of increases in temperature variation. Amphibians are especially susceptible to environmental change, particularly in early life stages where behavioral or physiological temperature regulation is limited. Using a mesocosm set up, we assessed how mean temperature (control and warming) and heat stress (chronic versus acute) could influence larval salamander growth and development when exposed to experimental heat waves. We monitored the salamanders from hatch to metamorphosis and compared the effects of temperature treatment on salamander growth, developmental timing, and stress hormone levels. This work aims to demonstrate how environmental conditions impact salamander larval development and the relative importance of these factors at different points in time. This work highlights how the role of temperature variation in salamander growth and development is context dependent given the larval life stage. Our findings provide insights into how taxa may be responding to increased environmental pressures due to climate change, and why we may see interspecific differences across natural populations.

Exploring the effects of low pH on red abalone (*Haliotis rufescens*) grown in co-culture

Chase Ebner, Geoffrey Osgood, Michael Graham, Luke Gardner, Scott Hamilton, Maya deVries

The critically endangered red abalone (Haliotis rufescens) is one of many marine calcifiers thought to be negatively affected by increasing ocean acidification. By using Integrated Multi-Trophic Aquaculture (IMTA), where two species from multiple trophic levels are cultured together, to grow both red abalone with red seaweed dulse (Devaleraea mollis) in one tank, we examined the pH buffering effects of seaweed on abalone metabolic physiology while further improving the IMTA system design for the aquaculture industry. Specifically, we grew 250 abalone per tank in 15 tanks assigned to 3 different pH levels (7.2, 7.5, 8.0; 5 replicate tanks per treatment) at Moss Landing Marine Labs' Aquaculture Facility. After 6 months, we coupled growth measurements and respirometry with indicators of oxidative stress to understand ocean acidification impacts on metabolic physiology. Preliminary results from the growth data showed red abalone grown in the high pH treatment were significantly heavier (8.0- 10.3g, 7.5- 7.38g, 7.2- 4.92g) and larger (8.0- 38.9mm, 7.5- 35.4mm, 7.2- 31.3mm) compared to those grown in the low pH treatments. This information will increase understanding of the broad physiological changes that both wild and farmed abalone will experience under changing ocean conditions

Sex, gender, and reproduction content that supports students with queer genders in biology courses

Sarah Eddy, Sam Ahler, Tom Schlechter, March E., Ly Gutierrez, O. Turner, Beth Wittmann, Kelly Lane, Aramati Casper

Queer undergraduates describe STEM classroom climates that are both hostile and silent on queer identities leading to experiences of social exclusion, devaluation, and discrimination. In the few studies specifically focused on trans and non-binary undergraduates (i.e. students with queer genders), they report more hostile conditions than any of their peers. In undergraduate biology, where core courses include topics related to sex, gender, sexual behavior and sexual and romantic orientation, the content itself may influence course climate. Yet, biology is the study of the diversity of life, including diversity across sex, gender, sexual behavior, and orientation, which also makes course content a prime site for narrative that support students with queer identities. We interviewed 53 undergraduates with queer genders to understand the narratives about sex, gender, sexual behavior, and orientation they encounter in biology courses. We identified three narratives that both supported the belonging of these students and their ability to challenge harmful societal narratives. These three narratives manifest in the classroom in multiple ways ranging from short disclaimers to elaborate case studies. The ways the narratives manifested impacted their efficacy for at least some participants. These narratives and how they manifest provide potential starting points for interventions designed to support students with queer genders in biology classrooms and, at the same time, more accurately teach the biology of sex, gender, sexual behavior, and orientation.

Behavioral correlates of within- and among-nest thermal variation in a cavity-nesting species

Omayah El-Salim, Emmy James, Kim Rosvall, Elizabeth Derryberry

Global temperatures are rising rapidly, reshaping the thermal landscapes that animals must navigate. For cavity-nesting birds, nest temperature strongly affects offspring development and survival, yet not all individuals experience the same conditions. Within a nest box, areas closer to the entrance may receive more airflow and stay cooler. Among nest boxes, there may be variation in thermal environments. We quantified thermal variation within and among nest boxes used by free-living tree swallows (Tachycineta bicolor). Using GIS mapping and iButton temperature loggers, we measured temperature differences within individual boxes and among nest sites. We also recorded environmental variables that may influence nest microclimate, such as canopy cover or water proximity. To link thermal variation to behavior, we scored chick movements throughout the nest box in ImageJ via scan sampling. We also monitored nest box usage across the breeding season to infer adult nesting settlement. If within-nest thermal variation is large, chicks may move toward

cooler microsites in the nest. If across-nest thermal variation is large, adults may preferentially nest in some boxes over others. By integrating behavioral observations with fine-scale thermal data, our study highlights how chick micro-movements and adult site selection may function as behavioral strategies for coping with warming climates. These insights also inform management practices, including strategic placement of nest boxes under climate change.

How much zooplankton do coral-reef fish eat (in situ)?

Hadar Ella, Eric Orenstein, Paul Roberts, Irena Kolesnikov, Tomer Shaulov, Jules Jaffe, Amatzia Genin

Coral reefs are among the most productive ecosystems on Earth. The unknown sources of allochthonous nutrients needed to support the reef's high productivity have puzzled researchers since the 1950's (termed the "Paradox of the Reef"). Recent studies have shown that the import of allochthonous nutrients through the consumption of plankton by reef inhabitants can resolve this enigma. However, zooplankton consumption has never been quantified in situ. Using a state-of-the-art, autonomous underwater microscope, we measured, for the first time, predation rates and prey selectivity by three species of common zooplanktivorous fishes in a Red Sea coral reef. Our method also allowed assessment of the effects of current speed, water temperature, and prey density on those rates. A single group of fish removed on average 30% of the zooplankton passing through it. Such a rate contributed a considerable amount of nutrients to the reef, partly explaining the "paradox". The effects of current speed, prey density, water temperature, as well as prey selectivity greatly varied among species. The inter-specific differences can explain corresponding differences in their typical group size and geographic distribution. Our study introduces a new technique to quantify in-situ zooplankton predation, thereby contributing to the understanding of ecosystem functioning in coral reefs.

Angular spring inverted pendulum model predicts three sea star gaits and torque–Froude scaling

Olaf Ellers, Amy Johnson

An angular spring inverted pendulum model, which outperforms other models in predicting slow walking in flies, was applied to sea star locomotion. The model predicts three gaits: crawling, walking, and grounded running. Crawling and grounded running (the "bouncy" gait) have been previously identified, while walking was detected here in kinematic data after being predicted by the model. Because the model does not use a leg spring, it requires constant leg length—a condition supported by nearly constant leg length observed in our data for grounded running. For crawling, the model requires unsynchronized podial movements and/or leg length changes, since individual podia cannot generate sufficient torque to lift the animal under fixed leg length. In grounded running, synchronous podia can generate enough torque to do so. The model further predicts locomotion at low Froude number, as observed, and that Froude number is a function we named Torque number (= dimensionless angular spring factor), which indexes the solutions to the governing differential equations. The model underestimates the observed period of grounded running, probably due to the assumption of a constant torque spring factor. Incorporating a temporally variable angular spring factor could improve predictions. Nevertheless, this simple model yields insight into low Froude number dynamics of sea star locomotion.

High-throughput screening of marine microbial extracts for antimicrobial activity

Aidan Elliot, Kirstie Francis

With the rise of antibiotic resistance genes, it is critical to revitalize efforts to discover new and effective treatments for drug-resistant pathogens. Marine microbes are a robust source of unique compounds, evolved in high stress environments, that hold the potential for new pharmaceutical discoveries. This project aims to screen crude extracts and fractions derived from marine microorganisms for antimicrobial activity. 200 chemical samples were tested via high-throughput screening for growth inhibition activity against Vancomycin Resistant Enterococci (VRE) and drug-resistant Candida auris. These pathogens are listed as serious and urgent threats respectively by the CDC. Of the 200 samples screened, 7 fractions had over 50% inhibition against one or more pathogens. All 7 of the active fractions exhibited activity against C. auris while only 1 active fraction exhibited activity against VRE, potentially indicating broad spectrum activity of this active compound(s). One of the fractions that was active against C. auris, SIEA1-12-24, was analyzed and further fractionated using high performance liquid chromatography (HPLC). The subsequent four fractions were then retested, and C. auris growth inhibition was observed in the last two fractions, indicating the active compound(s) elutes in the more non-polar portion of the solvent gradient. Future directions include purifying more material for compound identification and structure determination.

Habitat utilization of abyssal benthic boundary layer zooplankton influences community dissimilarity

Gabrielle Ellis, Oliver Kersten, Eric Vetter, Jeffrey Drazen, Erica Goetze, Craig Smith

Marine species ranges are often large, contributing to relatively high community similarity over space, with variations based on dispersal limitations and substrate requirements. Effective ecosystem management necessitates accurate species ranges, yet ranges are largely unknown within abyssal ecosystems, including those considered for deep-sea nodule mining. We tested the influence of habitat utilization (benthic, benthopelagic, holoplanktonic) on abyssal biogeography among benthic-boundary layer (BBL) zooplankton spanning a nodule ecosystem. Lander-mounted plankton pumps collected BBL zooplankton in-situ in the Clarion Clipperton Zone (CCZ, 28 stations, >3,700 km range), the target area for nodule mining. Community metabarcoding (18S V1V2, 18S V7V8, mtCOI) was used to characterize a diverse suite of taxa and define habitat assemblages. Community dissimilarity increased with increasing geographic distance, with stronger relationships observed from total, benthopelagic to benthic assemblages. Ranges were not significantly different based on habitat utilization (1,196 ± 56 km average range), suggesting that community dissimilarity across the seafloor is likely not due to dispersal limitation, but instead due to habitat availability. In the context of mining, many fauna had ranges that extended between nodule exploration licenses and neighboring regional protected areas in the CCZ, yet nodule-obligate fauna had among the most localized ranges (e.g., bryozoans, 165 ± 33 km). Our results stress that protected area designation must be based on habitat representivity and highlight the need for robust environmental data to ground-truth faunal habitat requirements.

Integrating extreme heat into studies of organismal behavior, physiology, and species distributions

Diego Ellis Soto, Dan Noble, Michael Kearney, Piet Arnold, Patrice Pottier, Owen Atkin, Alison Robey, Jeremy Cohen

A defining feature of climate change is the increasing frequency, intensity, and severity of extreme weather events. Among them, extreme heat is recognized as a critical driver of ecological and evolutionary change. Yet its integration into organismal biology remains limited, in part because definitions are inconsistent and metrics are not standard and user-friendly workflows and guides are lacking for many biologists. Intense heat episodes can exceed physiological limits, alter animal movement, restructure geographic ranges, and increase extinction risk more than changes in mean climate. We present a methodological roadmap, with reproducible code, for integrating extreme heat into studies of behavior, physiology, biophysical ecology, species distributions models (SDMs), and population dynamics. First, we provide standardized computational approaches to define and quantify extreme heat. Second, we fit species distribution models for California Quail (Callipepla californica) that include metrics of extreme-heat and showcase improved habitat suitability, particularly at range edges. Third, we compute biophysical simulations to quantify exposure and thermal stress of sleepy lizards (Tiliqua rugosa) during extreme heat across distinct microclimates. Finally, accounting for explicit thermal histories in population simulation models, we show that clustered heat extremes—missed by averages—can increase the risk of population collapse. As extreme heat events increase, incorporating their dynamics is essential for understanding ecological and evolutionary change, designing experiments across species' geographic ranges, and supporting conservation in a rapidly warming, and unpredictable, world

Agility is similar in escape and agonism in hummingbirds, but fighting is more behaviorally rich.

Rosalee Elting, Bo Cheng, Haoxiang Luo, Bret Tobalske

Aggressive encounters among hummingbirds are common and appear to escalate in a predictable manner. Our recent research suggests a looming stimulus elicits stereotypical, brief escape maneuvers requiring extreme power output and agility. We sought to test whether performance during intraspecific agonism would be more extreme than during escape. Using 3D kinematics from outdoors, we studied in detail an escalated encounter between two juvenile male Rufous hummingbirds (Selasphorus rufus) that included spiral maneuvering flight, upside-down flight and bill jousting. Total displacement during this fight exceeded that of escape in other species (165cm vs. 10cm). Climbing (0.65m) resulted in gain of potential energy not exhibited in escape (11.3mJ vs. 0mJ). To avoid collision with their competitor, fighting birds exhibited decelerations that were double the magnitude of those exhibited by escaping birds. Use of asymmetries in wing extension and trajectory were similar between escape and fighting. During fighting, maximum instantaneous asymmetry in wing extension was 18% (mean: < 4 %) and maximum instantaneous asymmetry in wingtip velocity was 12.9 m/s (97% of average wingtip velocity). Thus, while agonistic encounters may be resolved with behaviors of low power requirements (signaling, chasing), encounters can be behaviorally richer than escaping and comparable for peak agility and power requirements. ONR N00014-24-1-2044.

Humoral immune responses differ according to antigen in pythons

Daniel Emanuel, Dale DeNardo, Derek Benson, Susannah French

Humoral immunity provides a robust defense against pathogens through the production of antibodies with diverse functions, yet it remains poorly understood in ectotherms. In this study, we compared the extent and time course of the humoral immune response, measured as circulating levels of antigen-specific IgY to two commonly used non-pathogenic antigens in male and female Children's pythons (Antaresia childreni). Two subsets of snakes from the same colony were used; one subset received either lipopolysaccharide (LPS) or a control and the other subset received keyhole limpet hemocyanin (KLH) or a control. Blood samples were collected prior to treatment and subsequently at set intervals following the immune challenge. IgY concentrations were measured using indirect ELISAs for the specific antigen. LPS injections lead to an initial decrease in LPS-specific IgY and no significant IgY production was observed throughout the study. In contrast, KLH injections elicited a robust IgY response, increasing from day 21 through day 100 and subsequently decreasing after day 100. These results demonstrate that KLH may be a more effective antigen for studies investigating humoral responses in reptiles. This may be due to its novelty to these animals, whereas the snakes likely had variable prior exposure to LPS-like antigens, since they are in the walls of gram-negative bacteria. These results provide important context for understanding the variability of the humoral immune time course in reptiles.

Only some species that engage in injurious male-male combat have sexually selected shields

Zachary Emberts, Isaac McEvoy, Lauren Cirino

When individuals of the same species engage in one-on-one fights they are often fighting over access to food, shelter, or mates. Many species that fight over access to mates have evolved elaborated morphological structures that they use during these fights, which are referred to as sexually selected weapons. Several studies have shown that the size and shape of these weapons can influence offensive capability. Some species have also evolved morphological structures that enhance their defensive capability, which we refer to as sexually selected shields. However, much remains unknown about sexually selected shields, including which species have them. Here, we investigate 1) whether the leaf-footed bug Acanthocephala femorata has a sexually selected shield and 2) how increasing a male's defensive capability influences contest outcomes. This species was selected because it engages in injurious male-male combat and is closely related to another leaf-footed bug species, Pachylis neocalifornicus, that has a sexually selected shield. However, we found limited evidence, if any, to suggest that Acanthocephala femorata males have evolved structures to prevent fighting-related injuries from occurring. Moreover, when we experimentally enhanced a male's defensive capability, we found no evidence to suggest that it provided a fighting advantage. Thus, there appears to be limited selection to evolve sexually selected shields in this species. Overall, our results suggest that only some species that engage in injurious male-male combat have sexually selected shields.

Vibrio fischeri induces intrinsic apoptosis during *Euprymna scolopes* light organ development

Madison Emery, Elizabeth Heath-Heckman, Bethany Rader

The presence of beneficial microbes serves as a post-embryonic developmental cue in a wide array of metazoan species. However, the mechanisms through which mutualistic bacteria induce developmental processes such as apoptosis are not yet well understood. One of the leading model systems utilized to study bacteria-induced developmental apoptosis is the Hawaiian bobtail squid, Euprymna scolopes, whose symbiont Vibrio fischeri induces several developmental events upon colonization of the squid's light organ. Upon hatching the light organ possesses ciliated epithelial fields and appendages that facilitate the collection of V. fischeri from the ambient seawater. These appendages undergo regression via apoptosis following exposure to a combination of symbiont-derived lipopolysaccharide (LPS) and peptidoglycan (PGN). To better understand the molecular pathways underpinning bacterial-induced development occurring in these appendages, we collected isolated appendages from aposymbiotic and symbiotic E. scolopes light organs (18h) for RNA sequencing. Differential gene expression analysis indicates that symbiotic appendages are undergoing intrinsic apoptosis in response to excess levels of cytosolic calcium. To confirm, we performed Rhod-3 live staining and showed that symbiotic ciliated epithelial fields have more cytosolic calcium than their aposymbiotic counterparts. This work advances our understanding of how mutualistic bacterial cues can initiate signal transduction to induce developmental programming and may serve as a foundation upon which we can begin to disentangle the ways in which more diverse and complex microbial communities influence post-embryonic development.

Song performance under thermal stress: transcriptomic insights from zebra finches

Tara Empson, Melissa (Misty) Proffitt, Tamara Smith, Maëlle Lefeuvre, Emily Levy, Kim Rosvall, Elizabeth Derryberry

Rising global temperatures are altering the conditions under which animals perform fitness-related behaviors, including mate attraction. In zebra finches (Taeniopygia castanotis), male song is a key mating signal, but song output declines at high temperatures for some individuals more than others. We investigated the behavioral and neurogenomic mechanisms underlying this variation by exposing males to either thermoneutral or acute heat challenge conditions. Males that maintained lower body temperatures during the heat challenge panted less and produced more songs, suggesting a physiological basis for behavioral tolerance. Transcriptomic profiling revealed widespread temperature-related changes in brain gene expression (song control nuclei), but few in the syrinx (vocal control musculature). Our results demonstrate that responses to heat are phenotype-dependent and vary among individuals, providing a potential substrate for selection. Because females typically prefer high-output singers, mate choice may indirectly select for underlying mechanisms that promote behavioral tolerance of extreme thermal conditions.

Hydrodynamics of remora body shape

Catherine Eno, Aren Hellum, Brooke Flammang

Remoras (Family Echeneidae) comprise 8 extant fish species known to attach to live hosts through a highly modified dorsal fin, allowing phoresy on various host species. While attached, remoras experience a wide range of flow regimes due to host swimming speeds and body shape variability. All echeneids have a streamlined shape that may aid in reducing disruptive hydrodynamic forces. However, the variation in forces among echeneid body shapes has not been quantified. Resin-printed 3D models of each species were attached via their disc to a load cell in a high-speed water tunnel to measure drag, lift, and

moments. Force data was collected at speeds with respect to freestream flow to replicate the range of speeds and angles remoras experience on swimming and maneuvering hosts. We found that the slender generalist Echeneis naucrates experienced the lowest drag forces (8.8N at 10 m/s) as compared to the other generalist species E. neucratoides and Pterichthyes lineatus. E. naucrates was less sensitive to changes in speed and orientation angle, exhibiting a slower rate of change of drag with increasing velocity. Among the specialists and overall, the more bluff-bodied Remora brachyptera, known for exclusively attaching to fast swimming billfishes, experienced the highest drag force (28.8N at 10m/s). To further investigate the hydrodynamic forces, time-resolved 4D-PIV experiments were conducted on each model to characterize the flow field.

A secretory protein expression system for growth factor conditioned media using tilapia cell culture

Isabel Enriquez, Jens Hamar, Dietmar Kueltz

The colonial marine tunicate Botryllus schlosseri is a primitive chordate relative of higher vertebrates and capable of rapid asexual reproduction via new buds weekly, making it an ideal simplified model of chordate physiology studies. In vitro culture of Botryllus cells would greatly enhance mechanistic studies using this model. However, immortalized cell lines or extended primary culture methods do not exist for this species and most other marine invertebrates. Growth factors are key media components for in vitro cell culture of which Botryllus specific homologues are not commercially available. We have developed expression systems capable of high ectopic protein production from transposon transgene systems in a tilapia cell line. This system was modified to add a peptide secretory signal to expressed proteins leading to their secretion into the ambient media. Effectiveness of the system was verified using GFP which did not accumulate intracellularly and was enriched in the media compared to a GFP control without the secretory signal. Strong candidate Botryllus growth factors were identified by protein blast of well characterized vertebrate growth factors (such as FGF and IGF) against the predicted Botryllus proteome. Current work includes cloning these Botryllus growth factor coding sequences into the tilapia cell secretory expression system and application of the resulting conditioned media to Botryllus cells in efforts to increase cell proliferation. Supported by NSF grants NSF MCB- 2127516, IOS-2209383.

Ecological airdrops: can seabird guano supplement healthy coral reef microbiomes?

Hannah Epstein, Kalia Bistolas, Cassandra Benkwitt, Rebecca Vega Thurber

Seabirds provide a critical nutrient link between oceanic environments and tropical islands in what is known as the 'circular seabird economy', a process by which seabirds feed in open ocean, return to islands to nest and roost, and deposit guano on islands and nearshore habitat like coral reefs. Despite their importance, seabirds remain some of the most threatened bird taxa. Among the myriad climatic threats, localized bio-invasions like the introduction of invasive rats also endanger seabird populations through predatory activities, interrupting key nutrient transfers. Eradicating invasive rats is a management action now recognized for its potential to provide cross-ecosystem benefits, sparking calls to promote marine conservation via island restoration. Yet, we lack effective monitoring that crosses this land-sea interface. Microbes may hold the key as they respond rapidly to nutrient shifts and can provide early biological indicators as rats are eradicated and seabirds return to island ecosystems. Here, we examined both spatial and temporal changes in island-adjacent coral reef microbial community compositions, including in seawater, marine sediments, and corals, to assess the impact of seabird nutrients before, during, and after rat eradication on a tropical Pacific atoll. Some microbial taxa correlated strongly with nutrient levels entering nearshore habitats and may represent promising microbial indicators for characterizing the impact of seabird nutrient subsidies on reef and organismal health and assessing the efficacy of cross-ecosystem management practices.

Scanning scaley shark skin: Quantifying 3D variation in denticle morphology of bonnethead sharks

Hannah Epstein, Jamie Knaub, Tricia Meredith, Marianne Porter

The epidermis of shark skin is covered by dermal denticles, tooth-shaped scales embedded in the dermis, which contribute to drag reduction, abrasion resistance, and hydrodynamic performance. Previous comparative work on denticles shows that denticle shape and ridge spacing vary interspecifically. Denticle morphology also varies along the body and is correlated with ecology. When focusing on one species, the bonnethead shark (Sphyrna tiburo), we found that denticle ridges and overlap between denticles varied with age classes. Our previous work used scanning electron microscopy to assess denticles in 2D. Here, we quantified 3D variation in denticles across body regions (dorsal and ventral) of female bonnetheads (N=8) using micro-computed tomography (micro-CT) scans to examine ridge morphology and overlap from various perspectives. We created 3D segmentations of denticles using SlicerMorph, and measured denticle crown aspect ratio (length:width), ridge height, ridge spacing (distance between ridges), and denticle density and overlap across dorsal and ventral regions. We hypothesized that dorsal denticles would exhibit higher aspect ratios, more pronounced ridges, and lower density, to maximize drag reduction, while ventral denticles would have opposite morphometrics, including more overlap, for greater protection and abrasion resistance. The use of high-resolution scans enables precise 3D quantification of denticle morphology, offering insights into intraspecific shark variation and biomimetic design with broader ecological and engineering applications.

Complex arrangement: The impact of intertidal environments on the lateral line of bony fishes

Jimena Escamilla Reyes, A-bel Gong, Lauren Simonitis, Aubree Jones

The mechanosensory lateral line system in fishes responds to the local environmental hydrodynamic cues. Lateral line canals are subdermal bony structures containing neuromast receptor organs, and canal morphology varies among bony fishes in patterns defined by canal absence, reduction, or branching patterns. The hydrodynamic conditions in intertidal zones offer an extreme example of selective pressure for the canal system, therefore studying canal variations in intertidal fishes helps us understand sensory adaptation to this enviroment. Lateral line canals function as filters for hydrodynamic noise, therefore we hypothesize that their complexity is an adaptation to the conditions within intertidal zones. To examine the connection between canal morphology in intertidal fishes and intertidal enviromental conditions, we conducted fractal analysis using micro-CT derived diagrams to quantify cranial lateral line canal complexity in six intertidal fish species from intertidal zones on the North American Pacific and Atlantic coasts. Interspecies comparisons in fractal dimension were analyzed to consider the influence of ecological and enviromental factors (e.g., feeding, homing, movement, tide shifts, and current speeds). We predict that higher fractal dimensions (i.e., more complex canals) will be correlated with species living in enviroments characterized by higher current speeds with closer periods of tidal shifts, and that behavioral ecology will be a weaker predictor of canal complexity, indicating that lateral line complexity is primarily impacted by enviromental factors.

Astragalus and calcaneal shape predict locomotor mode

Lauren Essner, Victor Munteanu, Priscila Rothier, Andrew Orkney, Brandon Hedrick

Mammals have diversified into an array of different ecological niches, with corresponding locomotor modes arising to best transverse the environments in which they inhabit. As they specialize towards different locomotor habits over evolutionary time, their skeletons become a patchwork of inherited and adapted structures woven into a single morphology. If a locomotor mode requires a specific morphology to act, ecology would overwrite inherited structures. However, if a widely usable morphology supports several locomotor modes, it would not require morphological modifications and would thus reflect underlying phylogenetic structure. The ankle is integral to locomotion with widely varying astragalus and calcaneus shapes across Mammalia. Using 3D geometric morphometrics, we established that both phylogeny

and locomotor niche structure ankle bone shape in a caniform dataset of 30 species. Distribution across morphospace revealed a strong divide by family and body mass in the astragalus, while ANOVAs established that scansorial, semi-aquatic, cursorial, and terrestrial locomotor modes have significantly different morphologies. However, the calcaneus was more similar across families and only semi-aquatic and terrestrial locomotor modes were significantly different from one another. We demonstrate that the two highly integrated ankle bones are influenced by different factors, and in order to further explore the trends revolving around body mass, phylogeny, and locomotor modes, we are compiling an expanded dataset comprised of families across Mammalia.

Incremental Q10 of heart rate during early development in zebrafish (*Danio rerio*)

Jack Eudy, Warren Burggren

Fish typically respond to higher temperatures, in part, through modulation of heart rate to increase their oxygen extraction and delivery capabilities. Previous studies have found that the change in heart rate over a specified temperature range shows a consistent pattern in adult fish. However results are limited and inconclusive regarding fishes early in development. Zebrafish (Danio rerio) embryos were raised at 23 °C, 28 °C, and 33 °C, then changes in heart rate were recorded while the embryos were either heated or cooled in 1 °C increments over a range of 28 °C to 33 °C. These recordings were carried out daily for the first week of development in all three treatment groups. While there was no significant difference across development in the mean values of Q10 in embryos raised at 28 °C, there was some evidence of a negative linear relationship between Q10 and higher temperatures emerging in week old zebrafish. These results may lead to a better understanding of how cardiac responses to heat develop and could be impacted by environmental factors during early life stages.

Divergent Patterns of craniofacial modularity shape the early flatfish radiation.

Kory Evans, HoWan Chan

Integration and modularity among traits are central to adaptation and morphological diversification, yet how these patterns evolve across populations and clades is not well understood. Flatfishes (Pleuronectiformes) provide a powerful system to address this question. They are the most asymmetrical vertebrates, developing a body plan in which one eye migrates across the skull, leaving one side blind and the other with two eyes. Flatfishes evolved from symmetrical ancestors that first exhibited fluctuating asymmetry before shifting to fixed dextral or sinistral forms. The earliest-branching lineage, Psettodes, still shows extreme fluctuating asymmetry within populations, while the starry flounder (Platichthys stellatus) has independently converged on similar variation. These repeated origins of fluctuating asymmetry provide a rare opportunity to study how trait covariation shaped the evolution of flatfish asymmetry. We integrate micro-CT scanning, geometric morphometrics, and phylogenetic comparative methods to examine integration and modularity in Psettodes, P. stellatus, and 120 additional flatfish species. By comparing population-level and macroevolutionary covariance structures, we test for similarities in patterns of trait covariation within and between species. We hypothesize that convergence in P. stellatus will align more closely with evolutionary patterns across flatfishes, whereas Psettodes will show distinctive covariance patterns reflecting its early-branching position. By combining population-level data with deep-time comparisons, our study reveals how integration and modularity shape the emergence of novel asymmetrical body plans.

Investigating construction behavior in bumblebees *Bombus impatiens*

Jordan Anthony Facundo, Melanie Kimball, Felicity Muth

Construction behavior is the process by which animals build, modify, or arrange structures to enhance survival and reproduction. Birds' nests are the most well-studied example, but many insects build complex structures. Bumblebees use secreted wax to construct their hives, forming protective nest coverings and creating honeypots to store honey. Ongoing work indicates that bumblebee construction behavior is flexible and may be affected by experience, but we still know little about this behavior. Here we addressed whether bees have a preference for where they build honeypots when starting a colony. Specifically, we asked whether bees had a preference for radial symmetry or proximal building when constructing their nests. To test this, we presented bees with a 'model' 3D-printed honeypot that they readily stored honey in. We then tested their preference for building on two 'incomplete' 3D-printed honeypots: one placed opposite to the honeypot ('symmetrical') and another adjacent to the honeypot ('proximal'). These results will provide insight into how bees make decisions about nest construction and may contribute to a broader understanding of insect construction behavior.

Inhibition of dopaminergic signaling in *Luida clathrata* reduces food-induced movement

Joshua Fairhead, Jadon Fetrow, Kara Taylor, Ellie Vincent, Chris Shelley

Translocation and many behavioral responses of sea stars are achieved by the coordinated activity of hundreds of motile tube feet, powered by a water vascular system. In most animals the motivation to move and the coordination of movement is in part controlled by the neurotransmitter dopamine and previous work has shown that the dopamine receptor antagonist haloperidol at 100 micromolar can inhibit the righting response (in which an inverted sea star will right itself) of Luidia clathrata. To further investigate the role of the dopaminergic system on behavior in Luidia, we determined the IC50 of haloperidol on the righting response and measured the effect of haloperidol on their movement velocity. In the presence of food (chopped clams), the sea stars increased their movement velocity, and this increase in velocity was abolished in the presence of 100 micromolar haloperidol. Examination of tube feet motility clearly showed that tube feet were still able to move in the presence of haloperidol, indicating that the effects on haloperidol were not due to disruption to the mechanics of tube foot movement. Given that haloperidol inhibits both the righting response, and movement velocity in response to food, this suggests a role of the dopaminergic system in the general motivation of behavior in sea stars, irrespective of the stimulus type.

Sexes are polymorphisms: describing and understanding sexual diversity as phenotypic variation

Jay Falk

Recent work has emphasized the need for more precise and multivariate ways of describing sex. I propose that the study of phenotypic polymorphism provides such a framework. Phenotypic polymorphisms are discrete variants within a species; although sexes represent a type of polymorphism, they are rarely described in these terms. I use a variety of examples from across nature to demonstrate that the mechanisms underlying the production and adaptive maintenance of polymorphisms are the same as those that produce sexes—no unique genetic, developmental, or evolutionary principle distinguishes sexes from other polymorphisms. I further highlight cases in which other polymorphisms play as central a role to reproduction as sex itself, underscoring how a polymorphism-based framework can capture the diversity of reproductive strategies more clearly. Finally, the polymorphism framework is flexible—encompassing discrete and continuous variation as well as genetically and environmentally determined forms—and thus enables a more descriptive, less assumption-driven discussion of reproductive types and their evolution.

Kidney gene expression has diverged with loss of parental care in stickleback

Victoria Farrar, Colby Behrens, Alison Bell

Shifts in reproductive behaviors like parental care can co-occur with shifts in multiple physiological systems beyond the brain and reproductive system. In the three-spined stickleback (Gasterosteus aculeatus), the kidney plays such a role, producing spiggin, a proteinaceous glue males use to build nests, in response to androgens. To understand how the kidney may be shaped by divergence in reproductive strategies, we sequenced transcriptomes of kidney tissue from breeding males from two recently diverged ecotypes: the parental commons and the non-parental whites found in Nova Scotia,

Canada. Transcriptome-wide, there were nearly 1.5 times more differentially expressed genes between the ecotypes at 4 days post-fertilization (when parental care peaks in commons) as compared to when males were territorial, and over three times more differentially expressed genes between these stages in commons compared to whites. Spiggin gene 2C was expressed significantly higher in commons of both stages than whites. Given its putative antimicrobial properties, lower spiggin 2C expression in whites might reflect whites' reduced need for nest microbial defenses because they don't provide care. Kidney steroid sensitivity may also differ; whites exhibited increased androgen receptor 2, but reduced estrogen receptor 1 expression compared to commons. Together, these results indicate a signature of parental care on the kidney transcriptome, and illustrate how diverging reproductive strategies may alter multiple physiological systems.

Comparative analysis of flexural stiffness in the wings of migratory and non-migratory dragonflies

Siti Fauziyah, Kathleen Apaez, Dylan Brown, David Ehrhardt, Marianne Alleyne

Dragonflies are known for their agility in flight, enabled by their lightweight, flexible, and structurally complex wings. These wings act as deformable airfoils, consisting of relatively rigid cuticular longitudinal and cross veins that support thin membranous cuticle between them. During flapping, dragonfly wings undergo dynamic, multi-directional loading that induces complex deformations. Consequently, the wings must remain stable enough to preserve their shape and resist structural failure.

Although the mechanical properties of dragonfly wings, particularly flexural stiffness, have been studied, comparative analyses across species with differing life histories are limited. Here we compare fore- and hindwings of migratory and non-migratory dragonflies within the Libellulid family. Wings were detached from the thorax, clamped at the root in a cantilever configuration, and subjected to free-bend tests in which displacement was applied at the base, mid, and tip to measure flexural stiffness. Wing deformation and twisting angle were measured using digital image correlation (DIC). Eight individuals of 15 species were studied in this manner.

Load-displacement results show a clear separation between migratory and non-migratory groups, with non-migratory species bearing slightly higher loads. DIC further captured fine-scale deformation patterns, allowing us to determine which structure deforms most when a load is applied.

By characterizing wing stiffness across species with differing flight behaviors, this work advances our understanding of the biomechanical adaptations that contribute to dragonflies' exceptional flight performance.

The effect of temperature and tropical milkweed on monarch butterfly migration disruption

Ken Fedorka

North America's monarch butterfly (Danaus plexippus) has become a well-established model for studying migration disruption. In recent years, the number of individuals in reproductive diapause along the migration route has declined, coinciding with reduced overwintering populations in Mexico and rising winter-breeding populations in the southern U.S., suggesting some migrants break diapause to drop out and breed. Elevated temperatures and tropical milkweed can each trigger reproductive development during migration, potentially driving this dropout. Understanding which factor is of greater influence is critical for conservation, as the corresponding management strategies may be at odds. To assess their relative influence, we experimentally exposed wild-caught migrants to warm or cool migratory temperatures and either tropical milkweed or a non-milkweed plant, followed by warm or cool overwintering temperatures without plants. Warm migratory temperatures initiated mature oocyte (MO) development and increased MO abundance, mating frequency, and mortality risk in the absence of milkweed during both the migration and overwintering phases. Milkweed exposure during migration, however, only initiated MO development during overwintering. While both factors influenced reproductive development, temperature appeared to be a more robust reproductive cue. This raises important conservation questions and suggests current strategies should be approached with caution until further data are available.

Structural equation modelling reveals how allometry shapes integration in avian cranial evolution

Ryan Felice, Andrew Knapp, James Thorson, Jack Oyston

Testing hypotheses of phenotypic modularity involves assessing whether groups of traits covary more strongly with each other than with parts outside the group. Quantifying phenotypic traits is complex and challenging, with morphological data usually consisting of proxy variables by necessity, rather than complete descriptions of form. Structural Equation Modelling (SEM) is a flexible statistical framework ideally suited to these challenges, as it analyzes complex covariance relationships where observed variables are proxies for unobserved underlying variables of interest.

The avian cranium has been debated as an example of phenotypic modularity. While some have proposed the bird skull is composed of several functional or developmental modules, others have suggested the skull is highly integrated, varying allometrically. Using SEM, we found no evidence for either a single evolutionary module or a 'foraging' module consisting of the beak and jaw muscles. Instead, brain shape and rostrum shape influence a module consisting of the neurocranium and jaw musculature. All variables, with the exception of rostrum shape, were found to be strongly influenced by size, specifically body mass rather than brain volume, supporting the idea that allometry is a major influence on craniofacial integration in birds. These results provide new insights into likely drivers shaping the evolution of the skull in birds, highlighting the advantages of applying these modelling approaches to evolutionary questions.

Cyborgs! An interdisciplinary course on the integration of biology and technology

Kathryn Feller, John Rieffel, Jennifer Mitchell

A neuroethologist, a computer scientist, and an English professor walk into a bar and emerge with a new course on CYBORGS! We currently live in an era where problems can be solved through the integration of computer technology and biological organisms. Cybernetic organisms, or "cyborgs," represent the ultimate integration of biology and technology since these are organisms living with abiotic parts. The development of cyborgs and the technology that surrounds them requires us to understand how such tech works, to consider evolving definitions of humanity, to negotiate the ethics of technological interventions, to face the challenges of creating new categories of identity, and to acknowledge the complications inherent in metaphors for disability and discrimination. In this talk, I will explain how two colleagues and I developed a course introducing undergraduates to biological and computer science concepts fundamental to cyborg technology and how to critically evaluate the consequences of introducing such technology. The course included a series of hands-on experiments involving brain computer interfaces, electromyogram state machines, 3D motion-tracking systems, and Braitenberg robotics. Experiments were paired with reading and writing assignments to critically evaluate the role of such technological solutions in society. Students were not just trained in the fundamentals of how to develop cyborgs, but whether or not such technology should be developed for society.

Compounding the problem: Patterns of compound eye evolution in air and water

Kathryn Feller, Lorian Schweikert, Tanner Mierow, Alexandra Kingston

Animal visual systems evolve to meet the ecological demands of their users. Though the physics of light is a major force driving the evolution of animal eye optics, our understanding of the interplay between environmental medium (air or water) and other ecological pressures is limited, especially for animals with compound eyes. To address this, a database of visual acuity measurements from 385 arthropod species was compiled from the literature and used to test the association between visual acuity and the following ecological factors, while accounting for the effect of shared evolutionary history: body

size, environmental light, foraging strategy, environmental medium, and horizontal structure of the visual scene. While compound eye visual acuity in water was significantly worse for all aquatic species relative to air, medium alone was insufficient to predict acuity. The combination of all tested factors (except body size) significantly predicts compound eye visual acuity. Recent experimental work with amphibious arthropods found that visual acuity is preserved across both air and water through multiple morphological adaptations that yield amphibious optical performance. Similar patterns of amphibious optical eye adaptations were found both across the development of a single toebiter species (Belostomatidae) as well as among diverse arthropod lineages with amphibious ecologies. Taken together, this work demonstrates how the fundamental factor of living in either air or water (or both) shapes compound eye evolution.

Sexually dimorphic inhibition in the Xenopus laevis vocal circuit

Alex Ferfas, Erik Zornik

Sexually differentiated behaviors stem from sex differences in underlying neural circuits. Xenopus laevis mating vocalizations provide a useful model for studying sexually dimorphic behaviors, as calling is highly distinct across sex. Male calls (30-60 Hz) have a higher frequency than female calls (6-16 Hz). These vocalizations are controlled by a central pattern generator (CPG) made up of premotor and motor vocal nuclei located in the hindbrain. Inhibitory motor feedback is needed to produce the high-frequency calls seen in males, but its role in females is largely unexplored. In male brains, blocking GABA-signaling in the isolated premotor circuit (without feedback inhibition) induces a burst of spontaneous vocal activity before silencing all vocal activity. Currently, we are locally blocking premotor GABA-signaling in male and female brains in order to investigate the effects of blocking inhibition in an intact circuit. Additionally, we visualized the expression of GABA-related genes with HCR-FISH in male and female vocal circuits, finding GABAergic neurons in both vocal nuclei. Together, our results may reveal the degree to which inhibition signaling contributes to the sexual differentiation of vocal patterns.

Evidence for disease tolerance in RNA virus detection pathways in little epauletted fruit bats

Ken Field, Luis Víquez-R, Imran Ejotre, Thomas Mazzarulli, Dennis Foe Anguyo, Lisa Powers, Kassim Adiga, Alfred Alumai, Morgan Andama, Ashlyn Sak, Jack Sutton, Isabel Steinberg, Matthew Repke, DeeAnn Reeder

We investigated the humoral immune response of Epomophorus labiatus to an Orthoebolavirus zairense (EBOV) vaccine construct along with various adjuvants. We hypothesized that the strength of the immune response would vary depending on the immune pathways shaped by the co-administration of adjuvant. We captured 67 bats and maintained them in our bat vivarium in Arua, Uganda. Bats were assigned to five treatment groups: a sham-treated group, a group receiving EBOV virus-like particles (eVLPs) alone, and three groups receiving eVLPs combined with different adjuvants: LPS, Poly(I:C), or cGAMP. After 21 days of primary immunization, all bats (except the sham group) received a booster dose of eVLP. We found moderate increases in weekly anti-GP titers following primary immunization with eVLPs. Notably, the LPS-eVLP group exhibited the most substantial pre-boost titers, significantly surpassing those receiving eVLPs alone. The cGAMP group also demonstrated a higher response, while the Poly(I:C) group did not show significant differences compared to eVLPs alone. After the booster, all groups displayed strong anti-GP titers. These results support our hypothesis that dampened immune responses to RNA viruses in this bat are related to coevolution with filoviruses. We also found evidence that cGAMP-sensitive pathways (such as STING) are active in this bat, despite point mutations reported to inactivate STING in tissue culture.

Allometric change in brain and endocast of ray-finned fishes

Rodrigo Figueroa, Stephanie Pierce

Ray-finned fishes are highly morphologically diverse and occupy virtually all aquatic environments. One aspect of their morphological diversity that remains poorly explored is neuroanatomical variation. From a clade-wide sampling it is possible to discern considerable variation in brain morphology and brain size across taxa, but little is known about the impact of ontogeny in neuroanatomical variation. Here we investigate the impact of ontogeny in size and shape of brain and brain cavity space (endocast) in ray-finned fishes. Our data is obtained through diffused-iodine contrast-enhanced computed tomography (dice-CT) of museum collection specimens and scans available on Morphosource. Our results show a similar pattern of allometric change in brain and endocast relationship as that described for coelacanths and crocodiles, in which endocast grows at a faster rate than the brain causing a negative shift in brain/endocast ratio with growth.The allometric rate differ between taxa, with Polyodon showing the slowest rate while some teleosts (e.g. Channa, Acarychthys) show fast rates. Interestingly, despite differences in gross brain morphology with growth, there is little accompanying change in endocast morphology. For the few taxa that show ontogenetic change to endocast morphology, variation is mostly restricted to the inner ear. These results reinforce that brain/endocast ratio show significant negative change with ontogeny even though vertebrates show a positive relationship between brain and body sizes through ontogeny.

Turnkey 3D digital morphology: MorphoCloud

Jean-Christophe Fillion-Robin, Murat Maga

Many applications that traditionally were run on desktop computers are now available on the cloud as web applications. The benefit of cloud computing is obvious, it frees the user from using a specific computer at a specific location. It also allows users to scale the computing resources to the task without making a capital investment. While the NSF has been sponsoring a free, public cloud-computing farm (JetStream2) for the benefit of the research community, its utilization by biologists has been low due to the high requisite technical knowledge to operate the platform.

Here we present the MorphoCloud On Demand Instances, a free cloud-computing platform powered by JetStream2, pre-installed with 3D Slicer image analysis software and the SlicerMorph ecosystem. Users can request an instance by following the instructions at https://instances.morpho.cloud. Once their requests are approved and the instance is created, they can start using SlicerMorph through a web browser in a few minutes. Instances are ideal for computationally heavy digital morphology tasks such as photogrammetry or AI-assisted segmentation. The platform is specifically aimed for educators or researchers that may lack the necessary computing infrastructure at their institutions. The initial four hour session can be indefinitely extended by the user while they are actively using the instance. Each instance can be kept up to 120 days, allowing them to be available throughout an academic semester.

Quantifying range of motion in the avian tail

Alexandra Fillman, Christina Harvey

Birds have notably different tail shapes than current aircraft, with a unique range of motion that contributes to their control effectiveness. Bird tails, supported by a specialized musculoskeletal system, have one control surface plane that provides four degrees of freedom—incidence, spread, rotation, and lateral flex. This research aims to quantify the range of motion across multiple avian species to describe and quantify the four degrees of freedom present in the tail muscular system. We hypothesize that certain degrees of freedom, such as rotation, become constrainedas others, such as inclination, increase. This hypothesis will be tested through a systematic investigation of coupling within the avian tail range of motion, with the goal of establishing reference ranges that inform future studies of tail control effectiveness across a wide variety of avian species. Furthermore, these results will define baseline ranges of motion across multiple species and support clinical decision-making in avian rehabilitation, thereby advancing our understanding of avian biological systems.

The effects of salinity and algal food on the timing and frequency of larval cloning in sea stars

Elisabeth Fink, Jonathan Allen

Larvae of the sea star Asterias forbesi, a keystone species of the North American Atlantic coast, are able to clone by fissioning perpendicular to the anterior-posterior axis. Both anterior and posterior pieces have the capacity to regenerate, forming two genetically identical larvae. The frequency of this phenomenon varies in response to environmental conditions, such as the availability of phytoplankton food. In this study we examined the effects that salinity, food quantity, and food type have on cloning frequency. We monitored cloning for 8 weeks, until many larvae began metamorphosing. After 4 weeks, there were distinct differences among treatment groups. On average, low salinity treatments cloned more than 3 times as frequently as high salinity treatments. Larvae fed more phytoplankton cells cloned more than those fed less. Additionally, larvae fed Rhodomonas lens in combination with other phytoplankton species cloned almost twice as frequently as larvae fed the same quantity of cells, but without R. lens. However, after 8 weeks, none of these conditions had a statistically significant effect on cloning frequency. Therefore, while previous studies suggest that echinoderms clone at a higher rate under high food and low salinity conditions, it is possible that in A. forbesi these conditions instead cause cloning to occur earlier in development without affecting the total number clones produced by a population of larvae.

The impact of extinction on biological communities through deep time

Gianpiero Fiorentino, Phillip Barden

Island biodiversity is significantly threatened by extinction processes that are challenging to study due to the complexity of the fossil record. Ants, with a well-preserved fossil history, offer valuable insights into extinction dynamics. The island of Hispaniola, located in the Caribbean, is known for its Miocene amber deposits dated to 16 million years ago. The ants of this island are ecologically and morphologically diverse, with more than 140 extant species and 90 fossil species, making it a unique system for studying how extinction affects island communities. In this study, we describe patterns of faunal turnover evidenced by the fossil record of Hispaniola. To quantify structural changes over time, we constructed a morphospace that includes both fossil and modern ants. We then reconstructed the ecology of the fossils using a machine learning approach to assess the impact of niche occupation on community assemblages. We found significant differences in morphospace occupation, primarily related to the extinction of large-bodied and arboreal specialist ant species. We also found greater ecological diversity in the fossil record, indicating a significant reduction in ecological niche occupation on the island.

Vitellogenin synthesis in the reproductive organs of Petrolisthes Cinctipes and heat stress's impact

Matthew Firpo, Brian Tsukimura

Rising temperatures throughout the world have caused heat stress to become a primary concern in a range of species, especially those that live in coastal regions like the California coastline. This heat stress can impact a range of physiological processes within organisms, such as reproduction. Petrolisthes cinctipes, the flat porcelain crab, lives in the rocky intertidal region of Northern California coastline and regularly feels the impact of heat stress. We know that P. cinctipes produce a precursor protein known as vitellogenin (Vg) which is vital in the production of egg yolk during reproduction. Additionally, we know that Vg can be found within the hepatopancreas and ovaries of P. cinctipes, however we are unsure where within these organs Vg is synthesized, and the relative activity of each of the organs. To define the locations of synthesis, in situ hybridization was performed on the hepatopancreas and ovaries to find where within these organs Vg mRNA synthesis occurs. Synthesis locations were primarily found within the hepatopancreas, suggesting that Vg is then moved from the hepatopancreas to the ovaries for use in egg development. Heat stressed crabs had decreased production of Vg, suggesting that rising temperatures have an impact on P. cinctipes reproduction.

Comparative hydrodynamic analysis between foreflippers and hindflippers of sea turtles

Frank Fish, Sophia Sebo, Mimi Williamson, Rebecca Bottiglio-Kramer

Sea turtles of the superfamily Cheloniodea possess pectoral and pelvic limbs that are modified as wing-like foreflippers and paddle-like hindflippers for aquatic locomotion. The foreflippers are the main propulsive structure that are oscillated in a flapping motion to generate a lift-based thrust, whereas the hindflippers are used mainly for maneuverability. To assess the hydrodynamics of the fore- and hindflippers of the different species of sea turtles, the flippers of preserved museum specimens were 3D-scanned, and models of the isolated flippers were 3D printed. The models were tested in a recirculating flow tank, and measurements of lift and drag were obtained with a multi-axis force gauge at angles of attack of ranging from -20 to 20 deg. At positive angles of attack, lift coefficients for foreflippers were higher than for the hindflippers, but conversely lift coefficients were higher for the hindflipper than the foreflippers at negative angles. Drag coefficients were routinely lower for the hindflipper compared to the foreflippers. The data collected demonstrates hydrodynamic differences between sea turtle fore- and hindflippers. The shape and performance among the various species of the two sets of flippers can be applied in the design of biorobotic systems.

Double down on delta: otariid collective hindflipper hydrodynamics

Frank Fish, Sophia Sebo, Megan Leftwich

The function of the hindflippers in water by members of the pinniped family Otariidae (sea lions, fur seals) has been largely ignored. The digits of the hindflippers can collapse (adduction) or spread (abduction) the interdigital webbing. When fully abducted the hindflippers have a triangular shape up to 30 deg, reminiscent of a delta-wing. Previous research showed that like delta-wings, abducted hindflippers generate a lift at high angles of attack without stalling. However during turning maneuvers, each hindflipper does not act alone. The pair of hindflippers forms a double-delta that increases planform area with a large composite angle. To investigate the hydrodynamics of the double-delta, individual hindflippers of flipper sets from deceased California sea lion, Steller sea lion, Guadalupe fur seal, and Northern fur seal were 3D-scanned and attached at their base using Blender software. The outer angle of the composite flippers ranged from 48 to 65 deg. The flipper sets were tested in a flow tank at attack angles ranging from -20 to 20 deg and lift and drag were measured with a multi-axis force gauge. Despite differences between species for planform area and angle, double-deltas performed similarly with no stall detected over the range of attack angles. The composite double-delta configuration of the otariid hindflippers provides lift generation to effect high performance aquatic maneuvers such as turning and porpoising.

Sink or swim: Hybridization of razorback and flannelmouth suckers leads to malformed caudal fins

Olivia Fitzgerald, L Patricia Hernandez

While the genetic basis of hybridization is well studied, the musculoskeletal anatomy of hybrids is often overlooked. To understand how hybrid progeny may perform in the wild, there must be a detailed phenotypic analysis of resulting anatomy. The rampant hybridization between the flannelmouth (Catostomus latipinnis) and endangered razorback sucker (Xyrauchen texanus) represents an ideal model system for such an analysis. An ontogenetic series of cleared and stained specimens from female razorback and male flannelmouth was used (preflexion mesolarvae to juveniles) to assess skeletal development in hybrids and parental species. Profound differences in the caudal fin were uncovered, showing severe truncation and loss of all ventral skeletal elements (dorsalization). Of 64 examined hybrids, 18 were classified as malformed (28.12%), and 16 hybrids (25%) had the truncated, dorsalized phenotype. Growth rates of the caudal fin elements were analyzed, with phenotypically normal hybrids developing at an intermediate rate between the two parental species. We hypothesize that the absence of the posterior portion of the ventral larval fin fold prevents ventral elements of the caudal fin from developing and creates the truncated, dorsalized phenotype. We further predict that hybrids with malformed caudal fins die early in development (< 25

mm). These findings illustrate the usefulness of examining hybrid morphology and development, as it reveals phenotypes that are not seen in adults, thus informing future genetic analyses and conservation strategies.

The mechanism and function of courtship songs in a weapon-wielding rhinoceros beetle

Sophia Fitzgerald, Brook Swanson, Dilyn Duryee, Doug Emlen

Conspicuous sexually selected traits typically evolve due to either strong intrasexual competition or mate choice. Possessing both extreme weapons and complex, multimodal courtship is rare. The Japanese rhinoceros beetle (Trypoxylus dichotomus; 'JRB') is surprising in this respect. Renowned for their large, condition-dependent 'pitchfork' horns, JRB males also perform ritualized courtship consisting of three distinct, alternating song types and abdominal trembling. The benefits of large weapons are well documented in this species, but the mechanism of sound production and the functional significance of courtship remain unexplored. Here, we characterize the multimodal courtship signals and putative sound production mechanism. Using behavioral assays, acoustic and vibrational analyses, and scanning electron microscopy, we demonstrate that JRB stridulatory organs are elytro-abdominal structures. Songs with distinct spectral and temporal characteristics are produced when males alternate between vertical, lateral, and figure-8 abdominal movements. Additionally, we manipulated the diet of adult males and found that courtship traits (e.g., song rate) are influenced by adult feeding regime: well-fed males sang faster than poorly-fed males, suggesting that song attributes may reflect biologically relevant information like male body condition. We also incorporated female traits (e.g., body condition, fecundity) in our analyses of mating responses. Our work expands our understanding of this otherwise-textbook large-weaponed, resource defense mating system by incorporating the impact of male songs and female physiology on the fitness of both sexes.

Roundtable: Neurodivergent perceptions, experiences, and perspectives in biological sciences spaces

Brooke Fitzwater, Alexandra Tissot, Taormina Lepore

Neurodivergent awareness and diagnosis rates have increased in the past few years, but there is still a dearth of resources and conversation within our biological spaces on our presence, contributions, and perspectives as neurodivergent biologists. We invite biologists of all levels, from undergraduate up to emeritus professors, who identify as neurodivergent to join us in a roundtable discussion about our experiences navigating academia. As part of our symposium on disabled and neurodivergent perspectives in the biosciences, we will have a semi-structured conversation with topics falling under three categories: exploring our successes and struggles as neurodivergent biologists, neurodivergent student and instructor classroom experiences, and our strategies and suggestions for navigating academia as neurodivergent scientists. Through this discussion and the resulting publication, we seek to share our own experiences and voices in an effort to help build community as well as to center our presence within our fields, discussing both the challenges we face and strategies we suggest to help make classroom, lab, field, and departmental spaces more accessible and inclusive for all biologists.

Spatial variation in sex-biased parasitism and mixed evidence for Red Queen dynamics in a vertebrate

Brooke Fitzwater, Laney Woynaroski, Riley Wood, Eoin O'Hearn, Christopher Blanar, Ryan Earley

Sex-specific variation in traits can lead one sex to be more parasitized than the other, and males are frequently more parasitized. Spatial variation may further influence host sex-parasite interactions. Additionally, biparental reproduction is an evolutionary puzzle because it produces half the offspring compared to uniparental reproduction, but can provide novel gene combinations that allow populations to co-evolve with parasites. We used mangrove rivulus fish (Kryptolebias marmoratus) to explore sex-biased parasitism and the Red Queen Hypothesis (RQH). Rivulus populations consist of predominantly self-fertilizing hermaphrodites and very few males, and biparental reproduction (outcrossing) is rare except in some Belizean locales. We surveyed fish for both external and internal macroparasites in six populations (3 Belizean, 3 Floridian) that varied in their sex ratios and rates of outcrossing. We observed higher percentages of males and parasite species diversity and richness in Belize. Hermaphrodites had higher parasite species richness and were more parasitized by acanthocephalans. However, males were only more parasitized by Ascocotyle sp. digenean trematode metacercariae in a single population. Our findings suggest that rivulus may be using both resistance and tolerance strategies to mitigate the costs of parasites, thus providing mixed support for the Red Queen Hypothesis. Together, our results highlight the importance of spatial gradients and host sex in ecological relationships, and exhibits that males are not always the more parasitized sex.

Biomechanics of heron predatory strikes

Rachel Fleming, Elizabeth Brainerd, Thomas Roberts, Irish Folds, Gregory Lee, William Kallstrom

The remarkable speed and accuracy of heron and egret predatory strikes present a compelling system for understanding the biomechanics of rapid, goal-oriented movement in complex multi-joint systems. These iconic wetland birds use precise coordination of 16 neck joints and numerous muscles to uncoil their long, flexible necks, propelling the head towards prey with impressive speed and accuracy. Our research used high-speed video to investigate the biomechanics of feeding strikes in heron and egret species in their natural habitats. Using frame-by-frame point tracking of the eye throughout each strike video, we quantified head kinematics during strikes, including trajectory, velocity, and acceleration. Despite the need to coordinate movement across 16 intervertebral neck joints, we found that the trajectory of the head consistently follows an impressively straight line to the prey. We also estimated strike-generated force, work, and power using species-specific head mass estimates. Prey type and capture success were determined via visual observation and photography. We analyzed how kinematic measurements and prey capture success rates vary among species and individuals, and assessed the influence of various postural and environmental factors on strike kinematics and prey capture outcomes. This research provides a foundation for examining principles governing rapid, multi-joint predatory movements, and may offer insights into evolutionary biomechanics and inspiring bio-inspired designs for agile robotic systems.

Histological investigation and collagen typing of tendon in response to exercise during maturation

Natalie Flores, Sera Guevara, EmilyGrace Pineda, Angela Horner

Tendons are vital components of the musculoskeletal system that transmit mechanical forces, yet their capacity to adapt and repair declines with age, increasing injury risk. This decline may stem from reduced cellular turnover following skeletal maturity, limiting structural remodeling. While the effects of aging and exercise-induced loading are well studied in muscle, less is known about how tendons respond to these factors or how mechanical loading interacts with age-related changes. Most research has focused on either biomechanical or cellular aspects, leaving a gap in tissue-level integration. Our study examined tendon extracellular properties with a focus on collagen remodeling in response to exercise at different maturation stages in mice. Male and female mice were divided into young (3 weeks) and adult (11 weeks) groups, with subsets given voluntary wheel access for 10 weeks and sedentary controls maintained. All groups were subsequently aged to one year before tendon harvest. Plantaris and tibialis anterior tendons were collected for either protein analysis of type I collagen via western blot or histological staining (hematoxylin and eosin, Picrosirius red) to assess collagen composition and fibril organization. Preliminary western blot results indicate that tendons exercised at younger and older ages remodel differently, with significant variation in collagen I levels. Ongoing histological analyses aim to compare fibril alignment and morphology across groups. This integrative approach provides insight into how exercise timing influences age-related tendon remodeling.

Double trouble: immune dynamics of Cane Toads and Lungworms along their invasive range in Australia

Felipe Floreste, Tsering Chan, Greg Brown, Hongyuan Chen, Fernando Gomes, Vania R Assis, Richard Shine, Lee Rollins

Range-expanding invasive species can be optimal models to study rapid evolution. Although native to South America, cane toads (Rhinella marina) were introduced in Australia 90 years ago, and have spread under the selection of new challenging environments. In addition, toads carried along the co-introduced lungworm Rhabdias pseudosphaerocephala, but the host-parasite interactions depend on the location within the invasive range. Invasion-front (western) toads host higher numbers of lungworms in their lungs than those from range-core (eastern) populations, and show a lower metabolic investment in immune responses. To investigate the causes of spatial differences in immunity among the populations, we tracked innate immunity parameters (plasma bacterial killing ability - BKA, and neutrophil to lymphocyte ratio - NLR) as well as the gene expression of nematode-induced immune mediators (cytokines IL-13Ra, IL-25, IL-6, IL-10) in the spleen and lungs of naïve toads from different parts of the invasive range after infection with lungworms in a common-garden experiment. The experimental infection induced an immune response, but infected toads in intermediate sites had lower inflammatory cytokine gene expression in the spleens compared to other locations. Conversely, range-core toads showed lower plasma BKA overall. Our results unravel novel insights on ecoimmunology trade-off mechanisms in the cane toad colonization of northern Australia, while opening new venues for investigating the complex relationship between hosts and parasites during an invasion, and host investment in immune responses.

Tracking immune responses to bacterial and fungal antigens in a freshwater turtle (*Trachemys scripta elegans*)

Felipe Floreste, Natalie Haydt, Jen Terry, Isabella Davis, Lori Neuman-Lee

Emerging diseases pose major threats to wildlife, and ectotherms are particularly vulnerable in a rapidly changing world. In aquatic species such as freshwater turtles, the shared use of water bodies can facilitate the transmission of bacterial and fungal pathogens. Understanding how individuals respond to these infections is essential for predicting disease outcomes and developing conservation strategies, yet the reptile immune response remains poorly understood. Cytokines are proteins released by leukocytes to mobilize the immune response and are biomarkers of inflammation dynamics. We characterized the early time-course of the reptile immune response to bacterial and fungal antigens (lipopolysaccharide – LPS, and zymosan, respectively) using a chelonian model (Trachemys scripta elegans). Turtles were split into four groups (control, saline, LPS and zymosan) and euthanized at 0-, 12- or 36-hours post-treatments. Spleens and livers were collected to quantify pro- (IL-1b and IFN-g) and anti-inflammatory (IL-10) cytokine gene expression, while blood was collected to assess the heterophil to lymphocyte ratio (HLR). All injected groups, including saline, increased HLR compared to non-manipulated controls. Furthermore, HLR continued to rise from 12 to 36 hours post-treatment in injected turtles. Our preliminary results highlight the redistribution of leukocytes induced by a stimulus in the first days of the chelonian innate immune response. Next steps will shed light on the molecular mechanisms of the immune response against significant antigens threatening reptiles in the wild.

Sex-specific plastic response in craniofacial bones following foraging stresses

Mary Grace Flowers, Karisa Bruce, Kory Evans, Kara Powder

Phenotypic plasticity refers to the differential response of genotypes to environmental factors, which can generate considerable morphological variation. The skeleton can have a plastic response to mechanical stresses through a process called bone remodeling. Our goal was to investigate the plastic response of the facial skeleton to different foraging environments. We hypothesized that males and females may have different levels of plasticity, which could generate sexually dimorphic morphologies. To examine this, we utilized a cichlid fish model (Tropheops sp. 'red fin') that has a significant plastic response to foraging mechanisms. Sibling fish were forced to suction feed (low stress) or scrape (high stress) for eight week long trials, and the resultant 3D facial skeleton was examined using micro CT scanning. We found that high stress feeding causes sexually immature fish to significantly shift their mandible and opercles more posteriorly, resulting in a more steep facial profile (p=0.0013). Further, the sexes have a differential response with females showing increased levels of plasticity (p=0.0034 versus p=0.0996). This variable plastic response between sexes may contribute to sexual dimorphism of the skull, observed across many vertebrates. These results also have implications for fields like dentistry and orthopedics that rely on bone remodeling, as distinct treatments may be needed for the sexes. Work supported by the Clemson Creative Inquiry program and NIH P20GM121342.

The gut microbiota promotes growth and development in lizard hatchlings

Samantha Fontaine, Madeline Desmond, Tosha Kelly, Allison Remick, Brian Trevelline

The gut microbiome is a critical regulator of host physiological function, impacting diverse phenotypes from digestion to immunity, metabolism, and behavior. In particular, the presence of microbes during early life appears to be essential for normal host development. These early-life microbial exposures can impact host physiology throughout the lifespan, potentially shaping host ecological and evolutionary trajectories. However, almost all research in this area has been conducted in model laboratory species due to a lack of tractable experimental systems in non-model vertebrates. This gap limits our understanding of how the microbiome affects fitness determining phenotypes across the lifespan in wild hosts. Here, we developed the first axenic (i.e., germ-free) rearing system for reptiles using the common wall lizard (Podarcis muralis). To generate axenic animals, we incubated eggs under sterile conditions, raised hatchlings in a sterile environment, and inoculated them daily with a sterile solution (axenic) or a fecal slurry from adult lizards (conventionalized). After 8 days, we observed differences between axenic and conventionalized hatchlings in limb growth, internal organ size, gene expression across several tissues, and immune system development. Our work demonstrates a critical role for gut microbiota in the early development of reptiles. Further, the common wall lizard is a successful invasive species and we can use our novel system in future work to understand the impact of microbiota on their ecology in invaded habitats.

Hopping into the past: determining fluid fixation impacts on DNA from microhylid toad specimens

Meghan Forcellati, Alexander Salis, Christopher Raxworthy

Most natural history museum voucher specimens predate the widespread curation of cryogenic molecular-grade tissue collections. If biologists could recover DNA from these older specimens, they could unlock vast reservoirs of new genetic knowledge, particularly for rare or recently-extinct species. Many vouchers contain endogenous DNA, but the quality and quantity vary considerably with preparation practices. In herpetological collections, most specimens are initially fixed in either alcohol or formalin (fluid-fixation) and then stored in alcohol over the long term. Both practices damage DNA, making the successful recovery of endogenous genetic material from fluid-fixed specimens difficult or rare. In this study, we use novel extraction methods, single-stranded library preparation techniques, and target enrichment to study mitogenomic recovery from 55 fluid-fixed Madagascar narrow-mouthed toad vouchers (Microhylidae: Cophylinae), catalogued in the American Museum of Natural History (AMNH) and University of Michigan Museum of Zoology (UMMZ) herpetological collections. For 31 AMNH paired samples, we directly compare assemblies and alignments between two treatments applied to the same individuals: formalin-fixed and cryogenically-preserved tissues, which were field collected in the 90s to early 2010s. We also compare the extent to which the different data types yield different phylogenies for all samples. Preliminary results suggest that fluid-fixed voucher mitogenomes are recovered with a high rate of success (for N=30: mean coverage: 3.8X; median coverage: 0.95X), and that they have excellent potential for systematic utility.

To bite or not to bite: the tongue-bite-apparatus in mormyrid fishes (Osteoglossiformes)

Kassandra Ford

A large portion of teleost fishes have pharyngeal jaws, a secondary set of jaws located in the throat of the fish that are repurposed from gill rakers. These jaws are used for processing prey items after the prey is captured by the oral jaws. In a smaller subset of teleosts, the Osteoglossomorphs, the pharyngeal jaws are noticeably absent, and instead enlarged hyoid and palatine bones protrude into the oral cavity, a morphology called the Tongue-Bite-Apparatus (TBA). Mormyridae is a family of weakly electric fishes within this group that contains a high amount of craniofacial diversity. While the overall skull shape diversity has previously been quantified in Mormyridae, far less is known about the morphological diversity of the TBA in this family. This study will examine the TBA of Mormyridae using 3D geometric morphometrics and phylogenetic comparative methods. We expect to find correlations in size and shape of the TBA based on phylogenetic relationships, diet, and habitat type, based on examinations of the skull. Future studies will include examinations of integration and modularity of the jaw systems, as well as investigations of dentition patterns and biomechanical function across species.

Mechanics of jellyfish swimming under high hydrostatic pressure

Mitchell Ford, Thomas Litschel, Sean Colin, John Costello

Deep-sea organisms experience hydrostatic pressures hundreds of times greater than those near the surface. These extreme pressures present different challenges to organisms specifically adapted for deep-sea life compared to organisms that live in shallow waters. Although prior work has examined physiological adaptations of deep-living animals, hydrostatic pressure effects on shallow-living species are not well understood. In this study we expose shallow-water jellyfish (Aurelia aurita) to hydrostatic pressures equivalent to a range of 0–3000m depth to examine the effects of pressure on the biomechanics and fluid dynamics of locomotion. Jellyfish are an ideal model for examining environmental effects on different body tissues due to their simple body plans and lack of a central nervous system. A single layer of epithelial muscle cells contracts the bell to generate propulsive forces, while elastic fibers in the extracellular matrix provide for passive relaxation. Under high hydrostatic pressure both the contraction and relaxation rates are slowed, and when pressure is removed the relaxation rate immediately returns to normal, but contraction rate remains slowed. Microscopy reveals differences between the epithelial muscle fibers of normal versus pressure-treated jellyfish that may explain why bell contraction does not immediately recover after the jellyfish are removed from the pressure treatment, and particle image velocimetry is used to examine how the pressure effects on swimming kinematics affect the hydrodynamics and reduce locomotor performance.

Using LC-MS/MS to assess steroid production in a territorial female bird after a GnRH challenge

Josephina Fornara, Jonathan Trinidad, G. Troy Smith, Kim Rosvall

For territorial species, agonistic interactions are a fact of life. An individual's level of aggressiveness is thought to be mediated by its physiology, including its capacity to produce steroid hormones. Past research has focused on just one or a few hormones as proximate regulators of aggression, yet we know these hormones do not act in isolation. Here, we applied the tried-and-true method for measuring an individual's steroidogenic capacity, the GnRH challenge, to stimulate the HPG axis and measure all detectable steroid hormones in plasma. We conducted this study in free-living female tree swallows (Tachycineta bicolor) during the peak of territorial competition. After passively trapping females in their nest boxes, we collected an initial blood sample, administered either GnRH or saline, and then took another blood sample thirty minutes later. Separately, we used a standard resident-intruder assay to quantify aggressiveness in these same individuals. Using liquid chromatography with tandem mass spectrometry (LC-MS/MS), we then measured each individual's 'cocktail' of steroid hormones. Together, these data allow us to investigate how variation in territorial behavior relates to an individual's baseline hormonal milieu, as well as her steroidogenic capacity.

Sketching science: interdisciplinary approaches to teaching upper-division biology

Kristy Forsgren, Veronica Ardi-Pastores, Michael Maxwell

The Biology Through Art project integrates artistic expression – primarily drawing – into upper-division biology curricula to enhance student comprehension and engagement. This interdisciplinary program aligns with pedagogical values of integrative biology and includes training in fundamental art techniques for biology instructors through collaboration with professional artists. These collaborations have supported the implementation of art-based activities across diverse biology courses. To date, 28 biology courses at eight institutions have engaged 785 students in structured interventions involving drawing, writing, and control treatments. An additional nine courses serving 256 students introduced artwork on an exploratory basis. Findings indicate that integrating art into biology instruction increases student engagement, creativity, and classroom energy. End of course surveys reveal that most students prefer art activities over writing or no activity. Faculty observed greater attentiveness and enthusiasm during art-based sessions. Faculty also report renewed excitement for teaching and a stronger sense of community through interdisciplinary collaboration. This NSF-funded program demonstrates that artistic practices can enrich biology education by fostering deeper learning and faculty development. These outcomes are especially relevant to the SICB community, which values cross-disciplinary approaches to understanding biological complexity. Biology Through Art offers a replicable model to enhance conceptual understanding and engagement in STEM through creative, integrative pedagogy.

Gut microbiota and diet variation between green sea turtles with and without fibropapilloma tumors

Anna Forsman, Chris Sarkis, Erin Seney, Brandon Hoenig, Kara Andres

The tumor disease fibropapillomatosis (FP) is associated with cheloniid herpesvirus 5 and has been documented across all sea turtle species. Green turtles (Chelonia mydas) are particularly affected, with up to 60% of juveniles exhibiting visible tumors in some populations. Although tumor presence results in mortality for some individuals, most appear to resolve the disease over time. There are still many unknowns about FP transmission and host immune defenses throughout disease establishment and progression, which may limit conservation strategies for marine turtles. We characterized differences in gut microbiome and diet compositions between green turtles with FP tumors (FP+) and those without tumors (FP-). Because multidirectional interactions between host-associated microbiota and the host immune system are critical to immune system development and function, we hypothesized that gut microbial communities would differ between turtle disease states. Our results indicate that the gut microbiome of non-diseased turtles exhibited higher microbial richness than in FP+ turtles. The diet consumed by FP- turtles was also of higher richness than for FP+ turtles. Both the gut microbial community composition and dispersion differed with FP status, suggesting disease-associated effects. We will discuss specific microbial taxa of interest that may be important for understanding FP tumor development in sea turtles. By improving knowledge of the connections among gut microbiome, diet, and FP, we can improve rehabilitation, conservation, and habitat management strategies for population recovery.

Neuropeptide Y in the city: Neural mechanisms underlying urban and rural songbird aggression

Taylor Fossett, Samuel Lane, Isaac VanDiest, Elizabeth Gilbert, Kendra Sewall

Urbanization presents animals with novel environmental conditions. One way that animals respond to changing conditions is by altering their behavior. Urban song sparrows (Melospiza melodia), for example, are reliably more aggressive than their rural counterparts. However, the neural mechanisms that underpin these behavioral differences are unresolved. Neuropeptide Y (NPY) is associated with aggression in certain contexts, such as foraging and resource defense. Our urban sites have lower abundance and diversity of arthropod prey compared to our rural sites, which could result in increased foraging pressure for urban song sparrows. We hypothesize that NPY may mediate

aggression in response to food limitation in urban areas. To explore the relationship between aggression, urbanization, and NPY, we compared relative mRNA expression of NPY and its receptors NPY1R, NYP2R and NPY5R in the hypothalamus of urban and rural male song sparrows. Urban males had higher relative mRNA expression of NPY5R and trended towards higher expression of NPY1R compared to rural males, but we found no habitat differences in expression of NPY and NPY2R. Aggression was negatively correlated with mRNA expression of NPY1R, but we found no correlation between aggression and NPY, NPY2R and NPY5R. Our results suggest that the NPY system is affected by urbanization, possibly due to variation in food availability.

Adult neurogenesis and resilience to lead toxicity in urban wall lizards (*Podarcis muralis*)

Emma Foster, Emily Holt, Miranda Horn, Chelsea Vadnie, Alex Gunderson, Eric Gangloff

Lead (Pb) poses a serious threat to human and animal health, with effects including impairments in neurodevelopment. Lead pollution is particularly prominent in urban environments, where our previous work demonstrated that introduced common wall lizards (Podarcis muralis) can tolerate lead levels considered unsafe for humans without any deficit to physiological and cognitive performance. In this study, we characterized the effects of lead toxicity on the lizard brain at the cellular level. Lizards possess a widespread capacity for adult neurogenesis, which has the potential to reverse neurotoxin-induced damage. We hypothesized that after ingesting lead, lizards would exhibit increased neurogenesis in the medial cortex—a homolog to the mammalian hippocampus—to mitigate lead-induced damage. To investigate this, we divided adult lizards (N = 36) into nine treatment groups based on lead dosage (control, low, high) and time of sacrifice following the dosing period (5 days, 15 days, 30 days). The lizards tolerated blood lead levels orders of magnitude greater than those observed in the field and most exhibited a decrease in lead level over time. Through the use of BrdU and TUNEL immunohistochemistry with fluorescent microscopy, we are quantifying and comparing lead-induced neuronal damage and neurogenesis among treatment groups. Understanding the mechanisms underlying neurological resilience to lead toxicity in urban wall lizards will inform studies of neuroregenerative mechanisms across species, with implications for both conservation and human health.

Body wall morphogenesis and the origin of the amniote thorax

William Foster, Paul Gensbigler, Gabriel Bever

The tetrapod body wall was the site of significant evolutionary innovation both during and after the water-to-land transition. Unsurprisingly, the limb has dominated body wall studies and now serves as an established model for morphogenetic mechanisms and their evolution. The developmental basis for other critical aspects of body wall structure, function and evolution remain understudied, however, leaving this core region with unrealized heuristic potential. Here we encroach on this potential by targeting the developmental dynamics of the thoracic body wall, especially with regards to the strong but flexible morphology that is critical to amniote physiology. We employ multimodal imaging, including whole mount fluorescent immunohistochemistry, to document body wall morphogenesis in a phylogenetically broad sample of tetrapod embryos, with the aim of identifying developmental features derived for amniotes. Comparison with an amphibian outgroup shifts the origin of several characters onto the amniote stem including sternal ribs, intercostal muscles, and unification of somitic and somatopleural mesoderm at and across the lateral somitic frontier. These novelties are explained by the establishment of a derived signalling relationship between ribs and intercostal musculature that can be traced via morphological analysis of the stem amniote fossil record. Costal respiration, expressed in the crown as a highly integrated functional system, was a product of initially humble, yet novel interactions between ancestrally segregated mesodermal cell populations.

Being plastic is fantastic? How life cycle plasticity impact morphology in Alpine newts

Morgane Fournier, Clara Pierson, Vivien Louppe, Isabelle Toussaint, Morgane Taillades, Fanny Gagliardi, Gabriel Ferreira, Christina Kyriakouli, Julien Clavel, Anne-Claire Fabre

Metamorphosis is common across animals, involving profound morphological changes often associated with an ecological transition. Some salamander species not only possess a complex life cycle, with complete metamorphosis and habitat shifts, but also have the remarkable ability to have a facultative life cycle, expressing either a simple or complex one depending on populations. In population with a simple life cycle, individuals bypass full metamorphosis and remain in a single habitat. This is the case of some European species, like the alpine newt (Ichthyosaura alpestris), exhibiting even sometimes both strategies within the same population. We propose to test the following predictions: individuals in populations with complex life cycles, by producing distinct morphologies, might enhance phenotypic modularity, allowing skeletal elements to evolve more independently and promoting their morphological diversity and adaptability. Conversely, simple life cycles may foster stronger trait integration, potentially constraining evolutionary flexibility. Using museum specimens from several European populations, we quantified adult morphological variation using linear measurements and geometric morphometrics, contrasting populations with complex and simple life cycle. We used disparity analyses to test whether populations with a complex cycle are more morphologically variable than population with a simple one. We also assessed whether developmental strategy predicts higher modularity or integration, and examine how these patterns relate to adaptability. Our results will clarify how the expression of facultative developmental strategies shapes morphological variations in salamanders.

The role of urbanization and corticosterone in auditory sensory processing in house sparrows

Brooke Fox, Kelly Ronald, Ashley Lauraine

Urban habitat expansion will introduce new anthropogenic challenges for wildlife populations. These challenges may hinder animal communication and contribute to increased stress levels. This study aimed to investigate the physiological consequences of stressors on the house sparrow (Passer domesticus), an urban-adapted songbird. Specifically, we examined how urbanization affects stress hormone (i.e., corticosterone, CORT) levels and their relationship to auditory processing.. To test this, we manipulated CORT in urban and rural house sparrows using mitotane, an injectable drug shown to reduce circulating CORT temporarily. Blood was analyzed for baseline CORT to measure stress responses. Auditory processing was measured in a pre and post-test design using auditory brainstem responses, which determine the ability of an individual to detect sounds at different frequencies and intensities. We hypothesized that birds treated with mitotane would have a change in auditory sensitivity, resulting in two different possibilities. First, we could predict that birds treated with mitotane would have lower stress responses and perhaps enhanced auditory sensitivity. In contrast, we could predict that animals treated with mitotane would have decreased stress responses and decreased auditory sensitivity. This research addresses a critical gap in understanding how CORT influences sensory functioning. The results will provide critical insights into the effects of urbanization on wildlife communication and physiology, informing conservation strategies in increasingly urbanized environments.

Investigating probiotic potential of Pseudoalteromonas rubra in multiple invertebrate species

Brayden Fracassa, Sam Ruemmler, Ciaran Fitzpatrick, Megan Harrington, Mia Sarris, Alicia Schickle, Casidhe Hughes, Maggie Hill, Marta Gomez-Chiarri, David Rowley, Koty Sharp

Vibrio coralliilyticus is a pathogen affecting ecologically and economically important aquatic animals, including oysters, and may contribute to coral disease. With warming oceans favoring Vibrio proliferation, probiotic treatments offer promise for mitigating marine disease and climate stress. Two strains of Pseudoalteromonas rubra were isolated from temperate coral

(Astrangia poculata) culture systems. These strains of P. rubra produce prodiginines, which have previously been linked to antibacterial protection and larval settlement in tropical corals. Our isolates inhibited multiple Vibrio species known to be coral, finfish, and shellfish pathogens. In pathogen challenge and rescue assays, the pretreatment of eastern oyster (Crassostrea virginica) larvae with P. rubra (10^5 cells/ml) prevented mortality by the shellfish and coral pathogen V. coralliilyticus RE22 (10^5 cells/ml). Importantly, P. rubra exposure did not significantly impact cell density of cultures of microalga Tisochrysis lutea, a common aquaculture feed. Treatment of the anemone Exaiptasia diaphana with P. rubra after exposure to V. coralliilyticus decreased mortality. Ongoing work includes further development of P. rubra as a probiotic, testing in non-model cnidarians and additional aquaculture species, and assessing effectiveness against multiple Vibrio strains.

Dynamic morphospaces for animal locomotion: A case study in bird flight

Lydia France

Animal locomotion is inherently dynamic, yet many morphological analyses treat shape as static. However, morphospaces (i.e., a mathematical representation of the organism's shape) have many dimensions and their axes can represent abstracted representations of morphology or behavior. Here, we review the historical uses of morphospaces and suggest that dynamic characteristics should be embedded into morphospaces to accurately capture fundamental principles of locomotion. First, we synthesize the rich history of morphospace analysis in the evolutionary field and connect this to its emerging role in behavioral analyses. Then, we use a case study from a large dataset of Harris' hawk flight data to show the implementation of dynamic morphospace analysis. Finally, we offer suggestions for how future locomotor behavioral studies can leverage novel machine learning and artificial intelligence tools to facilitate translation of biological principles into engineering design and control strategies.

Vibe check: function of mechanosensory structures in adult aquatic salamander behavior

Gaby Franco, Jeffrey Olberding

Many aquatic animals rely on sensing the movement of water to detect objects or other animals, particularly in water with low visibility. Adult aquatic salamanders possess neuromasts, structures on the surface of their skin that are similar to those found in the lateral line of fishes. In fishes, neuromasts in the lateral line detect water flow, pressure, and vibrations, aiding in behaviors such as foraging, schooling, predator avoidance, and prey capture. However, there is little knowledge on how the neuromasts of adult aquatic salamanders inform their behavior. We hypothesize that these structures serve a mechanosensory role in adult aquatic salamanders similar to that in fishes, and specifically aid in detecting and capturing prey. We tested neuromast function in two species of semi-aquatic salamanders, Pseudotriton ruber and Desmognathus fuscus. First, neuromasts were visualized under fluorescent microscopy using DASPEI vital staining, then salamanders were submerged in a cobalt chloride solution (0.005–0.01 M) for fifteen minutes to ablate the neuromasts. Ablation was confirmed post-treatment with DASPEI staining. Behavioral tests were performed and compared before and after neuromast ablation including responses to an artificial vibration and the presence of live prey. Preliminary results indicate significantly reduced behavioral responses post-ablation, indicating that neuromasts do provide mechanosensory information that informs behavior. Future experiments will test additional species with variation in neuromast morphology and distribution.

Spring-loaded cell puncturing devices of viruses and bacteria

Alec Fraser, Nikolai Prokhorov, Fang Jiao, B. Pettitt, Simon Scheuring, Petr Leiman

Contractile Injection Systems (CISs), which include bacteriophage tails, bacterial Type VI Secretion Systems (T6SS), and phage tail-like bacteriocins such as R-type pyocins, are molecular machines that puncture cell membranes. Despite their diversity, all CISs share a conserved architecture: an external contractile sheath, an internal rigid tube, and a baseplate. Their initial extended form is a high-energy metastable state, comparable to a stretched spring. Upon receiving a trigger such as target recognition or mechanical stress, the sheath contracts, driving the tube into a target cell. The contraction is rapid, coordinated, and irreversible.

Although atomic structures of extended and contracted CISs were known, the actual mechanism of contraction had remained unclear. We combined structural biology, thermodynamics, force spectroscopy, and novel modeling to examine the ~1-million-atom R-type pyocin sheath–tube complex. Our analysis shows that contraction has an activation energy of ~160 kcal/mol, releases ~2,160 kcal/mol of heat, and generates a puncturing force exceeding 500 pN. The modeling procedure reconstructs the trajectory of every subunit, defining the structure of the elusive transition state. We validated this description through mutagenesis and biophysical experiments.

Our results reveal that contraction propagates through the pyocin as a wave with a "wavelength" approximately equal to the particle's length. This work provides the first quantitative, experimentally confirmed account of how a CIS punctures membranes, offering new insights into the operation of these remarkable contractile nanomachines.

Influence of zebra finch group personality on neophobic reactions

Eleanor Fraser, David Kikuchi, Sabine Kraus

Individual differences in behavior that are consistent over time define personality. Avian personality are typically studied in isolated individuals, but individual behavior can be a joint product the individual and its social environment. To better understand the relationship between individual and collective contributions to measurement of personality, we studied neophobia in captive zebra finches (Taeniopygia Gutta). We hypothesized that neophobia could be influence by (1) individual personality, (2) the average personality a group, or (3) that each group forms a unique culture that would vary in a manner unrelated to individuals or their average tendencies. Using finches housed stable same-sex groups of two to four individuals, we assayed individual latency to approach 11 different novel objects presented next to their food dishes. Our hypotheses predicted that there would be a correlation between individual personality, average cage personality, or group identity on behavior towards novel objects. Preliminary analyses indicated no significant effects of individual boldness, aggression, or exploration on neophobia (latency to feed, time spent with object, general activity), nor effects of average group personalities or group culture. However, there were strong individual effects on all neophobia measures, and strong effects of stimulus type – birds were very frightened of snakes.

Three-phase embryonic basis of novel facial development in ghost-sharks (chimaeras)

Gareth Fraser, Campbell Al-Khafaji, Ella Nicklin, Lily Frierson

Chimaeras (Holocephali), comprising three oviparous (egg-laying) families, are the last living lineage of a diverse and ancient group of cartilaginous fishes (Chondrichthyes). One species, Callorhinchus milii (Callorhinchidae), has emerged as an ideal model for developmental studies in this understudied group, offering the chance to study the development of morphological relics of their diverse and ancient past. Here we describe the 3-phase transition of head development in elephant shark embryos and highlight the major craniofacial shifts that lead to the development of novel anatomical structures; (i) the early embryonic rostral bulb, a novel embryonic precursor for facial morphological novelty, (ii) a transient and conserved hatching gland that emerges from the rostral bulb, and (iii) the earliest developmental emergence of the tenaculum, a sexually dimorphic head clasper unique to male chimaeroid fishes. Our work highlights the importance of evolutionary and developmental studies in rare or understudied vertebrate clades that have evolutionary heritage and relic morphology not otherwise accessible for developmental studies.

Body size and sex predict winter destination in a migratory songbird

Nicolas Frasson, Keith Sockman

The geographic locations and environmental characteristics of habitat during non-breeding periods can vary widely between individual migrants, even within a species or population, and the phenotypic traits associated with that habitat selection are not well understood. However, sex and body size could play roles due to energetic demands, intraspecific competition, and life-history constraints. In order to better understand the role of body size and sex in individual selection of non-breeding habitat location, we captured Lincoln's sparrows (Melospiza lincolnii) early in their breeding season, determined sex based on the presence or absence of a cloacal protuberance, and assessed body size from the first-axis factor scores of a principal component analysis of several morphological measures. We estimated each individual's non-breeding location using analysis of stable hydrogen and oxygen isotopes in toenail clippings collected on the breeding grounds. We discovered simultaneous and independent effects of size and sex, in that larger individuals and males migrated from locations closer to the breeding site than smaller birds and females. Our findings are consistent with the Early Arrival Hypothesis in which males compete for breeding territories and therefore benefit from proximity and thus early arrival at the breeding site. Future research is aimed at better understanding why size and sex are related to non-breeding location, and whether there is plasticity in winter destination across years.

The complex life cycle of reef fishes and associated effects on ontogenetic variation of disparity

Bruno Frederich, Emmanuelle Huet, Heloise Maniquet, Laurent Mittelheiser, Amandine Gillet, Alex Dornburg, Vincent Laudet, David Lecchini

Most teleost fishes on coral reefs have a bipartite life cycle across two environments: (1) the pelagic zone for larval dispersal and (2) the reef for juvenile and adult stages. The transition of larvae to the reef, referred to as settlement, is accompanied by metamorphosis, a process regulated by thyroid hormones that enables physiological and morphological adaptations to the coral reef environment. While the open ocean is thought to be more homogeneous, especially regarding the diversity of habitats, intrinsic factors of coral reefs such as high spatial and ecological complexity may be involved in promoting high level of fish disparity. Overall, we aim to quantify and compare phenotypic variation in coral reef fishes at two ontogenetic stages - settling larvae and adults - across multiple biological levels. By using varied morphometric analyses, we show that the level of body shape disparity is higher at the adult stage at community and assemblage levels, supporting the hypothesis that the ecological complexity encountered in coral reefs sustains higher phenotypic variation among species. At the population level, patterns vary by species with either settling larvae or adults being the least disparate stage. These findings illustrate how reef fishes and their bipartite life cycle appear as an effective system for exploring how intrinsic and extrinsic factors operate to sustain phenotypic variation at the population, family and community levels.

Comparing remote and hand-held video observation methods for quantifying a marine cleaning mutualism

Jesse Freeze, Daniel Cryan, Craig Osenberg

Field studies of marine cleaning mutualisms use a variety of methods to quantify behavioral dynamics, with most studies typically utilizing data recorded by either human observers on scuba or snorkel or via remote underwater video. Even though human presence is known to significantly alter the behavior of marine fishes, the effects of human observer presence on cleaner-client dynamics have not been thoroughly examined. We quantified cleaner–client interactions at 13 bluestreak cleaner wrasse (Labroides dimidiatus) cleaning stations in Moorea, French Polynesia using hand-held and remote videos. Cleaning interactions were more common in remote videos, while clients avoided cleaners more often in hand-held videos. Client abundance and species richness were both greater in remote videos. Additionally, cleaning events involving piscivorous clients had a longer mean duration than events involving other client species. Our results suggest that human presence disrupts cleaning interactions by inducing antipredator responses among clients and subsequently limiting cleaners' access to clients. More broadly, our study indicates that human presence can bias studies of cleaning behavior and cleaner-client interactions. These potential biases should be considered when selecting field methods and when interpreting existing behavioral data.

Clownfish-hosting sea anemones show effective population declines concordant with fish symbionts

Matthew Freiler, Aurélien De Jode, Nicolas Salamin, Benjamin Titus

The symbiosis between clownfish (genus Amphiprion) and their host sea anemones (Order Actiniaria) is one of the most recognizable in the world. Despite the charismatic nature of this symbiosis, there is limited genomic data and ecological information for the host anemones in current literature. Here we use pairwise sequentially Markovian coalescent (PSMC) methods on diploid genomes to estimate the historical populations of host and non-host anemones in order to investigate the potential impacts of the symbiosis with clownfish on sea anemone demographics.

Preliminary results show a decline in effective population across all hosts in the Stichodactylina clade, beginning around 100,000 years ago. Though some also declined within this time frame, non-host anemones exhibited more variation in their population trends. The decline of hosts appears to be consistent with literature estimates of specialist clownfish populations obstained through multiple sequentially Markovian coaslescent (MSMC) methods. However, further investigation into this potential interaction, and the impacts of reference selection on the analysis is necessary.

Urban anoles differ in their responses to lead contamination: possible role of ecological niche

Alanna Frick, Alex Gunderson

Urbanization imposes novel selective pressures on wildlife, including chronic exposure to heavy metal pollutants such as lead (Pb). While lead is profoundly toxic to most vertebrates, recent work revealed that invasive brown anoles (Anolis sagrei) in New Orleans tolerate the highest blood-lead levels ever measured in a free-living vertebrate, with no apparent impairment. This raises the question of whether extreme tolerance is unique to A. sagrei or shared across the Anolis genus. Here, we present field and experimental data on the native green anole (Anolis carolinensis), a co-occurring species that occupies a more arboreal niche. This study tested two hypotheses: (1) green anoles experience lower lead exposure in the field due to reduced soil contact, where lead contamination is concentrated; and (2) the two species differ in physiological tolerance for lead, reflecting differences in evolutionary exposure history. To test these hypotheses, we measured blood-lead levels in field-collected anoles across New Orleans and conducted laboratory lead-dosing experiments. Green anoles carried significantly lower blood-lead levels than brown anoles at the same sites (ANOVA, $p < 0.05$) and exhibited markedly lower tolerance for lead in experimental trials (G-test, $p < 0.05$). These findings suggest that exposure to and tolerance for heavy metal pollution in urban environments may be shaped by ecological niche, highlighting divergent adaptive pathways in co-occurring species.

Examining speciation patterns in Northeast Pacific polychaetes

Lily Frierson, Gustav Paulay

The biodiversity of marine invertebrates remains relatively poorly studied, even in US waters. A major challenge in understanding this diversity is the abundance of cryptic species that are difficult to differentiate morphologically, although they are easy to differentiate with sequence data. A common pattern in cryptic species is geographic differentiation. Such allopatric distributions of sister species provide a window for understanding speciation mechanisms, furthering our understanding of the origin of their biodiversity. With this study, we explore cryptic diffentiation in marine polychaetes in the Northeast Pacific, focusing on evidence for genetic differentiation along a geographic gradient. Polychaetes are a diverse group of marine worms exhibiting various lifestyles, symbioses, and reproductive behaviors. Since polychaetes are typically

benthic, potential for geographic differentiation is high. Using sequences and samples from the Florida Museum of Natural History and the Los Angeles County Museum, approximately 350 taxa were selected for study in a phylogenetic context. COI sequences from the FLMNH and LACM were compiled, and additional sequence data for these taxa were downloaded from BOLD (Barcode of Life Data System) based on their identifications or by BLASTing sequences. Neighbor-joining phylogenetic trees were constructed from this data using MEGA. Clades showing evidence for geographic differentiation were selected for further analyses. Examples of geographic differentiation along the NE Pacific coast, suggesting ecological speciation among sister species, were revealed in 20 species complexes.

Characterization of the tuberous sclerosis complex in crustaceans

Levi Friss, Donald Mykles, Talia Head

Crustacean growth is dependent on molting, a process regulated by steroid hormones (ecdysteroids) produced in the Y-Organs (YO). mTOR, an important protein synthesis regulator in eukaryotes, mediates YO ecdysteroidogenesis as the animal prepares to molt. Rheb, a direct mTOR activator, and the Tuberous Sclerosis Complex (TSC)—a large GTPase Activating Protein (GAP) comprised of hamartin (TSC1), tuberin (TSC2), and TBC1D7 (TBC) in 2:2:1 stoichiometry—mediate mTOR activity as TSC promotes hydrolysis of Rheb-GTP to GDP, inactivating Rheb. Hormonal and growth factor signals converge on TSC via phosphorylation, and it's hypothesized that molt inhibiting hormone (MIH) signaling triggers protein kinase G-dependent TSC activation which inhibits mTOR-dependent ecdysteroidogenesis. Phylogenetic and bioinformatic analysis of the CrusTome RNAseq database identified TSC1, TSC2, and TBC genes across Pancrustacean taxa and determined molting effects on relative expression in the YOs of the decapods Gecarcinus lateralis and Carcinus maenas. In decapods, TSC1/2 and TBC were found to be 30-100 amino acids longer than human and murine orthologs and conserved domain architecture. Multiple leg autotomy (MLA) increased relative expression in TSC subunits in the late premolt stage in G. lateralis, while no significant change was observed on relative expression in C. maenas. Eye-stalk ablation (ESA) significantly increased relative expression of TSC subunits 5 days post-ESA in G. lateralis; no ESA data was available for C. maenas. NSF grant IOS-1922701.

The clean team: functional redundancy of cleaner species from a reef wide perspective

Catheline Froehlich, Sharia McCurry, Matthew Freiler, Korrie Brown, Emi Moran, Gavin Evans, Gillian Farmer, Kaitlyn Skrove, Reagan Howard, Semyra Reus, Benjamin Titus

Niche theory explains that no two organisms shall exhibit the same functional niche if they co-occur. However, functional redundancy is often observed within the same ecosystem, and this is thought to improve ecosystem resilience to environmental instability. Are we truly capturing functional redundancy or do similarly functioning species actually exhibit different niches? Here we investigated the functional redundancy of three different cleaner species (which remove parasites from client fishes) co-occurring on the same coral reef system in Utila, Honduras: cleaner shrimp Ancylomenes pedersoni, cleaner gobies Elacatinus lobeli, and bluehead wrasses Thalassoma bifasciatum. We sampled cleaning behavior, habitat characteristics, and fish community composition along three reef zones. Each cleaner species exhibited different habitat requirements, but some similarity in client diversity at a family level. Client diversity did not always represent the fish community composition at reef zones. On average, wrasses cleaned the most often, but exhibited the shortest cleaning lengths. Shrimp cleaned the least often, but exhibited the longest cleaning lengths. Gobies exhibited medium range for both cleaning variables. For all cleaners, there were more cleans in shallower reef zones, and for all cleaners, except wrasses, cleans were shorter in shallower zones. Our findings suggests that there may be less functional redundancy than expected in cleaner species. However, there are opportunities for some cleaners to fill role of others if species respond differently to environmental changes.

Biologically-informed gait of a sea lion for application to a robotic system

Sara Frunzi, Frank Fish, James Tangorra

The goal of this work is to use California sea lions (Zalophus californianus) as a biological model to understand kinematics used in aquatic-terrestrial transition and translate these gaits to an amphibious robot capable of walking. Biologically-based locomotion strategies have been used in aquatic and terrestrial robots, but little research has been done, comparatively, on these strategies for transitional gaits. California sea lions are adept at this transition and have superior land-based locomotory skills when compared to many marine mammals. Videos of sea lions walking with a tripedal gait (forelimb movement dragging the posterior body) were analyzed frame-by-frame to describe the kinematics. Specific points on the body were tracked (nose, shoulder joints, wrists, foreflipper tips) and used to form cyclical trajectories. Foreflipper lift was primarily caused by swinging the head laterally toward the stanced limb and pitching the lifting foreflipper about the body. The trajectories of the foreflippers (out of phase by 180°) were symmetrical, with a mean amplitude of 15.5°. The mean amplitude of the head's swinging was 13.7°, and the mean amplitude of the body's roll was 8.3°. A simplified model was developed with 11 degrees of freedom: head yawing, roll, pitch, and yaw of each foreflipper, two "scapulas", and wrists. This work analyzed and modeled forelimb and head kinematics during a sea lion tripedal gait for implementation on an amphibious biorobotic sea lion.

Raising offspring in extreme environments: optimizing thermoregulation during incubation

Reagan Frye, Juan Zuluaga, Elizabeth Derryberry

Thermoregulation during parental care has been well studied in many birds, yet less is known about the behavioral and physiological mechanisms that allow penguins to incubate chicks in extreme and changing polar environments. Here, we use thermography to investigate how breeding Adélie penguins (Pygoscelis adeliae) adjust behavior and regional body temperatures to optimize thermoregulation under a range of environmental conditions. We hypothesize that in colder conditions, incubating adults will increase peripheral blood flow to transfer heat to the chick, whereas non-incubating adults will restrict peripheral blood flow to avoid losing heat. In warmer conditions, we hypothesize that penguins will employ thermoregulatory behaviors to dissipate heat regardless of age or reproductive state. To test these hypotheses, we compared surface temperatures and thermoregulatory behaviors in incubating and non-incubating adult Adélie penguins at seven Antarctic sites in the Ross Sea region. Preliminary results indicate that trunk and eye region temperatures remain stable regardless of incubation, whereas appendage temperatures are elevated in incubating adults compared to non-incubating individuals, particularly on colder days. Such phenotypic flexibility highlights the delicate balance between adult thermoregulation and the energetic demands of parental care, offering new insight into the strategies endotherms use to raise offspring in extreme environments.

Repeated sampling reveals species-specific & species-independent markers of coral disease response

Lauren Fuess, Erin Shilling, Grace Klinges, Alex Veglia

Tropical coral reefs comprise one of the most biodiverse and ecologically important marine ecosystems on the planet. Nevertheless, the escalating effects of global climate change and other anthropogenic stressors have subjected reef-building corals to an increasing onslaught of mortality-inducing stressors. Reef environments are now characterized by frequent disturbance events, including bleaching and disease outbreaks. Still, we know very little about the host-specific factors that drive variation in response to these stressors within and amongst species. The recent outbreak of a devastating coral disease (SCTLD) affecting nearly 20 species of corals has provided unprecedented opportunities to investigate coral disease resilience. Here we detail a long-term sampling approach, combining ecological monitoring of individual coral colonies with repeated sampling of host physiology to identify signatures of host resilience. A multi-species sampling approach allowed for the investigation of species-specific and species-independent markers of

disease resilience and response. Gene expression analyses failed to detect significant differences amongst resistant and susceptible individuals prior to disease arrival, but did identify strong species-specific and species-independent markers of disease response. The insight gained from this expansive sample set will no doubt provide critical new insight regarding the mechanisms of host response to SCTLD with implications for management of these vulnerable ecosystem engineers.

Friction generation ability of Tidepool sculpins (Oligocottus maculosus)

Kourtland Fusilier, Austin Garner, Emily Kane

Intertidal fishes in the Pacific Northwest are faced with the extreme challenge of withstanding turbulence from breaking ocean waves, where the risk of dislodgement is high. Marine sculpins employ prehensile paired fins rather than low-drag profiles and/or suction cups to counter these forces and maintain their position on the substrate. Recent work suggests that microscopic epidermal textures on fin rays may serve as a friction-enhancing feature. To test this, we subjected anaesthetized tidepool sculpins (Oligocottus maculosus) to whole animal friction tests using a motorized tilt stage and 4 epoxy resin substrates casted from sandpapers of increasing roughness. As expected, performance increased on rougher substrates, with fish reaching angles of up to 70° and a static coefficient of friction of up to 2.1 on the roughest substrate. On the smooth substrate, sculpins produced greater static coefficients of friction than those reported for other fishes, including a subtidal sculpin species. Performance on rough surfaces was similar to skate egg cases, which also display a textured fibrillar surface correlated to increased friction performance. Therefore, we suggest that tidepool sculpins have enhanced friction-generating abilities compared to other benthic fishes, which is likely due to epidermal microstructures, further supporting our hypothesis.

Sex steroids and the regulation of reproductive behavior in woodpeckers

Matthew Fuxjager, Eric Schuppe

Steroid hormones play an important role in the regulation of vertebrate sexual behavior. Testosterone, for example, helps coordinate aspects of courtship and territoriality with the external environment, so that such behavior is produced during the right time, at the right place, and in the right way. Here, we present a set of studies that examine the relationship between testosterone and reproductive behavior in downy woodpeckers. We show how testosterone levels in both males and females of this species change across the year, and we present evidence that explores whether testosterone acts via skeletal muscles to shape the actuation of sexual displays. Through this work, we pinpoint some interesting potential innovations in androgenic signaling, such as the potential for de novo synthesis of testosterone in muscle cells that mediate display performance. Our work highlights the important of testosterone and its ability to shape sexual behavior, while opening new avenues of research into the mechanisms that underlie these effects.

Is night testosterone related with daily activity rhythms in male Great Tits (*Parus major*)?

Holland Galante, Emily Elderbrock, Skylar Anderson-Buckingham, Caroline Deimel, Michaela Hau, Timothy Greives

In seasonally breeding species, changes in sleep/wake rhythms often occur with seasonal changes in reproductive hormones, with earlier onset of activity cooccurring with seasonal increases in testosterone. Experimental manipulation has established that circulating testosterone levels alters circadian rhythms in captivity. However, it remains unknown how individual variation in endogenous reproductive hormonal rhythms influences individual phenotypic output of circadian rhythms (i.e. chronotype) in natural environments. Here, we investigate if individual differences in testosterone are related with daily rhythms in a wild songbird by addressing the relationship between natural variation in night testosterone levels and timing of individual daily activity in male great tits (Parus major). We have previously shown that testosterone peaks in this species after the onset of darkness. We captured males at night while roosting in nest boxes during the pre-breeding season in March, prior to female nesting. Blood samples were collected for testosterone assay, and individuals received a telemetry transmitter or accelerometer to track daily activity across pre-breeding, laying and incubation. We predicted that higher levels of testosterone will be related with earlier waking times and longer active days, potentially increasing reproductive success (number of offspring) through increased extra pair mating. Previous studies indicate that extra pair mating primarily occurs prior to dawn, however whether individual natural variation in peak night testosterone levels is driving increased access to extra pair mating remains unknown.

Cranial variability in 3D shape within steelhead trout from a dam-impacted watershed

Jacquelyn Galvez, Joanna Chen, Sophia Paz Fogel, Malia Magbual, Antonia Schwartz, Samantha Torres, Connie Zhang, Jack Tseng

Damming of river systems is one of the most consequential forces impacting freshwater environments. The past two decades have seen an increased research focus on understanding the cascading effects artificial damming has upon these habitats, particularly in relation to anadromous fishes whose migration patterns are highly modified by anthropogenic change. To date, most studies investigating the morphological impacts of artificial damming focus on changes in 2D body shape, particularly in relation to functional implications for swimming and/or feeding. In this study, we conducted the first 3D geometric morphometrics analysis on a fish population impacted by damming: steelhead trout collected along the Eel River. We developed a microCT dataset using museum specimens and investigated shape differences in several skeletal regions within the skull: cranium, orbit, preoperculum, and cleithrum. We tested for both temporal and spatial differences across the seasonal barrier impounding this watershed. Our findings reveal notable differences in preoperculum curvature between fish collected below and above Benbow Dam. This data-rich 3D approach validates field-deployable 2D GMM findings on these same specimens, particularly along an environmental spatial axis. This research lays the foundation for future work to test hypotheses of morphological integration, as well as skeletal estimates of biomechanical performance to estimate functional differences. These types of analyses will continue to enhance our understanding of the functional morphological shifts in freshwater fishes caused by human-built dams.

EcoTwin: Digital Ecosystem Representations Using GelSight Surface Measurements for Bioinspiration

Kaelyn Gamel, Seri Aldana, Anne Clark, Jillian Wilson, Kristina Kamensky, Christin Murphy

Global biodiversity represents an immense reservoir of evolutionary solutions, offering unprecedented opportunities to accelerate next-generation engineering breakthroughs. Field-based digitization techniques are becoming possible with technological advances offering the potential to expand bio-inspired research beyond current model organisms. Here we explore the concept of creating detailed digital ecosystem representations, or EcoTwins, that preserve both individual organism features and their environmental context for bio-inspired analysis. Using GelSight, a portable surface profilometer, we are developing a digitization pathway to construct a digital library of complex biological surface structures in biodiverse environments. To demonstrate the proof of concept, we visited a creek-bed field site surrounded by diverse plant species. Here we collected surface measurements on the various plant species present and analyzed surface structure, focusing on the functional and structural details of hydrophobic and hydrophilic leaf surfaces. We were able to capture and compare detailed surface data from the upper and lower leaf surfaces as well as the leaf stem structures and perform in-field analysis of surface roughness (kurtosis and skewness) and profile (max and min heights along a path). The resulting imagery and data are compiled into a digital representation of the field site overall, with functional tags to aid in bio-inspired inquiry. This project aims to serve as a starting point for conversation within the research community on taking an ecosystem approach to digitization and bio-inspired investigation.

Stigma development genes controlling carpel features relevant to pollination

Anthony Garcia, Avery Klein, Verónica Di Stilio, Saya Natsuume

As the site of pollination and fertilization, the stigma of the angiosperm gynoecium is critical for ensuring reproductive success. Pollination vectors exert great selective pressure on gynoecium morphology, giving rise to diverse stigma structures and functions. However, the genetic mechanisms underlying the development of these diverse reproductive structures remain incompletely understood. Thalictrum, a representative of the Ranunculales, has undergone multiple independent transitions from insect to wind-pollination, with flowers exhibiting carpel adaptations that include linear stigmas with feathery extensions. Our goal is to provide insight into the genetic mechanisms underlying stigma morphology in wind-pollinated flowers, as well as more generally into ancestral eudicot carpel developmental genetic pathways. To that end, we characterized the role of the conserved STYLISH (STY) gene family in Thalictrum thalictroides stigma development via targeted virus-mediated approaches. Our results suggest that the Thalictrum STY homologs control adaxial growth and stigma development, and regulate a genetic landscape involving auxin regulation, cell wall metabolism, and carbohydrate transport. Expression analysis in Thalictrum aquilegiifolium, which has a modified stigma morphology compared to T. thalictroides, shows that STY patterns the stigmatic surface. Together, these observations suggest that stigma adaptations in response to pollination mode may arise from regulatory modifications to conserved developmental networks.

Are rodent species described by locals? Colonial patterns in taxonomy

Naomi Garcia, Shailey Shah, Jennifer Gomez Fuentes, Leanne Gip, Lauren Bernardi, Yadira Gonzalez, Ulrike Muller

Taxonomic nomenclature is a historic record not just of natural history but also of inequity and colonialism. Recently biologists have begun to examine pervasive global inequalities evident in natural history metadata by quantifying how many species names honor people of European descent. Full binomial species names also contain the name of the persons describing the species. This study focuses on these describers. To investigate if species are described by people from the species' native range, we compared the birthplace of describers to species' native ranges, focusing on Rodentia. Our analysis of 2,712 rodent species revealed that just ten individuals of European descent account for 41.8% of all descriptions, with one British taxonomist contributing 19.7%. European rodent species were predominantly described by Europeans, although in 56% of the described species the describer's country was not within the native range of the species. In North America, describers were born within the country containing the species' native range, yet were overwhelmingly of European descent. In Africa, only 6.3% of species were described by local scholars, all of European descent. In South America, 53% of the species were described by South Americans. Our data set also documents considerable gender disparity: only 33 of 528 unique describers were women. These observations align with other studies that found colonial patterns in taxonomy.

Glucose tolerance worsens with age in a social rodent species (Octodon degus)

Tate Garcia, Josephine Low, Yuta Sato, Annalise Di Cicco, Ava Craig, Ava Choi, Carolyn Bauer

Diabetes is characterized by chronic hyperglycemia, or elevated blood glucose levels. In diabetics, hyperglycemia is commonly caused by insulin dysfunction, and the presence of diabetes increases with age in humans. The Chilean rodent Octodon degus can spontaneously develop diabetes, along with comorbidities such as cataracts and obesity. Therefore, we hypothesized that glucose tolerance would decrease with age in captive degus. To assess glucose tolerance, we fasted animals overnight, took baseline blood glucose readings with a glucometer, after which we injected each animal with a glucose bolus and took further blood glucose readings at 15, 30, and 60 minutes post-injection. Degus with higher integrated blood glucose levels were considered to have worse glucose tolerance. Our hypothesis was supported, as 4- and 5-year-old degus had significantly higher integrated glucose levels compared to 3-month-old, 8-month-old, and 3-year-old degus, although we found this trend was stronger in females than in males. However, we found that baseline, fasting glucose levels did not significantly vary between age groups. These findings suggest that degus may become more susceptible to diabetes as they age. Future exploration is needed to determine the cause of reduced glucose tolerance in degus, either by examining circulating insulin levels or conducting insulin tolerance tests.

Lack of correlation between burrowing and glucose tolerance in a social rodent (*Octodon degus*)

Tate Garcia, Yuta Sato, Josephine Low, Ava Choi, Ava Craig, Annalise Di Cicco, Alejandro Sánchez Alvarado, Carolyn Bauer

Alzheimer's Disease (AD) is a major neurodegenerative disorder and is a prevalent form of dementia that is positively correlated with age in humans. The Common Degu (Octodon degus), a diurnal rodent endemic to Chile, also demonstrates AD-like neuropathology, reduced cognitive function, and memory deficits with aging. A standardized method in measuring cognitive function in degus is through a burrowing test, as rodents naturally display burrowing behaviors and less burrowing could indicate cognitive dysfunction. Additionally, degus can spontaneously develop diabetes, which is notable as diabetes is a significant risk factor for developing AD in humans. We hypothesized that degus will exhibit less burrowing behavior as they age, and that degus with reduced burrowing behavior would have poor glucose tolerance. Therefore, we ran multiple burrowing trials for male and female degus ranging from 3-months to 5-years of age. Alongside these tests, we assessed diabetic symptoms through glucose tolerance tests with higher integrated blood glucose levels indicating poor glucose tolerance. Our results showed that burrowing behavior did not significantly vary with age and there was no significant relationship between burrowing behavior and glucose tolerance. These findings suggest that cognitive abilities do not significantly relate with age or glucose tolerance. However, cognitive function can be assessed through multiple other methods and we encourage further exploration of other cognitive tasks.

Regional dietary variability in Diamondback Terrapins (Malaclemys terrapin)

Steven Garcia , Jacqueline Brashears

Food chains shape a species' range and ecological niche by determining available energy and nutrients. The diamondback terrapin (Malaclemys terrapin), a saltwater-tolerant turtle, ranges from New York to Texas, but regional differences in diet remain unclear. This study examines whether terrapin diets vary by region. Regions were categorized as northeast coast, southeast coast, and Gulf Coast, with diet data grouped into five categories: vegetation, fish, mollusks, crustaceans, and insects. A literature review provided dietary data, and a chi-square analysis tested for regional differences. Findings will contribute to understanding the species' ecological role and inform conservation efforts.

Thermal quality and prey availability constrain energy budgets and shape selection in desert lizards

Guillermo Garcia Costoya, Akhila Gopal, Noa Ratia, Kate Bain, Kaitlyn Napier, Glen Forister, Ethan Carmona Hockstedler, Cody Chapman, Allison Dorny, Madison Glenwinkel, Shea McKendree, Karla Alujevic, Michael Logan

Raising temperatures and altered habitats threaten biodiversity worldwide. Terrestrial ectotheric animals are especially vulnerable, as they depend on the external environment to achieve physiological states that maximize fitness. Warm body temperatures that are close to a physiological optimum enable perfomring fitness-relevant activites like foraging and mating, but, since metabolic rate scales exponentially with body temperature, staying warm for too long might lead to prohibitive energetic costs. The ability of individuals to balance optimal body temperatures and energetic expenditure might vary by ecological context and be crucial for survival. To explore this interplay, we studied among and within-population differences in thermal environments,

food availability, and metabolic rate and how these variables interact to mediate survival in populations of western fence lizards (Sceloporus occidentalis) living at different elevations in the Great Basin Desert. We combine three years of mark-recapture data, measurements of resting metabolic rate, estimates of insect abundance, and spatially explicit maps of operative thermal environments at the scale of individual territories to quantify the effect of energetic deficit on survival. We found that differences in thermal quality among territories led to variation in energetic deficit within populations that generated selection on the thermal sensitivity of metabolic rate, although selection was stronger at lower elevation. Our findings emphasize the importance of understanding intrapopulation variation in thermoregulatory constraints and energetics when forecasting the fate of populations experiencing environmental change.

Improving cell culture conditions for proliferation of *Botryllus schlosseri* epithelial cells

Alison Gardell, Idriana Abinales, Baruch Rinkevich, Dietmar Kueltz

Despite decades of research, the development of methods to reliably generate cell culture systems for marine invertebrates has been challenging. There are currently only a few marine invertebrate cell lines available compared to the thousands that exist for vertebrates. Botryllus schlosseri is a colonial tunicate species found globally and is a close relative to vertebrates. We sought to improve medium formulation to support the proliferation and longevity of B. schlosseri epithelial cells in vitro. Previous attempts have yielded low cell growth of only ~30 cells per seeded tissue and senescence within a few days. For this study, wild colonies of B. schlosseri were collected from local marinas followed by microdissection of zooids and buds for primary explants. We tested various ratios of complete medium to seawater while controlling for total osmolality. We found that 75% medium with 25% seawater (75/25) and 50% medium with 50% seawater (50/50) yielded the most consistent growth and highest number of cells within a 5 day period. We ultimately selected the 50/50 medium formulation and harvested cells at 1, 3, and 5 days for bulk RNA sequencing and proteomics. Future work will characterize the molecular phenotype of B. schlosseri epithelial cells in vitro and use this information to further optimize their proliferative capacity.

Skeletal diversity and body size evolution in an endemic radiation of Indian frogs

Sonali Garg, S. D. Biju, James Hanken, David Blackburn

The Western Ghats region of India is home to several endemic anuran lineages that exhibit remarkable phenotypic and ecological diversity. Genus Nyctibatrachus, the most speciose of them, stands out for a nearly eight-fold adult body size range. For a group that otherwise lacks many striking external morphological characters, potentially informative assessments of variations in skeletal morphology are lacking. Using 3D micro-CT scans representing major species-group level clades, we identify a suite of characters that are diverse among congeners and generally known to be associated with reduction in body size as well as terrestriality in amphibian species. These include degree of ossification, shape and structural variations, fusion of skeletal components, and proportions with respect to body size. The findings provide insights into how these frogs phenotypically diversified to adapt and exploit different ecological niches within their restricted geographical range. The observed traits are also useful for better taxonomic characterization of the group. Furthermore, since all miniaturized species do not constitute a single monophyletic lineage within the larger Nyctibatrachus phylogeny, miniaturization and terrestriality may have together evolved more than once, independently, or were perhaps lost if the most recent common ancestor of Nyctibatrachidae was not large-sized and aquatic. Further testing of these hypotheses in a robust phylogenetic context is needed to gain clarity on the pattern and direction of trait evolution.

In vivo muscle contractions in snakes performing repeated locomotor trials using X-ray videos

Kelsey Garner, Henry Astley, Jessica Tingle

Snakes differ from limbed animals in that they rely primarily on trunk muscles to move through their environment. Quantifying how these muscles contract in vivo, including how contractions differ across locomotor modes and with repeated trials, would help us to better understand how snakes accomplish impressive locomotor diversity. With the advent of modern technology, it has become increasingly possible to collect and analyze large biomechanical datasets to incorporate questions of behavioral and physiological variation, such as change with repeated measures, into biomechanics studies. However, detailed descriptions are still lacking, and the use of sophisticated statistical analyses on such datasets is nascent. In this study, we implanted radio-opaque beads on opposing ends of the iliocostalis, semispinalis–spinalis, and longissimus dorsi muscles in four corn snakes (Pantherophis guttatus), and then used X-ray videos to record the snakes performing repeated trials for three different movements: lateral undulation, vertical undulation, and tunnel concertina. We used a mixed-model statistical approach to account for repeated measures of individuals and provide quantitative descriptions of contractions for three axial muscles during different types of locomotion. Our results provide evidence for some minor differences in muscle contraction between different locomotor modes, and the study as a whole also provides a model for incorporating sources of within-individual variation into biomechanics studies.

Emphasizing biodiversity in the instruction of sex-related topics in a developmental biology class

Deborah Garrity, Brandon Hylton, Aramati Casper

The concept of sex as a category classifying individual characteristics and the processes of sex determination are foundational to biology. However, instruction on these topics is often oversimplified. Students may develop a distorted impression that sex is typically a simple, genetically determined binary, and that mammalian sex determination mechanisms are universal across phyla. To address this, we developed an intervention for an upper-division developmental biology course that emphasized the biological diversity of sex-related topics. The intervention highlighted the remarkable variation in the number and types of sexes across biological phyla and showcased diverse mechanisms of sex determination. We used reflexive thematic analysis through the lens of the knowledge-in-pieces theoretical framework to analyze student pre- and post-assessments and identified three key themes: (1) sex is at least a little bit complex, even in humans; (2) seemingly simple socially-rooted concepts were challenging to restructure; and (3) conversely, conceptually complex but less familiar concepts shifted toward desired understandings more readily. We propose that students struggled to fully integrate their understanding of sex and sex determination due to the inherent complexity and ambiguity of terminology (e.g., the meaning of “sex”) and their incomplete yet persistent prior conceptions about how organisms acquire and express sex characteristics. Nonetheless, biology students expressed a strong interest in expanding their knowledge and recognized the importance of a broader and deeper understanding of topics.

XROMM analysis of a cranial ligament in turkeys

Samantha Gartner, Emily McParland, Ofubofu Cairns, Samantha Falcone, Thomas Roberts

Musculoskeletal ligaments are an essential, yet understudied, collagenous tissues that connect bone to bone and function to stabilize joints, transfer force, and absorb shock. Locomotor ligaments, like the human ACL, are well understood, but ligaments involved in feeding receive far less attention. Most birds have a prominent cranial ligament, the postorbital ligament (POL), which primarily functions to inhibit cranial kinesis. Here, we sought to characterize the mechanics of the POL in turkeys during feeding. We combined X-ray Reconstruction of Moving Morphology (XROMM) and electromyography (EMG) during turkey feeding to investigate the strain of the POL and the movement of the upper and lower jaws in vivo driven by activation patterns of the jaw opener and closers on six turkeys. The adductor mandibulae was active during jaw closing, while the depressor mandibulae was active at jaw opening.

The POL appears to stretch and relax in tandem with the opening and closing of the jaws, reaching average peak strain around 5% of the ligament's original length. This research is the first step towards understanding the mechanics of the POL in a bird skull during feeding and how this ligament moves alongside other elements in the musculoskeletal system. Future research will further investigate the material properties of the POL to gain an expanded understanding of the mechanics of a cranial ligament.

Thyroid hormones as candidates for explaining plumage polymorphism in the White-Necked Jacobin (*Florisuga mellivora*).

Lise Gatti, Jay Falk, Suvi Ruuskanen

Sex-specific coloration is widespread among avian taxa, yet its underlaying mechanisms remain poorly understood. In the white-necked jacobin (Florisuga Mellivora), a tropical lowland hummingbird, roughly 80% of the females have a plumage distinct from that of males (heterochromic plumage), while the remainder exhibit an ornamented plumage practically identical to males (androchromic plumage). This female-limited polymorphism provides an ideal system for studying coloration as both "male-like" and "female" morphs occur within a single sex. However, the developmental mechanisms that facilitate this polymorphism are still unknown. Thyroid hormones are promising candidates for explaining this phenomenon and more broadly, sexual dimorphism. Thyroid hormones stimulate molting and play a sex-specific role in plumage coloration. Furthermore, recent genomic comparisons of the white-necked jacobin female types implicate thyroid-related pathways in color development. Here, to assess the thyroid's role in driving sexual coloration, we tested whether circulating thyroid hormone levels differ between the two female morphs, and if the level in androchrome females mirror the ones observed in males. We collected plasma samples from 36 wild individuals (10 heterochrome females, 4 androchrome females, 9 juveniles, 13 males) and measured their respective circulating level of thyroid hormone using liquid chromatography-mass spectrometry. Bayesian regression was used to model the effects of sex, color type, and age. Additionally, we dietarily administered T3 to 8 individuals (4 heterochrome females, 4 males) to examine the effects of elevated T3 on feather regrowth, coloration and pattern. Our results provide exciting new insights on the role of thyroid hormones in driving sexual coloration across avian taxa.

How temperature and elevation influence rates of tissue regeneration in a woodland salamander

Olivia Gatto, Isabella Burger, Eric Riddell

Salamanders have long captivated biologists with their extraordinary ability to regenerate lost tissues, offering unique insights into the mechanisms of tissue repair and regrowth. Despite this, the influence of environmental variation on regenerative performance in wild populations remains poorly understood. Here, we compared rates of tissue regeneration and metabolic rates at different temperatures in the southern gray-cheeked salamander (Plethodon metcalfi) collected across elevations. We collected salamanders from high- and low-elevation sites and housed them at two acclimation temperatures (10°C, 20°C). Metabolic rates were measured immediately prior to tail amputation, and 40% of each tail was then removed to standardize regeneration. Tail growth was tracked weekly using microscope imaging, and metabolic rates were measured again after five weeks to assess the energetic cost of tissue regeneration. Individuals exposed to higher temperatures exhibited significantly faster regrowth than those at lower temperatures. We also found that salamanders from high elevations exhibited higher metabolic rates at cool temperatures but not at warm temperatures, a pattern consistent with countergradient variation. Metabolic rates differed between the two measurements (pre- and during regeneration) and varied across temperature and elevation, highlighting the energetic demands of tissue regeneration. These findings underscore the sensitivity of regenerative processes and metabolic function to environmental conditions and emphasize the importance of studying regeneration within an ecological context.

A dynamic canvas model of lepidopteran color pattern development and evolution

Richard Gawne, Kenneth McKenna, H. Nijhout

The color patterns of butterflies and moths are a uniquely tractable experimental system because they are composed of an underlying series of homologous characters. Although significant progress has been made in identifying candidate genes associated with specific pattern homologs, the mechanisms responsible for determining the positioning of elements, and the overall structure of patterns remain more-or-less unknown. To make preliminary progress on this front, we analyzed the positioning of pattern elements in multiple lepidopteran species. Surprisingly, we found that individual homologs tend to follow a robust set of relative positioning rules within and across species, indicating that changes in the location of elements in venous cells is unlikely to be a significant driver of pattern diversity. Instead, we suggest that a key determinant of pattern structure is variation in the size and shape of the wing itself. To test this hypothesis, we constructed a series of computational models which demonstrate that a wide range of patterns can be produced through a combination of: (i) robust relative positioning of elements, and (ii) continuous variation in geometric parameters such as the length of wing veins, and the angles of venous junctions. This 'dynamic canvas' approach to understanding lepidopteran patterns allows for the construction of integrative morphospaces that link color pattern topography and wing morphology via the physiological processes of growth, size, and scaling.

When resources become cues: tracing maternal resource transfer in an adaptive maternal effect

Haley Gee, Ryan Paitz, Katelyn Cannon, Renee Duckworth

Maternal effects on offspring phenotypes are an important part of how species adapt to their environments, but their proximate mechanisms are not well understood. Adaptive maternal effects may arise through general pathways that effect many aspects of offspring phenotypes, like nutrition, or specific pathways evolved to tailor key traits to respond to changing environments. Investigating these mechanisms requires the ability to manipulate maternal context and assess how this alters offspring developmental environment and traits. We capitalize on an adaptive maternal effect in western bluebirds where variation in territory quality influences adult offspring's aggression and dispersal behavior. We combine a large-scale ecological experiment, detailed measures of maternal yolk investment, and measurement of offspring HPA axis programming, including neural transcriptomic expression, to investigate the mechanisms that may underlie this maternal effect. We found that females on larger territories produced larger clutches with lower levels of trans-androsterone and estrogens. In turn, offspring from larger, more slowly produced clutches with larger eggs exhibited lower levels of stress-induced corticosterone. Yolk steroids were unrelated to HPA reactivity but may either influence clutch investment (estrogens) or organize adult aggression (trans-androsterone). Finally, there were sex-specific effects on HPA programming, with male offspring from high-competition territories showing higher HPA reactivity. These results indicate nutritional investment as the primary intermediary of maternal investment on bluebird offspring HPA programming, with yolk hormones potentially organizing specific traits.

Stunning secretions: how Ctenophore mucus rapidly incapacitates prey

Bradford Gemmell, Sean Colin, John Costello, Mande Holford, Miriam Gelashvili

Ctenophores (i.e. comb jellies) numerically dominate the macroscopic biota of oceanic habitats. Combined with unusually high prey capture efficiencies, this makes ctenophores influential marine predators. The contemporary description of ctenophore predatory success entails the use of adhesive cells, termed colloblasts, or sticky mucus for prey capture. However, adhesion alone does not explain the rapid immobility of prey upon contact and during transport to the mouth. We provide evidence that ctenophores can incapacitate prey during prey capture using toxins and this mucus plays a key role in prey incapacitation. Further, this paralysis is reversible, and prey can regain movement after mucus removal. We also dicuss the use bioimformatics to identify and

characterize the peptide toxins used by the ctenophore Mnemiopsis leidyi. The use of chemical toxins by ctenophores improves our understanding of importat trophic interactions in the ocean while the rapid and reversible nature of these interactions may contribute to novel bio-inspired drug development.

Early establishment of distinct locomotor patterns in anamorphic and epimorphic centipedes

Jiarui Geng, Hangjun Liu, Baxi Chong

Multi-legged animals such as centipedes move effectively across complex substrates, yet their locomotor strategies differ largely with developmental mode. In anamorphic centipedes, which gradually acquire additional legs over successive molts, body posture remains relatively straight across speeds and locomotion is dominated by direct leg waves (tail-to-head). By contrast, epimorphic centipedes, born with their full complement of legs, display body undulation at higher speeds and employ retrograde leg waves (head-to-tail). We hypothesize that these differences arise from developmental trajectories: anamorphic centipedes must adjust locomotor control to accommodate increasing leg numbers, whereas epimorphic centipedes avoid this within-lifetime scaling challenge. To test this hypothesis, we examined two juvenile species: Scolopendra subspinipes (epimorphic; N = 10; 38 legs; mean body length = 50.76 ± 0.1 mm; 301.8 mg) and Thereuopoda longicornis (anamorphic; N = 3; 8–10 legs; mean body length = 4.87 ± 0.1 mm; 2.9 mg). Preliminary trials showed that S. subspinipes achieved mean speeds of 4.18 ± 0.02 BL s^{-1} (21.2 ± 0.1cm s^{-1}) on flat ground, exhibiting body undulation and head-to-tail leg waves similar to adults. In contrast, T. longicornis moved at 11.7 ± 0.32 BL s^{-1} (5.7 ± 0.1 cm s^{-1}) with a straight body and tail-to-head leg waves. Notably, juvenile locomotor patterns in both species closely matched those of adults, suggesting that consistent locomotor strategies are established early in development despite distinct developmental modes.

Coiffed or coping? Feather corticosterone is correlated with grooming time in American kestrels

Claudia Gerecke, Sarah Bush, Martín Frixione, L. Michael Romero, Dale Clayton

Grooming is a metabolically demanding but important behaviour for both the maintenance of avian body condition and defence against ectoparasites. In American kestrels, Falco sparverius, individual time spent grooming predicts survival, with kestrels at the low and high extremes of grooming less likely to survive. To evaluate whether there is a physiological basis for the variation in grooming behaviour, we observed a population of kestrels in Puerto Rico. For each bird we determined the percentage of time spent grooming, the number of parasitic lice, and the stress exposure via feather corticosterone analysis. Among the birds in our study, there was no significant relationship between time spent grooming and ectoparasite abundance. In contrast, there was a strong negative correlation between corticosterone concentration and time spent grooming, suggesting that corticosterone could mediate grooming behaviour. This result was unexpected since feather corticosterone levels reflected corticosterone deposited approximately nine months prior to the collection of grooming data. The correlation between corticosterone and grooming further suggests the reduced survival of kestrels at the low and high extremes of grooming reflects stress responses that are overactive, or insufficient, respectively.

Feel like you're running in circles: Effects of ganglion removal on the nudibranch Berghia

Sandra Gerges, Cheyenne Tait

Many invertebrates are capable of extreme feats of regeneration. Here we unilaterally removed one pedal ganglion from the brain of the nudibranch, Berghia stephanieae, to determine the effect on behavior. In the first week, during healing, the nudibranchs showed minimal movement. After that first week, when exposed to a food stimulus, the nudibranch exhibited apparent paralysis ipsilateral to the missing ganglion. They attempted to navigate to the food, but the result was a sustained counterclockwise circling. We took videos of this behavior and found that speed was increased in manipulated slugs versus controls after food was added, indicating equivalent sensory arousal by food. However, there was extreme tortuosity of their path, and nudibranchs often did not reach food over many hours of attempted approaches. We proceeded with video for several weeks, noticing some recovery of behavior in some individuals. Our next steps are to correlate the state of the central and peripheral nervous system to level of behavioral recovery. We are using antibodies for serotonin and small cardioactive peptide, neurotransmitters present in pedal ganglion neurons and the body wall nerves that run the length of the foot, as well as phalloidin to stain actin. We hope to show the various ways the nudibranch nervous system compensates, or possibly regenerates, following severe injury.

Antarctic Cumacea

Sarah Gerken, Victoria VanderBrandt

Peracarid crustaceans are the dominant crustaceans in the Antarctic benthos, unlike most of the world oceans where decapods are dominant. Cumaceans can be very abundant, high density, and up to 68% of the peracarid community in this exceptional environment, and yet information is lacking on many aspects of their biology, starting with overall diversity and distribution around the Antarctic. Cumaceans are benthic brooders and poor swimmers, thus dispersal over large distances is somewhat unlikely. We recently sampled three areas around the Antarctic, the West Antarctic Peninsula, the East Antarctic, and the Ross Sea as part of a project exploring cumacean diversity, distribution, and adaptation in the Antarctic. A total of 51 morphospecies were identified across the three regions, with each region showing about the same number of morphospecies (30-37), with an additional 10-15 possible morphospecies present. Each region had morphospecies unique to it, a few morphospecies shared with each of the other regions, along with a group of morphospecies found in all regions. Approximately 20% of morphospecies are shared between the East and the Ross, with the West sharing 6% with each of the other regions. The circumpolar morphospecies are being tested with COI sequences and close inspection of taxonomic characters to determine if they represent groups of closely related species rather than truly circumpolar species.

Long-term captivity dampens the digestive enzyme activities of *Xiphister mucosus*

Donovan German, Jordan Buckner, Leyna Vo, Michelle Herrera, Karina Brocco French, Daniel Rankins, Jacqueline Vasquez, Asmita Pande, Kwasi Connor, Valentina I. Peña Gonzalez

Digestion is chemical process in fishes, driven by digestive enzymes. Hence, digestive enzyme activities are frequently measured as indicators of what nutrients a fish can digest. In this study, we explored what happens to digestive tract length and digestive enzyme activities in a marine herbivorous fish (Xiphister mucosus) fed in captivity for over two years. Captivity affects an animal's physiology, but the gut microbiome has received more attention than digestive biochemistry. Thus, we fed X. mucosus a diet primarily composed of dried algae collected from the same site from which the fish were collected for 26 months. Digestive enzyme activities were then measured and compared to wild-caught X. mucosus. The lab-fed fish showed significant reductions in amylase, trypsin, and aminopeptidase activities in comparison to wild-caught fish. Furthermore, the gradient of activity along the intestine (activities decreasing distally for amylase and trypsin, increasing for aminopeptidase) disappeared in the lab-fed fish. An 18% reduction in relative gut length in the lab-fed fish suggests that they ate less than the wild fish, which likely meant slower gut transit and more time for enzymes to interact with substrates. If this fish species is to be held in captivity for extended time periods (for display or aquaculture), they may do better with a live algal feed in an attempt to replicate the wild-gut phenotype.

Biodiversity of deep-sea fishes in the tropical Atlantic Ocean and Caribbean Sea

Mackenzie Gerringer, Chryssanthi Tzetzis, Jacob Calus, Abisage Sekarore, Erin Patton, Julia Cappiello, Emily McMahon, Nicole Fuller, Gabriel Rosado, Allison North, AJ Petty, Benjamin McPherson, Emily Morgan, Christopher Cook, Cole Janda, Andrew Kareeparampil, Olivia Knudsen, Brooke Licata, Peyton Mackey, Nathan Phillips, Megan Roell, Catie Sawyer, Makena Scarlata, Giovanna Sineo, Evan Weaver, Brett Woodworth, Kasey Cantwell, Daniel Wagner, Brian Kennedy, Thomas Morrow, Samuel Candio, Adam Soule, Anna Michel, Andrea Quattrini, Astrid Leitner

Earth's largest habitats, the deep oceans, are home to an incredible diversity of organisms that are adapted to low light, cold temperatures, often limited food availability, and high hydrostatic pressures. With increasing habitat depth, these environmental variables drive shifts biodiversity shifts across deep-sea communities. However, the relative influences of physical and biological factors in structuring deep-sea community composition remain complex to disentangle. Here, we document shifts in fish community biodiversity with increasing depth in the tropical Atlantic Ocean and Caribbean Sea using remotely operated vehicle and human occupied vehicle surveys across a 6000-meter depth range. We show significant declines in fish community biodiversity and abundance with increasing depth based on 1137 observations of at least 114 species of fishes. These changes correlate strongly with co-varying environmental factors such as declining temperatures and increasing hydrostatic pressure. These findings, which include data from a course-based research experience, add to our understanding of deep-sea fish biogeography, expanding depth and regional ranges for multiple taxa. At abyssal and hadal depths in and around the Puerto Rico Trench, most observations were of cusk eels in the family Ophidiidae, highlighting the importance of this understudied group to ultradeep ecosystems. These findings demonstrate the value of in situ observational approaches to study deep-sea fish ecology and behavior and inform understanding of how changes in temperature and pressure influence community diversity across depth.

Dactyl shapes and limb positioning associated with grasping in crabs

Brennen Gibbins, Kenneth Taylor, Alex Melendez, Glenna Clifton

Crabs are both diverse and versatile. The clade of "true crabs" (Brachyura) has repeatedly evolved specializations for walking, swimming, climbing, and digging. Moreover, individual crabs are capable of performing multiple behaviors all with relatively simple, almost planar, legs. Because crabs live and interact with diverse substrates, including often transitioning among environments and behaviors, they are a practical choice for inspiring robots that inspect irregular terrain, perform infrastructure maintenance, transition between underwater and dry substrates, and retrieve partially buried objects. With an intention towards improving the performance of an amphibious, crab-inspired legged robot, we (a) analyzed the dactyl shape of 10 crab species and (b) tested the grasping of cylindrical objects by an intertidal shore crab (Hemigrapsus nudus). We micro-CT scanned 40 crab specimens across 10 species, isolating the dactyl of the 3rd left pereiopod. Using geometric morphometrics, we identify key shape differences among species, particularly species specialized for gripping onto kelp. We also challenged one species of crab to support its weight by grasping onto cylindrical objects while upside-down. Crabs struggled to lift their body weight for cylinders with smaller diameters (38% of total leg length) and showed relatively consistent joint angles at the merus-carpus joint. This work will inform leg design and control for an amphibious robot, which will directly test the impact of these factors on grasping performance.

Beyond transcriptomics: leveraging biodiversity collections for venom gene evolutionary research

Miranda Gibson, Alonso Delgado, Aurélien De Jode, Meg Daly, Nicolas Salamin, Benjamin Titus

Sea anemones belong to the oldest venomous lineage in the world. Although all anemones have developed the ability to create and distribute toxins over time, the structure and function of these toxins differ between clades. These toxins are almost exclusively investigated with transcriptomic and proteomic methods, which are limited by the prevalence of expressed genes during collection and are notoriously difficult to preserve in the field. We propose a new method of toxin gene identification. Through low-coverage whole genome sequencing and reference-guided assembly, toxin genes can be identified and conserved for downstream analyses, increasing sample availability by using museum holdings and biodiversity collections. To trial this approach, we conducted short-read Illumina genome sequencing for each sea anemone species within Stichodactylina, a small clade of anemones containing species that host clownfishes. All samples had been collected and previously preserved for natural history and biodiversity collection research. We found that when compared with traditional transcriptomic methods, our approach exceeded the expected number of identified toxins per species. Additionally, we demonstrate that these toxins can be used to comprehensively identify gene copies, assess modes of selection, and predict structural models. This study provides a comprehensive investigation into venom gene evolution at multiple hierarchical scales within an ecologically and medically important sea anemone clade and continues to shed light on the evolution of the clownfish-sea anemone symbiosis broadly.

Using pose estimation to characterize behavioral variation in response to amphetamine

Erin Giglio, Elijah Tramm, Dana Mueller, Nicola Grissom

While individual variation is an important modulator of behavioral response to changes in environments, teasing apart the impact of genetic variation on neurodevelopmental signaling in terms of behavior can be difficult. New technologies like markerless pose estimation software (SLEAP) offer promising avenues for quantifying individual variation in behavior via large-scale analysis of motor behaviors in undirected conditions. We use a mouse model of human 16p11.2 hemideletion (del/+) - a copy number variation linked to neurodevelopmental diagnoses - to delve into these interactions. 16p11.2 del/+ mice have previously been demonstrated to have changes in their striatal molecular function and learning deficits as well as sex-divergent deficits in motivational behaviors. Dopaminergic signaling is involved in repetitive locomotor behavior, motivation, and decision-making, and amphetamine locomotor sensitization is a well-established paradigm of probing dopamine function. Here we investigate both the time scale and specific expression on sex- and genotype-specific response to amphetamine sensitization using markerless pose estimation software (SLEAP). We find differences between both sexes and genotypes in behavioral responses to amphetamine, including changes in behavior bout frequencies, duration, distance traveled, and total proportion of time spent moving within 90 minutes of injection. In particular, we find that male del/+ exhibit stronger behavioral responses to smaller quantities of amphetamine in terms of distance traveled as well as perseverative behavioral sequences in lieu of high-velocity motion.

A common maternal effect alters reaction norms of offspring developmental plasticity in a lizard

Anthony Gilbert, Sa'Nya Fleming, Sydney Wayne, Chris Norris, John Rodgers, Daniel Warner

Intergenerational (or within-generation) phenotypic plasticity (IGP) describes a phenomenon by which the environment parents experience during reproduction has a phenotypic, and sometimes, a fitness effect on offspring. Studies discriminate between phenotypic variation in offspring that is explained by either parental effects, or offspring developmental plasticity, to determine the ecological origins and evolutionary consequences of phenotypic variation. However, developmental plasticity may be affected by the presence of parental effects because how offspring respond to variation in their environment can be mediated by how parents respond to their own environmental variation. Understanding the physiological mechanisms of IGP, and its relevance for offspring fitness, requires characterizing how parental effects alter the reaction norms of offspring developmental plasticity. We manipulated parental diet of brown anole lizards (Anolis sagrei) to determine how the parental environment affects offspring plasticity when embryos are reared across varying thermal conditions. We found that diet variation of parents induced changes to the reaction norms of offspring body size, where a greater amount of plasticity in offspring was observed when parents experienced a low calorie diet.

These results suggest widespread parental effects can alter the capacity with which offspring respond to heterogeneity in their developmental environment. Consequently, differences in offspring reaction norms suggest that the parental environment can induce variation in plasticity that has consequences for how plasticity is expected to evolve in natural populations.

Squid chromatophore activity in the absence of neural activity

William Gilly, Joshua Rocamora, Nguyen Pham, Elisabeth Holm

Control of skin-color by chromatophores in squid and other coleoid cephalopods is carried out via motor axons from the brain, but there have been few studies of chromatophore function in the absence of nervous control that might reveal other mechanisms. Andrew Packard demonstrated coordinated, spreading waves of activity in areas of chronically denervated mantle skin in squid (Loligo forbesi and Doryteuthis opalescens) and proposed the existence of "horizontal" control within the skin itself that might complement "vertical" descending motor control in the case of normal, innervated skin. Electrophysiological recordings from dissociated radial muscle fibers of chromatophores using whole-cell patch methods show a total absence of voltage-dependent sodium (Na) current before and after denervation, but calcium (Ca) current density increases about 2-fold following denervation. It is likely that an associated increase in excitability leads to spontaneous chromatophore activity in denervated skin. We also find that spreading activity can be induced in normal (innervated skin) if axonal activity is blocked by tetrodotoxin (TTX) and Ca-based excitability is increased by blocking potassium (K) channels with tetraethylammonium (TEA) or 4-aminopyridine (4AP). Intracellular recordings under these conditions reveal slow, overshooting action potentials, whereas only large excitatory junction potentials are evident in the absence of TTX and K-channel blockers. These results are consistent with a horizontal control pathway that permits excitatory spread directly between chromatophores in the absence of neural activity.

Backyard feeders no longer safe? How perceived dangers at foraging sites affect songbirds

William Gilmour, Dorothy Zahor, Jamie Cornelius

Physiological and behavioral adaptations are necessary for survival. Passerines presumably alter their foraging behavior based on risks to best preserve their lives. To explore these potential modifications, we exposed backyard feeders commonly visited by songbirds to either a model cat or model rabbit. These models were implemented to simulate a 'dangerous' feeding site and a 'safe' feeding site respectively. Then, we looked at corticosterone (CORT) levels and behavioral metrics such as latency to approach and time spent at the feeder. We hypothesize that birds with a more sensitive hypothalamic-pituitary-adrenal (HPA) axis (i.e. faster downregulation of CORT release) are more likely to engage in risk-taking behavior as lower circulating CORT is thought to correlate with decreased vigilance in an individual when compared to individuals with higher circulating CORT. We predict individuals with sensitive HPA axes are more likely to be captured at 'dangerous' feeding sites compared to 'safe' feeding sites and that, irrespective of CORT levels, individuals are likely to have a greater latency to approach and less time spent per trip at 'dangerous' feeding sites compared to 'safe' feeding sites. Furthermore, we are considering how these metrics may be influenced by season and temperature. This ethological approach mixed with physiological data will yield results useful to future research and conservation efforts for songbirds that may contend with risky-foraging situations on a daily basis.

Wake structure and force production of a robotic bird

Ronan Gissler, Kenneth Breuer, Jeremy Bergman, Alexandre Waultre

The aerodynamic wake of a flier such as a bird or bat encodes the history of the force output of the flier. Additionally, it will impart forces and moments on a flier behind the lead flier. It's unclear how the structure of the wake is influenced by wingbeat kinematics, and here we aim to explore this question systematically with a flapping robot. We perform particle image velocimetry (PIV) behind a flapping robot mounted in a wind tunnel test section, and operating at a range of wingbeat frequencies (0 - 10 Hz), flapping amplitudes (10 - 30°, measured peak-to-centerline), and wind speeds (4 - 6 m/s). The robot uses a single DoF flapping motion, but the wings pitch passively due to deformation of the wing membrane. While typically aerodynamic power is estimated in flying animals using PIV, here we compare those estimates with direct measures of mechanical power required by the flapping mechanism and the aerodynamic forces, measured using a force sensor.

Caste- and age-specific thermogenic warm-up rates in bumble bees (*Bombus impatiens*)

Jordan Glass, Megan Dillon, Lauren Vaninger, Anna Cressman, Ripken Wellikson, Michael Dillon

Insects are often assumed to live too briefly to show meaningful signs of aging, yet social insects can survive long enough for age-related changes to emerge. Bumble bees (Bombus impatiens) provide an ideal system for testing this idea, as queens, workers, and drones differ greatly in lifespan and behavior. We asked whether thermogenesis – the ability to generate heat and recover from chill-coma – changes with age in each caste. Our results reveal clear and significant differences. Warm-up rates declined with age across all castes, but the pace and pattern of decline varied. Queens maintained higher warming capacity for longer than workers or drones, while drones showed the steepest decline. A strong interaction between caste and age underscores that aging in bees is not uniform but instead shaped by the distinct roles and life histories of each caste. Because thermogenesis underlies flight and foraging, these findings highlight how aging directly impacts performance and survival in pollinators. More broadly, our study demonstrates that insects, like other animals, show caste- and age-specific declines in physiological function – an overlooked but critical piece of their biology.

How pile properties alter the thermal balance of flying insects

Jordan Glass, Christopher Petranek, Alex Kurtt, Cagney O'Hara, James Foley, Michael Dillon

Flying insects face a thermal conundrum: flight generates both heat and the airflow that can cool their bodies. In bumble bees (Bombus impatiens), wingbeats generate airflow of up to 1 m s-1. Beyond powering lift, this self-generated wind cuts the rise in body temperature by more than half compared to still-air conditions. Yet insulation from body pile (fuzz) and its color further refine this balance. By comparing bees with intact, shaved, darkened, and lightened pile across scenarios of radiative gain, radiative loss, convective loss, and combined cooling plus heating, our preliminary results suggest that fuzz acts as a dynamic thermal blanket: it can trap heat when airflow is low and helps shed heat when light is intense. We also found that dark pile can absorb more sunlight, warming bees faster in still air, but under airflow, it also boosts convective heat loss more effectively than light-colored pile. These intertwined effects of self-generated wind and pile structure create a flexible thermal strategy, enabling bumble bees to stay within safe temperature limits across elevations and in rapidly changing environments.

Testosterone facilitates early crystallization in a wild caught songbird

Rebecca Glisson, Gregory Ball, Bernard Lohr

Few studies have examined the neural and hormonal mechanisms regulating bird song in juveniles during the song learning period, especially in a free-living songbird species that has been wild-reared. Further, while the hormonal control of song development has been mostly studied in males, testosterone administration is known to induce singing in adult females of some species who normally do not produce songs. We studied the role of testosterone in song development in wild-caught grasshopper sparrows, in which males sing two distinct song types and females do not normally sing. We implanted male and female birds with testosterone during the learning phase, recorded their songs, and collected brain tissue to measure the volumes of song control system (SCS) nuclei. Testosterone treated males crystallized (finished learning) both song types 8-10 weeks earlier than controls. Testosterone treated females produced song-like vocalizations with varying similarity

to male songs. Males had significantly larger volumes of SCS nuclei than females. Testosterone had a significant effect on the volume of SCS nuclei in grasshopper sparrow females, but not in males, who were already in breeding condition and possibly at maximal nuclei volume. Our work supports the idea that testosterone can have profound effects during the juvenile period on the song control system of both males and females, including the development of female song in species in which females do not normally sing.

The role of ecology in digestion: Measuring specific dynamic action in miniaturized chameleons

Gene Glover, Christopher Anderson

Miniaturization is a widespread phenomenon seen across clades which has profound effects on organismal body plans and ecologies. Miniaturized species experience different selective pressures than larger congeners including altered prey availability, prey acquisition constraints, and high mass-specific metabolic rates (MRs). To investigate how miniaturization may affect feeding frequency, we compared Specific Dynamic Action (SDA) in a miniaturized genus of chameleons (Brookesia spp.). SDA, broadly defined as the overall energetic "cost" of prey processing, varies by species' feeding frequency where infrequently feeding species exhibit higher peak MRs, prolonged MR elevations, and greater total energetic costs. We predict that Brookesia will show higher SDA costs than larger chameleon species, reflecting a comparatively infrequent feeding ecology. To begin to test this hypothesis, B. brygooi and B. thieli individuals were fed cricket meals equivalent to 3.5 ± 0.5% of their body mass following a 72-hour fasting period. Post-prandial MR was measured in 12-hour intervals overnight until MR returned to baseline (Standard Metabolic Rate). Our results reveal variability in digestive strategies employed by the two species with B. thieli exhibiting significantly longer duration, higher mass-corrected peak MR, and greater SDA cost compared to B. brygooi. These findings suggest differences in the feeding ecology between the two species, and they establish a foundation for future comparisons across a wider range of body sizes to further elucidate the ecological implications of miniaturization.

Health consequences for a shorebird wintering in a drought prone agricultural landscape

Kenneth Glynn, Jamie Cornelius, Ella Rader, Ben Sonnenberg, Madison Meeuwsen

Over the past several decades, global shorebird populations have been rapidly declining. This loss is often associated with the perturbation and/or destruction of habitat, however some species are using flooded rice fields as habitat alternatives. In the Central Valley, California, a tremendous conservation effort has been underway to promote rice fields as a suitable and sustainable habitat alternative to disappearing natural wetlands across the valley, irrespective of ongoing environmental instability from decades of drought. A large number of Dunlin (Calidris alpina) use these heavily modified interior habitats every year, despite the availability of nearby coastal habitats. Despite ongoing conservation action, recent evidence suggests that their populations are declining in the region. To elucidate the cause(s) of this decline and bolster conservation efforts, an assessment of physiological condition and health of these birds is needed. This study investigates the health and condition of Dunlin using flooded rice fields in the Central Valley, CA during their overwintering period (i.e., November - April) from 2021 to 2025, and the ways in which climate instability from drought may contribute to observed trends. Health metrics such as body condition (size-corrected mass), fat deposits, corticosterone, hematocrit and leukocyte counts (heterophil to lymphocyte ratios) vary across years, months and location, and these results are discussed in the context of drought and life history schedules.

Host-microbiome dynamics impact the thermotolerance of marine invertebrates

Victoria Glynn, Laura Fernandes de Barros Marangoni, Maxime Guglielmetti, Eunice Tapia, Viviane Ali, Helio Quintero, E. Rodriguez Guerra, Matan Yuval, Evan Lawrence, Rowan Batts, David Kline, Matthieu Leray, Phillip Cleves, Sean Connolly, Rowan Barrett, Hans Dam, Melissa Pespeni

Understanding the mechanisms underlying organismal responses to environmental stress has been a long-standing pursuit in evolutionary biology, but anthropogenic climate change has turned this interest into an imperative. There is growing appreciation for the importance of interactions between a host and its microbiome for species resilience to environmental change. I will present three vignettes that illustrate how interrogating microbiome dynamics can provide mechanistic insights into the factors underlying differences in thermal resistance across marine invertebrates. In the first vignette, I will share our findings when implementing a standardized acute thermal stress assay for corals across Panama's Tropical Eastern Pacific (TEP). We found that Pocillopora corals from nearby gulfs with distinct thermal dynamics differed in their ability to withstand thermal stress, with contrasting algal microbiome shifts. For the second vignette, we turn to an emerging model system for corals, the sea anemone Aiptasia. We found that besides driving divergent bleaching responses, hosted algal strain was the strongest driver of the prokaryotic microbiome. For the final vignette, we move past cnidarians to introduce a new system for host-microbiome interactions, the widespread Atlantic copepod, Acartia tonsa. I will present some preliminary insights on how microbes can shape genomic adaptation. By leveraging a diversity of systems and timescales, my work is elucidating how microbiome dynamics may complement genetic evolutionary trajectories in marine invertebrates.

Biomechanical relationship of extraocular muscle forces and scleral ossicles in fast-moving fishes

Jacob Goldman, Maria Laura Habegger, Grant Bevill

Teleost fishes represent the largest vertebrate clade, comprising 30,000 species and accounting for half of all known vertebrate diversity. The teleost skull is an irrefutable source of morphological innovation, and although it is often the central focus of morphologists, many of its structures remain underexamined. Scleral ossicles (SO) are bones surrounding the eye in some fishes and various vertebrate clades. As most research on SO has been conducted in non-homologous groups (e.g., reptiles), the functional role of SO in teleosts remains unclear. Previous hypotheses propose that fast-moving fish have robust SO to withstand amplified hydrodynamic pressures; however, taxa like tuna lack robust SO despite their speed, challenging this explanation. Extraocular muscle (EoM) morphology is conserved across vertebrates, except in teleosts with SO, where the EoM insert into these bones rather than the sclera. We hypothesize that SO biomechanically integrate with EoM such that SO robustness correlates with muscle torque output. To test this hypothesis, two fast-moving species, Thunnus atlanticus (Blackfin tuna) and Coryphaena hippurus (Mahi-mahi), were dissected, and the morphology of SO and all EoMs were quantified. Muscle forces were calculated by scaling each line of action with cross-sectional area. Positive correlations between SO thickness and EoM force suggest a biomechanical contribution to SO function, mirroring patterns in other skeletal elements. Additionally, variation in insertion sites suggests involvement in eye movement and potentially drag reduction.

Bat butt biology: sexual dimorphism is a major factor in determining bat pelvic shape

Caroline Goldstein, Andrew Orkney, David Boerma, Brandon Hedrick

Sexual dimorphism is prevalent across animals, and primarily present in traits linked to reproductive success. Male and female involvement in reproduction is dramatically different, and divergent male and female forms related to gestation and birth have been observed in a variety of mammals. This pattern is accentuated in bats, where neonates are commonly >40% of female body mass. Further, bats experience unique anatomical constraints due to their volant lifestyle and unique roosting habits potentially releasing locomotor constraints from the pelvis. In comparison, rodents are under more typical

anatomical constraints as they locomote quadrupedally and have much smaller offspring. We determined degrees of sexual dimorphism in pelvic shape in bats and rodents to establish the extent to which female bats morphologically accommodate for parturition. We hypothesized that bat pelves would exhibit substantial degrees of sexual dimorphism, especially when compared to rodents. Furthermore, we predicted that female bat pelves would be less integrated than their male counterparts, as well as less adapted to roosting ecology due to high parturition constraints. Using 3D geometric morphometrics on more than 60 species, we evaluated pelvic shape in morphospace and found strong sexual dimorphism in bats. Male bat pelves were significantly associated with roosting ecology, but female bat pelves were not. This suggests that males were able to adapt to locomotor optima while females were constrained by parturition.

New early Cretaceous mygalomorph spider fossils reveal diversity of ecological strategies

Elis Maria Gomes Santana, Ivan de Magalhaes, Antonio Alamo Saraiva, James Lamsdell

Fossil mygalomorphs are exceptionally rare, with only 35 species described among more than 1,400 known fossil spiders. Here, we describe two new species from the Early Cretaceous Crato Formation (Aptian, Northeastern Brazil), which represent the first reliable fossils of the extant families Idiopidae and Pycnothelidae. The first specimen (POHL 326) can be referred to Idiopidae based on an excavated palpal tibia bearing short, thorn-like spines. It also shows short posterior spinnerets and a generally more robust body. These characters align with the trapdoor-building lifestyle. The second specimen (POHL 336) can be referred to Pycnothelidae due to the presence of aspinose tarsi, three tarsal claws with one reduced, and the absence of a rastellum. It has a slenderer body, with elongated legs and reduced coxae, which indicate simple burrower behavior without the construction of trapdoors. Three spiders previously described from the same deposit and assigned to Dipluridae have elongated, laterally divergent spinnerets, which are consistent with sheet or funnel-web construction behavior. Together, these fossils pinpoint, in a single Early Cretaceous ecosystem, the presence of trapdoor builders, simple burrowers, and web-building spiders. This shows that the main ecological strategies of mygalomorphs were already well established around 115 million years ago and confirms that the connection between somatic characteristics and behavioral niche, observed in modern spiders, extends to the fossil record as a stable and functionally oriented pattern.

Understanding feeding ecology of *Teleoceras fossiger* and *T. aepysoma* via Mesowear

Gabriel Gonçalves, Reese Barrick

Teleoceras is a genus of rhinocerotids that was widespread across North America (20 Mya ~ 5 Mya). Teleoceras is characterized by having a large, rounded chest cavity and short limbs with relatively high crowned teeth and lower incisors modified into tusk-like teeth. Stable carbon isotopic analyses of T. proterum material from Florida strongly suggested that T. proterum was a terrestrial mixed feeder that heavily consumed C4 grasses. However, for material dated before 4.5 mya, nothing could confidently be said other than the fact that it was consuming C3 foliage. Studies continue to suggest that some species of Teleoceras were browsers/mixed feeders while others have . In this study, we used a 2D Geometric Morphometric Mesowear Analysis on eight T. fossiger individuals from the Late Miocene Minium and Jack Swayze Quarries of Kansas and four T. aepysoma individuals from the Early Pliocene Gray Fossil Site in Tennessee in order to understand their feeding ecology. We created a dataset of 82 equid individuals and 55 rhinocerotid individuals with dietary information collected from the literature to classify T. fossiger and T. aepysoma. Our results show a mixed feeding ecology for T. fossiger and a browsing feeding ecology for T. aeypsoma. Both of these dietary classifications align with previous studies. Analyses of T. fossiger gives us better understanding as to how much browse and graze T. fossiger consumed. Analyzing T. aepysoma provides a better explanation of T. aepysoma C3 grass or C3 browse preferences. By comparing the diet/feeding ecology of Teleoceras across temporal and spatial ranges, we can get an increased understanding of the responses to C4 grasses, and Teleoceras preferrences for C3 trees or C3 grasses overall.

Visuomotor behavior in 3D: vertical optomotor response in adult zebrafish

Ming Gong, Eric Tytell

Sighted animals use optic flow, the global motion of the visual scene generated by their own movement, to estimate their self-motions. A widely studied visuomotor behavior driven by optic flow is the optomotor response (OMR), in which animals move in response to moving visual stimuli to stabilize their perceived visual field. This behavior is especially extensively described for horizontal movements. However, animals like fish that inhabit aquatic environments also move vertically and encounter vertically moving visual patterns. Such vertical motions are important in many natural behaviors, such as swimming, feeding, and avoiding predators, which are both frequent and vital for ecological fitness. Despite its importance, little is known about whether and how fish respond behaviorally to vertical optic flow. We studied zebrafish because their optomotor response to horizontally moving patterns is well-characterized. We provided horizontally, vertically, and diagonally moving patterns under binocular stimulation via dual monitors for both individual adult zebrafish and groups. We confirmed previous results that adult zebrafish display a negative horizontal optomotor response, swimming in the opposite direction as a horizontal moving stimulus. We will discuss the response to vertically and diagonally moving patterns, and differences in the response among individuals and groups.

Spidey senses: The role of substrate-borne vibrations in *Lycosidae* hunting

Nat Gong, Pietro D'Amelio, Eileen Hebets

In the field of sensory ecology, wolf spiders (Lycosidae) have been widely studied for their use of vibratory cues during hunting, predator avoidance, and courtship. However, the sensory modalities preferred during these different behaviors might greatly differ throughout over 2,000 species in 120 genera of wolf spiders. Hunting, for example, might be driven by vision, vibrations, or both. I investigated whether substrate type influenced the hunting efficiency of the previously unstudied genera Trochosa and Pardosa in Portland, OR, hypothesizing that spiders would find and subdue prey more quickly on substrates that better transmit vibratory cues. In each trial, one spider and one cricket were placed in an arena with one of two substrate options, one (granite) known to absorb vibrations more than the other (filter paper). On average, Pardosa individuals took roughly three and a half times longer to make contact with the cricket on granite than on filter paper, while Trochosa individuals took roughly two thirds the amount of time. Were these results confirmed, Pardosa individuals may rely more on vibratory cues to hunt than do Trochosa individuals. Future work should investigate the interaction between vibratory and visual or chemical cues to provide insight into the unique sensory systems of each wolf spider species, connect it to their ecology, and infer how the use of multimodal cues has evolved.

Decoding the cellular and genetic basis of nectary development in Aquilegia

Yan Gong

Angiosperms are the most speciose and diverse plant lineage, and much of this great diversity is apparent in their floral organ. Many traits of flower development have evolved to facilitate plant-pollinator interactions. The presence of the nectary and its secreted nectar is among these traits. In angiosperms, floral nectaries are thought to have evolved many times independently. While a few core eudicots have been shown to share similar genetic architecture in regulating their floral nectary development, how nectary formation is controlled in other angiosperm lineages is still a mystery. Here, we examined cellular and molecular mechanisms behind nectary development in basal eudicot species Aquilegia. In Aquilegia, each elaborated petal spur bears a nectary at the tip. Recently, we identified STYLISH transcription factors as novel regulators of Aquilegia nectary development, and we employed gene expression profiling methods and RNAi-based gene silencing to probe the genetic pathways downstream of STYLISH. We uncovered a novel nectar sugar production pathway in Aquilegia nectaries. In addition, we examined the cellular basis of nectar secretion and found that the epidermal cells of Aquilegia nectaries

undergo program cell death to create channels to release nectar, and this holocrine secretion is enabled by active reduction of epidermal cell wall and spatial reorganization of the nectar sugar production pathway. Together, these results establish a novel model for nectary development research and provide a mechanistic understanding of holocrine nectar secretion mode in Aquilegia.

Why hovering is costly: inherent instability and active control of posture in *Polypterus*

Yuchen Gong, Mitchell Ford, Xuewei Qi, Neelima Sharma, Emily Hillan, Haibo Dong, Neil Shubin, Valentina Di Santo

Hovering in still water is inherently unstable: with minimal passive stability, fishes must continuously generate corrective forces to resist small disturbances. Comparative work shows that this instability is especially costly in species with high fineness ratios (long and slender body shapes), which elevate the metabolic demand of station-keeping. Polypterus senegalus, a particularly elongate fish, provides an ideal system for examining the mechanisms and costs of hovering. We quantified both energetic costs and control mechanisms by measuring oxygen consumption in parallel with hydrodynamic analyses. Respirometry revealed that oxygen consumption during hovering (130.2 ± 35.4 mgO_2 kg^{-1} h^{-1}) was ~2.4× higher than resting values (53.5 ± 18.2 mgO_2 kg^{-1} h^{-1}), confirming the high costs predicted for unstable morphologies. High-speed video, 3D particle tracking velocimetry (3D-PTV) , and computational fluid dynamics(CFD) captured fin kinematics, vortex dynamics, and the corrective forces stabilizing posture. Together, these approaches showed that hovering requires continuous fin motions to generate stabilizing flows and moments. By linking fin kinematics, vortex interactions, and metabolic costs, this framework establishes how Polypterus maintains postural control in still water and why hovering is costly. These results show that the energetic penalty of elongated body forms arises directly from the need for active stabilization. More broadly, they suggest that the metabolic expense of hovering has been an underappreciated selective pressure shaping fish body form, fin placement, and locomotor strategies.

Activity responses of *L. taylori* and *R. horribilis* tadpoles to sensory predatory cues

Dariana González Aguilar, Juan Abarca, Yash Sondhi, Pablo Allen, José Miguel Chaves-Fallas

Tadpoles must rapidly sense and respond to predation threats to survive the most vulnerable stage of anuran development. While previous studies have investigated the independent effect of visual or chemical predation signals on tadpole behavior, none have compared tadpole responses across multiple sensory modalities, or examined how species facing varying levels of predation risk respond to the same signals. This study investigates the activity responses of two neotropical tadpole species, Lithobates taylori (non-toxic) and Rhinella horribilis (toxic), to visual, chemical, and auditory predation signals. Sixty tadpoles of each species were collected from the San Luis River and CIEE Monteverde Tilapia Pond in Monteverde, Costa Rica. Tadpoles were exposed to shadows of predatory birds (visual cue), Belostomatid-treated water (chemical cue), or calls of the predator Chloroceryle americana (auditory cue). Activity was recorded 4 minutes before, 1 minute during, and 4 minutes after exposure using Portable Locomotion Activity Monitors (pLAMs). L. taylori tadpole activity differed significantly across experimental groups ($F(3, 32) = 5.195$, $p = 0.005$), particularly between auditory and control groups ($p = 0.009$). Conversely, R. horribilis showed no significant difference in activity level across treatment groups ($F(3, 32) = 0.35$, $p = 0.79$). These results suggest that toxic tadpoles, facing lower predation pressure, may not rely on immediate anti-predation responses, while non-toxic species may prioritize auditory perception for threat detection and avoidance.

Killing for a niche: T6SS competition among symbionts in the *Euprymna tasmanica* light organ

Perla Gonzalez Moreno, Michele Nishiguchi, Cara Adams

Symbioses between sepiolid squids and the bioluminescent bacterium V. fischeri can serve as a valuable model system to examine host colonization dynamics. Although multiple strains of V. fischeri are present in seawater, only a few colonize the squid light organ (LO). In this mutualism, some strains of V. fischeri encode for a Type VI secretion system (T6SS) – a molecular projectile weapon that can be deployed against bacterial competitors. Previous studies have demonstrated that V. fischeri symbionts utilize T6SS weapons to eliminate a susceptible V. fischeri strain within the LO crypts of Euprymna scolopes. Therefore, we sought to determine whether T6SS-armed V. fischeri could also obliterate susceptible strains within the LO crypts of E. tasmanica, a species with a larger geographical range and multiple ecotypes. To examine T6SS competition in-vivo, aposymbiotic E. tasmanica hatchlings were exposed to a combination of both T6SS-armed and susceptible V. fischeri strains labeled with fluorescent plasmids. At 48 hours, colonized juveniles were fixed and prepared for confocal microscopy. Our results demonstrate that T6SS-armed strains successfully eliminate the susceptible strain within the LO crypts of the host. Additionally, our results reveal that two T6SS-armed strains can coexist within the LO crypts during initial colonization. These findings suggest that T6SS competition regulates symbiont strain diversity within the LO of E. tasmanica, which in turn drives the biogeographical patterns of Australian V. fischeri ecotypes.

The effects of microcystin toxins on larval dragonflies

Victoria Good Buffalo, Ronika Ferrier, Ramandus Grayhat, Alayna Duncan, Sandy Lomakema, Anthony Lapsansky, Misty Peacock

Larval dragonflies are important components of aquatic food webs, preying on consumers of photosynthetic organisms and serving as prey for birds, fish, and other wildlife. However, these and other aquatic insects face an escalating threat from microcystin, a widespread freshwater biotoxin produced by cyanobacteria. Research on other aquatic insects has indicated that microcystin can have both lethal and sublethal effects even at low concentrations; however, research on the relationship between dragonflies and microcystin remains scarce. To address this gap in knowledge, we quantified the effect of this biotoxin on dragonfly larvae. Specifically, we measured the total distance traveled by dragonfly larvae (family Libellulidae) before and after toxin exposure. Because microcystin produces sublethal effects in other aquatic insects, we predicted that specimens exposed to microcystin would be less mobile after exposure, with stronger effects at higher microcystin concentrations. Contrary to expectations, we found no clear relationship between microcystin exposure and our proxy for dragonfly health, even at concentrations lethal to other species. This suggests that dragonflies from our collection site were tolerant to microcystin. To examine this possibility, we plan to quantify the microcystin concentrations in the water and animals at our study site and repeat our experiments using dragonflies collected from sites differing in toxin exposure.

Lengthy strides give long-limbed lizards a leg up at low temperatures

Colin Goodman, Stephen Deban

Lizards are morphologically diverse, ectothermic, and exhibit great variation in locomotor performance. These features have long made lizards a model for examining how locomotion responds to various perturbations in nature, including temperature; however, most research has focused on the impacts of temperature on whole-organism performance. We examined the impacts of temperature on kinematics of the stride, hindlimbs, and trunk in six lizard species (Ameiva ameiva, Basiliscus vittatus, Agama picticauda, Leiocephalus carinatus, Ctenosaura similis, and Leiolepis rubritaeniata). Lizard sprinting was imaged at 500 Hz, using a pair of cameras, at three ecologically relevant temperatures (20, 25, 33 °C). We found no systematic patterns of thermal sensitivity for kinematics of the hindlimbs or trunk. However, we found that the longest-limbed species (Basiliscus and Ameiva) relied most heavily on increasing stride length during the acceleratory phase, and exhibited the lowest thermal sensitivity of maximal velocity. Further, the species with the highest stride frequency (Leiolepis and Ctenosaura) exhibited the greatest accelerations at higher temperatures, yet these species exhibited the highest thermal sensitivity of maximal velocity. These results combined with the results of previously presented electromyographic and muscle contractile experiments demonstrate that the maintenance of higher stride frequencies is infeasible at lower temperatures.

Structural differences of teeth found in iron-biomineralizing molluscs

Madison Gott, Ashleigh Clayton, Rebecca Varney

Biological materials are often superior to manmade substances, and the teeth of chitons (Mollusca; Polyplacophora) are one of the hardest animal products. All chitons make iron teeth which they use to scrape algae from rocks. Teeth vary between species in the number of cusps per tooth (n=1, 2, 3, 4) and in the amount of iron oxide, iron oxyhydroxide, and calcium apatite in layers within the teeth. However, the interaction between evolutionary history and the physical properties of the teeth is unknown. Here we compare the mineral composition and mechanical properties of teeth in chitons possessing each type of cusp, as well as teeth from two limpets. We used scanning electron microscopy-energy dispersive X-ray spectroscopy (SEM-EDX) to measure the layers of internal minerals and we assessed the strength of different parts of the teeth. By contextualizing the material properties of these teeth within the evolutionary relationships among these animals, we can gain a better understanding of how biomineralization of iron evolved alongside tooth shape and function.

Shedding light on specificity: Strain dynamics in the *Siphamia-Photobacterium* symbiosis

Alison Gould

Despite the vast diversity of microorganisms in the environment, hosts selectively associate with specific microbial species that are often otherwise rare. While this species-level selectivity has been documented, the mechanisms governing strain-level diversity and the dynamics within these partnerships remain less well characterized. The bioluminescent Siphamia-Photobacterium mandapamensis symbiosis presents an ideal system for investigating these selective processes at both the species and strain levels. This binary, gut-associated partnership, which relies on symbiont acquisition through horizontal transmission, offers a reduced-complexity system for examining the mechanisms that regulate specificity from an evolutionary scale down to the molecular level. While a high degree of species-level specificity is maintained throughout the host genus, there is significant strain diversity in the symbiont community. A single Siphamia host harbors and average of 5-6 symbiont strains within its light organ, and genomic differences in symbiont strains have been observed between individual hosts, populations of hosts, and host species. The juxtaposition of high species-level specificity and strain diversity uniquely poises the Siphamia-Photobacterium system to address fundamental questions in microbial symbioses: How do hosts recognize and selectively acquire specific symbiont species and/or strains? What processes regulate strain-level symbiont diversity? How might symbiont strain dynamics influence adaptation to environmental change? Overall, this emerging model provides a framework for investigating the underlying molecular, ecological and evolutionary processes shaping host-microbe interactions across various scales, including the strain-level.

Gut microbiota on a global scale: fecal inventories of native and introduced House Sparrows

José Goyco-Blas, Jim Briskie, Kate Buchanan, Roi Dor, Henrik Jensen, Kim Mathot, Kailey McCain, Ho Thu Phuong, Mark Ravinet, Melissah Rowe, Elizabeth Sheldon, Jorgen Soraker, Massamba Thiam, Thinh Vu, Cedric Zimmer, Aaron Schrey, Lynn Martin, Kevin Kohl

Host-associated microbial communities, or microbiomes, confer a number of biological functions to their hosts. However, the factors that govern the membership structure of these communities are poorly understood, especially among avian hosts. Here, we collected feces from several populations of a globally distributed songbird, the House Sparrow (Passer domesticus) and used 16S rRNA gene sequencing to inventory the resident gut microbiota. Populations of sparrows spanned 5 native populations and 4 introduced populations of the species, paired for climatic conditions. We found that the gut microbiome of House Sparrows was dominated by the phyla Firmicutes and Proteobacteria, though the abundances of these taxa varied across populations. The membership of gut microbial communities was significantly distinct across sampling sites, with most variation in gut microbial membership being explained by genetic group of the host individuals, with some minor roles of host sex in structuring the gut microbiome. Prevalence of putative gut pathogens also varied across populations and sex. These results provide insight into the complexity of environmental and host factors that influence the gut microbiota of avian hosts.

Seasonal changes affect propagation of year-round resident songbird vocalizations

Alexander Graber, Kalina Sloat, Megan Gall

Animal communication signals are shaped by the physical environment in which they propagate. Acoustic signals can be scattered, reflected, or absorbed by objects, with each of these effects operating in a frequency-specific manner. The acoustic adaptation hypothesis predicts that animal signals evolve to optimize habitat-specific propagation. However, many habitats can be heterogenous, with differences occurring over both spatial and temporal scales. Moreover, the types of acoustic signals produced by year-round residents vary across seasons. Here, we tested the acoustic adaptation hypothesis in a multi-season propagation experiment using tufted titmouse (Baeolophus bicolor), black-capped chickadee (Poecile atricapillus), and white-breasted nuthatch (Sitta carolinensis) calls and songs. These species are ideal model systems for this question. As non-migratory residents of temperate forests they experience changes in habitat structure across the year. Additionally, their patterns of vocalization use vary seasonally, which may lead to differences in habitat-specific signal propagation across the year. We used a repeated-measures playback design to assess vegetation density, vocalization amplitude, and vocalization structure across four seasons at 14 temperate deciduous forest sites. We found that, generally, song propagation was strongly affected by season, while calls propagated similarly in all four seasons, although the effects were not homogeneous heterospecifically. These data support the acoustic adaptation hypothesis.

Liver and kidney clearance of nano- and microplastics in the fathead minnow (Pimephales promelas)

Gregory Grabowski, Rachelle Belanger, Levi Storks, Cornelius Harris, Miranda Jasinski, Sarah Magid

The degradation of plastics into microplastics (MP) and nanoplastics (NP) and its infiltration into living systems is well established. Initial qualitative clearance of MP and NP in freshwater fathead minnows (Pimephales promelas) using fluorescent microscopy of liver and kidney was conducted on fish demonstrating alterations in olfactory-driven alarm responses in Dr's Belanger and Storks' laboratories. Specimens preserved in 4% paraformaldehyde were provided, liver and kidneys were removed and sequentially prepared in sucrose gradients for cryostat sectioning at 30 microns. Sections were mounted with Vectashield mounting medium for fluorescence with DAPI (nuclei identification). Both MP and NP fluoresce similar to Alexa Fluor 546 (AF546), which was the filter used for their identification. Both controls (0 mg/L) for liver and kidney showed minimal background MP and NP using the AF 546 filter, however, the liver appeared to have more background particulates indicating it as the primary mode if clearance. Experimental treatments contained 1mg/L MP and 1mg/L NP with exposure for 42 days. Both MP and NP exposures appear to form more single and multiple vesicles in both liver and kidney tissue. The vesicles were more diffusely spread throughout the liver, whereas the kidney vesicles appeared to be regionally clustered in a nephron segment. Because this was not observed in controls, the kidney appears to clear plastic particulates only under experimental concentrations.

Guided by magnets, stars, odors, and friends: how Australian bogong moths find their way

Jesse Granger, Hui Chen, Linnea Rosberg, Eric Warrant

Nature is filled with examples of animals performing incredible feats of navigation. For instance, many species of birds, mammals, fish, and even insects migrate thousands of kilometers to highly specific locations. These migrators are ecologically important (often keystone species) at multiple locations because they disperse other less mobile organisms and move vital nutrients

between habitats. Additionally, these animals often have deep cultural significance for the people in their migration areas. Yet, despite their importance, the mechanisms that allow animals to accomplish long-distance navigation remain largely mysterious. Without knowing how these animals navigate, it is impossible to know how human activities may be affecting their ability to migrate, and where to best target conservation efforts.

Each spring, nocturnal Bogong moths (Agrotis infusa) travel over 1,000 kilometers across southeast Australia to specific alpine caves they have never visited before, where they spend the summer in aestivation. How these moths perform such an extraordinary journey is an open question. In this talk, I will explore four potential tools Bogongs moths use to guide their navigation: the Earth's magnetic field, the stars, cave odors, and I will especially focus on how they may potentially use the collective guidance of one another. Together, these stories allow us to gain new insights into how Bogong moths achieve their extraordinary migration.

Magnetic drift? No problem: migratory leatherback sea turtles have remarkable route fidelity

Jesse Granger, Michael James, Kenneth Lohmann, Emily Bond, Kyle Mitchell, Sonke Johnsen

Endangered Atlantic leatherback sea turtles (Dermochelys coriacea) migrate thousands of kilometers, yet the cues guiding their navigation remain unclear. Using long-term telemetry data from repeatedly tagged individuals, we show that female leatherbacks migrating northward from nesting beaches in Trinidad and Tobago to foraging habitat off the shores of Eastern Canada exhibited remarkable individual-route fidelity. We tested the hypothesis that they may be using a geomagnetic map to navigate by comparing simulated migratory routes—based on different navigational strategies—to observed tracks, accounting for yearly changes in the geomagnetic field. We showed that no combination of geomagnetic parameters alone could explain the turtles' high route fidelity. We therefore explored strategies that also included a celestially-mediated estimate of latitude. Our results additionally suggested that the turtles compensate for magnetic drift, potentially by applying a correction at the nesting beach. Of all the strategies tested, only latitude + corrected intensity both matched the turtles' route fidelity and could plausibly be maintained over their lifespans. This finding, using real-world animal migration data, suggests that geographic latitude may be used as part of a magnetic map, and that leatherback sea turtles can compensate for geomagnetic drift.

Collective swimming patterns in brief squid, *Lolliguncula brevis*

Morgan Grant, Ian Bartol

Group behaviors, such as shoaling and schooling, are common in fishes, providing benefits that include heightened predator detection and avoidance, improved foraging, and reduced locomotory energetic costs. Despite the ecological/energetic significance of collective swimming and the importance of cephalopods to food web dynamics and global fisheries, little is known quantitatively about how squids position themselves relative to neighbors and organize in groups. To better understand collective swimming patterns in squid, high-speed video of brief squid, Lolliguncula brevis, was collected as they swam in groups over a range of speeds in a water tunnel using a 3D camera system. The fastest group speed detected was ~48 cm/s (8.7 mantle lengths/s). At speeds < 2 2 cm/s (3.6 mantle lengths/s), mixed orientations were common within the group, with some individuals swimming arms-first (forward) while others swam tail-first (backward). At higher speeds individuals consistently swam tail-first. As swimming speed increased, group cohesion and polarization increased and fin frequency decreased, with squid relying more heavily on the pulsed jet for propulsion. Our findings indicate that shallow-water, euryhaline brief squid can form polarized schools, especially at higher group speeds, like larger loliginids and ommastrephids.

Delayed stretch "actuation" for asynchronous robotic flight

Nick Gravish

Insect flight muscle can be divided into two forms: 1) synchronous muscle in which each muscle contraction is exactly timed by a corresponding neural activation, and 2) asynchronous muscle in which the neural activation is desynchronized from wing motion and instead a delayed stretch activation response of the muscle generates wingbeats. In this talk we will review from the biological literature what is known of delayed stretch activation in the context of asynchronous flight. We will then describe our attempts to build flapping wing robots that emulate delayed stretch activation for wingbeat generation. This method of actuation presents several opportunities for robotic and biological flight which we will review.

Neurosteroid dynamics across courtship and paternal care in a seasonally reproducing teleost fish

Sofia Gray, Cecilia Jalabert, Jun Chen, Kiran Soma, Joseph Sisneros

Parental care is a fundamental social behavior that enhances offspring survival and parental reproductive success. Most mammals and birds exhibit maternal-only or biparental care, whereas paternal-only care is more common in fish. The plainfin midshipman (Porichthys notatus), a seasonally breeding teleost fish, exemplifies this strategy: males are the sole providers of parental care, responsible for nest guarding and oxygenation of eggs. Because males simultaneously invest in courtship and parental duties, they face profound trade-offs in resource allocation during the breeding season. Despite the clear ecological and evolutionary importance of these trade-offs, the neuroendocrine mechanisms underlying courtship and care in fishes remain poorly understood. In the present study, we developed and validated a method to extract and quantify steroid hormones (e.g., testosterone, 11-ketotestosterone, progesterone, estradiol, and cortisol) from teleost brain and plasma via state-of-the-art liquid chromatography-tandem mass spectrometry (LC-MS/MS). We applied this method to measure steroids in plasma and brain in three male reproductive states: courting males, early-stage paternal males, and late-stage paternal males collected from natural nests in the field. While plasma androgens are known to decline in paternal males, this is the first direct investigation of neurosteroid dynamics associated with parental care in a teleost fish. Because steroid signaling pathways are conserved across vertebrates, this research offers novel insights into the neuroendocrine regulation of parental care, with comparative relevance to mammals and birds.

Quantifying morphological elaboration and sexual dimorphism in moth antennae

Madeline Greco, Paul Masonick, Zaina Syeda, Bhavna Sinthjou, Ummat Somjee, Akito Kawahara, Simon Sponberg, Yash Sondhi

Moths commonly possess large, elaborate antennae critical for sensory perception. In males, elaborate antennae enhance their ability to detect female pheromones over long distances. However, some females also exhibit plumose antennae, which can aid in detecting host plant odors. This dual function suggests that both sexual selection and natural selection may influence antennal elaboration, and we aim to discover which is the primary motivation. We measured variation in antennal elaboration across two moth families, Sphingidae and Saturniidae, which had sufficient representation of males and females in digitized specimen databases. We used the software Husmorph to place landmarks on specimen images from over 200 genera to measure the approximate antennal dimensions, body size and wingspan. We compared circumference-to-area ratios across species and sexes. In Saturniidae, we find overall high levels of elaboration, but there is also large variation in the degree and extent of sexual dimorphism of elaboration. In contrast, Sphingidae had fewer instances of elaboration overall, with the exception of some Smerinthinae. More comprehensive species and generic sampling with this technique will help differentiate the relative roles of elaborate antennae across sexes. Our findings provide a foundation for deeper phylogenetic analyses of the evolution of moth sensory traits.

The effect of thyroid hormone on the phenotypic plasticity of zebrafish skulls

Kayli Greeley, William Cooper

Phenotypic plasticity can promote a species' success by shifting their development to match environmental conditions. It can also provide a "flexible stem" that promotes the evolution of new species that occupy different ecological niches. Divergence along a bentho-pelagic ecological axis has been a major evolutionary pattern among many successful fish clades. This typically involves specialization on benthic prey by producing strong bite forces and capturing elusive prey in the water column using fast jaw movements. Recent work also suggests that modulation of thyroid hormone signaling may have accompanied evolutionary changes in fish feeding mechanics. This project examined the role of thyroid hormone on skull plasticity in zebrafish constrained to use either hard or fast bites during juvenile development. Fish with different thyroid hormone levels (elevated, normal, nonexistent) received one of two feeding treatments starting at 35 days-post-fertilization (dpf) when skull ossification first permits the use of hard bite forces: 1) using hard bites to retrieve brine shrimp through nylon mesh; or 2) using fast bites to capture brine shrimp in the water column. Specimens were collected at three time points (45, 554, and 70 dpf) and µCT scanned to allow the quantification of differences in jaw morphology. Here we report how feeding strategy and thyroid hormone levels interact to affect the plasticity of jaw development in the zebrafish.

Examining eastern red-backed salamander movement patterns across artificial habitat arrays

Anna Green, Caroline Goldstein, Tiffany Suiters, Stephen Bredin, Lauren Essner, William Hooker, Andrew Orkney, Priscila Rothier, Kay Williams, William Ryerson, Brandon Hedrick

Understanding animal movement patterns is crucial for predicting species responses to habitat fragmentation and climate change. Eastern red-backed salamanders (Plethodon cinereus) are abundant forest floor predators and are commonly used as a model system for assessing salamander population dynamics. Much work has been done attempting to understand how climate affects their ranges at regional scales. However, their fine-scale movement ecology remains poorly understood. We investigate salamander microdispersal using coverboard arrays and spatial capture-recapture methods to address three key questions. (1) We evaluate whether coverboard array organization creates high quality habitat and impacts perceived forest population density. We established nine coverboard arrays (50 boards each) across Ithaca, NY, with 12 additional outer boards positioned 3m from each array's perimeter and hypothesize that salamanders would move from outer boards to inner boards, inflating density within the array. Preliminary data suggest limited movement between outer boards and inner arrays, contradicting our sink hypothesis. (2) We then calculate density and maximum mean distance moved, predicting high-density areas will increase maximum movement distances as individuals compete for resources. (3) Finally, using translocation experiments, we mark salamanders and then move them 18-30m to test site fidelity and distance-dependent homing success. We predict higher homing success at shorter distances (18m vs 30m) and longer homing times at greater distances, demonstrating site fidelity and overland movement capacity in this species.

Yessotoxin recovery from shellfish samples using targeted LC-MS/MS

Thomas Greyeyes, Justice Black-Williams, Roberto Kannapell, Kah-Ty Natrall, Ruby Sheriff, Anthony Lapsansky, Megan Schulz, Misty Peacock

Yessotoxin is a phycotoxin linked with mass mortality of shellfish in the Pacific Northwest. This is an immediate concern for coastal communities because inaccurate reporting endangers Indigenous food sovereignty and commercial shellfish operations. To determine yessotoxin concentrations in shellfish, chemical and solid phase extraction are used to isolate and purify toxin and remove unwanted analytes from matrices. Samples are then quantified with targeted liquid chromatography tandem mass spectrometry (LC-MS/MS). However, there are still matrices that cause potential inaccuracies with toxin recovery. For this matrix study, six species of shellfish were harvested from the coast of the Salish Sea, WA, USA and processed for yessotoxin. Samples were then spiked with a known concentration of yessotoxin standard (NRC CRM, Canada), re-analyzed and percent recovery was calculated to determine matrix impacts. The average yessotoxin recovery across all six species of shellfish was 46%, indicating that there are large matrix impacts across shellfish species that need to be explored.

Why frogs call

Marcos Gridi-Papp, Olivia Chung

Advertisement calls of anurans can physically attract mates for reproduction and deter sexual competitors but recent evidence (in review) indicates that they can also trigger ovulation and egg laying in females. We examined the very-close interactions between the male and female túngara frog (Engystomops ""Physalaemus"" pustulosus) during courtship to test if the male's behavior would show a role of the calls in triggering egg laying. We eliminated the need for mate attraction and any signs of sexual competitors then gave each male a choice between immediately amplecting the female to secure his mating opportunity or calling. We assigned pairs into acoustically isolated enclosures small enough to keep the female within reach of the male and prevent each pair from hearing any frog calls other than the ones emitted by the male. We then recorded their behavior using an infrared camera. The majority of the males called before amplecting the female. Furthermore, some males amplected first, then released the female, called for a while and amplected her again before egg laying commenced. Our data indicate that the male may need to call in order to trigger ovulation if the female has not been stimulated enough by the sound of the chorus. The results also provide evidence that males may be able to assess the readiness of females for egg laying.

Environmental effects on corticosterone in nestling tree swallows (*Tachycineta bicolor*)

Erica Griffin, Conor Taff, Maren Vitousek

For an individual, the ability to cope with challenges is fundamental to surviving in a changing environment. The corticosterone stress response has a major impact on the ability of an organism to react to the challenges of rapid environmental change. Previous research has shown that when faced with a prolonged cold snap, adult female tree swallows increase their baseline and stress-induced corticosterone levels, and that individual variation in corticosterone levels predicts reproductive success during challenges. Tree swallows are advancing reproduction with warming springs and are more likely to encounter cold snaps during breeding, which can reduce reproductive success. Here, using data from a long-term study of free-living tree swallows collected from 2013-2025, we show that nestling tree swallows show an immediate increase in corticosterone levels when ambient temperatures fall below a threshold of 18.5°C, which has previously been identified as the threshold at which insect availability begins to decline. As a result of earlier reproduction, nestlings are more likely to experience cold snaps during development, making it especially important to understand their effects. Ongoing work is also testing whether male and female nestlings display dimorphism in their corticosterone responses to further our understanding of how nestlings are responding to thermal environmental shifts.

Testing a core assumption of natural selection: Do individuals match behavior to phenotype?

Kathleen Griffin, James Stroud

Most studies of natural selection assume that animals with different body types all try to use the same 'optimal' habitats. Under this view, an organism's fitness is determined by how well its morphology matches the population average. However, this assumption overlooks a critical factor: animal behavior. If individual organisms can behaviorally compensate by using habitats that suit their body type, then our predictions about who survives and reproduces may be wrong. We tested this possibility in a population of Anolis cristatellus lizards in Miami, Florida, tracking habitat use of marked individuals (n=259) in an island population. We tested whether lizards with different morphologies—long vs. short limbs, large vs. small toepads—use different habitat types that

match their functional abilities. We predicted that long-limbed lizards would favor broad surfaces (where sprinting ability is advantageous), short-limbed lizards would use thin branches (where stability is key), and large-toepad lizards would climb to greater heights (where grip strength matters most). Our findings reveal whether a fundamental assumption underlying natural selection studies holds true in nature. If animals match their behavior to their bodies, then evolutionary biologists need to rethink how selection works in nature—and acknowledge that behavior might be just as important as morphology in determining survival.

Examining whether individual ecomorphs arise through phenotype-environment matching in Anoles

Kathleen Griffin, James Stroud

Caribbean Anolis lizards are a well-studied example of niche specialization: across different islands in the Greater Antilles, 'ecomorph' phenotypes have independently and convergently evolved in response to similar habitat use, generating consistent ecology-form-function relationships. Recent evidence suggests this macroevolutionary pattern may be mirrored at the individual level, with individuals varying in habitat use within the same species. However, whether individual morphological variation predicts habitat specialization within populations remains unclear. We conducted an extensive field study on an entire island population of Anolis cristatellus in Miami, Florida, collecting repeated observations of habitat use for marked individuals (n=5,779 observations for n=259 lizards with at least three observations). We tested whether morphology predicted habitat use through its relationship with functional performance: specifically, that long-limbed lizards would consistently use broad surfaces, short-limbed lizards would use thin branches, lizards with large toepads would use higher perches, and those with small toepads would use lower perches. We found that there were both perch height (Within Individual Component/Total [population] Niche Width [WIC/TNW] = 0.622, $p < 0.01$) and perch width specialists (WIC/TNW = 0.619, $p < 0.01$) in this population. Our findings connect micro- and macroevolutionary processes by revealing whether the same morphology-ecology relationships that drive adaptive radiation also operate within populations, potentially providing the raw material for evolutionary diversification.

Hormonal influences on sexually dichromatic plumage across the avian tree of life

Emily Griffith, Jay Falk

Sexes are complex, multicomponent phenotypes that include traits both directly and indirectly involved in sexual reproduction. Secondary sexual traits are defined by divergence in size, ornamentation, or general appearance between the sexes, but are not directly involved in gamete production. For example, color differences between the sexes (dichromatism) in birds are a hallmark example of a secondary sexual character that is associated with sexual signaling and mate choice. Previous work has shown that the physiological and genetic mechanisms that underlie presence or absence of secondary sexual characters in birds are highly diverse across the avian clade. Here I review the literature on hormonal influences on sexual dichromatism across the avian tree of life. Hormones such as estrogen, testosterone, and cortisol are known to have important impacts on the development and regulation of plumage coloration across an individual's lifetime, but their influence on sexual dichromatism has yet to be placed within a broader comparative or phylogenetic framework. I will use phylogenetic comparative methods to visualize the evolution of different hormonal impacts on sexual dichromatism, review the individual and combined effects of hormones on phenotype, and discuss the interplay among genes, hormones, and within-species sexual variation.

An aberrant bird provides insight into the plumage and genomics of North American orioles

Emily Griffith, Lukas Musher, Kevin Omland, Robert Mulvihill, Steven Latta, Jocelyn Hudon, Jason Weckstein

The discovery of any bird with unusual plumage characteristics can immediately spark inquiries about its origins. In Western Pennsylvania, an aberrant oriole was discovered with characteristics overlapping multiple icterid taxa, including the tail spots of a Baltimore Oriole (Icterus galbula), the song of an Orchard Oriole (Icterus spurius spurius), and the overall plumage coloration of the Ochre Oriole (Icterus spurius fuertesi) – an Orchard Oriole subspecies from Mexico. We extracted pigments from feathers from the unknown oriole and found that it had shared a pigment profile with both Orchard and Baltimore orioles. We then sequenced whole genomes for the unknown oriole and several Baltimore, Ochre, and Orchard orioles. We examined these data for signals of admixture and found that the aberrant oriole was the result of a rare hybridization event between Baltimore and Orchard orioles. Finally, we identified heterozygous SNPs associated with the ""Ochre"" phenotype in the hybrid and compared them to the Ochre subspecies. Our findings provide insight into the utility of hybrids and whole genome data in the context of a broader conversation about species limitations, hybridization, and uncovering the relationship between genotype and phenotype.

Comparative effects of acclimation on temperature sensitive and robust movements in chameleons

Noah Gripshover, Etti Cooper, Madison McIntyre, Krystal Tolley, Graham Alexander, Christopher Anderson

Ectotherms are dependent on environmental temperature to mediate their physiology and performance. Despite the importance of temperature on ectotherms' survival, species and populations can persist in a wide range of thermal environments by acclimating to acute temperature changes or evolving physiological adaptations to specific temperature regimes. The feeding mechanism of chameleons is a compelling system to test the extent to which acclimation or adaptation impacts performance across temperatures in movements with varying thermal sensitivity. For example, their ballistic tongue projection is powered by the recoil of pre-loaded elastic elements and performance is weakly affected by temperature, while their muscle-powered tongue retraction is strongly affected by temperature. Previous results have shown some acclimation effects to temperature in tongue projection, but the role of acclimation has not been tested in tongue retraction. We compared tongue retraction performance to tongue projection performance among five chameleon species (Bradypodion spp.) collected across South Africa inhabiting different thermal environments. We recorded feeding performance at five temperatures (15°C––35°C) using high-speed video before and after a two-month acclimation period to a common laboratory environment. Our results show how differing degrees of thermal sensitivity impact patterns of acclimation between tongue movements and illustrate how temperature dependent tongue retraction may be under different evolutionary pressures to specialize, highlighting the importance of using integrative approaches to study complex behaviors in an ecological and evolutionary context.

Morphological variation is related to dietary specialization within arthropod-eating snakes

Noah Gripshover, Patrick Hennessey, Edward Stanley, Jeffrey Streicher, Christian Cox

Morphological variation plays a crucial role in shaping the ecology and evolutionary adaptations of organisms. Within snakes, skull morphology is particularly important as it is the primary mechanism to capture, subdue, and consume prey. Previous studies have investigated the role of diet and habitat shaping skull morphology, but have focused on many snake species with diverse diets and habitat uses. A comprehensive understanding of the role of morphology in dietary specialization requires examining skull morphology variation within a clade that has dietary and habitat use specialization. We studied fossorial species in the genus Tantilla and other related species that specialize on dangerous arthropod prey. We collected landmark data from micro-CT scans, dietary data, and phylogenetic geometric morphometrics to

test for the evolutionary drivers of diet on the shape of snake skull. We found the mandible, quadrate, supratemporal, and maxilla were the primary bones associated with dietary preferences. Despite the shared constraint of fossoriality, centipede specialists separated from other species by having shorter quadrates and mandibles, suggesting a smaller gape related to their elongate prey. Surprisingly, the rear-fang size and mechanical advantage did not significantly differ among species that consume dangerous arthropod prey, suggesting a conserved trait for prey subjugation. These findings highlight the role of dietary specialization driving morphological divergence in arthropod-eating snakes and the importance of integrating ecological traits into studies of morphology.

Blood metabolites correlate with changes in temperature in high-elevation nestlings

Campbell Grizzel, Jessica Karr, Olivia Noonan, Thomas Hahn, Jamie Cornelius

Fluctuations in precipitation, temperature, and intensified storms are proliferating as the earth warms. This growing variability can impact migratory timing, food availability, and nestling survival in high-elevation breeding songbirds. Mountain white-crowned sparrows (Zonotrichia leucophrys oriantha) are a species physiologically adapted to withstand harsh conditions experienced on their high-elevation breeding grounds. However, their nestlings cannot rapidly regulate body temperature as ambient temperatures shift and food availability declines. Thus, we predict that nestlings may alter their energetic physiology, reflected in decreasing glucose and increasing ketone levels, to rely more heavily on endogenous stores to thermoregulate. From mid-June to late July 2025, we monitored 35 nestlings on two meadows near Tioga Pass, CA. Nestlings were banded and sampled for blood metabolites (glucose and ketones) within a two-hour window at 6-8 days old. Weather data (minimum, maximum, and average daily temperature) were analyzed across days and between sites. After controlling for size, nestlings had lower glucose when average daily temperature was low. Ketone levels did not vary with Julian date or temperature, though glucose and ketones were negatively correlated. Neither brood size nor nestling age influenced metabolite levels. Understanding how temperature change impacts nestling metabolites offers insight into species' survival limits in variable habitats. Further research is needed to explore metabolite shifts across developmental stages to clarify how environmental factors drive physiological processes.

Sensory-skeletal integration underlies diverse bone fusion patterns in cave dwelling fish

Joshua B Gross

Across development, sensory systems integrate specialized cells and tissues to generate a functional unit. An example of this integration is the lateral line mechanosensory system of fishes and amphibians, which senses changes in water movement. Organs of the lateral line – neuromasts – co-localize to ossification centers for facial bones. In the freshwater model system, Astyanax mexicanus, suborbital facial bones fuse owing to approximated neuromasts, suggesting fusions are an indirect consequence of eye regression. Here, we compared adult bone fusions from eyeless cavefish derived from three independently-derived populations – Pachón, Tinaja and Molino localities. Despite known asymmetries impacting the cavefish craniofacial complex, no asymmetric bias was observed in facial bone fusion in these populations. Surface fish showed almost no fusion, but cave morphs harbored significant fusion varying in severity by population. We conclude that facial bone fusion is not a simple function of eye regression, since each eyeless cavefish population had distinct patterns of fusion and severity. Rather, intra-population bone fusion is likely a function of eye degeneration timing. Early eye degeneration (e.g., in Pachón cavefish) has a more profound effect on neuromast positioning and consequential fusion pattern. Tinaja and Molino cavefish demonstrate slower and more gradual eye regression, which likely interferes less with neuromast positioning, resulting in less severe fusion phenotypes. This work showcases how aberrations of sensory-skeletal development can lead to remarkable intraspecific phenotypic variation.

Reexamining the evolutionary history of the mammalian medial pterygoid muscle

David Grossnickle, Lucas Weaver, Kai Jager, Julia Schultz

The medial pterygoid muscle is a functionally important jaw adductor that helps generate complex masticatory movements in mammals. However, relative to many other soft tissue structures, its early evolutionary history remains uncertain. In therians (placentals and marsupials), the medial pterygoid muscle develops medial to Meckel's cartilage and inserts on the mandibular angular process. Similarly, non-mammalian cynodonts are often reconstructed with a medial pterygoid passing medial to the ossified Meckel's cartilage, inserting on the dentary pseudangular process. Thus, the medial pterygoid is traditionally thought to have remained medial to Meckel's cartilage through its evolutionary history. We highlight an issue with that interpretation: the medial pterygoid muscle inserts lateral (not medial) to Meckel's cartilage in monotremes and early mammal fossils that lacked an angular process. This suggests that the muscle either 1) is evolutionarily labile in terms of its relative position to Meckel's cartilage or 2) did not insert on the pseudangular process of early cynodonts and instead inserted dorsal to Meckel's cartilage. We support the latter hypothesis and argue that the medial pterygoid did not shift medial to Meckel's cartilage until the evolutionary ear-jaw separation in cladotherians (therians and close relatives), with the shift triggering the evolution of the mandibular angular process. This conclusion is in line with growing evidence that concomitant evolutionary changes in cladotherians catalyzed hearing and feeding specializations.

Video tracking of circadian rhythm of Drosophila melanogaster over an extended period of time

Taya (Tianni) Gu

The study of circadian animal behavior requires precise and automated methodologies to accurately quantify simple activity metrics. This study introduces a novel system for high-resolution, long-term monitoring of social behavior in Drosophila melanogaster under controlled thermal conditions. Existing methodologies (e.g. DAM system) often fail to capture the subtle complexities of behavior over extended durations, are mainly focused in isolated animals and in a binary quantification of behavior (awake/asleep). Our system integrates custom 3D-printed behavioral arenas with high-resolution digital cameras and open-source computer vision software (i.e. Fly tracker), which allows for robust and precise data collection. This data information allows us to understand fruit fly behavior beyond coarse activity metrics and allows for the quantification of fine-scale individual locomotion, social interactions, and group dynamics at a comparatively high temporal resolution. This capability is particularly critical for dissecting how ambient conditions, such as temperature, modulate the intricate patterns of daily activity and circadian rhythms. As a proof of concept, the system was used to record fly behavior in small social groups under standard (25ºC) and elevated (30ºC) temperatures. This system offers the investigation of the interplay between thermal environments and innate behaviors, with broad applications in neurobiological and ecological research.

Ontogenetic Patterns in Correlophus ciliatus Toe Pad Performance

Maddie Guerin, Travis Hagey

Gecko adhesion has been widely studied, especially the frictional and adhesive properties of their toe pads, which enable them to cling to various surfaces. Previous studies indicate toe pad performance depends on toe pad area and micromorphology with these traits varying widely across species. Allometry is the study of the relationship between the size of an organism's body and the size of their body parts. We tracked adhesive morphology and performance of three live crested geckos (Correlophus ciliates) as they grew from hatchings to adults (~15 months) to see how their toe pads change as the animal grows bigger. We used the angle of toe detachment as our measurement of performance, which measures the maximum ratio of frictional to adhesives forces generated by a toe pad. We were specifically interested in how changes in lizard mass, toe pad area and shape, shed cycle, temperate and humidity may influence adhesive performance. Preliminary results suggest shed cycle

and individual lizard have a significant effect on performance while mass and macroscopic morphology do not appear to significantly affect angle of toe detachment.

Arboreal squirrels have greater countershading, but only in extratropical realms

Edu Guerra, Emma Carney, John Kamerer, Chris Law, Sharlene Santana

Countershading, a pattern where animals are darker on the back and lighter on the belly, may aid in background matching and reduce three-dimensional cues. Sciuridae (squirrels and relatives) are ecologically diverse and show notable variation in countershading, potentially reflecting differences in predator avoidance across vertical strata. We tested whether countershading is associated with arboreality in Sciuridae using pelage brightness data from standardized photographs of 842 museum specimens representing 218 species. We quantified dorsoventral brightness contrast and tested associations with relative tail length (a proxy for arboreality), locomotion strata, nesting behavior, and additional predictors including habitat openness, biogeographic realm, latitudinal zonation, and body mass. Using PGLS models, we found greatest support for an interaction between tail length and realm (AICcW=0.558). This supports the hypothesis that species with more arboreal lifestyles exhibit stronger countershading, but only in extratropical realms (Nearctic and Palearctic). In these regions, complex light environments may make dorsoventral luminance gradients effective at masking body shape and/or improving background matching, thereby enhancing concealment. This pattern is absent in Indomalaysia and the Neotropics, while Afrotropical squirrels showed a reversed pattern, likely due to long-tailed ground squirrels using their tails for sun protection while foraging during hottest parts of the day. These results suggest that the evolution of countershading in Sciuridae is shaped by ecological, behavioral, and biogeographic factors.

Comparative morphometrics and biomechanics of the backbone and vertical septum in reef fishes

Olivia Guerra, Gregory Bound, Mark Westneat, Linnea Lungstrom

The vertebral column of fishes plays a key role in locomotion, providing both the stiffness and flexibility needed for body-caudal-fin locomotion. Here we integrate morphometrics of the backbone with a deeper look at the vertical septum (VS), a series of collagen fibers connecting the neural and haemal spines, to test hypotheses about its role in force transmission during swimming mechanics. Using polarized light to reveal fiber directions in the interspinal windows of the VS, we identify anatomical variation in the form of fiber angle and organization among reef fish families with differing modes of locomotion. Patterns range from a single, mostly vertical fiber array, to complex arrays with multiple fiber directions. Physical biomechanical models were created to illustrate the functional role of the VS, and test the idea that the vertical septum allows for neural and haemal spines to maintain spacing between spine segments due to the collagen fibers' tensile elasticity. We conclude that dynamic VS loading and unloading keeps the spines aligned within the vertical plane during bending, resulting in spine torsion and energy return to improve force transmission to the tail during swimming. We suggest that new insights into locomotor function in fishes may be attained through a deeper look at the structure and material properties of soft, tensile tissues.

Identifying modular genetic regulators of skeletal growth and proportion

Galilea Guerrero, Wenhao Cui, Aditya Saxena, Hannah Grunwald, Cameron Tumey, Kimberly Cooper

Despite remarkable vertebrate limb diversity, the genetic mechanisms modulating bone growth to generate limbs of varying lengths remain unknown. We address this fundamental question using the bipedal lesser Egyptian jerboa, which has evolved radically elongated hindlimbs with disproportionately elongated feet but retains a mouse-like forelimb morphology. To identify genes associated with differential growth, we performed comparative transcriptomic analyses between mouse and jerboa hindlimbs and forelimbs. Among a set of 1,755 candidate genes, we identified 17 candidate growth regulators that lie within a predicted interaction network containing genes that are also differentially expressed in jerboa and mouse feet, most of which have no known skeletal function. We predict that these candidate regulators modulate bone growth and may have causatively driven the evolution of skeletal proportion in jerboas. To test whether these putative growth regulators are sufficient to modulate bone growth, we assessed the effect of their misexpression on chondrocyte proliferation and differentiation in vitro as well as their ability to alter skeletal elongation in vivo using chick models. Our analysis identified novel growth regulators that are sufficient to promote (ISL1, BACH2) or repress (CRABP1, LUZP2, MAFB) chondrogenesis in vitro, as well as inhibit skeletal growth in vivo. Ultimately, identifying modular genetic regulators that may be causative of differential skeletal growth can help elucidate the mechanisms by which skeletal proportion is established in the vertebrate limb.

Death by bicarbonate: ion stress in burrowing shrimp (*Neotrypaea californiensis*)

Emma Guerrini Romano, Andrea Durant

Intertidal crustaceans experience temporal fluctuations in salinity. Many will conform to the external environment at salinities above brackish levels, whereby key inorganic ions (Na+, Cl-) are similar between seawater and hemolymph. Here, we investigate physiological responses of burrowing shrimp (Neotrypaea californiensis), a major bioturbator and pest species of tidal flats, to sodium bicarbonate (NaHCO3) solutions posing an ionic, pH, and alkalinity challenge. Laboratory exposures resulted in total mortality of shrimp when exposed to saturated NaHCO3 solutions in seawater. We tested two hypotheses to explain this occurrence: (1) shrimp mortality results from conversion of ammonium to toxic ammonia due to increased basicity from bicarbonate presence and (2) mortality results from systemic ion and water balance failure due to major changes high NaHCO3. We measured osmolality and ion concentrations (Na+, Cl-, K+, Ca2+, pH, NH4+) in hemolymph, body water content, protein expression of critical ion pumps (Na+/K+-ATPase and Na+-K+-Cl- cotransporter) in the gills, as well as gill morphology and ultrastructure using microscopy across different levels of NaHCO3 solutions. This research provides a mechanistic explanation for how shrimp fail to osmoconform to significant ion imbalances in seawater, independent of salinity change as a sole driver, and this results in mortality. Beyond its physiological relevance for multi-ion stress responses, this research provides oyster growers with a potential chemical control method for infested land.

Finite element analysis of theoretical eulipotyphlan vertebrae with varying trabecular architecture

Joseph Guillen, Tristan Stayton, Nina Kent

As body size decreases, the role of trabecular bone in supporting mechanical loads may become less important. Smaller mammals have fewer trabeculae, which may result in trabecular bone playing a reduced role in load-bearing. This project investigates whether trabecular bone contributes less to vertebral strength in small mammals, focusing on Eulipotyphla, which includes shrews, moles, hedgehogs, and solenodons. Eulipotyphla contains some of the smallest mammals, making it ideal for size-related studies. We used Finite Element Analysis (FEA) to assess how trabecular orientation, diameter, and number affect the theoretical performance of the vertebral centrum. A representative vertebral column was modeled in Onshape, meshed with Meshmixer, and incorporated into an FEA workflow. A MATLAB script was used to generate FE files with specific trabecular architectures.Once parameters are assigned, model generation and analysis are fully automated. Here we modeled three loading conditions - compression, torsion, and bending - using isotropic material properties. Morphometric measurements taken from museum specimens were analyzed using principal component analysis (PCA): PC1 reflected overall size, while PC2 captured height variation. PCA informed the morphology of the centrum model, enabling shape adjustments. Preliminary results indicate that having fewer trabeculae leads to higher von Mises stress, particularly under non-axial loading conditions.

Island Effects in Western Fence Lizards (*Sceloporus occidentalis*)

Alex Gully, Marie Bunker, Stacey Weiss

The Island Syndrome is a pattern that explains several linked phenotypic traits that can manifest differently in island populations in comparison to mainland populations. This syndrome includes the Island Rule which states that smaller vertebrates will experience gigantism on islands while larger vertebrates will experience dwarfism. Reptiles, especially small lizards, do not strictly follow this rule. We investigated whether the small, sexually dimorphic lizard *Sceloporus occidentalis* (Western fence lizard) exhibits the Island Syndrome across six beach populations in the Puget Sound region (Washington, USA): three mainland and three island. From 226 individuals, we measured snout-to-vent length (SVL), body condition, body depth, and head depth. Females had significantly larger body size and males had significantly larger relative body depth and head dimensions. Island populations were significantly smaller with relatively deeper heads than mainland populations. Thus, *S. occidentalis* lizards follow an inverse Island Rule where island populations of small lizards tend to evolve smaller body sizes. Other traits, like limb morphology, should be quantified to more fully define the Island Syndrome being expressed by *S. occidentalis* in the Puget Sound. Comparative work within and across species would help determine the role of geography and biotic factors that contribute to the varying ecomorphological shifts in trait expressions that are prevalent in the Island Syndrome.

Consequences of the neutral evolution of phenotypic plasticity

Alex Gunderson

How phenotypic plasticity evolves under natural selection is a question that has garnered great theoretical interest. However, little effort has been devoted to understanding the neutral evolution of plasticity. Two classic conceptualizations of plasticity in previous theory view plasticity as either a byproduct of selection on the phenotypes expressed in different environments (hereafter the "character states" model), or as a reaction norm that directly evolves (hereafter the "reaction norm" model). In a classic analysis, DeJong (1995) showed that under selection the character states and reaction norm models are interchangeable. But do these models yield interchangeable results when only neutral evolutionary forces are at play? Assuming a simple two-environment system, I explore the scenario in which the parameters of the character states and reaction norm models evolve only via a neutral Brownian motion process. I find that the outcome of evolution differs for the two model types. Specifically, the character states model yields a pattern consistent with genetic assimilation, while the reaction norm model does not. The results with the character states model also hold over a wide range of genetic covariances between the phenotypes expressed in each environment. Expectations for the neutral evolution of plasticity would benefit from greater scrutiny.

Nereus: a metachronal swimming robot for swarm-based sensing in turbulent flows

Peter Gunnarson, Nils Tack, Thales Silva, Aditya Iyer, Nora Ayanian, Monica Wilhelmus

Metachronal swimmers including shrimp, krill, and copepods are adept at swimming in dense swarms and in highly turbulent flow environments—their collective motions have been observed in coastal regions, the open ocean, and underneath sea ice. However, the specific hydrodynamic mechanisms and benefits of swarm-based metachronal swimming are not yet fully understood. In this work, we hypothesize that the coordinated beating of appendages offers hydrodynamic benefits for navigating challenging turbulent flows. To test this hypothesis experimentally, we utilize our recently developed Nereus robot, which is propelled by two rows of five appendages each that mimic the morphology of marsh grass shrimp (Palaemon vulgaris). Each of the ten flexible appendages are individually controlled and capable of real-time estimation of applied hydrodynamic forces, enabling flow sensing and obstacle detection through proprioception. Using these measurements of appendage-level torques, we investigate the hydrodynamics and optimal gaits of metachronal swimming in a variety of unsteady and turbulent flow environments in a water channel. Additionally, we investigate swarming with multiple free-swimming, self-contained robots. The results of this work present a compelling blueprint for deploying swarms of highly agile ocean-exploring robots to map and explore the most challenging and critically undersampled regions on Earth.

Behavioral drivers of vocal communication across reproductive contexts

Caleigh Guoynes, Catherine Marler, Michael Sidorov

Social communication is important for mammalian reproductive and parental behaviors, yet our understanding of how differences in social behavior and context influence vocal production remains limited. Here, we assess ultrasonic vocalizations (USVs) across two critical social contexts: courtship and parental care. First, we investigated courtship USVs in Angelman syndrome (AS), a neurodevelopmental disorder characterized by communication and motor deficits, using C57BL/6J mice. Our previous results showed that AS mice make fewer vocalizations with altered properties during courtship, and we hypothesized that the motor deficits associated with AS may be contributing a large role in the USV production deficits. In this study, we wanted to determine the relationship between social and motor behavior and USV production. To do this, we used DeepLabCut and DeepSqueak to temporally synchronize vocalizations and behavior. Preliminary results suggest that specific social behavior is a prerequisite for USV production during courtship, and additional results on the relationship between social and motor behavior and USV production will be reported. Second, we examined how social context impacts parental care and vocal production in Peromyscus californicus, a monogamous biparental species. We hypothesized that the presence or absence of pups would alter the vocal production of the parents, and that USV production would correlate with parental behaviors. Results will be reported. Together, these studies highlight the importance of social behavior and context in eliciting rodent USVs.

A miniature neural recording and stimulation backpack for insect behavior research

Arvind Gupta, Lingsheng Meng, Aditya Ganesh, Jean-Michel Mongeau, Kaushik Jayaram

Studying the neuromechanics of locomotion in natural environments is often hindered by need to tether expensive instruments for high-fidelity measurements. Leveraging recent advances in low-cost custom electronics fabrication, we created lightweight, customizable, and easy-to-use open-source neural recording and stimulation "backpack" system that minimally influence insect behavior. They comprise low-power wireless microcontroller(s), sensors (IMUs, cameras, etc.) with dedicated neural chips (Intan) and are designed to be small (14x22 mm), light (1.4g), and power-efficient (182mW, runtime 2 hours with 160mAH) which is ideal for monitoring neural activity in freely behaving insects such as cockroaches. Our initial prototype has interfaces for 8-channel recording and 4-channel stimulation and is capable of recording 50 sec of data at 10 kHz. Our target applications include precise stimulation at the antennae and the antennal mechanosensory and motor center (AMMC), neural recordings from the ventral nerve cord or AMMC, allowing us to understand touch-based perception in cockroaches without tethering the body or hindering locomotion. Our backpack can be configured to record under user-defined conditions using a custom GUI, which provides data logging, command-based control, and real-time data visualization. By combining neural recording, stimulation, and motion sensing into a single and low-cost platform, this system expands the tools available for neuromechanical and ecological research and provides new insights into animal behaviors in their natural environments.

Motor-state dependence of acoustic mate recognition in mosquitoes

Saumya Gupta, Takuro Ohashi, David Purnomo, Jeff Riffell

In many animals, sensory perception is tightly linked to motor states. Movement can modulate, drive, or feedback into sensory circuits, shaping how organisms sense their environment. In mosquitoes, detection of female flight tone

by males for mate localization is thought to be strictly flight-dependent. This inference comes from a mismatch between female wingbeat frequencies and the tuning of auditory neurons in the Johnston's organ (JO), suggesting that during flight, males can detect female tone because of nonlinear interactions between its own and female wingbeats. Whether female acoustic detection is truly flight-exclusive remains untested. We examined auditory responsiveness across motor states in Aedes aegypti males. In phonotaxis assays, freely-walking, wingless males reliably oriented toward female flight tones, albeit less frequently than flying males. Electromyographic recordings revealed that walking bouts are accompanied by brief activation of indirect flight muscles, suggesting flight motor circuits are engaged during walking and may contribute to acoustic detection. Strikingly, however, in both freely walking and tethered assays, males in resting state responded robustly to female tones. Supporting this, preliminary evidence from two-photon imaging shows that auditory neurons in the AMMC also respond to female specific flight tones in quiescent animals. Together, these results demonstrate that detection of mating cues is not rigidly gated by flight. Instead, motor states may modulate auditory sensitivity, with flight circuits potentially enhancing but not mandating female detection.

Ostracod brain anatomy: evidence for ancestral mushroom body and central complex in Pancrustacea

Alexandra Gurgis, Gabriella Wolff

Learning is an adaptive behavior, allowing organisms to integrate sensory stimuli and adjust to changing conditions. In insects, brain structures known as mushroom bodies are central to learning and memory, but their evolutionary origins remain unresolved. Far less is known about comparable structures in crustaceans. Only a few taxa surveyed so far, such as stomatopods, have insect-like mushroom bodies, while analogous structures in others are morphologically divergent or reduced. This raises questions about whether similar structures evolved independently, or if mushroom bodies have diverged from a shared ancestral ground plan. To address this, we explored the brain anatomy of ostracods, the oldest known crustaceans in the fossil record and belonging to a sister clade to all other pancrustaceans. Using micro-CT, 3D reconstruction, and immunohistochemistry, we studied two species, Vargula tsujii and Skogsbergia lerneri, creating the first detailed models of ostracod neuroanatomy. We identified putative mushroom bodies exhibiting features shared across pancrustaceans, including enriched DC0 expression, a molecular signature of insect mushroom bodies. These findings provide the first evidence of mushroom bodies in ostracods, supporting their presence in the last common ancestor of all pancrustaceans. Additionally, we describe an insect-like ostracod central complex and characterize their compound eyes. This research expands knowledge of ostracod neurobiology, advances our understanding of the evolution of learning and memory centers, and enables more accurate reconstruction of the ancestral pancrustacean brain.

Conservation of the endangered Dunes Sagebrush Lizard: insights from whole-genome sequencing

Sydney Gutierrez, Lee Fitzgerald, Lauren Chan

Whole-genome sequencing used with annotated reference genomes are valuable tools for conservation biology. They allow researchers to delineate conservation units, assess population resilience and connectivity, and evaluate the adaptive potential of populations. These approaches are particularly valuable for studying habitat specialists because such species tend to have geographically restricted ranges and high sensitivity to disturbance. The Dunes Sagebrush Lizard (Sceloporus arenicolus) is federally listed as Endangered under the ESA and is a habitat specialist endemic to the shinnery oak-sand dune ecosystem of southeastern New Mexico and Texas. Previous studies have delineated ten genetically distinctive conservation units that correspond with geographic breaks in suitable habitat. Effective management in the face of habitat degradation by oil and gas mining requires further assessment of these units as well as a better understanding of the evolutionary uniqueness of each, including historical demographics and patterns of local adaptation. We constructed an annotated reference genome for the Dunes Sagebrush Lizard and conducted whole-genome resequencing of 100 individuals throughout the range. We re-evaluate phylogeographic groups with whole genome data and estimate historical demographic parameters for each group, providing important information for conservation efforts.

Fluid ejection of xylem and phloem feeding insects in the United States and Amazon rainforest

Nami Ha, Elizabeth Clark, Stanley Stupski, Jaime Nina, Jacob Harrison, Saad Bhamla

Hemipteran insects feed on plant sap, either from the xylem, the phloem or both. After feeding, they eject liquid waste using different kinematic strategies, producing droplets, bubble foams, or jets through catapulting, squeezing, or wax-coating. To understand how these small insects can overcome surface tension and viscous forces, we explore liquid waste ejection in various Hemipteran species from the United States and the Amazon rainforest. First, we review previously studied cases of fluid ejection in Hemipteran insects, including sharpshooters, spotted lanternflies, aphids, annual cicadas, and spittlebugs. Second, we present high-speed imaging data and photographs of fluid ejection in other Hemipteran insects, such as periodical cicadas (Brood XIX) filmed in Georgia, United States, as well as red-bordered stink bugs and annual cicadas filmed in the Amazon rainforest. We found that periodical cicadas eject droplets, which contrasts with annual cicadas that expel jet fluid. Another finding is that red-bordered stink bugs drip droplets, a behavior not observed in other Hemipteran insects to date. Moreover, we observed jet ejection in annual cicadas during flight. This study contributes to extending the fundamental understanding of fluid ejection by Hemipteran insects that feed on plant sap.

Uncoiled morphing barbules enhance water absorption and retention in sandgrouse ventral feathers

Nami Ha, Maria Martinez, Yang Geng, Elizabeth Clark, Ling Li, Saad Bhamla

The motivation of this study is to systematically understand how and why uncoiling the reconfigurable barbules can enhance water absorption and retention in sandgrouse ventral feathers. Here, we hypothesize that 3-4 coils in dry barbules are programmed to transform into L-shaped barbules with a single coil upon hydration, which leads to elastocapillarity-driven enhanced water absorption and lower evaporation compared to the other barbule geometries. To support our hypothesis, we visualize the barbule and feather geometries of sandgrouse ventral feathers in dry and wet states using high-speed imaging, light microscopy, and micro-CT imaging. The mechanical and structural properties of the barbules describe their hydration-driven reconfiguration dynamics. Compared to feathers with one or no coil in their dry barbules, sandgrouse ventral feathers in the fully wet state show respectively 2-6-fold and 2-4-fold higher performance in the normalized water absorption and retention. The L-shaped wet barbules create a large water reservoir within feathers due to the elastocapillarity, supported by the normalized dry – wet feather area change (A*) of 1-2, in contrast to feathers with single-coiled dry barbules showing A* values of 3-5. Our findings suggest the programmability of water absorption using coiled barbules with specific geometries, which would further extend the research scope toward the development of barbule keratin-based morphing materials.

Glutamatergic and GABAergic expression in the social decision-making network in green anoles

Arya Haala, Bobbi Lovstad, Nicolet Limas Mejia, Rachel Cohen

Social behaviors arise from the social decision-making network (SDMN), where neural activity influences various social behaviors across vertebrates. Green anoles (Anolis carolinensis) display seasonal dimorphism in territorial and reproductive behaviors aligned with morphological and physiological changes. These lizards possess brain structures homologous to those in the SDMN of other vertebrates, particularly the preoptic area (POA) and ventral medial hypothalamus (VMH). Lesion studies have shown that the POA regulates male reproductive behaviors, while the VMH is important for female reproductive behaviors. It is unknown whether the neuron composition of the

SDMN changes seasonally to support behavioral shifts. This project examines the presence of glutamatergic and GABAergic neurons in the POA and VMH to determine whether these neuron types vary between the breeding and non-breeding seasons. Brains were collected from male and female lizards in both seasons and sectioned. Using immunohistochemistry, one series was processed for GABAergic neurons (GAD65), a second was processed for glutamatergic projections (VGLUT2), and a third was Nissl-stained to localize regions. GABAergic cell bodies were counted, and glutamatergic projection density was measured. We predicted seasonal variation in GABAergic neuron numbers and glutamatergic neuron density. This would help determine whether glutamatergic and GABAergic neurons play a role in regulating seasonal dimorphisms in social behavior.

Antarctic meiofaunal communities assessed by metabarcoding

Kenneth Halanych, Lauren Baena, Andrew Mahon

Benthic communities of the Antarctic coastal shelf hold incredible biodiversity with highly productive ecosystems. Although the epifauna and in fauna are relatively well known, meiofaunal populations in this region of the planet have not been well characterized in terms of their biology, biodiversity, community structure, and which environmental parameters influence changes in populations. These small animals living in the top few centimeters of the sediment are critical for driving bentho-pelagic coupling mechanisms and likely have an important role in recycling nutrients especially from seasonal plankton bloom die offs. Here we expand on previous regional metabarcoding studies to explore meiofaunal diversity around most the Antarctic, including sample from the Eastern Antarctic region. Surprisingly, some species of meiofaunal, which generally have offspring with limited dispersal capabilities, show little genetic differentiation over 5500 kilometers. Roughly 10% of observed operational taxonomic units occur at every sampling location despite differences in granulometry and nutrients. Interestingly, bottom temperature and dissolved oxygen (rather than depth, salinity, fluorescence, or ice cover) were more strongly correlated with community composition, suggesting that environmental changes due to climate change may have a pronounced effect on meiofaunal communities. We also explore whether observed differences in meiofaunal communities are consistent with recognized biogeographic provinces observed for the overlying macrobenthos.

The scientific endeavor and free expression: following the data in a SICB-centric career exploring how animals move

Melina Hale

The study of animal movement integrates research broadly across body systems and SICB divisions. Animal movement and the anatomical systems that control it have been a focus of SICB and the scientific organizations from which the society descended since their beginning, nearly 125 years ago. The 250 th anniversary of the United States in 2026 is a time of reflection as a country and on our place in it as scientists. Free expression principles, as captured in the first amendment of the US constitution, have underpinned the scientific endeavor in the US and have been critical to its flourishing; global and immigrant voices have always contributed to that vibrancy. With the Society's history as a framework, this talk will examine SICB-related science over the latter half of US history. I will focus on our commitment to free expression as scientists and connection to the civic enterprise and will build on decades-long threads of animal movement studies that have shaped my career and research.

Control theory analysis of rice root gravitropism

Madison Hales, Yu Yang, Aradhya Rajanala, Christopher Pierce, Mingyuan Zhu, Noah Cowan, Daniel Goldman

Tropisms allow plant roots to respond to stimuli such as light, touch, and gravity via a closed-loop cascade of physical sensing, chemical signaling, and directed growth through differential cell elongation. These tropisms play a key role in roots' ability to navigate soil heterogeneities, but quantitative mechanistic links between sensing and behavior remain unclear. To address this gap, we use techniques from control theory, which has been used to characterize the role of neuromechanical feedback in animal systems, to study how rice roots (O. sativa) generate corrective gravitropic feedback during growth. We developed an apparatus to apply sinusoidal gravitational stimuli to roots growing in a transparent gel and recorded their growth trajectories from two orthogonal views. The root tip angle oscillated at two superimposed frequencies: the applied stimulus frequency (24-0.8 cycles/day) and a secondary frequency (approximately 12-24 cycles/day). This secondary oscillation frequency was likely associated with circumnutation, a helical growth pattern associated with rice. The gravitropic response behaves as a time-delayed low-pass filter with unity feedback, attenuating frequencies above ~5 cycles/day and exhibiting a response latency of about 10-minutes, adding prominent phase lag at high frequencies. We suggest that the delay reflects the time taken for the stimulus to be sensed via statoliths in the root cap and then for the physical auxin signal to be transmitted to the elongation zone, where the growth response occurs.

Homefield advantage in action: climbing and sprinting performance in *Podarcis muralis*

Devon Haley, Hayden Kelner, Brittney Parks, Tyler Williard, Brooke Bodensteiner, Sean Giery, Eric Gangloff, Bryan Juarez

How organismal phenotypes respond to novel environments is a central question in biology, particularly important in introduced species. Common wall lizards (Podarcis muralis) are an urban-tolerant species native to Europe but widely invasive, particularly in Ohio, USA, where they are found in a variety of habitats. To test for variation in organismal phenotypes correlated with habitat differences, we studied the thermal ecology of sprinting and climbing performance in lizards from cooler forest and warmer human-built wall habitats. Specifically, we tested the 'homefield advantage' hypothesis – that phenotypes are optimized to the environments in which organisms live. We predicted that lizards from the forest (N=20) would locomote faster at lower temperatures and on bark, while lizards from the wall habitat (N=18) would be faster at warmer temperatures and on stone. We measured sprinting and climbing performance for each individual at each of five temperatures on both bark and stone. Additionally, we measured critical thermal minima (N=12) and maxima (N=12) in lizards from each habitat, allowing us to create full thermal performance curves for each individual and extract the maximum performance, optimum temperature for performance, and performance breadth to test our hypothesis. Our findings have important implications for understanding the drivers of variation in performance traits, which may facilitate the spread of this species into new habitats around southern Ohio and beyond.

Are pelvic parasympathetics really a thing? Example of the Burmese python

Margaret Hall, Megumi Shimizu, Jordan Golden, Dalton Kiniry, Dominik Valdez, Erin Simons, Justin Georgi

Autonomics traditionally are divided between the sympathetic and parasympathetic systems. Preganglionic sympathetic cell bodies are found in the spinal cord in the thoracic and lumbar regions. Preganglionic parasympathetic cell bodies are found in the brainstem and sacral spinal cord. In the mammalian pelvic region, parasympathetic splanchnic nerves extend from the pelvic spinal nerve ventral rami to provide preganglionic parasympathetic axons that synapse in pelvic ganglia to innervate pelvic organs. However, in recent years debate has arisen about whether sacral parasympathetics are part of the parasympathetic system, or if they are, in fact, a continuation of the sympathetic system. Some have suggested that there is a gap between preganglionic autonomic cell bodies in the spinal cord because these dermomyotomes are involved developmentally in creating the tetrapod hindlimb. To investigate this, we dissected an adult male Burmese python (Python bivittatus), because it is nested within Tetrapoda but does not possess a hindlimb. We observed splanchnic nerves exiting the sympathetic chain at every level, and did not find any parasympathetic splanchnic nerves attached to any spinal nerve ventral rami. Instead, we found that all pelvic organs received innervation directly from splanchnic nerves extending from the sympathetic chain.

Revisiting the Palimpsest: The Developmental Basis for the Evolution of Covariance

Benedikt Hallgrimsson

The concept of morphological or phenotypic integration has deep origins in evolutionary biology, first as an explanation for apparently non-adaptive evolutionary changes and later as a basis for meaningful units of evolutionary change. Starting in the 1970s, the concept was reinvented, driven by multivariate statistical methods, quantitative genetic theory and evolutionary developmental biology. A major step in this reinvention was the development of the latent variable model for integration. The palimpsest model builds on this earlier work by creating a framework to connect developmental processes to the latent variable structure of genotype-phenotype maps. Here, we use a series of simulations and analyses of mouse and human craniofacial morphometric data to illustrate how the palimpsest model enables interrogation of phenotypic covariance structures. A major finding from both simulations and empirical data is the sensitivity of covariance structures to changes in the variances of the processes that underlie them as opposed to changes in the developmental connections between processes and traits. We discuss the implications of these findings for the evolvability and genetics of complex phenotypes.

A physiological balancing act: Lipid oxidation and water balance in migrating hummingbirds

Shayne Halter, Blair Wolf, Carlos Martinez del Rio

Hummingbird diets are composed mostly of dilute nectar. Thus, high rates of energy use require them to ingest and then dispose of large amounts of water. Their kidneys are well suited to get rid of water, but are unable to conserve it by concentrating urine. Hummingbirds must dispose of excess water when fed and conserve it while they fast at night. To conserve water, hummingbirds cease renal filtration at night, yet they still lose water through evaporation. Migrating hummingbirds often enter torpor to conserve energy. We investigated the interplay between energy use and water balance in four species of torpid and non-torpid migrating hummingbirds at a stopover site in southwestern New Mexico. We measured nighttime CO2 production, lipid depletion, and water balance in Selasphorus rufus (Rufous), Selasphorus calliope (Calliope), Sealasphrus platycerus (Broad-tailed), and Archilochus alexandri (Black-chinned) hummingbirds. We found that both energy use and water losses were lower in torpid hummingbirds, but that both torpid and non-torpid individuals remained in neutral water balance, due to the almost exact match between water produced by lipid catabolism and respiratory water losses. Metabolic water production compensated effectively for night evaporative losses in all but torpid S. Platycercus, which were in slightly negative water balance. Lipid catabolism in hummingbirds seems adequate to maintain water balance overnight in both torpid and non-torpid hummingbirds.

How feeding ecology and physiology contribute to niche differences among sympatric tropical *Chiton*

Adriana Halvonik-Sanchez, Amy Maas, Claudia Benitez-Nelson, Eric Tappa, Daniel Speiser

A longstanding goal in evolutionary ecology is understanding how species diversity is maintained, especially among closely related sympatric species. One approach to addressing this question is identifying how sympatric species partition available resources and occupy distinct ecological niches (i.e., roles in an ecosystem). We investigated how niche differences in feeding ecology and physiology may help maintain species diversity among Chiton, ecologically important grazers in rocky intertidal and subtidal zones. First, we hypothesized that Chiton species would have similar feeding ecologies because intertidal chitons have previously been shown to be generalist grazers. Second, we hypothesized that Chiton physiological parameters would be associated with the vertical zonation of each species because environmental conditions (e.g., oxygen, salinity, temperature) can vary drastically within a few meters or centimeters within the intertidal zone. To test the first hypothesis, we quantified stable isotope ratios (of δ13C and δ15N) and algal accessory pigments from Chiton tissues and environmental epibenthic samples (i.e., potential food sources). To test the second hypothesis, we estimated metabolic rates and thermal tolerances in seawater and air. We found that three of the four sympatric species have similar dietary habits and occupy similar trophic positions. We also found that the physiological tolerances of Chiton species are associated with their vertical zonation. This study demonstrates how niche differences among ecologically similar, closely related species may help maintain species diversity.

Drab or dazzling: The effects of temperature on Vanessa cardui pupal iridescence

Mia Hamaguchi, Yuichiro Suzuki

In migratory species, phenotypic plasticity may provide an organism with a strategy for adapting to local environments by expanding its ability to give visual cues; for example, it may offer better camouflage against predation. In this study, the effect of temperature on the iridescence of pupae was examined in the painted lady butterfly, Vanessa cardui, a migratory butterfly species. It was found that an increase in temperature led to a decrease in the iridescent area of pupae. Additionally, changing the temperature of the growth environment during the fourth instar revealed a prolonged sensitive period for temperature-dependent iridescence change, which begins before the fourth instar. To explore the mechanisms of pupal iridescence in response to temperature, the cuticular structure of V. cardui pupae was imaged using TEM microscopy. It was found that increasing temperature led to thicker pupal cuticles; in particular, the endocuticle had greater spacing between layers at higher temperatures. These findings suggest that V. cardui follows the pattern of temperature change-induced iridescence variation and that temperature influences the endocuticle spacing underlying iridescence in V. cardui. Given that V. cardui is a migratory butterfly, the ability to change its pupal iridescence may be an adaptation to the diverse habitats it occupies. Current efforts are directed at identifying the developmental mechanism by which the amount of iridescence may be altered.

Evaluating latitudinal and sex specific differences in wing melanization of Pieris rapae butterflies

Davit Hambardzumyan, Sabah Tabel, Sohum Anumula, Saige Pompura

Pieris rapae is a widely distributed butterfly species found across North America. Wing melanization, especially at the forewing apex, is believed to play a role in thermoregulation and UV protection, making it an important trait for environmental adaptation. We addressed two questions: (1) Is wing apex melanization related to latitude? (2) Do males and females differ in melanization levels? We hypothesized that thermoregulation will drive butterflies from lower latitudes to have greater melanization regardless of sex. To test these questions, we analyzed 572 digitized museum specimens of Pieris rapae (370 females, 202 males) sourced from iDigBio, spanning a latitudinal range of approximately 20.3° to 56.7° N. Using ImageJ analysis software, we quantified the proportion of melanization in the forewing. We performed t-tests to analyze sex differences and a linear regression analysis for latitude variation. Our results revealed a strong relationship between wing apex melanization and latitude ($R^2 = 0.661$, $p < 0.0001$), indicating that about 66% of the variation in melanization could be explained by latitude, with lower latitude individuals exhibiting greater melanization. A statistically significant but weaker relationship was found between melanization and sex ($R^2 = 0.094$, $p < 0.0001$), suggesting slight differences between males and females. Our findings highlight the role of latitude and sex in wing melanization, contributing to our understanding of environmental adaptation in insects.

Energy density and fatty acid analysis of forage fish from the Northwest Atlantic

Lauren Hamilton, Tebyan Ahmed, Chelsea Richardson, Ali Ishaque

Understanding the trophic dynamics of forage fish is essential for assessing ecosystem health and the transfer of energy through marine food webs. This study evaluated the diet profiles and energy densities of five key forage fish species from the Northwest Atlantic: Alewife (Alosa pseudoharengus), Atlantic Herring (Clupea harengus), Atlantic Mackerel (Scomber scombrus), Butterfish (Perprilus triacanthus), and Silver Hake (Merluccius bilinearis) using fatty acid

biomarkers and proximate composition analyses. Results revealed variations in dietary sources (p=0.001), but the primary fatty acids consisted of brown algae, diatoms, and dinoflagellates. Energy density varied between species: Alewife had the highest energy density with 24.56kJ/g dry weight, much of that coming from its lipid energy, and Atlantic Mackerel had the lowest with 22.84kJ/g dry weight. EPA concentrations followed expected patterns and were lower in samples from stations with higher ocean surface temperatures, but this was found to be insignificant (p=0.44). DHA concentrations tended to be higher in samples from stations with higher surface temperatures, but this was also found to be insignificant (p=0.75). These findings highlight species-specific nutritional profiles and potential shifts in prey quality due climate change, emphasizing the importance of monitoring forage fish species.

Behavioral type and microglia activity predict social decision-making following LPS and OT treatment

Emma Hammond, Patrick Monari, Elsa Luebke, Aimee Johnson, Anthony Auger, Catherine Marler

Among social species, an inflammatory response can lead to increased affiliation or withdrawal. The affiliative versus withdrawal response during an immune challenge varies both by species and by individual. However, the social and biological factors leading to this decision are unknown. We hypothesized that LPS would increase affiliation in California mice, but the decision to engage in affiliation during an inflammatory state depends on 1) prior affiliation with a conspecific, 2) OT activity, and 3) microglial activation. We measured effects of low-grade inflammation induced by lipopolysaccharide (LPS) on both affiliation with a familiar same-sex conspecific and the effects of intranasal oxytocin (OT) or peripheral OT antagonist. OT and LPS combined increased huddling in females, suggesting that LPS and OT effects on affiliation may be sex-dependent. In males LPS effects depended on behavioral phenotype – less affiliative "non-huddlers" showed increased time with a familiar conspecific following LPS, but with no effect in the affiliative "huddlers." Elevated microglia activity in the DG negatively correlated with time in the social chamber during a sociability test, and microglia activity in the mPFC negatively correlated with time in close proximity to a familiar conspecifics. Additionally, peripheral cytokine release was associated with increased social behavior in huddlers. In summary, we speculate that inflammation can increase affiliation, and that this may depend on 1) degree of sociality and 2) microglia activity.

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Battle of the burrow: analyzing stomatopod territorial based contests

Sophia Hanscom, Jackie Benson, Megan Porter

Animals continuously experience competition for resources which in some instances, when the benefit of the resource outweighs the cost of defending it, drives the presence of territoriality. Territoriality defines the defensive behavior of a resource for exclusive use and has been described in many marine crustaceans. Individuals engaging in territorial behavior must assess their competitor and the desired resource to determine if the benefit is worth the risk. Stomatopods are among the taxa that exhibit territoriality and will compete against con- and heterospecifics. This study aimed to assess the territorial contests of Gonodactylaceus falcatus to determine the characteristics responsible for influencing the outcome of size-matched contests. Both intra- and intersexual contests were conducted and 37 of the 49 contest pairs were tried twice holding the same position against the same individual. The majority of repeated contests resulted in the same individual winning, but the driver of this outcome remains unknown. While the majority of intrasexual contests were won by the resident (~73%), the trend was significantly decreased for intersexual (~52%), with males winning slightly more than females in both resident and intruder positions. The marked difference in intra- and intersexual competitions may be a result of the documented sexual dimorphism of G. falcatus' weaponry. As investigations of intersexual contests across taxa are extremely rare, this proposed hypothesis leads to additional questions and requires further research.

The relationship between weapon and body size predicts signaling behavior in a weapon-bearing insect

Mollie Haremza, Christina Salerno, Noraly van Meer, Christine Miller, Janice Yan

Animals often use physical traits, such as enlarged weapons, to convey information such as competitive ability to potential opponents. These signals are generally assumed to be reliable; however, exceptions can occur. By examining the relationship between signal strength and competitive ability, we can detect potential examples of unreliable signals in the animal kingdom. We investigated this using the leaf-footed cactus bug, Narnia femorata, (Hemiptera: Coreidae) which use enlarged hind limb weapons both for fighting and signaling to examine the relationship between weapon size and body size. We found that some males had oversized weapons for their body while others had undersized weapons for their body. Using existing data from competitive trials between male leaf-footed cactus bugs, we then examined how the relationship between weapon and body size was related to fighting and signaling behavior. We found that compared to those with oversized weapons, those with undersized weapons relied more heavily on signaling than attacking while fighting. We also found that having disproportionately large weapons predicted a male's likelihood of achieving dominance. Our findings therefore suggest that individuals with undersized weapons may use increased signaling to avoid conflicts that they are less likely to win which can lead to occasional unreliable signals. Overall, our findings point towards a lack of reliable correlation between signaling behavior and contest success, suggesting the possibility of unreliable signaling.

Identifying candidate eye regression regulatory elements in Astyanax mexicanus

Ashlynn Harlow, Marcos da Silva, Devin Shennard, Suzanne McGaugh, Johanna Kowalko, Wynn Meyer

Non-coding regulatory elements can be important drivers of evolutionary change. Despite this significance, regulatory elements remain hard to identify because they often lack the defined sequence patterns found in protein-coding regions. We here identify candidate regulatory elements for genes previously associated with eye regression in the Mexican tetra (Astyanax mexicanus). A. mexicanus is an effective model for this comparative approach since it exists as both surface and cave populations, with cave fish having lost functional eyes. Using publicly available Genomic Evolutionary Rate Profiling (GERP) scores from the Ensembl 65 fish alignments, we identified highly conserved regions (GERP > 2) in the A. mexicanus surface fish genome

near 10 genes previously associated with eye regression in this species. Comparing the sequences of these regions with homologous regions in the Pachón cave fish reference genome, we identified 19 putative regulatory regions with a GERP score greater than 2, a length of at least 20 base pairs, and at least one sequence difference between surface and cave reference genomes. We are validating these sequence differences in putative regulatory regions by PCR amplification and sequencing in laboratory populations of surface and cave fish. In future work, we will functionally assess both alleles in each region through enhancer reporter assays in zebrafish. By studying these candidate regulatory elements, we can advance understanding of how non-coding sequences drive evolutionary adaptation.

Neural mechanisms of efficient collective behavior in zebrafish

Roy Harpaz

A striking example of collective behavior is fish schooling, where animals simultaneously integrate cues from numerous neighbors to coordinate movement. How the brain manages such computations, often in highly dynamic and cluttered environments, remains largely unknown.

We investigated these processes in larval and juvenile zebrafish using behavioral experiments in both naturalistic and virtual reality environments. Our results show that zebrafish avoid computational overload by relying on simplified visual statistics, specifically the visual occupancy patterns of neighbors on their retinas, to guide movement decisions. They integrate and average these patterns independently within each eye, then apply a “winner-take-all” strategy for binocular integration.

Although genetically encoded, these computations display remarkable flexibility. Social responses occur within milliseconds, yet their strength dynamically adjusts over longer timescales, from minutes to hours, based on prior experiences of social density. Zebrafish estimate social density through temporal integration of neighbor-induced looming signals, suppressing responses in crowded conditions and enhancing them in lower-density environments.

Mathematical modeling confirms that these efficient computations accurately explain collective behaviors across zebrafish development. Using brain-wide imaging at cellular resolution, we identified distinct neural clusters for monocular visual integration and specialized clusters in the left habenula for binocular processing. These findings offer the first brain-wide neural circuit description underlying complex social interactions in zebrafish, paving the way to explore how learning, internal states, and genetics shape these circuits and behaviors.

Propulsion and interaction of wave-propelled interfacial swimmers

Daniel Harris

When an asymmetric floating body is internally or externally vibrated, the self-generated capillary wavefield can lead to steady propulsion or rotation. Such wave-driven propulsion was recently documented in nature for the case of a honeybee bound to an air-water interface. In this talk, I will discuss several related and recently discovered artifical systems that leverage this propulsion mechanism. On a vibrating fluid substrate, freely floating particles are shown to self-propel along straight paths or rotate in place, depending sensitively on the particle asymmetries and driving parameters. By combining multiple asymmetries, particles can be remotely steered along curvilinear trajectories via modulation of the driving frequency alone. Such surfing particles interact at a distance through their mutual wavefield, and exhibit a rich array of collective dynamics. Particle-level actuation can also lead to propulsion as realized by the “”SurferBot””: an untethered centimeter-scale vibrobot that self-propels along a fluid interface using an onboard vibration motor and battery. Overall, these accessible and tunable macroscopic systems serve as novel platforms for exploring propulsion and interaction at a fluid interface. Relationships to relevant biological systems will be discussed.

Inspiring curiosity from failure: Lessons from field-based courses

Jacob Harrison, Justina Jackson, Saad Bhamla

Curiosity is a vital skill that should be developed in early-career scientists. However, choosing curiosity-based projects often involves uncertainty, and scholars may struggle to opt for exploration over more dependable research projects. However, we argue that curiosity-based research is critical, not despite the failure, but because of it. Failure provides opportunities to adapt and refine questions and approaches. We illustrate these learning outcomes through the in-situ Jungle Biomechanics Lab (JBL), a field-based research course in the Peruvian Amazon Rainforest. The JBL program prioritizes curiosity-based research, pushing students to explore new questions while managing the logistical challenges of remote field settings. These unpredictable conditions highlight the difficulties of experimental biophysics research but also foster creative solutions and inspire novel questions and research directions. By combining curiosity and failure as learning objectives, the JBL program fosters an environment that promotes risky science and provides opportunities for early-career scientists to develop their curiosity.

Muscle levers and elastic springs: A comparison in morphology and jump performance in orthopterans.

Shannon Harrison, Charles Deeming, Gregory Sutton

Jumping in orthopterans is powered by two distinct biomechanical strategies: direct muscle actuation and elastic energy storage in cuticular springs. These contrasting mechanisms provide a valuable model for understanding the evolution of power amplification in jumping insects. Here, we compare muscle-actuated katydids (Ensiferans) and spring-actuated grasshoppers (Caeliferans) using high-speed kinematics and micro-CT scanning to investigate how differences in actuation mechanisms and lever mechanics shape jump performance in two contexts: escape and targeted jumps. Three-dimensional reconstructions of internal musculoskeletal anatomy such as muscle volume, fibre lengths, moment arms and spring structures allow detailed quantification of hind leg architecture. When this is combined with high-speed kinematic data (including jump trajectories, take-off velocities, angular velocities, and energetics) it allows us to generate real time force estimates of during the hind leg extension phase of jumps. This combined approach helps us to answer the broader question of how morphological variation influences the evolution of jumping performance across the two distinct orders of orthopterans.

Uncovering mechanistic determinants of host phenotypes using microbial systems biology

Erica Hartmann, Jack Sumner

Host phenotypes are caused by a multitude of interacting factors, including but not limited to the microbiome. The advent of high throughput sequencing technology revolutionized our ability to characterize host-associated microbial communities. Early microbiome profiling studies often focused strategies such as 16S rRNA gene amplicon sequencing to assess the relative abundance of host-associated microbiota. Waves of technological improvement and an ever-increasing knowledge base led to accessible multiomic profiling. However, harmonizing experimental design and data analysis still presents a technical challenge. Here, we discuss an integrated approach to rigorous, parsimonious, and impactful research on host-associated microbial communities. We present a conceptual analysis of the strengths of different ‘omics methods and how they can best be combined to complement each other. Augmenting relative abundance data with absolute quantitation can dramatically change the resulting insights. Functional profiling with various meta’omics strategies ultimately enables linking microbial profiles with phenotypic trait expression. Finally, while many sequencing studies are observational, it is critical to integrate experimental validation to mechanistically explain relationships between the microbiome and host phenotypes. The inherent complexity of the host microbial ecosystem presents a unique challenge to distilling mechanisms of host-microbiome dynamics, as microbial and host factors are often confounded. Creative new systems enable high-throughput manipulation of microbiomes in ways that will help test hypotheses generated from correlative results and move towards truly translational research.

Panel discussion | Learning from the past and present to advance our future

Christina Harvey, Jasmin Wong, Vikram Baliga

This moderated panel discussion includes five invited speakers spanning fields and levels of experience. There are two major themes for this panel: a) generate discussion about how future studies can integrate evolutionary analyses to advance engineering insights and b) highlight how to mentor the next generation of researchers to sit at the interface between engineering and biology, and value the diverse set of knowledge that each discipline provides.

Anatomical observations of cryptic species within *Coryphella trilineata* complex

Zoey Harvey, Megan Schwartz, Rebecca Varney

The use of integrative taxonomy for the documentation of Earth's biodiversity has recently revealed an abundance of hidden diversity among nudibranchs. To explore the potential species delimitation of the nudibranch, Coryphella trilineata, 11 specimens were collected from tires on a floating dock at Friday Harbor Laboratories, WA, USA. Radular morphology and most external anatomy were in accordance with the species description by O'Donoghue (1912); however, the differing morphologies of rhinophores proved divergent from the original description. Additionally, multiple specimens deviated from both the yellow-tipped rhinophores and brick-red cerata described. Rhinophores with several different morphologies, including deep annulations, shallow annulations, and wrinkled rhinophores, were present among the individuals sampled. Rhinophore morphology has been used to distinguish several nudibranch species; therefore, the presence of multiple distinct types suggests possible cryptic diversity. The radula of the wrinkled-rhinophore specimen matched the species description overall, though its lateral teeth may differ. No other known Coryphella species overlapping in range and morphology with C. trilineata resemble the specimens collected. DNA barcoding data were not available at the time of abstract submission, but will be informative in answering the question about these potentially cryptic forms.

Bioinformatic analysis of crustacean myostatin

Leah Hasstedt, Talia Head, Donald Mykles

Molting in crustaceans is the process through which a crustacean sheds its exoskeleton to grow. This process is hormonally regulated by two endocrine glands, the X-organ (XO) and the Y-organ (YO). The YO synthesizes and secretes molting hormones called ecdysteroids that cause an animal to progress towards molting. Molting is a cyclical process through which the YO transitions through four physiological states: basal, activated, committed, and repressed. Myostatin (Mstn), also known as growth differentiation factor 8 in vertebrates, is characterized as an inhibitor of protein synthesis in muscles. However, Mstn/Activin signaling also plays a role in transitioning the YO from the activated to the committed states. The purpose of this research is to characterize Mstn in crustaceans. Phylogenetic analysis of crustacean Mstn was inferred using the CrusTome transcriptomic database of 189 crustacean species. Preliminary data suggest that crustaceans express two isoforms of Mstn, which differ by eight amino acids in the propeptide domain. Expression of Gl-Mstn in the YO of the blackback land crab, Gecarcinus lateralis, in response to the molt induction (multiple leg autonomy and eyestalk ablation) was assessed from transcriptomic data. Future work will characterize the Mstn receptor, an Activin type 2 receptor, to better understand the role of Mstn signaling in the crustacean YO across the molt cycle. NSF grant IOS-1922701.

Determining transient, visiting, and resident symbionts in microbiomes

Kent Hatch, Jose Moscoso

Marine invertebrate hosts have a degree of control over their microbiome. This microbiome may be established early in life but may be greatly influenced by environmental conditions in later stages. Thus, determining which microbes sampled are part of the holobiont vs which are environmental background becomes very important. Many studies incorporate parallel environmental samples to characterize the background microbial community, but rarely do they try to use this as a control for environmental contribution to the organism's microbiome. Statistical tests or other means are generally not, but should be employed to distinguish which microbes found merely occur as a result of their presence in the environment vs. those that are an integral part of the organism's holobiont. Determining the best methods for doing this is up for debate.

In the heat of the moment: sex-specific responses of zebra finches to acute heat exposure

Benjamin Haussmann, Margaret McGrath, Danica Vo, Kevin Pham, Ali Amer, Brynleigh Payne, Natalie Gassman, Tonia Schwartz, Haruka Wada

A recent increase in the frequency of heat waves has urged researchers to examine organismal responses to acute extreme temperatures. If sexes differ in their response to extreme temperatures, heat waves can disproportionately affect males and females. Accordingly, our study investigates the sex-specific metabolic and endocrine responses to an acute heat exposure. We assigned male and female zebra finches to a control (22°C) or a heated treatment (42.5°C). Birds were moved to an incubator for three days of acclimation before being exposed to their treatment temperature for five hours. We collected blood samples pre- and post-treatment to measure blood concentrations of corticosterone, glucose, and beta-hydroxybutyrate. We found that male and female zebra finches differed in their corticosterone response to acute heat. Control males showed no differences in corticosterone from pre- to post- treatment, however, heated males increased corticosterone after heat exposure. Interestingly, control and heated females showed a similar increase in corticosterone from pre- to post-treatment. Under heat, both sexes similarly increased glucose levels, but neither sex increased beta-hydroxybutyrate in response to heat. These sex-specific physiological responses to transient extreme temperatures are critical as sex differences and weather events can potentially lead to population instability. Continued work on oxidative damage to DNA will be discussed to provide further insights into sex-specific physiological consequences of acute heat exposure.

A decadal review of Washington Ocean Acidification Center's zooplankton monitoring program

Morrigan Havely, Kit Yu Karen Chan, Amanda Winans, Olga Kalata, Emily Seubert, Jan Newton

Zooplankton are effective bioindicators of environmental change due to their short life cycles and sensitivity to water chemistry. Ocean acidification (OA) is one such environmental change threatening marine ecosystems. Urbanized coastal regions like Puget Sound in Washington State, which experience freshwater input and seasonal upwelling, are already showing pH values lower than those predicted for the open ocean by the end of the century. Over the past decade, the Washington Ocean Acidification Center (WOAC) has gathered data from triannual cruises to monitor carbonate chemistry and plankton dynamics in Puget Sound. Using microscopy-based species identification and enumeration, zooplankton abundance has been estimated to be 1.7 times greater in summer than in spring, which coincides with post spring increases in phytoplankton blooms. Specifically, northern sites show a three-fold increase in zooplankton abundance compared to southern sites, possibly due to freshwater influx and slower water circulation in the south. Seasonal peaks in abundance may be intensified by marine heatwaves, as northern sites have experienced positive temperature anomalies in 2014 and 2022 twice the magnitude of non-heatwave years. Ongoing analyses of species composition aim to identify OA-sensitive taxa and track changes in zooplankton abundance and Puget Sound's carbonate chemistry over time. It is critical to understand the impacts of shifting environmental conditions on species abundance and subsequent implications on higher trophic level species that rely on these plankton populations.

Biology isn't binary: lessons from four years of trans-centered community building in biology

Hazel Havens

Creating an environment in departments and classrooms in which all students are able to thrive and fully contribute is an ever-present task for the biology educator. Transgender students in particular can sometimes have a complicated relationship with biology as a subject: those opposed to transgender rights often misguidedly gesture to biology when formulating a larger anti-trans argument. Without active intervention, we run the risk of allowing talented and curious students to develop the mistaken impression that working in the field of biology is not for them. Educators, too, can feel caught off guard by what is a new and emerging tranche of "hot button" questions in the generalist biology classroom. Here, we discuss lessons from four years of programming within the biology department at the University of North Carolina at Chapel Hill aimed at addressing these twin issues. We share the strategy, evolution, and successes of an annual barbecue fundraiser supporting trans causes. We also share insights from our educator-focused programming that aims to provide tools and peer-reviewed information pertinent to the biology professor. Both of these components have implications for trans-inclusive programming generally. In particular, that inclusive programming can be more effective when based on shared cultural context, and biology professors are often more receptive to programming that centers peer-reviewed research.

Caudal fin ray morphology reflects ecological demands in elongate fishes

Olivia Hawkins, Megan Vandenberg, Cassandra Donatelli, Eric Tytell

Ray-finned fishes are characterized by their intricate, morphologically varied, bony fin rays, but the functional consequences of this incredible diversity is only documented for a handful of species. The form-function relationship of the caudal fin rays has received surprisingly little attention despite their role in swimming for many species; even less attention has been given to the caudal fins of elongate fishes, as it is assumed that their bodies are the most significant control surface. One group of morphologically and ecologically diverse elongate fishes are the zoarcoids (pricklebacks, gunnels, and relatives) which live across shallow intertidal habitats to the deep subtidal. To determine if ecological demands shape caudal fin ray diversity in the zoarcoids, we used micro-computed tomography to 1) compare the overall caudal skeleton across species, 2) describe the fin ray morphology in a functional context, and 3) test the link between morphology, phylogeny, and ecology. We found that intertidal fishes have higher proportions of unsegmented regions of the fin rays while nearshore species have more branching of the fin rays at their distal end, suggesting that intertidal fishes have passively stiffer fins than nearshore species. Differences in caudal fin ray morphology in elongate fishes may reflect functional adaptations of the fin for navigating between rocky crevices or swimming vertically in the water column.

Endocranial shape variation in relation to climate in primates

Ariyanna Haygood, Chris Law, Sharlene Santana, Michael Berthaume

Brain evolution is a complex process impacted by many factors, yet these remain largely unknown. As a diverse mammalian clade defined by encephalization and reliance on learned behaviors, primates serve as a well-suited subject to examine how brain morphology may be associated with environmental factors. Brain size has been shown to be linked to seasonality in lemurs, but the exact morphological changes are unknown, and whether this trend is shared across all primates remains understudied. Here, we tested the hypothesis that climatic factors contributed to differences in endocast morphology among primate species. We predict that investment in regions associated with higher learning and processing may be correlated with greater variability in rainfall and temperature due to behavioral flexibility needed to survive in variable climates. To test our hypothesis, we microCT scanned 124 skulls across 82 primate species and quantified endocranial morphology using geometric morphometrics. We tested whether differences in endocast morphology across species are correlated with temperature and rainfall. Our preliminary results suggest a significant relationship between endocast morphology and climatic variables, particularly changes in the positioning of the cerebellum and spinal cord. Overall, our findings enhance the understanding of the evolutionary mechanisms of brain evolution and may help better predict how future climate change may affect the evolution of organisms.

Integrating environmental DNA and traditional barcoding reveals higher zooplankton species richness

Caroline Haymaker, Amanda Schupner, Mallori Standley, Megan Schwartz, Rebecca Varney

Zooplankton play central roles in marine food webs, energy transfer, and nutrient cycling, yet their biodiversity remains poorly documented. Environmental DNA (eDNA) metabarcoding offers a rapid way to assess species richness, but its performance relative to traditional approaches is still being evaluated. We compared hand-sorted zooplankton samples that were DNA barcoded to bulk eDNA samples that were metabarcoded at Friday Harbor Laboratories, WA, USA, integrating results from student projects targeting specific taxa. One project focused on larval polychaetes, using scanning electron microscopy (SEM) to document morphological variation and validate sequence data. Other projects examined mysids and copepods, refining their taxonomic identifications. Both methods recovered diverse operational taxonomic units (OTUs), but each captured unique subsets of the community. eDNA was highly effective for broad biodiversity discovery, while hand sorting with direct sequencing added taxa and generated voucher specimens with images, improving reference libraries. Combining these complementary approaches yields a more comprehensive picture of local zooplankton diversity and strengthens future eDNA-based biodiversity assessments.

From jars to gigabytes: NHMLA's marine invertebrate journey with DigIn

Caroline Haymaker, Regina Wetzer

The Natural History Museum of Los Angeles County (NHMLA) has been an active contributor to the NSF-funded DigIn Thematic Collections Network, which set out to expand digital access to marine invertebrate biodiversity. By digitizing wet collections, refining high-volume workflows, and mobilizing legacy data, NHMLA has increased the visibility and accessibility of historically underutilized specimens while training students and volunteers in modern digitization practices.

While these efforts have yielded hundreds of thousands of digital records and images now discoverable through portals such as iDigBio, GBIF, and OBIS, the process was not without obstacles. Variability in specimen condition and preservation required flexible imaging solutions, reconciling legacy station data with modern taxonomic frameworks posed ongoing challenges, and working within a geographically distributed network demanded a balance between standardization and local adaptation.

As a result, the project provided both immediate gains in data accessibility and lasting lessons about scalable workflows, institutional collaboration, and the value of sharing local innovations across collections. NHMLA's experience demonstrates how large-scale digitization can both advance biodiversity research and strengthen institutional capacity for future initiatives.

Anatomical anomalies: the three-legged lizards of LA

Alyssa Head, Taylor Glaser, Alice Hibbert-Davies, Amber Singh, Jackson Wolfe, Kinsey Brock

The morphology-performance-fitness (MPF) paradigm predicts that changes in morphology directly influence locomotor performance, which in turn shapes the fitness of an individual. This framework has been well supported across squamates, particularly with respect to limb length variation across a variety of habitats. Following this logic, dramatic morphological changes resulting from injury should impact performance ability and the individual fitness. While sampling introduced Italian wall lizards (Podarcis siculus) in San Pedro, Los Angeles, we encountered two individuals who were both missing most of one of their limbs. We collected morphological data to estimate limb volume in both injured and uninjured individuals, assessed overall body condition, and quantified their straight-line sprint speeds. We then compared these data to uninjured conspecifics to evaluate the effect of limb loss. Contrary to

expectations, limb loss did not guarantee a reduction in sprint performance. These results highlight the potential for within-lifetime adaptability that can allow injured lizards to compensate for morphological deficits to maintain performance ability.

Roles of serotonin and AGC kinases in the molting gland of *Carcinus maenas*

Talia Head, Donald Mykles

Molting in crustaceans is stimulated by the synthesis of molting hormones, ecdysteroids, in the molting gland (Y-organ, YO). Ecdysteroid synthesis by the YO is negatively regulated by a neuropeptide called molt-inhibiting hormone (MIH), which is synthesized and secreted by the X-organ/sinus gland complex (XO). MIH signaling in the YO acts through second messengers cAMP and cGMP, which activate protein kinase A (PKA) and protein kinase G (PKG), respectively. Transcriptomic analysis of the decapod YO has revealed the presence of 99 G protein-coupled receptors, including receptors for the biogenic amines serotonin, dopamine, and octopamine. In this study, serotonin enhanced the effects of MIH in the YO of the green shore crab Carcinus maenas, by further reducing ecdysteroid secretion relative to MIH alone. PKA and protein kinase C (PKC) are established downstream effectors of serotonin receptors in mammalian cells. Using pharmacological activators and inhibitors, the effects of PKA and PKC on ecdysteroid secretion were measured in the presence or absence of serotonin and MIH. We hypothesize that the neurohormone serotonin initiates a signaling cascade with converges with the MIH pathway to modulate ecdysteroid synthesis in the YO. NSF grant IOS-1922701.

Dopaminergic input to the antennal lobes of generalist and specialist *Drosophila* species

Jessica Hearn, Gabriella Wolff

Olfaction is a crucial sensory modality for both generalist and specialist insects, allowing them to find food, shelter, and mates. While generalists feed on a variety of hosts, specialists are limited to one or a few. How generalists use olfactory cues when switching hosts is unresolved. Does neuromodulation by biogenic amines, like dopamine, allow generalists to reshape the way the olfactory circuit prioritizes certain odor cues? This mechanism might facilitate learning odors, such as those associated with hosts available at different times. Are there differences in the patterns of dopamine neuron innervation to the antennal lobes (primary olfactory brain areas) between generalists and specialists that confer increased neural plasticity to the former? Here, we use immunohistochemistry to reveal dopaminergic cells within the antennal lobes of Drosophila species with different foraging strategies, including D. simulans, which is a generalist that feeds on a variety of fruits, and D. sechellia, a specialist on the Morinda fruit. This work will provide insights into the role of dopamine in the antennal lobe and how neural plasticity in the olfactory circuit might facilitate different foraging strategies.

Crunching Data: Analyzing the form-function relationships of echinoid jaws with deep-learning meshes

Nicholas Hebdon, Alexander Ziegler, Jeffrey Thompson, Elizabeth Petsios

With their rich fossil record, sea urchins (Echinodermata: Echinoidea) offer valuable insight into macroevolutionary mechanisms of morphological change. One feature of particular interest in this regard is their feeding apparatus, the Aristotle's lantern. Its role in feeding should mean, that throughout evolution lantern morphology is strongly linked with changing life modes and mechanical constraints/necessities. Due to lack of soft tissue preservation, interpretations of echinoid fossils often rely on the biomineralized test and more specifically, the perignathic girdle. This structure acts as the attachment site for lantern muscles. Evaluating morphological change in the perignathic girdle first requires understanding the relationship between musculature and girdle morphology in extant species. Here, we present a novel workflow using deep learning, Python automation, and high-performance computing to rapidly segment numerous 3D imaging datasets and convert them into meshes. From these, we extract biomechanically relevant metrics (i.e. muscular volume, cross-sectional area, etc.) and relate them to girdle geometry. We focus on two major muscle groups attached to the girdle, whose size and arrangement likely correlate with life mode. Our findings reveal diverse girdle-muscle arrangements across "regular" sea urchins, with distinct anatomies linked to specific feeding strategies and life habits. This work provides a foundation for robust biomechanical analyses. Moreover, our system-agnostic, scalable scan-to-model workflow supports the creation of similarly large datasets, advancing future research in functional morphology.

Beyond the enclosure: kinematics of captive vs. wild meerkats

Sarah Heckmann, Kelly Diamond

Animals use different gaits when moving at different speeds and through different environments. Accredited zoos attempt to replicate natural environments for captive animals, but there are limitations to how similar the environment of a captive animal can be to that of wild individuals. We were curious if gait kinematics differ between wild and captive individuals. One of the main differences in the environments of zoo-housed animals is the presence of zoo guests. For example, our previous work demonstrated that captive meerkats (Suricata suricatta) spent less time moving when zoo visitor presence increased. In this study, we wanted to examine gait differences between captive and wild meerkats while walking and running. Footage was obtained for captive meerkats at the Memphis Zoo and for wild meerkats from online, open-access videos. We predicted that, because wild meerkats likely have increased space to move and must avoid predation attempts, the limb angles would be larger and duty factors smaller in wild individuals compared to captive meerkats. We compared the duty factors, the percentage of time that each foot is spent touching the ground in a gait cycle, and limb angles between our captive and wild videos. This study aims to serve as a foundation for future work concerning how welfare can be classified and quantified in captive animals.

A decade of red-backed salamanders in Ithaca, New York

Brandon Hedrick, Caroline Goldstein, Isha Chauhan, Stephen Bredin, Lauren Essner, Vincent Farallo, William Hooker, Danielle Keerbs, Andrew Orkney, Priscila Rothier, William Ryerson, Kay Williams, Amy Yang, Christopher Sutherland

Since ectotherms use their environment to thermoregulate, they are highly susceptible to climate change. Lungless salamanders (Plethodontidae) are especially vulnerable given that they respire entirely through cutaneous respiration. Their thin skin limits the temperatures and moisture levels at which individuals can be successful. Plethodon cinereus (Red-Backed Salamander) has been extensively studied for decades and is often used as a model system for studying salamander biology and ecology. We examine how P. cinereus populations have changed in a forest over a 10-year span using spatial capture-recapture methods through wooden coverboards. Four sites were established in 2014 and were measured between 2014–16, and we established two new arrays in 2023. This gives us three datasets, the original 2014 data, the new sites established in 2023, and the re-activated 2014 sites (measured from 2024-2025). Using these datasets, we examine changes in coverboard preference, salamander life span, and changing population structure across ten years. Approximately 6% of salamanders rediscovered in 2024 had been initially captured and marked in 2014 demonstrating individual salamander longevity. Preliminary data show higher densities in the new sites than the 2014 sites potentially indicating a population shift, but no differences were found in individual home range size or movement patterns. These data suggest population persistence despite 10 years of warming climate and changing precipitation.

Changes in flap-glide behavior for European Starlings in small group flight

Tyson Hedrick, Sonja Friman, Cory Elowe, Siyang Hao, Alexander Gerson, Kenneth Breuer

Prior work from our group demonstrated metabolic energy savings for the European Starlings following behind a leader in a small-group wind tunnel flight context. However, the published analysis focused on metabolic

measurements plus the relative flight position in the group and provided little insight into how the bird flight behavior changed from solo to group flight and behaviors associated with cost savings in group flight. Here we use accelerometer data to fill this gap, highlighting how overall flight behavior and the drivers of flight costs shift between solo and group flight. Data were collected from eleven European Starlings flying solo and as groups of two or three birds in the Brown University animal flight wind tunnel. The metabolic energy expenditure of one bird in each flight set was measured through the decay of 13C given as an injection of 13C NaBi before flight. Position in the wind tunnel was continuously monitored using four cameras, and a 3-axis accelerometer mounted to the back of each bird provided high frequency measurement of flight movements. In solo flight, continuous low-effort flapping reduced flight costs. Group flight increased the fraction of flight time spent flapping, but also broke the link between continuous flapping and low cost. Instead, low cost group fliers used a slow burst-coast rhythm, while high cost group fliers had irregular short periods of flapping and coasting.

Secondary flightlessness in waterfowl: Mallards, Indian Runner Ducks, and their hybrid offspring

Ashley Heers, Willa Coultley, Sandy Gregorio

Developing wings play an important role in the locomotion of immature birds. Though this has been a focus of studies on rudimentary wing function, rudimentary flight apparatuses also occur in secondarily flightless birds. Here we explore developmental attributes of secondary flightlessness in waterfowl. We hypothesized that the loss of flight is associated with increases in leg investment and performance that at least partially compensate for reduced wing investment and performance. To test this idea, we measured the development of wing and leg investment and performance during multiple behaviors in Mallards (Anas platyrhynchos), Indian Runner Ducks (a domesticated, flightless derivative of Mallards), and their hybrid offspring. As in previous studies, all three groups show evidence of tradeoffs: leg investment and performance decline with the onset of rapid wing development. For their size, Mallards have the highest wing investment and performance and Runner Ducks have the lowest. However, the declines in leg investment and performance are the most extreme in Mallards, partially because hybrids and Runner Ducks regain some leg muscle after wing growth slows. Coupled with other changes, this may suggest that the loss of flight frees birds to invest more in their legs. Our data may also suggest that during the evolution of flightlessness, the body and hind limbs change more rapidly than forelimbs — possibly because flight imposes strong constraints on the flight apparatus.

On being the right brain-body size

Christopher Heesy, Leigha Lynch

Contemporary critiques of the replicability and rigor of comparative interspecific brain size studies commonly conflict about the causes of why. I suggest that variation in body mass complicates allometric analyses designed to investigate ecological and life-history contributions of relative or residual brain size. I quantify the impact of intraspecific variation on allometric analyses by quantifying variability in body, brain, heart, liver, and kidney masses in over 100 mammal species where values came from the same individuals. Heart, liver, and kidney masses were included because these organ systems are known to scale allometrically with body mass. I compared variability in body and organ system masses using Sokal and Braumann's formulation of coefficient of variation (CV). Most body and organ mass CVs are at least twice as variable as brain mass CVs. Organ and body mass CVs correlate in many species, whereas brain mass CVs correlate with neither body nor other organ system mass CVs. I suggest that body masses obtained from online databases of mammalian life-history and morphometric data for use in some comparative analyses do not always represent the amounts of variation due to seasonality, population demographics, and other factors. I suggest that investigations of intraspecific allometry present a major opportunity for comparative neuroanatomists to clarify the mechanistic relationship in brain and body sizes in mammals and other vertebrates.

Role of the tail in gecko locomotion across substrates of varying compliance and diameter

Sadie Heidemann, Aaliyah Roberts, Benjamin Wasiljew, Maya Philips, Jessica Carter, Andrew Moura, Austin Garner

Arboreal lizards (e.g., geckos) possess a variety of morphological features that allow them to effectively navigate their environment during fitness-relevant tasks such as avoiding predation and seeking resources. Tails influence jumping and climbing performance of arboreal lizards, two locomotor modes of relevance to survival in complex three-dimensional arboreal environments inundated with substrates of varying surface properties. Much research has focused on how geckos and other arboreal lizards navigate substrates of variable diameter by using their tails as stabilizers. Arboreal substrates (e.g., branches and leaves) also vary in compliance (i.e. flexibility), yet there is a considerable gap of knowledge on the interactive effect of compliance and diameter on arboreal lizard locomotion. We ran Phelsuma grandis across nine different compliance-diameter treatments to explore how arboreal lizards modulate tail use and center of mass on locomotor substrates of variable difficulty. Lizards were recorded using high speed videography while running on a custom-built apparatus that allowed the independent manipulation of compliance (n = 3 levels) and diameter (n = 3 levels). Locomotor kinematic analyses were performed to quantify tail movement and changes in gait. Understanding how tails contribute as a balancing organ will broaden our knowledge of the locomotor costs of caudal autotomy in arboreal lizards and contribute to the design of bio-inspired robots that can operate in similarly challenging environments.

Suppressing transgenerational lipid provisioning during mosquito diapause impacts egg desiccation

Mara Heilig, Marten Edwards, Peter Armbruster

Maternally-regulated photoperiodic diapause is a crucial form of transgenerational phenotypic plasticity that enables overwinter survival in a wide range of temperate insects. Despite the well-established adaptive significance of diapause, the molecular and physiological basis of transgenerational photoperiodic diapause signaling remains largely unresolved. Since the accumulation and storage of nutrients, particularly lipids, is a hallmark of diapause preparation and diapause maintenance, we hypothesized that increased nutrient accumulation and provisioning mediate transgenerational diapause signaling. To test this hypothesis, we suppressed transcripts of two lipid metabolism genes, lipid storage droplet-2 (LSD2) and diacyl-glycerol O-acyltransferase (DGAT), using RNA-interference (RNAi) in the maternal generation of the Asian tiger mosquito, Aedes albopictus. We show that a reduction in maternal LSD2 transcript abundance following a blood meal reduces egg triglyceride levels. In contrast, a reduction in maternal DGAT1 transcript abundance has no impact on egg triglyceride levels. Suppression of LSD2 in adult females also leads to a decrease in desiccation resistance of eggs, affects egg overwinter survival, and leads to a decrease in the starvation tolerance of larvae that hatch from eggs produced by females with suppressed LSD2. However, knockdown of LSD2 does not affect diapause incidence, the timing of diapause termination, and post-diapause development. Taken together, our results indicate that transgenerational lipid provisioning affects diapause-associated overwintering fitness traits, but not the regulation of entry into diapause or termination of diapause.

Transcriptomics of chill coma reveal strongly tissue-specific responses

Mara Heilig, Lahari Gadey, Jenna Tomkinson, Greg Ragland

Some elements of physiological responses to stress are cell-autonomous, such as the classic heat shock protein response. However, comparatively little is known about the tissue-specificity of thermal stress responses in general, and much less is known about the detectability of cell autonomous responses across tissue types. We exposed Drosophila melanogaster fruit flies to a time series of chilling consistent with classic chill coma experiments that simulate cooling to a temperature that abolishes locomotory ability and thus induces chill coma in insects. We sampled four tissues at ordered time points before and after chill coma induction, including the larval gut, as well as the adult

central nervous system, ovary, and gut. Standard mRNAseq followed by differential expression analyses across temperature/times and tissue types revealed highly tissue- and life-stage-specific transcriptomic responses during chilling stress. These results suggest that whole organism physiological responses to complex thermal stress in nature likely reflects the integration of distinct responses across tissues. This highlights that mRNAseq from whole organism homogenates may often yield an incomplete snapshot of transcriptomic responses to stress.

Impacts of water availability on the endocrine stress response in free-living *Octodon degus*

Sarah Heissenberger, Sarah DuRant, Denyelle Kilgour, Elizabeth Atkinson, Myles Ross, Jessica Morales-Valenzuela, Loren Hayes, Carolyn Bauer

Organisms are facing increasingly unpredictable environmental conditions as a consequence of climate change. As many areas of the world are projected to become more arid over the next century, species will likely face the stressor of decreased water availability. The endocrine stress response allows an individual to mobilize physiological resources in order to meet ecological challenges, and involves changes in levels of glucocorticoids. We assessed the relationship between the endocrine stress response and water availability in free-living Octodon degus; this arid-adapted rodent is native to central Chile, which recently experienced a megadrought. Using wild populations of frequently captured O. degus, we water-supplemented a population of individuals during trapping; a second population did not receive water supplementation (controls). Water supplementation began during the mating season (June) and lasted through the end of lactation (Nov). We collected individual fecal samples from males and females during both mating and lactation, and fecal cortisol metabolites were quantified using an EIA assay. We predicted that fecal cortisol metabolites would be increased in control individuals as compared to water-supplemented individuals. Understanding how individuals cope physiologically with water stress - and how this response varies between individuals and across time - may help identify susceptible demographic groups and critical periods, which can inform species conservation and management strategies.

Effects of egg incubation temperature on nestling immunity and responses to parasitism

Allison Helferich, Carissa Leung, Bridget Sleath, Sila Inanoglu, Lorraine Perez, Ryan Shannon, Sarah Knutie, Ashley Love

Temperatures experienced in early life can impact the development, health, and survival rate of avian offspring. Avian parents can control the thermal environment experienced by developing embryos through incubation behavior, and slight differences in mean incubation temperature can have lasting effects on offspring traits, including immunity. Thus, the temperature experienced by eggs could affect how nestlings respond to pathogens and parasites as well as influencing how parasites move through populations. In this study, we manipulated nest temperature during the late egg incubation period in eastern bluebirds (Sialia sialis). When nestlings were 13 days old, we collected a blood sample to make blood smears, which were used to count the proportions of five different white blood cell types. We found that nestlings from experimentally cooled nests had a lower proportion of basophils than nestlings from control and experimentally heated nests. The presence of nest ectoparasites also affected some aspects of nestling immunity, but this effect varied by temperature treatment, suggesting that incubation temperature affects not only the immune system of nestlings, but also how they respond to parasites.

A spiraling mystery: the causes and consequences of mirror symmetry in a globally-distributed animal

Rebecca Helm, Tom Iwanicki, Casey Dunn, Nikolai Maximenko, Sam Church

By-the-wind sailor jellies live at the ocean's surface, and travel across the global ocean by harnessing the wind. These jellies have a fleshy protruding sails, which occurs in two mirror forms: "left" and "right". Left- or right- facing sails are pushed in different directions, and in the 1950s A.I. Savilov predicted that right-handed sailors would concentrating inside Northern hemisphere anticyclonic gyres, while left-handed sailors would be pushed out toward coastal margins; the opposite being true for the Southern hemisphere. However, after an extensive review of the literature at the time, a review published in Nature concluded that by-the-wind sailor distribution was "not yet satisfactorily explained." In this presentation, we leverage the global reach of community science and advances in molecular biology and oceanographic modeling to test Savilov's hypothesis, unspiralling the causes and consequences of mystery of mirror symmetry at the ocean's surface.

Open-access µCT workflows for teaching homology and function in comparative vertebrate anatomy

Devya Hemraj-Naraine, Matthew Kolmann, Jack Rosen

Comparative vertebrate anatomy (CVA) courses introduce students to the evolution, morphology, and function of vertebrate and chordate body plans, with a central focus on the relationship between form and function and the recognition of homologous structures across lineages. Traditionally, these concepts are taught through gross dissection, but such approaches are often limited by accessibility, preservation quality, and the inability to revisit specimens after use. To address these challenges, we are developing a publicly available library of annotated, segmented micro-computed tomography (µCT) datasets that capture three-dimensional anatomy of model fishes: bowfin (Amia), dogfish (Squalus), and African lungfish (Protopterus). These datasets include skeletal scans as well as contrast-enhanced preparations that highlight musculature and brain tissue, providing multiple anatomical systems for comparative study. By centering on these classic models, our resource allows students and researchers to explore evolutionary transformations (such as the changing roles of the jaws or hyomandibula) in high resolution, with emphasis on questions regarding homology, form, and function. The datasets are fully compatible with open-source software (3D Slicer), lowering barriers for undergraduates, instructors, and online learners, especially at institutions with limited access to collections or imaging facilities. In doing so, this project creates an interactive, digital platform for comparative anatomy that extends traditional pedagogy, supports independent inquiry, and broadens access to high-quality anatomical data. This work was supported by the National Science Foundation award DBI-2301406.

Niche partitioning among pacus and piranhas along a neotropical river gradient

Devya Hemraj-Naraine, Matthew Kolmann, Carmen Montana

The Neotropics hold the most diverse freshwater fish communities in the world, far surpassing temperate and subtropical environments. In these diverse communities, we should expect the finest level of niche partitioning among syntopic species, particularly among close relatives. The Neotropical family Serrasalmidae (piranhas and pacus) provides a powerful model for studying fine-scale niche partitioning in tropical freshwater communities, encompassing morphologically diverse species that range from herbivores to specialized carnivores. We investigated resource use among five serrasalmid species -- Catoprion absconditus, Serrasalmus rhombeus , Metynnis altidorsalis, Myloplus rubripinnis, and Pygopristis denticulata -- using stomach content (n = 537) and stable isotope analyses (n = 116). Gut content data revealed clear dietary specialization: Metynnis altidorsalis and Myloplus rubripinnis were predominantly herbivorous, while the piranhas Catoprion absconditus and Serrasalmus rhombeus were specialized ectoparasites and flesh-feeders, respectively. Stable isotope ratios ($\delta^{13}C$ and $\delta^{15}N$) supported these patterns, revealing distinct isotopic niches. Catoprion occupied the highest trophic position (highest $\delta^{15}N$), even exceeding S. rhombeus, while Pygopristis, an omnivore, showed overlap with both S. rhombeus (higher $\delta^{15}N$) and M. rubripinnis (lower $\delta^{15}N$). Carbon signatures also differentiated herbivores: M. rubripinnis fed primarily on C_4 plants, whereas M. altidorsalis relied on C_3-based sources.These patterns highlight the distinct isotopic niches among these serrasalmid species, with the exception of P. denticulata, which may occupy a flexible trophic role shaped by resource availability.

Unraveling non-lethal predation by the wimple piranha (*Catoprion absconditus*)

Devya Hemraj-Naraine, Matthew Kolmann

Parasitism is exceptionally rare among vertebrates, making ectoparasitic fishes like Catoprion, a piranha which only feeds on fish scales, a valuable model for studying the evolution of specialized scale feeding strategies. Catoprion's already narrow niche may be even more restricted than previously thought: although this ectoparasitic species is believed to feed on fishes up to three times its own body length, the specific prey species it targets remain largely unknown. It is also unclear whether Catoprion preferentially selects prey with larger scales or species with more weakly-attached scales. To unravel how ectoparasitic fishes like scale-feeding piranhas arrive at their niche, we took an integrative approach—extensively sampling every fish species in the community; collecting scales from these potential prey; dissecting stomachs of Catoprion; chemically staining scales for imaging and microscopy; measuring the force required to remove scales from potential prey fishes; and conducting morphometric analyses to assess patterns of scale size across the community. Stomach content analysis identified scales from Hoplias malabaricus, Leporinus arcus, and Hoplerythrinus unitaeniatus, all of which possess large scales. However, there was no statistically significant difference in scale dislodgement force between prey and non-prey species. These findings suggest that Catoprion may prioritize prey based on scale size or overall body size rather than the mechanical ease of scale removal, indicating a potential trade-off between scale profitability and foraging efficiency.

Assessing the association between nematodes and immune responses in White-throated Sparrows

Rhiannon Henderson, Cynthia Downs, Christopher Whipps, Chris Briggs

An outstanding question in avian disease ecology is how intraspecific variation in mating systems affects immunology and disease risk. Theory predicts that individuals with more mating partners are more likely to be positive for vector-borne parasites, either due to co-infection with chronic sexually transmitted infections or from regular movement in search of mates leading to greater environmental risk of parasitism. White-throated sparrows (Zonotrichia albicollis) have two morphs: white-striped birds are promiscuous, whereas tan-striped birds are monogamous. We utilized this system to study how morph relates to endoparasite presence and immune health as well as biological sex. We identified nematode microfilariae in blood samples through microscopy and genetics, and quantified immunity using a bacteria killing assay against Escherichia coli. Microfilaria presence and immune function were not correlated, and variation in immune function across individuals was not explained by morph or sex (N = 75). The microfilaria samples were genetically most similar to Aproctella species, a known parasite in sparrows. Next steps include further characterization of this nematode, and to assess if adult worms are causing tissue damage as seen in other Aproctella/sparrow relationships. This study provides a baseline on how behavioral variation is associated with immunology and presents an opportunity for further questions surrounding possible effects of nematodes on immune function in an avian model and if morph associated behaviors have an impact on disease risk.

Assembling the genome of a bat (*Epomophorus labiatus*) with an XO sex determination system

Ava Hendrix, Jesse Gunn-Cheu, DeeAnn Reeder, Luis Víquez-R, Imran Ejotre, Lisa Powers, Ken Field

Several members of the Pteropodidae family of bats are among the few mammals described without a Y chromosome. In these animals, sex is presumably determined by the dosage of the X chromosome. Additionally, bat genomes can reveal the genes involved with viral tolerance, as bats are notably asymptomatic to certain viruses. Therefore, we assembled the genome of a male epauletted fruit bat (Epomophorus labiatus) using Pacbio HiFi reads and Hi-C sequencing data to generate chromosome-scale scaffolds. The resulting assembly spans 2.1 billion bases, with a current BUSCO completeness score of 98.2%. With visualization tools PretextView and HiGlass, we manually curated the assembly into 17 autosomes and an X chromosome. Annotation was performed with the pipeline Funannotate, which integrates gene predictions from the Braker3, Toga, and Stringtie pipelines. These annotations will enable us to perform comparative genomics to identify positively-selected immune-related genes across bat lineages. Additionally, we have obtained a karyotype from testes samples collected in Uganda to confirm the absence of a Y chromosome in this species. We will also identify the genes under selection that facilitate this XO sex determination, including genes found on autosomes that are present on Y chromosomes in other bat species. Ultimately, this work will increase our understanding of the evolution of mammalian sex determination and the evolutionary genomics of bat immunity.

A field guide to different "neophobia" testing paradigms in ecological and biomedical research

Marquise Henry, Michael Wilson, Christine Lattin

Neophobia, an aversive response to novel foods, objects, and environments, is a widespread and often repeatable behavior that impacts an animal's ability to persist in human-altered environments. Neophobia is also used as an indicator of anxiety and can be impacted by anxiolytic and anxiogenic drugs. Because of its ecological and biomedical relevance, neophobia is highly studied. Depending on the animal species and the specific goals of the research, different studies employ various methods for measuring "neophobia", including novel taste paradigms, open field tests, novel object tasks, and marble-burying tests. However, we propose that not all of these experimental designs are appropriate for measuring neophobia and may instead measure neophilia, exploration, or other behaviors. Here, we review the neophobia literature focused on neurobiological and physiological mechanisms, summarize the numerous testing methods used in different experiments, and evaluate whether they truly are assessing neophobia according to our previously published guidelines. More consistent methodology in neophobia studies would allow biomedical and ecological researchers to increase the consistency of their results and facilitate conversations across biological disciplines.

Rapid trait divergence with limited parallelism in gene expression during non-adaptive radiation

Nicholai Hensley, Hayden Waller, Kerry Shaw

The predictability of evolution, as seen in the preponderance of convergent phenotypes at the macro-evolutionary timescale, is largely attributed to the persistent drive of natural selection. Adaptive radiations exemplify this pattern, with rampant gene re-use underlying shifts in adaptive traits during rapid divergence. Here, we test whether evolution is equally predictable in a non-adaptive radiation: the repeated shift between slow and fast singing in Laupala swordtail crickets. Looking at differential gene expression across two independent shifts in song, we find that changes in expression are largely idiosyncratic with respect to trait transition. Across the genome we observe heterogeneous patterns of both concordant and discordant expression between repeated shifts, and find a small signal of parallel gene expression within QTL on chromosome 5. Thus, despite the relatively short divergence time between these species pairs (< 5 my), and in stark contrast to previous work localizing interspecific song variation to similar QTLs, evolution appears largely convergent as homologous loci undergo independent changes in expression. The oligogenic architecture of male song, intermediate level of divergence, or differences in the strength or direction of non-ecological selection (e.g. sexual) between repeated phenotypic transitions may make evolution less repeatable in nonadaptive radiations.

The influence of light and noise on avian body condition: A multi-pollutant approach

Jennifer Heppner, Clinton Francis, Sara Lipshutz, Eva Moylan, Tessa Patton, Abimael Romero, Marlen Terrazas, Courtney Tuskan, Trenton Voytko, Isaiah Woodard, Jennifer Phillips

The global expansion of human-dominated landscapes has introduced novel environmental challenges, including widespread sensory pollutants like artificial light at night (ALAN) and anthropogenic noise. These pervasive pressures disrupt fundamental sensory systems wildlife rely on, affecting responses to

environmental cues and compromising their physiological state. However, most research has focused on the isolated effects of single pollutants on a limited number of species, neglecting the interacting nature of urban environments with sensory pollutants and life history traits. Therefore, we investigated the isolated and combined effects of sensory pollutants on five free-living avian species. Our focal species, two anthropogenic adapters (chipping sparrow, Spizella passerina, and western bluebird, Sialia mexicana) and three less tolerant species (gray flycatcher, Empidonax wrightii, mountain bluebird, Sialia currucoides, and ash-throated flycatcher, Myiarchus cinerascens), represent a range of life history traits including nesting habit, migratory status, and diet. Using data from a five-year study in an experimental system that eliminates confounding urban variables, we quantified the effects of noise, ALAN, and their interaction on male and female morphology and body condition, a key indicator of physiological health. We expect sensory pollution to have stronger negative effects on the three less tolerant species, and a neutral to positive effect on more tolerant species. Ultimately, this study will provide insight into how species traits influence avian vulnerability to multiple sensory pollutants, offering crucial information for conservation.

Skull shape diversity of species-depauperate Gonorynchiformes rivals that of all Ostariopysan orders

L Patricia Hernandez, Allyson Evans, Guillermo Orti, Dahiana Arcila, Nathan Lujan, Ricardo Betancur-R, Rose Peterson

The gonorynchiforms are a morphologically diverse yet species-depauperate lineage of ostariophysan fishes whose phylogenetic relationships have been the subject of long-standing debate. Multiple alternative hypotheses have been proposed based on both morphological and molecular evidence, with much discrepancy among generic-level relationships. As the sister-lineage of the immensely speciose Otophysi, Gonorynchiformes represents a valuable comparative framework for understanding the evolution of species richness and morphological disparity within Ostariophysi. Here, we present a time-calibrated, phylogenomic hypothesis of Gonorynchiformes. Our results align with the most recent molecular phylogeny of Gonorynchiformes, inferring Gonorynchus as the sister-lineage to all other gonorynchiforms and finding support for the monophyly of the miniaturized lineages Cromeria and Grasseichthys. Additionally, we assess patterns of three-dimensional cranial shape disparity across 16 gonorynchiform species and make preliminary comparisons across a sample of 28 ostariophysans. Using geometric morphometrics, we find that gonorynchiforms occupy a disproportionately large region of morphospace, with some taxa, like Phractolaemus ansorgii, exhibiting extreme morphologies not observed elsewhere in ostariophysan trait-space. These findings suggest that significant morphological disparity can evolve in species-poor lineages, highlighting the potential importance of small, neglected clades in understanding broader patterns of morphological diversification and the evolutionary potential of the teleost skull.

Effects of thermal stress during pregnancy on offspring performance in livebearing fishes

Makailyn Hernandez

While the maternal environment and associated effects impacting offspring development and performance are becoming increasingly documented, their potential role in promoting evolutionary responses to changing environments is less well understood. Livebearing fishes have internal fertilization and gestation, lack post-parturial care and have contrasting nutrient provisioning strategies allowing isolation of the maternal effects of pregnancy. Females of one matrotroph and one lecithotroph species were exposed to either a control or elevated, stressful temperature during mating and pregnancy. The objective of this study was to examine variation in female fecundity and subsequent offspring performance through maturity between temperature treatments and provisioning strategies. Since variation in provisioning strategies results in temporal differences in metabolic costs associated with reproduction pregnancy and associated maternal effects may represent an opportunity to modulate trade-offs related to the maternal-offspring conflict. I will be discussing the outcomes of thermal stress on the maternal environment and its impacts on offspring growth and development, particularly the extent to which the direction and strength of maternal-offspring conflict varies between provisioning strategies.

Thermal stress and pyrethroid resistance in the invasive mosquito *Aedes aegypti*

Matthew Hernandez, Abraham Velazquez, Brian Tsukimura

The invasive mosquito Aedes aegypti poses significant public health risks in California urban environments, where high summer temperatures coincide with peak mosquito biting activity increasing the risk of dengue virus transmission. This study investigates the role of heat shock protein (HSPs) interactions with target site resistance (kdr) mutations and metabolic resistance mechanisms. Using CDC bottle bioassays with CDC technical grade R?-cyhalothrin (10 µg/mL), time-mortality data was collected from three temperature-treated Madera strain (MAD) female mosquito groups (18 °C, 26 °C, and 34 °C). Controls used were the lab reared Rockefeller susceptible strain (ROCK) and a lab-reared MAD susceptible strain. An ultra-low volume spray (ULV) field trial at three sites, one site per temperature treatment, was conducted with wild-type F0 female Ae. aegypti and the susceptible MAD strain using commercial grade Demand CS. Pools of surviving and knocked down/dead mosquitoes were collected from each assay and field trial for RNA extraction and RNA-seq. Expression analysis of the genes of interest (HSP70, HSP20, HSP83, CYP9J32, CYP9J28, CYP6M11, CYP6BB2, V410L, V1016I, and F1534C) will establish the relationship between HSPs and pyrethroid resistance. Preliminary findings suggest higher temperatures confer increased resistance. This research will inform vector control strategies by integrating both technical and practical resistance in field populations to support more effective and targeted Ae. aegypti management in California.

Effects of egg jelly on sperm performance in Green Frogs

Andrea Jivanny Hernandez Ramirez, Tenniyah Jennings, Lula Dalupang, Ariel Kahrl

In sexually reproducing organisms, fertilization depends on interactions between the sperm of a male and the egg of a female. In amphibians, the jelly surrounding the eggs plays a critical role in this process. Previous research has shown that egg jelly alters sperm motility and plays a role in sperm capacitation. In the green frog, a common pond-breeding species, we investigate how sperm motility and longevity vary over time (analyzed at 0, 30, 60, 90, and 120 minutes after exposure) in different media: pond water versus egg water (water exposed to freshly laid eggs), and predict that the egg water of L. clamitans enhances sperm performance compared to natural pond conditions. Our study will shed light on how compounds from L. clamitans egg jelly affects sperm function, both in terms of motility and longevity, advancing our understanding of reproductive interactions in anurans.

Emergence of functional heart-brain circuits in a vertebrate

Luis Hernandez-Nunez, Joana Avrami, Keyue(Sky) Shi, Areni Markarian

The early development of sensorimotor circuits is essential for survival. While exteroceptive circuits are well characterized, far less is known about viscerosensory pathways that convey internal inputs to the brain and transmit motor commands to organs. Technical barriers—including in utero development and invasive access in mammals—have hindered their study. We use larval zebrafish, whose genetic tractability and optical transparency enable investigation of cardiosensory and cardiomotor circuit development. We designed experimental rigs that combine calcium imaging, optogenetics, and all-optical cardiac physiology to define the emergence of cardiac autonomic circuits. We found that the minimal functional unit for cardiac control requires brain-to-heart innervation but not intracardiac neurons. At this stage, heart rate acceleration during external challenges results from withdrawal of tonic vagal inhibition. We also identify a hindbrain vagal premotor nucleus that controls heart rate. Later, sympathetic innervation enhances the amplitude and speed of responses, as the anterior sympathetic ganglion acquires the ability to drive cardiac acceleration. Soon after, vagal sensory neurons innervate the heart. Distinct subsets track decreases or increases in heart rate during spontaneous fluctuations, threats, or optogenetic perturbations. Thus, the staggered onset of

each circuit limb provides a unique framework to study neural dynamics under three regimes: (1) unidirectional brain-to-heart communication, (2) dual efferent control, and (3) closed-loop feedback via vagal sensory input.

Examining the effects of food quantity on performance of the temperate coral Astrangia poculata

Catherine Hernando, Jayde Waibel, Elizabeth Silver, Anna Dormitzer, Danielle Moloney, Randi Rotjan, Justin McAlister

Most corals are heterotrophic and filter feed on zooplankton; thus, the amount of energy available to these corals is variable, as it depends on the patchy spatial and temporal distribution of zooplankton in the water column. Food quantity influences coral physiological performance by affecting how much energy can be allocated towards growth, recovery, metabolism, movement, repair, and reproduction. Astrangia poculata is a facultatively symbiotic temperate coral found on hard substrates in coastal waters from Cape Cod to the Gulf of Mexico. Unlike many other coral species, A. poculata exhibits variable levels of photosynthetic algal symbionts. Thus, these corals can obtain energy using heterotrophy, autotrophy, or a combination of both. To assess whether food quantity affects performance, and in turn its potential impact on coral energetics, we exposed individual polyps of A. poculata to diets of varying amounts of fresh hatched brine shrimp and measured changes in respiration rate, buoyant weight, tissue surface area, and qualitatively-scored polyp extension to gauge feeding behavior. To isolate the energetic contributions of heterotrophy, this study exclusively utilized aposymbiotic corals, which are largely heterotrophic. Determining how differences in food quantity, and ultimately how heterotrophic and autotrophic energetic resources, affect performance will allow for better parameterization of dynamic energy budget models built to predict the impacts of environmental changes on coral biology.

Mixology of metamorphosis: life cycle shifts shake up salamander pheromone cocktails

Madison Herrboldt, Ronald Bonett

Evolution in the timing of ontogenetic events (heterochrony) can drive life cycle shifts and produce punctuated patterns of trait evolution. Yet, there have been few tests of the impact of heterochrony on the evolution of reproductive signals, despite its potential role in both phenotypic and lineage diversification. Here, we use comparative transcriptomics to test how the loss of metamorphosis affects male salamander courtship pheromone gene expression, cocktail composition, and gland morphology in Eurycea, a clade with multiple independent life cycle transitions. Phylogenetic analyses identified at least four divergent Plethodon Modulating Factor (pmf) copies, and ten divergent Sodefrin Precursor-like Factor (spf) copies expressed in the mental and caudal glands. Pheromone gene expression is tissue-specific: pmf and some spf variants are restricted to the mental gland, while other spfs are predominantly expressed in the caudal gland. We observed punctuated changes in mental gland pheromone gene expression profiles in paedomorphic lineages that do not undergo metamorphosis, coupled with extreme mental gland reduction in at least one lineage. These shifts in expression correlate with changes in androgen signaling in the integument, providing a potential regulatory mechanism for this signal diversification. Altogether, our results illustrate how life cycle transitions can generate saltatory changes in mate recognition systems, potentially reinforcing ontogenetic evolution.

Organochlorine contaminants in sharks and rays of southern California

Luci (Danny) Herrera-Lopez, Kady Lyons, Becca Prezgay, Ryan Freedman, Christopher Lowe, Varenka Lorenzi

Legacy organochlorines remain elevated off Southern California owing to historical DDX disposal and urban inputs. We quantified DDX (DDT and metabolites), 53 PCB congeners, and chlordane analytes in muscle and liver of three elasmobranchs: Pacific angel shark (Squatina californica), bat ray (Myliobatis californica), and leopard shark (Triakis semifasciata) collected from Los Angeles, Santa Barbara, and the northern Channel Islands. Tissue samples were prepared by Soxhlet extraction, cleaned on silica columns, and analyzed by GC/MS. Contaminant burdens varied by species, site, and tissue. Individuals from Los Angeles exhibited the highest concentrations, exceeding those from Santa Barbara and the northern Channel Islands; angel sharks carried the largest loads; bat rays were intermediate; and leopard sharks were lowest across compounds. Liver concentrations exceeded those in muscle, yet cross-tissue relationships were not significant. Relative to FDA screening thresholds for edible muscle, most measurements were at or below guidance levels, but ecological exposure remains ongoing. These patterns show that Southern California sharks and rays retain substantial legacy DDX and co-occurring PCBs and chlordanes, with implications for site-specific monitoring, seafood advisories, and environmental justice outreach in coastal communities.

Morphological insights into differing grazing kinematics across species of climbing gobiid fishes

Marta Hess, Heiko Schoenfuss, Richard Blob

Sicydiine gobies exhibit an amphidromous lifestyle, characterized by an oceanic larval phase followed by migration to in-stream adult habitats. Many of these species graze on diatomaceous algae in freshwater streams. Grazing involves the extension and retraction of the upper jaw to scrape across rock substrates, dislodging diatoms. However, grazing sicydiine species show differing degrees of upper jaw kinesis, even within genera. The West African Sicydium brevifile and the Caribbean Sicydium punctatum, respectively, show exceptionally high and low premaxillary protrusion during feeding. To understand the morphological underpinnings of these kinematic differences, we micro-CT scanned species of the sicydiine genera Sicydium, Sicyopterus, and Stiphodon. Then, we digitally segmented and isolated the functionally relevant bones of the upper jaw. We identified morphological differences between taxa with potential implications for grazing performance. Notably, a posteriorly directed hook-like ramus on the ascending process of the premaxilla is absent from the species with the greatest observed premaxillary protrusion. The presence of this ramus may reduce the protrusible distance of the premaxilla during feeding. These morphological differences in grazing gobiid fishes suggest a trade-off between the stability and mobility of the upper jaw. Further studies will examine the implications of upper jaw mobility on waterfall climbing ability.

Ciliated larvae ingest and select bacteria-sized particles based on surface charge

Terra Hiebert, Anne Thompson, Kelly Sutherland

Cell surface properties are a fundamental aspect of microbial physiology that can influence interactions with predators. While these traits are known to mediate predator avoidance in pathogens and soil microbes, their role in shaping predator-prey dynamics in the ocean remains understudied. Many marine invertebrate larvae use ciliated bands to actively remove particles from the water, but they are overlooked as microbial predators. Using artificial particles mimicking bacteria in size (0.5 to 1 μm), we investigated how particle surface charge affects ingestion by marine invertebrate larvae that use ciliated bands to capture prey (plutei of the sand dollar Dendraster excentricus), a common mode of filtration in planktonic larvae. We found that 1) D. excentricus larvae ingest bacteria-sized particles and that 2) particle surface properties (i.e., charge) significantly influence ingestion. To our knowledge neither finding has been shown previously. Together, these findings suggest that microbially-derived biomass may be important in supporting larval populations and that microbial surface traits could mediate selective grazing by ubiquitous marine larvae. This study highlights the need to better characterize surface properties of key microbial taxa and examine a range of possible predators. Understanding these microscale interactions is critical for refining models of the marine microbial loop and larval ecology.

Finding flight in deep time: testing skeletal correlates for soft-tissue and functional characters

Tobin Hieronymus, David Waugh

Fossils provide data on evolutionary trajectory and morphological novelty that are unavailable from extant species alone. Despite this potential, there are persistent challenges for inferring function from skeletal morphology. Studies of extant taxa have established many-to-many mapping of morphology and function as a generally occurring pattern. Several studies that have used broadly defined categories of function across larger clades have failed to recover functional signal known to be present within daughter clades. The set of studies presented here contrasts the use of continuous and categorical measures of skeletal morphology, soft tissue morphology, and biological role as means of recovering functional signal, focusing on the hand-wing of coraciimorph birds and its relationship to flight ecology. While qualitative measures of morphology and ecology are broadly available for this clade, they only provide a useful heuristic for deciding which morphological traits to investigate further. Retaining several fine-grained qualitative ecological characters from natural history accounts recovers marginal signal, but that signal is lost after taxa are grouped into flight style categories using the same data. Inferring functional novelty and evolutionary dynamics using fossils is most likely to succeed by meeting in the middle, using quantitative performance data across a phylogenetic sample greater than typical biomechanics experimental designs (10 - 20 taxa) and a focus higher within the avian crown than typical flight evolution studies (Oligocene coraciiforms instead of Archaeopteryx).

The effect of human pressure on the flight initiation behavior of Mountain White-crowned Sparrows

Lyla Higgins, Savannah Troy

The summer is a peak tourism season in the Colorado Rocky Mountains, but is also the breeding season for many montane bird species, resulting in an increase in bird-human interactions and coexistence. I measured the effect that human activity has on the flight initiation behavior of Mountain White-crowned Sparrows (n=35) from urban and rural habitats in Colorado's East River Valley. I also looked at how these effects change over the course of the breeding season. To observe this, I measured the flight initiation distance of individuals in high, moderate, and low human activity areas over the course of the summer breeding season. I tested starting distance, breeding season stage, and human pressure as predictors of flight initiation distance and found only starting distance to be a significant predictor, indicating that in this system, human activity and breeding season stage did not significantly affect the flight initiation behavior or Mountain White-crowned Sparrows. This research is important because human activity in wild spaces is increasing and understanding how birds respond and adapt to human activity is essential for their conservation.

Neural coding of conspecific courtship songs across divergent Drosophila species

Breyton Hill, Ayush Pathak, Alexandra Venuto, Christa Baker

Despite the widespread use of sounds to communicate, how evolution shapes auditory systems to recognize species-specific acoustic signals is not well understood. Drosophila are excellent models for studying the co-evolution of auditory and sound production systems due to their species-specific courtship songs and the ability to target similar cell types across species. In Drosophila melanogaster, males use wing extensions to produce two song types (pulse and sine) directed at silent females. In the divergent D. virilis species, both males and females sing sex-specific pulse songs as part of a duet. This duetting behavior raises the question of how male D. virilis brains integrate acoustic feedback from their partners to shape their own song production.

Song production is largely controlled by the male-specific P1 neurons, which integrate external sensory cues with internal mating drive to generate songs. To test how P1 neurons represent conspecific songs, we used genetic lines targeting putative P1 neurons in both species to record neural activity via calcium imaging during song playback. We found that P1 neurons in both species responded to conspecific songs. D. melanogaster P1 neurons responded most strongly to pulse song, confirming previous reports. Ongoing work is testing whether D. virilis P1 neurons respond more strongly to male or female song. Studying P1 neurons across species allows for an evolutionary understanding of the neural basis of communication.

Eye color in scallops is associated with latitude and UV exposure

Haley Hines, Tad Dallas, Daniel Speiser

Eye color is thought to play many roles in nature. In some animals, eye color is involved in mate selection and in others it has a functional role in vision. External coloration can be useful for vision because it keeps light from entering an eye except through the pupil. Scallops are a promising group for studying the ecology and evolution of eye color because their eyes contain an external pigmented layer that, depending on the species, can appear blue, black, red, or gold. We asked why scallop species vary in eye color by investigating the relationship between eye color and global geospatial occurrence data. We found that species with black or gold eyes tend to occur at higher latitudes (above 30°N and below 30°S) and species with blue or red eyes tend to occur at lower latitudes (between 45°N and 45°S). We propose that the evolution of scallop eye color has been influenced by UV exposure. Blue eyes in scallops get their color from UV-scattering nanospheres and blue-eyed species tend to be found at latitudes where UV exposure is relatively high. In contrast, black eyes in scallops lack these UV-scattering nanospheres and black-eyed species tend to be found at latitudes where UV exposure is relatively low. We are currently exploring if UV-scattering nanostructures are present in red or gold scallop eyes.

Living on the edge: the evolutionary dynamics of extreme fish body shapes

Jennifer Hodge, Samantha Price

Fishes have evolved such a striking diversity of shapes that it is hard to imagine forms they have not evolved. Here we explore the evolutionary dynamics that allow fish lineages to reach extreme body shapes, and the influence of those shapes on the tempo of evolution. Using a three-dimensional morphospace defined by standard length, maximum body depth, and maximum fish width for over 8,200 teleosts, we identified species in the outer 5% as occupying extreme regions of shape space. These extremes represent the limits of extant fish form and highlight unoccupied areas of morphospace, suggesting strong evolutionary or functional constraints. We use this space to ask three questions. First, is the evolution of extreme shapes concentrated in specific radiations (deep nodes), or do extreme shapes arise convergently across many shallow lineages? Just as importantly, how often do species that appear extreme at a global scale also appear extreme in the context of their close relatives? Second, does body size constrain evolution into extreme regions of morphospace? Third, do lineages with extreme morphologies also show elevated rates of phenotypic evolution or speciation, or are they evolutionary "dead ends"? By integrating species-level morphometrics with phylogenetic comparative methods, we reveal how evolutionary history, body size, and diversification dynamics interact to shape the boundaries of fish form, and how our inferences about constraint and innovation depend on phylogenetic scale.

Identifying nuclear genomic compensation to mitochondrial genomic variation

Reed Hodges, Damilola Odumade, Benjamin Camel, Emily Beck

Mitochondria play important roles in energy production and regulation of apoptosis, the cell cycle, calcium homeostasis, and more. Mitochondria perform these functions using elements encoded in their own genomes (mitogenomes) and through collaboration with nuclear-encoded elements. Maintaining compatibility between these two genomes is difficult. Mitogenomes are inherited largely independently from nuclear genomes – typically maternally inherited in contrast to biparentally inherited. Mitogenomes also evolve at a rate that is estimated to be ten-twenty times that of the nuclear genome. Differences in inheritance patterns and evolutionary trajectories can be problematic when the faster evolving mitogenome becomes incompatible with

the slower evolving nuclear genome. Mito-nuclear incompatibility can lead to mito-dysfunction, breaking down cellular processes regulated by mitochondria. In humans, mito-dysfunction has been linked to a myriad of diseases such as Alzheimer's disease, diabetes, cancer, ALS, and multiple sclerosis. Understanding the role of mitogenomic variation in maintaining mito-nuclear compatibility is important but difficult to study because we are unable to synthetically edit the mitogenome and inbred models lack mitogenomic variation. The Beck Lab uses threespine stickleback fish as a model to study mito-nuclear genomic interactions because they have evolved two distinct mitochondrial haplotypes (mitotypes). These mitotypes have extremely high sequence-level divergence in regions of admixture suggesting genomic compensation in the nuclear genome accommodates mitogenomic variation. We use genomics and population genetics to identify nuclear compensation to mitogenomic variation.

Killer Babes: Recently-settled sunflower star juveniles are better urchin predators than adults

Jason Hodin, Fleur Anteau, Michael Brito, Fiona Curliss, Rebecca Guenther, Saul Hodin, Augustin Kalytiak-Davis, Pema Kitaeff, Julia Knopf, Chloe Schwab, Willem Weertman

The disappearance of sunflower stars (Pycnopodia helianthoides) from California following the 2013 Northeast Pacific outbreak of seastar wasting disease (SSWD) contributed to an alarming ecological phase shift from healthy bull kelp forests (Nereocystis luetkeana) to widespread barrens. The release of predation pressure on kelp-eating purple urchins (Strongylocentrotus purpuratus) following the declines of sunflower stars appears to have been a major driver of this phase shift. Published modeling studies suggest that the presence of sunflower stars can maintain the kelp forest state, and that sunflower star recovery can help restore this foundational habitat. These modeling results are based upon pre-SSWD sunflower star population estimates as well as lab experiments measuring ad libitum adult sunflower star predation rates on adult purple urchins. These models have not yet included our and others' observations that recently-settled sunflower stars (0.7-3.0 mm in diameter) are also predators on recently settled urchin juveniles. Here we present data showing that these juvenile-on-juvenile predation rates of sunflower stars on urchins are 10x or more higher that the corresponding adult-on-adult rates. We will discuss the implications of these findings both for kelp-urchin-sunflower star ecosystem dynamics, as well as for restoration aquaculture strategies to breed and release sunflower stars back into the wild.

Hatch day aerobic capacity predicts current, but not future, reproductive success in a wild-breeding passerine

Brett Hodinka, Tony Williams

Parental care is assumed to require sustained, high-intensity activity sufficient to generate costs of reproduction which, in turn, are assumed to have a physiological basis. Most studies have sampled birds late in chick-rearing, thus sampling only successful birds, which may be the very individuals that can "work hard" while avoiding physiological dysregulation.Here, using wild-breeding European starlings, we blood sampled individuals at hatch—thus including putative low-quality individuals that subsequently failed—to test the idea that individuals differ in their physiological response to the rapid onset of increased activity, following the hatching of chicks. We assessed the predictive capacity of five physiological traits in relation to workload ability, current productivity, and future fecundity and survival. We found systematic variation in hatch day physiological state across breeding attempts and years: birds were in better overall physiological state during first broods relative to second broods in the same year and/or in an ecologically "good" year. Measures of aerobic capacity were positively related to measures of workload ability and current productivity—but not future fecundity or survival—and were context dependent: an ecologically "good" year was characterized by higher hematocrit and hemoglobin and resulted in greater current reproductive success, relative to a "poor" year. Our study suggests that hematocrit and hemoglobin may be functionally significant in predicting immediate reproductive fitness consequences, but that these costs are context dependent.

Crab-solutely resilient: unraveling the genomic basis of heat and pH tolerance of two porcelain crab

Cecilia Hodson, Jonathon Stillman, Dr. Eric Armstrong

Climate change poses a growing threat to marine life, underscoring the need to understand genomic mechanisms behind key adaptations like thermal and pH tolerance. The recently published genomes of two porcelain crab species, Petrolisthes cinctipes and Petrolisthes manimaculis, offer a unique opportunity to explore how genome structure influences physiological responses to environmental stress. These crabs exhibit distinct physiological responses to thermal and pH stress, likely due to adaptations to their respective habitats; P. cinctipes inhabits the thermally variable upper intertidal zone and demonstrates a higher thermal tolerance, while P. manimaculis occupies the stable subtidal zone.

My research leverages existing RNA-seq data and these newly available genomes to investigate evolutionary shifts linking genome structure to physiological adaptations. My analysis revealed differentially expressed genes between varying thermal and pH conditions, finding that P. cinctipes displays significantly more upregulated genes associated with stress response than P. manimaculis. Functional annotation revealed an overrepresentation of processes related to metabolism, pH regulation, and chitin production in P. cinctipes. Further analysis into gene family expansion will provide insight into vital physiological responses to environmental stressors. Overall, this approach aims to uncover the genomic basis of heat and pH tolerance in a diverse group of crustaceans, improving our understanding of how genomes drive physiological adaptations and providing critical insights into how marine organisms may respond to changing ocean conditions.

Ecomorphology and evolutionary dynamics in the Weberian apparatus of ictalurids

Jennifer Hoeflich, Juan Liu

The Weberian apparatus, a hearing specialization unique to Otophysans, is known to be particularly morphologically diverse in catfishes (Siluriformes). This study aims to investigate morphological variations, ecomorphology, and evolution of Weberian apparatus in Ictaluridae (North American catfishes). We sampled 136 specimens representing 47 extant species using X-ray–based computed tomography. Landmark-based geometric morphometrics were conducted to quantify the scaphium, tripus, and associated peripheral structures, followed by eco-morphological and evolutionary modeling analyses. First, low phylogenetic signal and elevated disparity through time suggest that the ictalurid Weberian apparatus has been evolving under divergent selection. Second, four ecological factors showed significant associations with Weberian apparatus morphology after phylogenetic correction: stream velocity, climate, coloration and centroid size. Lastly, we found a clear signal of modularity between the scaphium, tripus, and peripheral structures, despite the functional linkage of the structures. The relative magnitudes and overall temporal patterns of disparity are distinct for each tested structure, and the evolutionary rates of the modules were significantly variable. No single evolutionary model was dominantly supported in our analyses, especially, evolutionary mode was variable across all genera. Notably, Ameiurus may be under neutral or stabilizing selection — having potentially switched evolutionary mode compared to the other ictalurids. Each of the tested structures and genera likely evolved independently in relation to auditory function, contributing to the wide variety of forms observed in the catfish Weberian apparatus.

What affects honey bee recruitment to pollen sources?

Elizabeth Hoeksema, Morgan Carr-Markell

Honey bees face multiple stressors, including low floral diversity and poor nutrition, which increase colony mortality. This high mortality rate could have detrimental effects on our sources of food in the future. Pollen is an essential part of honey bee diets, but we know less about how they choose pollen sources than how they choose nectar sources. Honey bees use signals called dances that let them recruit other bees to preferred resources. We tested whether the ease of collection, or the plant source quality would affect the probability of the honey bees performing recruitment dances. The bees were placed in an observation hive, and a mesh tent prevented the bees

from accessing natural pollen sources. We used artificial flowers to present pollen foragers with an alternating sequence of options. In experiment one, we presented bees with ground Brassicaceae or ground Asteraceae pollen. In experiment 2, we presented them with artificial flowers that were easy or difficult to enter. We recorded the visits of individually marked bees to the artificial flowers and their behavior when they returned to the observation hive. Honey bees were more likely to dance to advertise Brassicaceae pollen than Asteraceae pollen along with advertising flowers that are easier to collect from than those with less accessible pollen. We discuss the possible implications of these results for honey bee preferences in natural landscapes.

The effects of land use on hymenopteran and odonate occupancy of solar facilities

Tristan Hoerschelmann, Sofia Maass, Dmitry Kutcherov, Sushant Potdar, Grace Hirzel, Kiana Kasmaii, Ethan Royal, Andrew Ruegsegger, Jennifer Ogle, J.D. Willson, Erica Westerman

Solar energy is one of the fastest growing sources of anthropogenic land use, but its implications for biodiversity remain complex and represent an emergent field of study in insects. As land use intensifies, pollinator populations face increasing stress. With rapid expansions in renewable energy infrastructure, such as solar, it is critical to understand how land use factors impact pollinator occupancy. To do this, we conducted visual surveys from 2023 to 2025 to estimate how land use factors inform Hymenoptera and Odonata occupancy in 60 solar facilities and control sites across Arkansas and Kansas. These occupancy models incorporated covariates such as surrounding cropland, water cover, tree cover, human development, size of solar facility, vegetation diversity, and percent native vegetation within solar facilities. Results indicate that the presence of water, native vegetation, and cropland were the strongest predictors of Hymenoptera and Odonata occupancy in solar arrays. In Hymenoptera, covariate effect size varied by family. Generally, the presence of water and cropland decreased the probability of occupancy among hymenopterans, while native vegetation did the opposite. In Odonata, all covariates had a slightly positive effect on the probability of occupancy. These findings highlight the complexity of insect responses to human development. Our results can be used to inform land management strategies and decisions to support pollinator biodiversity amid expanding renewable energy development.

Tick-tock! Do clock genes underlie variation in circadian rhythm activity patterns within cichlids?

Chloe Hoff, Niah Holtz, Evan Lloyd, Craig Albertson, Alex Keene

The partitioning of ecological niches is key to the maintenance of biodiversity, especially in complex species assemblages. Differences in circadian rhythm are a particularly important way in which species partition their niches. However, the underlying genetic mechanisms that regulate variation of this trait are poorly understood. Here, we made a hybrid cross between a diurnal and a nocturnal cichlid (Astatotilapia calliptera x Tropheops sp. “red cheek”). We reared the resulting F2 population in two social contexts (individual vs group housed), filmed individuals at two distinct developmental stages (juvenile and adult), and quantified activity levels during various times of a 24 hour cycle (day, night, dawn + dusk). Finally, we mapped QTL for total, day, night, and crepuscular activity levels, as well as for the day:night activity ratio. We detect numerous robust QTL, and find that the genetic architectures are distinct between developmental stages and social contexts. Notably, clock genes co-localize to many QTL peaks across all groups. These results highlight the genetic complexity of variation in the circadian timing of locomotor activity. They also implicate clock genes in modulating these behaviors. Future studies that dive deeper into clock genes in this evolutionary model system may help to elucidate the neurogenetic mechanisms that allow complex assemblages to arise and be maintained over time.

Investigating the form and function of ptychocytes, a stinging cell unique to tube-dwelling anemones

Ana Hoffman Sole, Leslie Babonis, Kennedy Bolstad

Stinging cells are unique to cnidarians (corals, sea anemones, jellyfish, etc.). Throughout the evolution of cnidarians these cells have diversified into subtypes with various forms and functions. Nematocytes, a subtype found in all cnidarians, are used for prey capture and defense. When triggered, a pressurized capsule releases a harpoon and a venom-filled tubule in one of the fastest movements in nature. Ptychocytes, a subtype found only in tube-dwelling anemones, lack the harpoon and venom found in nematocytes. Instead, a long tubule builds the tube in which the anemone lives. We fired nematocytes and ptychocytes collected from the North American tube anemone, Ceriantheopsis americana, to characterize differences in speed and dynamics of tubule release during tube formation. Using high-speed video, we found that while nematocytes can completely discharge their harpoon and tubule in three milliseconds, ptychocytes take one full second. Because ptychocytes fire three orders of magnitude slower than nematocytes, we expected that ptychocytes have thinner capsules, particularly at the apex where firing begins. We examined apical morphology using scanning electron microscopy and light microscopy. We observed ptychocytes, unlike nematocytes, vary in the degree of apical bending, which might play a role in creating a more durable mesh for their tube. These results offer insights into the evolutionary path that enabled ptychocytes to specialize for a novel function.

Resilient brains: behavioral and physiological homeostasis in highly variable environments

Hans Hofmann, Peyton Wong, Syed Husain

Maintaining organismal homeostasis, reproduction, and behavior in highly variable environment is challenging. Yet the neural and molecular systems that enable diverse organisms to adapt to these challenges remain woefully understudied. How does the hypothalamus – which is central to homeostasis and reproduction in all vertebrates – respond to increased environmental variability, in real time and on seasonal and decadal time scales, enabling animals to survive, and thrive, in highly variable environments? We used the Longear Sunfish (Lepomis megalotis), a colonially breeding freshwater fish, to gain insight into the cellular and molecular plasticity mechanisms that afford neural systems resilience in changing environments. We first used remote sensing data and data obtained from water quality monitoring stations along streams to quantify environmental variability for 20 L. megalotis habitats along the longitudinal precipitation and latitudinal temperature gradients that characterize the diverse eco-regions of Texas. We found remarkable short- and long-term variability within and across sites. Next, we employed drone-based AI-aided video tracking to quantify space use and reconstruct the social networks of nest-holding L. megalotis males. Finally, we used single nucleus RNA-sequencing of the hypothalamus to reveal that the activity numerous pathways involved in energy and temperature homeostasis as well as stress physiology co-vary with environmental variability across time scales. Together, our results provide novel insights into the brain’s ability to survive and thrive in changing environments.

Effects of habitat disturbance on chronic stress and immune function of wild Western Deer Mice

Jillian Holtcamp, Laurie Dizney, Ashley Beck, Elizabeth Addis

Wildlife species face many human-caused challenges, including habitat alteration and disturbance, which may cause a stress response. Continuous exposure to stress (i.e., chronic stress) has been shown to cause significant negative effects on immune function in humans and laboratory animals, however this relationship is not well understood in wildlife. In this research, we hypothesized that chronic stress would increase as habitat disturbance increased, which in turn would negatively affect immune function. Using Western deer mice (Peromyscus sonoriensis) as our model organism, we live-trapped twenty sites in and around Spokane, Washington ranging from a national park (least disturbed) to a college campus (most disturbed). Trapping occurred over three years (2023-2025) during 2 weeks in May. Chronic

stress was assessed from hair corticosterone via radioimmunoassay analysis. Immune function data were obtained from blood samples in two ways. First, we evaluated total white blood cell (WBC) counts per mL of blood. Next, we measured the percentage of several types of leukocytes via flow cytometry. Together, the WBC counts and flow cytometry percentages allowed us to estimate absolute counts of the specific leukocyte types per mL of blood. Our findings will provide valuable information on how habitat disturbance directly impacts the health of wildlife species, as well as why some species can tolerate high levels of disturbance while others cannot.

Evolution and genetic basis of complex spatiotemporal behaviors in cichlids

Niah Holtz, Andrew Conith, Chloe Hoff, Evan Lloyd, Alex Keene, Craig Albertson

Organisms oft evolve on the basis of differential access to habitats due to complex physical and social interactions. As such, behaviorally-driven habitat partitioning is of great importance in maintaining complex communities, yet the genetic bases of such behaviors are relatively poorly understood. Cichlids represent an extraordinarily diverse group of fishes that display a suite of intra- and interspecific behaviors, which maintain complex communities. While habitat partitioning in cichlids is well-studied on dietary and environmental axes, modern technologies allow a better understanding of the minutiae of daily spatiotemporal behaviors, their evolution and underlying genetic basis. Here, we characterize these behaviors in a phylogenetically diverse (n = 38) species sample of Lake Malawi cichlids as well as in an F2 hybrid population (n = ~400) between a diurnal and nocturnal species. Twenty-four-hour measures of individual locomotor activity are labeled using Computer Vision (CV), and the resulting coordinate data are used to measure spatial bias in locomotor activity and the presence of stopping behaviors. Spatial bias provides insight into total tank usage, while stopping behaviors reflect how fish are using specific areas of the tank. These data are mapped onto a phylogeny and in a QTL analysis to examine the evolution and underlying genetics of temporal and spatial partitioning. Our combined results inform a better understanding of the nature of complex behaviors

Exploring the genetics of trait tradeoffs in Astyanax mexicanus using a cave x surface hybrid cross

Niah Holtz, Amanda Powers, Joshua B Gross, Craig Albertson

The adaptation to cave environments has occurred repeatedly across a broad phylogenetic array of organisms, from fish to spiders. This process is highly stereotyped, oft characterized by loss or reduction of eyes and pigmentation concurrently with expansion of sensory systems, such as chemoreception and tactile sensation. While the repeated nature of cave adaptation implies inherent evolutionary tradeoffs, the mechanisms underlying these changes are poorly understood. Coevolved cave-adapted traits could arise through common selective pressures, pleiotropic effects, or commonalities in developmental origin. Astyanax mexicanus (Mexican tetra) is a fish with a surface morph and multiple independently evolved cave morphs, providing an excellent opportunity to investigate cave adaptation in an integrative context. We utilize a hybrid cross between a surface and cave morph (n = ~90 F2) to investigate potential genetic mechanisms underlying covariation in cave traits, including those that have been both expanded (e.g., jaw width and tooth number) and reduced (e.g., muscle volume and melanocyte density). Associations are investigated phenotypically via two-block PLS analyses, as well as genetically via QTL analysis. Our results provide evidence for genetically driven covariation between disparate traits (e.g, cranium shape and melanocyte density), and further an understanding of developmental and genetic causes underlying the rapid and stereotypical evolution of cave-adapted traits in A. mexicanus.

Body-size reconstruction of Channel Islands rattlesnakes reveals evolutionary dynamics.

Zoe Homewood, Greg Pauly, David Ledesma

The Northern Channel Islands today consist of four main islands that sit 20–115 km off the Santa Barbara coast, but these islands were once connected as the superisland Santarosae during the last glacial maximum. Santarosae was home to rattlesnakes (Crotalus sp.) as evidenced from fossil vertebrae 32,000 to 12,000 years old. Little is known, however, about these snakes including their size, extinction timing, and ecological roles. We used allometric scaling relationships in modern rattlesnakes to reconstruct body size for fossils. We measured vertebrae of 39 modern rattlesnakes across eight species as well as 42 fossil middle trunk vertebrae. We focused on the neural arch because this skeletal feature is consistently preserved in both modern and fossil specimens. We found a significant correlation between body size and neural arch width, supporting the reliability of neural arch width as a model for body size. Models were able to predict body size for modern test specimens within 81.7 mm. The average body size predicted from fossil vertebrae was 926.6 mm (range 672.0–1455.8 mm). Thus, Channel Islands rattlesnakes were relatively large compared to mainland relatives and other island snake taxa, raising questions about why they did not follow the expected pattern of island miniaturization. This work demonstrates that prior to the arrival of humans, the rattlesnake was the largest non-avian, terrestrial predator on Santarosae.

Characterization of the innate immune response to plasmid DNA in *Botryllus schlosseri*

Rachel Hong, Jens Hamar, Dietmar Kueltz

Plasmid DNA is a powerful tool in cellular mechanistic studies but is interfered by the innate immune response (IIR). Botryllus schlosseri is a significant chordate model in which the IIR remains largely unknown. Identification of the Botryllus genes involved in IIR can improve plasmid-based experiments in this animal. An initial characterization of the Botryllus IIR was performed by BLAST homology searches of well-established human proteins involved in IIR against the B. schlosseri proteome from which multiple candidate Botryllus homologues were identified. Gene specific primers were designed for each gene for regions of strong sequence homology. Two treatment groups were formed including Botryllus animals micro-injected with plasmid DNA and a non-injected control group. Tissue samples were harvested 24 hours post micro-injection followed by RNA isolation, cDNA synthesis, RT-PCR using the gene specific primers, and gel electrophoresis. From this analysis, differential transcriptional regulation of toll- like receptor (TLR) and interferon regulatory factor (IRF) homologues between treatment groups was indicated. Subsequently, Botryllus homologues of genes that are typically downstream of IRF signaling pathways were investigated and differential regulation of interferon induced proteins with tetratricopeptide repeats (IFIT) homologues was observed. Current work includes identifying changes in gene expression in response to inhibition of specific nodes in these pathways to further characterize B. schlosseri IIR to plasmid DNA. Supported by NSF grants NSF MCB- 2127516, IOS-2209383.

New species of Acoela (Xenacoelomorpha) from Oregon and Washington

Matt Hooge

The Acoela are a diverse group of worms inhabiting intertidal, subtidal, and pelagic environments, with many species living interstitially within silty sediments. Although such habitats are relatively uncommon along the northeast Pacific coast, they do occur in several bays, inlets, and sheltered beaches. Of the more than 400 known acoel species, only 13 have previously been reported from the Pacific coast of North America. In this study, I collected acoel specimens from sediment and algae, documented living worms using Differential Interference Contrast (DIC) microscopy, preserved specimens for DNA barcoding, prepared histological sections, and used fluorescence microscopy to examine musculature in whole-mounts stained for F-actin with fluorescently labeled phalloidin. This investigation resulted in the identification of 20 acoel species, including 8 that are new to science.

Replaying the tape of death: biological signal in fossils is contingent on their taphonomic history

William Hooker, Andrew Orkney, Brandon Hedrick

Separating biological signal from surrounding noise is essential for robust comparative morphological analyses, especially for fossils whose original biological shapes have been altered by taphonomic deformation. Using 3D geometric morphometrics, we first examined the effect of taphonomic deformation on biological signal. Then, to disentangle how taphonomy alters shape, we investigated the effects of deformation by focusing on two aspects of taphonomy: (1) depositional environment and (2) post-mortem orientation in sediment. We started by simulating taphonomic deformation on crania of the extant synapsids Procyon lotor and Didelphis virginiana that have known original biological signal using deformation magnitudes derived from crania of the fossil synapsid Diictodon feliceps. Biological trends were clear prior to simulated deformation, but signals were strongly obscured after, suggesting that shape variation in fossils is not strongly related to true biological difference, but dominated by taphonomic overprinting. We next evaluated the effect of depositional environment in trilobites. Salterocoryphe salteri from the orogenically-influenced Valongo Formation shows deformation intensity tied to host-rock lithology, contrasting with the relatively undeformed Isotelus gigas of the Trenton Group. Finally, disparity among individual in-situ Cyrtospirifer inermis brachiopods is attributable to post-mortem orientation in sediment. Altogether, these results demonstrate how taphonomic history filters biological signal in the fossil record. Ultimately, recovering the real signals from the surrounding taphonomic noise will enhance our understanding of macroevolutionary change over geological time.

Oral and pharyngeal jaw shape across diets and ontogeny in Prickleback fishes (Stichaeidae)

Richard Hoover, Kassi Price, Brian Whelan, Kassandra Ford

The pharyngeal jaws of fishes are considered a key evolutionary innovation due to the separation between prey acquisition via the oral jaws and prey processing via the pharyngeal jaws. However, the relationship between the oral and pharyngeal jaws varies widely across fishes, and the ontogenetic relationship between these structures is understudied. Pricklebacks (Stichaeidae) are a useful model for studying fish feeding, as certain species have convergently evolved omnivory and herbivory and shift in diet over ontogeny. Pricklebacks span several diet types and possess varied oral jaw morphotypes, with physiological and morphological differences between species that eat different diets. Here, we use high resolution microCT imaging to explore the relationship between oral and pharyngeal jaw shape over ontogeny in 5 species of pricklebacks. We describe and compare the shape of the upper and lower oral and pharyngeal jaws using 3D geometric morphometrics. We examine allometry in shape over ontogeny and the modularity of the jaw system. Preliminary results show larger, more robust pharyngeal jaws in herbivores and gracile pharyngeal jaws in carnivores, with relatively high separation between oral and pharyngeal jaw shapes.

Assessing the impact of sequential staining on microCT data integrity in amphibians

Megan Hostetter, Dominik Valdez, Christopher Heesy, John Phillips, Leigha Lynch

X-ray microtomography (microCT) is a high-resolution, non-destructive imaging modality commonly paired with contrast-enhancing staining techniques that enable quantitative three-dimensional (3D) analysis of soft tissue structures. While contrast-enhancing stains are increasingly used to improve soft-tissue visibility in microCT, few studies have examined how applying two different staining protocols to the same specimen can influence structural integrity and volumetric measurements of the central nervous system (CNS). To address this gap in knowledge, we compared volumetric data derived from microCT scans of tadpoles stained with buffered Lugol's iodine and phosphotungstic acid (PTA). Twenty Lithobates heckscheri tadpoles collected near Dothan, Alabama were subjected to a diffusible iodine-based contrast-enhanced computed tomography (diceCT) protocol, destained, and subsequently stained with PTA. The CNS was segmented from each set of scans using AVIZO and brain and ventricle volumes were collected. The percent difference between iodine and PTA stained specimens was 60.92% for ventricle volume and 50.81% for CNS volume, with a substantial reduction in volume in the PTA scans. Because both protocols are tailored to reduce shrinkage in nervous tissue, this result is surprising and suggests a negative interaction between the two protocols. Understanding how sequential application of multiple staining protocols to the same specimen may compromise data integrity is important for ensuring reliable and interpretable results particularly when using specimens that may have been previously stained.

Metabolic changes in bottlenose dolphins during periods of reduced energy acquisition

Dorian Houser, Angelo Incitti, Williams Cassondra, Dan Crocker, Randy Sacco

Potential anthropogenic impacts to toothed whales include reduced foraging opportunities or increased foraging effort through disruption of feeding behaviors, displacement from foraging grounds, or displacement of prey. To assess how reduced energy acquisition affects metabolism in a representative toothed whale, five bottlenose dolphins (Tursiops truncatus) were subject to a 25% dietary restriction over seven days and the resting metabolic rate (RMR; mL O2/min) and associated metabolic hormones (cortisol and free triiodothyronine (fT3)) measured. Three measurements were made over a baseline week wherein subjects had normal dietary intake, and three additional measurements were made over the following week under energy restriction. The RMR was measured via flow-through respirometry in the morning while animals were post-absorptive and voluntary blood samples were collected immediately afterward. Energy restriction significantly lowered RMR (mean suppression=10.6%; $F_{4,10} = 10.61$, $p = 0.0013$), but no effect of time was observed, suggesting that RMR suppression occurred by the time of the first treatment measurement (i.e., within 72 hours of dietary restriction) and did not further decrease. Metabolic hormones were directly related to RMR (cortisol: $t = 2.696$, $p = 0.0122$; fT3: $t = 2.782$, $p = 0.0099$) and significantly interacted ($t = 2.464$, $p = 0.0207$). Whereas reductions in fT3 serve to lower the RMR, synergistic reductions in cortisol likely defend blubber stores through reduced lipolysis. Results suggest that dolphins rapidly engage metabolic controls to defend energy stores in the face of moderate reductions in energy acquisition.

Cloacal microbial diversity is associated with competitive phenotypes in socially polyandrous Jacana

Jennifer Houtz, Kimberly Acosta, Mae Berlow, Sara Lipshutz

The composition of host-associated microbial communities may correlate with the overall status of the host, including physiology and fitness. New bi-directional hypotheses suggest that sexual behaviors can shape, and be shaped by reproductive microbiomes, which may be particularly important for species with mating systems that feature strong sexual selection. These dynamics have been particularly understudied in female animals. Using 16S rRNA sequencing, we compared the cloacal microbiome of females and males from two socially polyandrous bird species that vary in the strength of sexual selection, Jacana spinosa (Northern Jacana) and J. jacana (Wattled Jacana). We hypothesized that the strength of sexual selection would shape cloacal microbial diversity, such that the more polyandrous J. spinosa would have a more diverse microbiome, and that microbiomes would be more diverse in females than in males. If the reproductive microbiome is indicative of competitive status, we also hypothesized that cloacal microbial diversity would be associated with competitive traits, including plasma testosterone levels, body mass, or weaponry. We found no differences in microbial alpha diversity between species or sexes, but we did find that microbial beta diversity significantly differed between species. We also found a positive relationship between microbial alpha diversity and testosterone in female J. spinosa. Future experiments are needed to explore the potential drivers of correlations between the cloacal microbiome and competitive phenotypes in socially polyandrous jacanas.

The lower bulbs go, the larger bulbs grow

Cody Howard

Herbaceous plants with renewal buds positioned below the soil surface are commonly referred to as geophytes. This growth habit is particularly prevalent in climatically seasonal and disturbance prone habitats across the globe. By placing buds below the soil surface, plants' sensitive growing points are better protected from above ground disturbances, that can include frosts and/or fires. However, deeper bud placement likely requires the plant to rely on stored resources before breaching the soil surface, and geophytes generally have relatively large underground storage organs, such as bulbs, corms, or stem tubers. Here, across taxa, we examined the relationship between the size (i.e., diameter) of an underground storage organ and its depth within the soil column. Across 44 distinct Ledebouriinae (Scilloideae, Asparagaceae) species from South Africa and Zambia, we measured bulbs at their widest diameter and their depth in the soil. Across taxa, larger bulbs were found to be positioned deeper in the soil, using both phylogenetically informed and uninformed analyses. Within individual species, a similarly positive relationship between bulb size and bulb depth was generally found, but there were a few instances where larger and smaller bulbs were found at similar depths. In general, our study suggests that for plants that emerge from below the soil surface, greater energetic costs (as indicated by wider bulbs) are required for emergence from deeper depths. Within species, our findings may indicate that older bulbous plants have larger and deeper bulbs. Older plants have survived for a longer time and therefore have grown larger bulbs, which allow for the plants to burrow themselves deeper into the soil (i.e., deeper bud placement) which offers greater protection from above ground disturbances.

Pigeon guillemots as a model of maritime urban adapters

Emma Howell, Amy Cook

In the 21st century, expansion of human built environments into wildlife habitat has forced many species to contend with a new array of adaptive challenges that bring them into increased contact with humans.The concept of urban avoiders and adapters has been explored extensively in passerines, but has not been applied to seabirds. This diverse group frequently nests in large colonies and feeds on schools of bait fish, making them both ideal sentinels for oceanic conditions and also extremely vulnerable to human encroachment. The Pigeon Guillemot (Ceppha columba), a diving bird of the alcid family, is unusual in that it nests in relatively small colonies that are often observed in urban areas. Across two colonies on the island of San Juan, the timing and content of prey deliveries were recorded over one to two hour periods in the morning and late afternoon. One colony was larger and located on a natural cliff face, while the other was smaller and located in a busy marina. Despite these striking differences, parents at both locations were able to deliver prey to nests at the same rate, though birds at the marina offered their chicks a wider diversity of prey. Exploring behavioral alterations in this species across the urban gradient may illuminate what adaptations are necessary for seabirds to tolerate increased exposure to humans and their activities.

Cold tolerance in the intertidal zone: ice binding protein mechanisms in intertidal invertebrates

Yin-Chen Hsieh

Intertidal organisms in the Arctic and subarctic regions are subject to extreme temperature fluctuations, particularly in the winter seasons. Temperature fluctuations present a risk of severe cellular damage in these organisms due to ice crystal formation. Many ectothermic organisms thus utilize ice-binding proteins (IBPs) to prevent ice (re)crystallization and to control ice nucleation. There is currently a wide gap in scientific understanding of IBP form and function in intertidal invertebrates. These invertebrates are often sessile or sedentary and are subject to routine freeze-thaw cycles of increasing severity due to a globally volatile climate. Given their diversity and abundance towards the polar regions, and their critical roles balancing ecosystems between the lower marine and upper terrestrial zones, IBP research into this group of organisms is essential. Through a combination of freezing assays, -omics, and bioinformatic approaches, we aim to characterize putative classes of IBPs in selected echinoderm species in the North Pacific, analyzing their potential evolutionary origins by comparison with well-studied IBPs from marine or terrestrial organisms. We predict the structure and functions of these putative IBPs, and validate our methods with a proof-of-concept case of IBP detection not previously shown in a certain teleost fish. This project's overall goal is to generate an IBP screening framework and platform that combines computational and experimental approaches to exploring the diversity, evolutionary origins, and ecological functions of IBPs.

Bird bathing and feather maintenance

David Hu, Xueyi Xie, Josien Janssen, David Lentink

Birds use feathers for flight, visual display, and insulation. How do they keep them clean and organized? In this talk, we will show birds keep their feathers maintained through bathing in water and flapping their wings. We film over 30 birds bathing in nature and in the lab and study the submergence of over 38 bird carcasses. The average bird bath is 31 seconds, which is sufficient for birds to absorb 10 percent of their body mass in water, a relatively large amount compared to the water absorbed by mice, dogs and humans during a bath. Feathers are held together by microscopic hooks called barbules. We show birds can keep the hooks together by rapid shaking which causes collisions re-fastening. We demonstrate this fastening with natural and 3D printed bird feathers.

Spatiotemporal calcium signaling precedes shell formation in *Biomphalaria glabrata* embryos.

Chi Huang, Kaitlin Garcia, Wei Xu

Calcium-related biomineralization is a conserved biological feature across many animal phyla, primarily with structural and protective functions. While the chemical composition, cellular origins, and developmental mechanisms of biomineralization vary across taxa, calcium signaling is universally conserved across species. As a second message that regulates intracellular signaling processes, calcium oscillations during embryonic development are key elements in various vertebrate models, which influence bone and teeth development. It remains unclear whether intercellular calcium waves and related conserved signaling pathways also coordinate the biomineralization process in the mollusks. Using freshwater snail Biomphalaria glabrata as a model, we monitored the calcium dynamics of the embryos from blastula stage (12 hours post-fertilization) through the post-gastrulation stage, over 14 hours period preceding visible calcification spot (40-50 hours). Intracellular calcium accumulation, visualized with the calcium dye Fluo-4, gradually accumulated and spatially organized on one side of the gastrula. For 20 hours post-fertilization, calcium signal surrounded the blastopore-like structure. With continuous development, the signals expanded towards the margin, forming a ring-like structure. This suggests early intracellular calcium activity may precede and potentially initiate shell formation. Besides, genes involved in the calcium signaling pathway, including calmodulin and its downstream effectors, were upregulated during gastrulation, consistent with observed calcium patterns. The spatial overlap between gene expression areas and early calcification sites supports a critical role of the calcium signaling in early shell development of gastropods.

Robust control versus adaptive motor learning in hawkmoths

Elliot Huang, Varun Sharma, Yaqing Wang, Simon Sponberg

Animals maintain reliable behavior across diverse dynamic conditions. For example, Manduca sexta hawkmoths sustain flight despite variation in body size, wing damage, and environmental conditions. Many vertebrates maintain reliability by adapting sensorimotor control to altered dynamics in virtual or augmented reality paradigms. However, whether such motor learning extends to hawkmoth object-tracking is unknown. Hawkmoths can hover to feed from an artificial robotic flower, tracking its movements to maintain position. Inspired by vertebrate paradigms, we developed a closed-loop robotic flower system that alters the sensory feedback gain of hawkmoths during foraging. In the control condition, the flower executed a baseline pseudo-random sum-of-sines motion. In the augmented condition, the moth's real-time position was filtered and superimposed onto the baseline motion with a gain of 0.7. This effectively caused the flower to "run away," requiring compensation to maintain performance. We recorded eight moths, alternating between control

and augmented conditions. Frequency analysis showed that hawkmoths preserved their tracking dynamics (gain and phase) across conditions, causing position-tracking error to increase by 49.5% ± 33.8%. These results indicate that hawkmoths rely on robust rather than adaptive control under complex stimuli, even at the cost of greater error. This pattern suggests constraints on adaptive compensation in agile invertebrates. Future work will test whether adaptive control is possible under more predictable and repetitive stimuli.

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Zebrafish cupula deflections reveal flow sensitivity during locomotion

Zihao Huang, James Liao

Despite over a century of research on the lateral line system, a fundamental question remains unresolved: to what extent does a neuromast deflect during swimming? This uncertainty limites our understanding of what fish sense during swimming, in particular, corollary discharge and the balance between afferent and efferent signaling in moving fish. Without knowing the mechanical thresholds for cupular deflection, we cannor determine the sensory processing during locomotion. To address this, we investigated the deflection modes of superficial neuromasts in larval zebrafish (Danio rerio) using a combined experimental and numerical approach. We designed a gravity-driven flow apparatus with precise flow rate control to quantify cupular deflection under biologically relevent conditions. Preliminary results show that deflection amplitude scales with flow rate, with pronounced bending along the cupula's long axis. At typical coasting speeds (U ≈ 2.9 mm/s), we observed moderate bending deflections at ~36°, suggesting that neuromasts remain mechanically engaged during the gliding phase of burst and coast swimming. We hypothesize that higher cupular deflections are reserved for activating avoidance responses. Complementary numerical modeling promises to reveal the corresponding mechanical properties of the cupular matrix and the fluid-structure interactions that govern its dynamic reponse. Our results will provide the first precise in vivo visualization of cupular deflection, providing a quantitative basis for interpreting lateral line activity during both self-generated movements as well as external stimulation.

Mate or wait? The trade-offs between survival and reproduction in an extreme thermal environment

David Hubert, Ehren Bentz, Robert Mason

Balancing survival and reproduction under thermal stress presents a fundamental evolutionary challenge, particularly for ectothermic vertebrates in extreme and unpredictable environments. Using male red-sided garter snakes (Thamnophis sirtalis parietalis) from the Interlake region of Manitoba, we investigated how organisms navigate this trade-off through behavioral and physiological plasticity. We combined field observations, behavioral assays, and transcriptomic profiling to characterize thermoregulatory behavior, physiological limits, and molecular responses to acute thermal challenge. Snakes displayed remarkably consistent critical thermal limits (CTmax ≈ 40 °C; CTmin ≈ 1 °C) and operated perilously close to lethal thresholds during reproductive activity. Behavioral thresholds for courtship and voluntary withdrawal (≈35 °C) occurred within 4–5 °C of CTmax, indicating that males routinely prioritize mating opportunities until survival becomes immediately at risk. Transcriptomic analyses revealed rapid, tissue-specific shifts in gene expression that were activated at sublethal temperatures, demonstrating that molecular defenses anticipate and support risky behavioral decisions. Together, these results highlight the precision and context-dependency of thermal decision-making, in which selection has shaped reaction norms that maximize reproductive effort while maintaining a minimal safety margin. Our findings suggest that extreme phenotypic plasticity may buffer populations against acute thermal stress but may also constrain long-term adaptive potential as climate warming narrows safety margins.

The pooling paradox: When more isn't always better in metabolomics

David Hubert, Dylan Porter, Mark Phillips

Metabolomics provides a powerful window into the functional state of biological systems, but inconsistencies in experimental design can limit the reproducibility and comparability of results. One critical factor is pooled sample size, particularly in studies of small-bodied organisms such as Drosophila. Variation in trait expression within and among individuals suggests that the number of organisms pooled per sample may strongly influence metabolomic outcomes. Here, we examine how pooled sample size (5, 50, or 100 flies) affects metabolite detection in Drosophila melanogaster populations with either high standing genetic variation (outbred) or low variation (inbred), sampled at young (14 days) and old (40 days) ages. Using semi-targeted high-resolution mass spectrometry, we quantified metabolites to assess how sample size influences detection of age-related metabolic differences and whether this effect depends on genetic variation. We found that intermediate pooled sample sizes (50 flies) captured the greatest metabolite variation in outbred populations, with a similar but weaker trend in inbred populations. These results highlight the importance of pooled sample size in metabolomic study design and demonstrate that the level of standing genetic variation should also be considered when planning experiments.

Investigating the monophyly of *Sigambra* (Annelida: Phyllodocida: Pilargidae)

Sonja Huc, Kenneth Halanych

Pilargidae Saint-Joseph, 1899 (Annelida: Phyllodocida) is a small family of polychaete annelid worms with only 12 genera and just over 100 accepted species. Current research using mitochondrial genomes has shown that the genus Sigambra Müller, 1858 may be non-monophyletic, because Ancistrosyllis McIntosh, 1878 falls in between two Sigambra clades. Instead of reflecting the actual state of this genus, the non-monophyly could be a result of undersampling, as only one Ancistrosyllis, three Sigambra, and six other pilargid mitogenomes have been used. To verify this, we have sequenced multiple additional pilargids. After assembling the mitogenomes, we annotated them and ran maximum likelihood phylogenetic analyses. The reconstructed tree continues to show Sigambra as non-monophyletic, and including the type species of the genus, Sigambra grubii Müller, 1858 has given insight into which Sigambra clade truly belongs to this genus. The tree has allowed us to reassess the morphological diagnostic characters between these genera. This includes the chaetiger number at which hooks start, pharynx marginal papillae count, parapodium and cirri shape, antennae length and size, and ventral cirri presence on the second chaetiger. This study has more than doubled the number of publicly available pilargid mitogenomes, giving much greater resolution to the intrafamilial relationships within Pilargidae. The elucidation of the true Sigambra has also opened the possibility of erecting a new pilargid genus to fix the current non-monophyly.

Assessment of Benzo[a]pyrene-induced renal toxicity and mitochondrial dysfunction in zebrafish

Chelsea Hughes, Nishad Jayasundara, Richard Di Giulio

Polycyclic aromatic hydrocarbons (PAHs) are widespread environmental pollutants that pose a growing threat to ecosystems and human health. Benzo[a]pyrene (BaP), a well-characterized PAH, is known to exert toxic effects across multiple organ systems. However, its impact on renal function remains poorly understood, particularly in aquatic models. Aquatic organisms are frequently exposed to BaP through ingestion of contaminated sediments, prey, and organic material, yet it remains unclear how this exposure route affects renal physiology. To investigate the effects of BaP ingestion on kidney function, adult transgenic Tg(fabp10a:nanoLuc-RAPD3) zebrafish (Danio rerio) were exposed to BaP (12.5 or 125 µg BaP/g diet) for 24 days. Proximal tubule function was monitored throughout the exposure period by quantifying low molecular weight proteinuria. At the end of the study, basal respiration in the kidneys was assessed using the Seahorse XF Analyzer to evaluate mitochondrial function. Additionally, mitochondrial DNA (mtDNA) integrity was evaluated by quantifying mtDNA damage and copy number to further assess

mitochondrial health. This research aims to provide new insight into the nephrotoxic potential of BaP in aquatic organisms, highlighting its role in disrupting mitochondrial function. This work was supported in part by NIH T32 funding.

To feed or fight: sexually dimorphic skulls and jaw biomechanics in Aneides salamanders

Jonathan Huie, Karly Cohen, Jaimi Gray, David Blackburn, David Wake

Predators often have jaws and teeth that reflect the mechanical properties of their prey but male-biased agonistic behaviors can promote dimorphic features that overlap with feeding traits. Lungless salamanders of the genus Aneides exhibit highly modified skulls and dentitions as well as hypertrophied jaw muscles initially hypothesized to be adaptations for feeding. While some species are sexually dimorphic, with males having larger heads than females, others are secondarily monomorphic in that both sexes express the large heads originally in males. To help disentangle cranial evolution in Aneides, we used µCT scanning coupled with contrast stains and 3D geometric morphometrics to compare skull shape, jaw musculature, and jaw biomechanics between males and females of all 10 species. We found that interspecific evolutionary trends towards robust skulls and larger theoretical bite forces were mirrored by intraspecific differences between males and females. Additionally, the extent of dimorphism was both species and trait-dependent. For example, A. ferreus and A. vagrans had dimorphic crania but monomorphic jaws, while A. lugubris was consistently monomorphic. All of these species consume relatively high proportions of large, hard-shelled arthropods, suggesting their jaws are primarily adapted for feeding. Meanwhile, the black salamanders (A. flavipunctatus complex) have completely dimorphic heads, possibly reflecting frequent male-biased intraspecific combat. Overall, our findings suggest that diet and agonistic behaviors have operated in tandem, yielding novel phenotypic diversity in Aneides salamanders.

Ecological drivers of lagomorph skeletal diversity

Coby Huizenga, Chris Law, Nia Brice

Variation in the mammalian skeleton is often associated with different locomotor behaviors. Here, we tested how different burrowing and locomotor behaviors affected the body shape and appendicular skeleton of lagomorphs (hares, rabbits, and pikas). Lagomorphs are a great model system because they exhibit several specialized locomotory modes and predator avoidance strategies including cursorial hares, saltatorial rabbits, and scrambling pikas. We predicted that more cursorial lagomorphs would exhibit more elongate body plans and limbs allowing for longer strides, whereas burrowing lagomorphs would exhibit more robust bodies and limbs due to the forces involved in digging. To test our predictions, we quantified the body shape and appendicular skeleton of 36 lagomorph species from 65 skeletal specimens held at natural history museums. We then used a series of PGLS models to examine how body size, locomotor mode, burrowing behavior, and evolutionary relationships contributed to variation in body shape and appendicular skeletal diversity. We found that increased size was associated with decreased elongation; however, contrary to our prediction, there was no significant difference in body shape among lagomorph groups. Furthermore, although locomotor mode predicted some aspects of limb morphology, we found that burrowing lagomorphs exhibited no differences in forelimb or body robustness. This project clarifies ecological factors influencing lagomorph evolution and paves the way for future studies to test the effect of the examined behaviors on their skeleton.

Gene expansions and the evolution of cnidarian intracellular symbioses

Ryan Hulett, Victoria Brown, Phillip Cleves

As animals, we live intimately associated with microbes and these interactions are a fundamental feature of our biology. An intriguing case of animal-microbe interactions as well as a remarkable example of extreme cell biology is the cnidarian-dinoflagellate intracellular symbiosis. Several cnidarian lineages (e.g., anemones, corals, and jellyfish) have the ability to establish intracellular symbioses with photosynthetic dinoflagellates. The dinoflagellates enter cnidarian host cells and alter host gene expression, leading to transcriptionally distinct symbiotic cell-states. A subset of the genes expressed in these symbiotic cell states are associated with the expansion of key gene families in cnidarian genomes, offering an opportunity to explore how gene duplications are associated with symbiosis. Here, we investigate the putative neofunctionalization of symbiosis-associated genes (SAGs) in the anemone Exaiptasia diaphana (Aiptasia), a research model for cnidarian-dinoflagellate symbiosis. First, we identified SAGs in bulk RNA-sequencing by comparing the transcriptional profiles of symbiotic and aposymbiotic Aiptasia. Next, we classified the duplicated gene repertoire in Aiptasia, focusing on SAGs. Finally, we utilized single-cell RNA-sequencing data coupled with mRNA in situ hybridization and genetic perturbation to investigate the expression and function of tandemly duplicated genes associated with symbiosis. This work explores how gene duplications and neofunctionalization drive evolutionary novelty within cnidarians and more specifically, demonstrate that tandem gene duplications can be co-opted into novel cell states.

Effect of the fungicide azoxystrobin on life history and defense of the Common Milkweed

Ariel Hullender, Megan Kobiela

The widespread use of fungicides has raised concerns about their impact on non-target species. Azoxystrobin, a broad-spectrum fungicide, is commonly used in agricultural and turf fields, posing potential risks to native plants like the common milkweed (Asclepias syriaca) and the monarch butterflies that rely on them. While fungicides can protect plants from some pathogens, they can often elicit negative effects on mitochondrial respiration. In milkweed, reduced mitochondrial respiration could affect chemical and physical defenses that protect the plant from insect herbivory, like latex production, cardenolide levels, and trichomes, which can have negative consequences for monarch butterflies and other insects that rely on milkweed. In this study, I investigated the effects of azoxystrobin on milkweed growth, leaf counts, latex production, cardenolide levels, and trichomes. To do this, I measured these endpoints in control plants and treated plants after 1, 2, and 3 doses of azoxystrobin. Azoxystrobin treatment did not affect any endpoint we measured in milkweed. However, there was greater leaf production over time, which was unexpected because leaf production was expected to be consistent across our timeline. Genetic strain was also a significant predictor of plant growth. Our data suggests azoxystrobin use on milkweed may be safe for monarchs. This research contributes to the broader effort to mitigate the environmental impact of pesticides and protect vulnerable plant and animal species in agricultural and recreational landscapes.

A dozen years of baleen hormones: What have we learned, and where do we go from here?

Kathleen Hunt, Jen Jelincic, Josh Reed, C. Loren Buck, Leslie New

In 2014, progesterone was reported to be detectable in the baleen of bowhead whales. Subsequent research made clear that all steroid and thyroid hormones are detectable in baleen of all mysticetes, with patterns across the baleen that reflect recent individual history. Early research necessarily focused on validations, e.g. verifying that progesterone peaks correspond to calving events, and glucocorticoid peaks to documented stressors. Emergent patterns suggest that baleen hormone data can provide unique insight into inter-calving interval, pregnancy loss, timing and location of breeding, sexual maturity, senescence, and effects of various stressors. Many methodological questions remain to be resolved, but the field is increasingly shifting from descriptive case-study reports to testing ecological questions of broad significance. Addressing such questions will require larger sample sizes of individuals, a daunting task given that a single baleen specimen can generate >150 separate samples requiring months of labor. The time may therefore be ripe for a baleen-hormone research consortium wherein data can be pooled across research teams. Useful models for such research consortia exist for sightings data for certain species, and could be adapted for time-series physiological data for multiple species. Though the logistics will be complex, the benefits could be substantial if we truly wish to understand, and help, these long-lived, cryptic, fascinating species, especially in an era of dramatic global alterations and reduced scientific support.

Probiotic host–microbe interactions shape growth & physiology of juvenile red drum: a Bayesian view

Ione Hunt von Herbing, Wren Busby, Brook Milligan

Host-associated microbial communities influence vertebrate physiology, but separating microbial from environmental effects remains challenging. Probiotic supplementation experimentally manipulates microbiomes, yet impacts on host growth and condition are variable and not consistently detected with standard statistical approaches. We tested two PrimaLac® probiotic application methods in juvenile red drum (Sciaenops ocellatus, 4–15 g): water-soluble PrimaLac® added to tank water (WSP; 28 and 56 days at 3% feeding) and PrimaLac® incorporated into feed (PESF; 56 days at 3%, 4%, and 5% feeding). We measured mortality, growth (wet mass, length, specific growth rate, feed conversion efficiency), external morphological condition indices (MCIs), physiological condition indices (PCIs; fasting/fed glucose and lactate), and water quality. Standard statistical analyses showed relationships between probiotic supplementation and improved survival, growth, condition indices, and water quality, but did not clearly identify which traits were most affected. In contrast, Bayesian hierarchical models revealed probiotic-mediated shifts in mortality, growth, condition, physiology, and water quality, demonstrating host–microbe–environment interactions across biological scales. These models quantified uncertainty, allowed inference across treatments, and uncovered patterns not consistently detected with conventional approaches. By revealing probiotic effects on host performance, Bayesian models provide a powerful tool for resolving variability in host–microbe interactions and offer proof-of-concept for integrating microbial dynamics into predictive models of fish performance under shifting environmental conditions.

Novel female exposure increases fecundity in adult male prairie voles but not meadow voles

Jess Hurd, Yurika Watanabe, Gracie Toben, Alexandra Ford, Craig Miller, Casey Sergott, Dale Kelley, Zoe Donaldson, Liz McCullagh

Female prairie voles exhibit a unique form of induced ovulation and will not begin estrus cycling until they are exposed to an unfamiliar conspecific male. The presence of a similar form of reproductive activation in male prairie voles and its relevance to a socially monogamous lifestyle has not been investigated. Here, we compare the testis mass, testicular histology, and mature sperm count of naïve and female-paired prairie vole males (a socially monogamous, biparental species) and meadow vole males (a closely related promiscuous species). Paired prairie voles exhibit 41% larger testes and 85% higher mature sperm count than naïve prairie voles. No difference was seen between naïve and paired meadow voles. Male prairie voles housed with their female littermates through adulthood exhibit no difference in testis mass or mature sperm count compared to naïve males housed with other males. This indicates the presence of male specific reproductive activation in prairie voles like that seen in females. Further, while naïve meadow voles exhibited greater testis mass relative to body mass than naïve prairie voles, there was no difference between paired prairie voles and naïve nor paired meadow voles. This partially contradicts the prediction of sperm competition theory – demonstrating that the presence of social monogamy in a species can have complex effects on male reproductive physiology and plasticity.

Redheads aren't blondes, and other fun facts from a course on sex, gender, and sexuality

Jerry Husak, Patricia Maddox

Undergraduate biology courses often describe biological variation in overly simplistic ways, often to the detriment of student understanding. However, biologists themselves often frame research in overly simplistic ways. This impacts what kinds of questions are asked, as well as how they are asked, which can have impacts on society at large. We are an integrative biologist and sociologist who co-teach a course on sex, gender, and sexuality (BIOL/SOCI 275 – Born this way?) to majors, non-majors, and all levels of students, and with no pre-requisites. We cover key sociology theory and numerous topics in organismal biology to help students understand that binary classification systems typically fail at capturing biological diversity. We also examine the impact of phenotypic plasticity on total phenotypic variation to break the myth that genetic determinism equals "biology" in the context of trait variation. Our course explores the impact of society on both how science is done and how phenotypes develop. Surveys of students reveal that our combination of sociology and biology enhances their understanding of both disciplines and makes them feel confident to discuss complex, controversial topics with others. Even though this is a course about humans, a myriad of integrative biology topics are covered for students who would not otherwise have them. We describe these, as well as other key objectives of the course and their outcomes.

Signatures of selection on the exercise response in green anole (*Anolis carolinensis*) lizards

Jerry Husak, Mahaut Sorlin, Simon Lailvaux

Whole-organism performance traits are key predictors of fitness and thus targets of selection. However, performance is not static and can improve with increased use: the exercise response. While this phenomenon has been well studied in humans, we know surprisingly little about trainability in other animals. It is also unclear how or if the training response is adaptive. Since the exercise response is ancestral in vertebrates and has been conserved in all lineages studied, there should be detectable signatures of selection on how individuals respond to exercise training. We show that the response to endurance training is greater and more variable in juveniles compared to adults in green anole lizards, suggesting stabilizing selection. We also examine variability in the time it takes for the response to plateau in three locomotor performance traits. Our data hint at an effect of selection on the exercise response, but more studies are necessary across taxa and types of performance.

Effects of anthropogenic light and noise on deer mouse immune health

Diana Hutchings, Ashley Beck, Elizabeth Addis, Laurie Dizney

As natural landscapes are increasingly transformed by human development, wildlife faces new ecological and abiotic challenges. Most research has focused on ecological impacts of these changes, including increases in establishment of non-native species, increased competition, and changes in biodiversity. Fewer studies have examined the impact of abiotic changes, such as artificial light and anthropogenic noise, on wildlife. These factors can interfere with physiological processes such as sleep, metabolism, and hormone regulation, all of which play important roles in maintaining immune function. We examined the relationship between light, noise, and immune function, predicting that immune function would be negatively impacted by elevated levels of anthropogenic light and noise. To test this, we captured Western deer mice (Peromyscus sonoriensis) across twenty field sites ranging from a national forest to city parks, allowing us to compare a single species across varying levels of disturbance. At each site we collected data on light (lux) and noise (dB) using a HOBO data logger. We assessed immune function with total white blood cell counts. By examining the relationship between abiotic stressors and immune system impacts, our study provides insight into how anthropogenic environmental changes may affect wildlife health.

Traveling on a budget: novel insights into movement & energetics of migrating Atlantic striped bass

Caroline Ianniello, Steven Zottoli, Brian Prendergast

Despite extensive research on striped bass (Morone saxatilis) migratory patterns, relatively little is known about their offshore migratory behavior – or its effect on their seasonal energy expenditure. Here, we describe the use of pop-up satellite archival tags (PSAT) to characterize high-resolution changes in striped bass behavior over their entire migratory cycle. PSATs recording triaxial acceleration, depth, temperature, and illumination level at 5 second intervals were attached to adult striped bass in Woods Hole, MA in autumn and were recovered the following summer. These data represent the first complete annual records of migration for individual striped bass, permitting new insights into the interplay of behavior, energetics, and seasonality. We used generalized linear models to identify strong effects of temperature, time-of-year, and illumination on VeDBA. Water temperatures >20°C increased

VeDBA in a manner that suggests disproportionate effects of temperature on energy needs as temperatures increase. We also documented striking circadian and aperiodic vertical movements within the water column that often exceeded 5 km/day and varied markedly over the migratory cycle. Increased energetic demands due to water temperature and vertical movements may tilt the striped bass energy budget towards satisfying the metabolic requirements of activity and away from growth and reproduction. Future studies aim to use PSAT technology to better understand how energetic expenditure across the migration cycle may inform striped bass management and conservation.

Early and late life effects on tendon material property in mice

Apolo Ibanez Rincon, Angela Horner, Kevin Banda, Sadie Sandoval, Noel Calderon

Tendons are connective tissue attaching muscle to bone, functioning in series with muscle but remodeling much slower. Tendons become relatively inert post-skeletal maturity, forming a tendon core during early ontogeny. Although tendons can remodel later in life, this may be regionally limited. To compare the effects of early versus late life exercise on tendon mechanics, we investigated tendon material properties from mice exercised on wheels. An early-life cohort was given access to a running wheel beginning at age 3 weeks (N=36), an older cohort beginning at age 20 weeks (N=36), and a control group had no running wheel (N =36). After 10 weeks of training, all mice were housed until age 52 weeks, and then euthanized and frozen until tested. The plantaris and tibialis anterior tendons were dissected and measured. Tendon length and cross-sectional area (CSA) were obtained from images, and the tendon was marked to record strain during cyclic loading tests at 250 Hz. Finally, a ramp-to-failure test provided tensile modulus, stiffness, and tensile strength. Preliminary data suggest that early-life exercise does not impact failure force or length in plantaris tendon across groups. However, older exercised adults trended toward higher failure forces in the tibialis anterior tendon ($p = 0.0546$). Results suggest age and region impact tendon mechanics, with current work aiming to understand the role of ontogeny in tendon structure and performance.

Does selective breeding for high voluntary wheel-running alter the pelvis in a sex specific manner?

Marisol Ibarra, Theodore Garland, Elizabeth Webb, Katrina Jones

The pelvis is the attachment site for vertebrate hindlimbs and is responsible for supporting the weight of the upper body and transferring it to the lower limbs, facilitating balance and mobility. The pelvis is composed of the sacrum, coccyx, and paired hip bones (ilium, ischium, pubis). Research across taxa with different locomotor behaviors indicates that pelvic morphology in terrestrial mammals may be shaped, in part, by evolutionary trade-offs between reproductive demands and locomotor performance. We used the artificially selected High Runner (HR) lines of mice to analyze pelvic morphology in relation to daily movement distance and sex. In this model, outbred house mice (Mus domesticus; Hsd:ICR strain) were selectively bred for increased voluntary wheel running to create four HR lines and four non-selected Control (C) lines. These lines have been used to study correlated responses in exercise physiology, behavior, neurobiology, and genetics. Whole-body CT images were obtained from 200 mice at generation 93. 3D geometric morphometrics methods are being used to analyze pelvic shape based on 44 landmarks. We expect divergence in pelvic morphology between the HR and C lines, and that this will be greater for males than for females because the latter are somewhat constrained by reproductive demands. Supported by NSF grant IOS-2038528 and a Butterfly Project Fellowship.

DNA methylation among house sparrows (*Passer domesticus*) from paired native and introduced locations

Oluremi Ige, Aaron Schrey, Natalie Schrey, Daniella Ray, M. Ellesse Lauer, Elizabeth Sheldon, Kailey McCain, J. Dylan Maddox, Kevin Kohl, Mark Ravinet, Jim Briskie, Kate Buchanan, Roi Dor, Henrik Jensen, Blanca Jimeno, Kim Mathot, Ho Thu Phuong, Melissah Rowe, Jorgen Soraker, Massamba Thiam, Thinh Vu, Cedric Zimmer, Lynn Martin

House sparrows (Passer domesticus) have been successfully introduced on every continent excluding Antarctica. The breadth of their introduction success and their near global distribution make them a good model to study epigenetic variation among populations. Epigenetic mechanisms are those that alter phenotype without altering DNA sequence. These mechanisms are critical for rapid adaptation to novel environments. Here, we focus on one epigenetic mechanism, DNA methylation, as it already has established importance to introduced house sparrows. We use epiRADseq to screen differently methylated regions across a reduced representation of the house sparrow genome from blood samples. We compare DNA methylation of individuals across six geographic locations paired by environmental factors between native (Israel, Norway, and Spain) and introduced (Australia, Canada, and Senegal) populations. Our objective is to investigate the differences in DNA methylation between introduced and native populations by characterizing levels of variation in DNA methylation, identifying differently methylated regions among paired locations, and assessing the effect of introduction history and geographic location on DNA methylation.

Built to burrow: digging deep into the vertebral morphology of Pacific sand lance

Elynore In, Owen Proulx, Bart Boom, Cassandra Donatelli, Karly Cohen

Pacific sand lance (Ammodytes personatus) are small head-first burrowing fish distributed throughout the North Pacific Ocean. Despite lacking typical morphology of other burrowers, their elongate bodies allow for rapid burrowing through undulation. Vertebrae support full-body movements like swimming and bear the mechanical load for the axial skeleton. We hypothesize that structural changes in vertebrae, such as changes in mineralization and shape, enhance undulatory performance and help generate the forces needed for burial. We microCT scanned 22 sand lance (SL 33-95mm) to estimate the bone mineral density and characterize shape variation along the length of the fish and over ontogeny. To identify the causal mechanisms of efficient undulation, we developed a soft robot inspired by the sand lance with varying density distributions to mimic changes in vertebral mineralization. We found sand lance vertebrae were 1.25 times denser near the head and tail regions compared to the middle. Additionally, the main drivers of vertebral shape variation were the prominence of the hemal spine and the angle of the neural and hemal spines relative to the centrum. Preliminary results of physical testing indicate that robots with denser head and tail regions may have greater tailbeat amplitudes and therefore more efficient movement. These localized morphological increases in density and shifts in spine orientation may serve as additional support and points of force transmission for initiating and sustaining burial.

Reconciling muscle-tendon trajectory estimates derived from joint vs. tissue-level measures in situ

Lauren Infantino, Chloe Dang, Caitlin Bemis, Manny Azizi, Monica Daley

Understanding the interactions of muscles and elastic structures during locomotion requires methods that can measure and experimentally vary the dynamics of muscle-tendon units (MTUs). Direct measures of muscle force and strain are often infeasible, motivating reliance on kinematic approaches that estimate muscle-tendon unit (MTU) behavior. While accessible, these approaches don't capture the interactions of muscles and tendons, which can decouple length changes of muscle fascicles from joint-level motion. Dynamic changes in muscle architecture, non-linear tendon deformation, and strain transients complicate this relationship and limit the utility of kinematic data to describe muscle-tendon dynamics. In this study, we use kinematic data during running and in vivo data from the guinea fowl lateral gastrocnemius (LG) to compare different methods of estimating MTU length trajectories

over the stride cycle. We compare MTU lengths derived from joint-level data (using joint kinematics and moment arms) to lengths derived from tissue-level measurements (using fascicle lengths, pennation angle, and tendon strain). We use the trajectories and activation timing to drive the lengths of an in situ muscle-tendon preparation of the LG. Preliminary results demonstrate that fascicle dynamics, velocity transient timing, and force observed in vivo can be replicated in situ. This framework allows for controlled replication of in vivo patterns, providing a platform to experimentally vary critical parameters that influence the control, mechanics and energetics of movement. NSF DBI 2319710

Insect-parasitic nematode Steinernema as an emerging genetic model for nutritional immunity

Sally Ireri, Victoria Chen, John Marken, Richard Murray, Frederick Tan, Javier Carpinteyro-Ponce, Xiaobin Zheng, Heidi Goodrich-Blair, Alex Grossman, Mengyi Cao

Nematodes are valuable genetic models for studying host–microbe interactions because of their simplistic immune system. Insect-parasitic nematodes of the Steinernema genus maintain a binary symbiosis with Xenorhabdus bacteria. During the Steinernema lifecycle, symbiotic bacteria colonize multiple specialized host tissues at the anterior intestine. As a result of their single-species, genetically tractable microbiome and the recent establishment of genetic tools, such as CRISPR-Cas9 genome editing, Steinernema nematodes represent a promising but underexplored invertebrate model for studying mutualistic immunity. Our recent study reports that, Escherichia coli Nissle 1917 (EcN), a mild pathogen of Steinernema hermaphroditum, colonizes previously undocumented niches that differ from symbiont-associated sites. In infective juvenile nematodes, EcN cells are phagocytosed by coelomocytes (immune cells), accumulate in posterior intestinal vacuoles, and infiltrate the inter-cuticular space. Furthermore, RNA-sequencing data reveal that host nematodes exhibit distinct transcriptomic responses to symbionts versus pathogens. In particular, iron metabolism pathways are differentially regulated, suggesting that host tissues fine-tune iron homeostasis to support beneficial interactions with symbionts while defending against harmful microbes. We will present current work focusing on HRG-1 (heme-responsive gene 1), a conserved heme transporter that is upregulated in Steinernema nematodes in the absence of Xenorhabdus symbionts. Our work establishes Steinernema as a model system for the study of essential micronutrients, such as trace iron, which is known to play a crucial role in mammalian host nutritional immunity.

A reevaluation of the constrained lever model in the primate feeding system

Jose Iriarte-Diaz, Amy Martin, Myra Laird

The constrained lever model (CLM) predicts that jaw adductor muscle forces must pass through the “”triangle of support”” (ToS) to prevent temporomandibular joint (TMJ) distraction during biting. However, this model assumes the TMJs are level with the occlusal plane, which is not the case in most mammals where TMJs are elevated. We tested CLM predictions using virtual 3D muscle models of 167 individuals from 97 primate species as well as variation in joint reaction forces at different gapes (0-40°) and with different muscle force configurations. We found that the position of the resultant muscle force (RMF) relative to the ToS poorly predicts vertical TMJ stability. At occlusion, while 56% of species had RMF outside the ToS, only 20% exhibited distracting vertical forces at their working-side TMJ. However, when applying an oblique ToS force criterion (perpendicular to the inclined ToS plane), 97% of species showed forces matching RMF position predictions. Joint stability increased with gape but had limited variation with taxonomy and across diet categories. These results provide strong evidence that the CLM is a poor predictor of RMF position relative to the ToS when the TMJs are elevated. These findings suggest future applications of the CLM should either focus on taxa with TMJs near the occlusal plane or calculate joint reaction forces directly to assess joint stability in mammals with elevated TMJs.

Studying the scaling of shark morphology through 3D modelling

Duncan Irschick, Isabel French-Luce, Joel Gayford, George Lauder, Jodie Rummer, William Nguyen, Joshua Medina

The scaling of morphology, from small species to large, is a fascinating topic that is central to our understanding of form and function in all animals. Elasmobranchs present tremendous diversity in overall size, body shape, diet, and swimming habits. Nonetheless, prior work with elasmobranchs has shown that the main body axis scales isometrically across many species of dramatically varying size, life history, and ecology. We explored this surprising topic in more detail using 3D modelling to examine the scaling of individual body parts (e.g., fins, head shape, tail shape) across a subset of shark species that vary dramatically in size, shape and ecology. We also integrate embryo sharks into the scaling research to try and understand if these scaling patterns occur very early in ontogeny. Our work provides a unique window into using 3D modelling to study scaling by virtually “”dissecting”” animals to study the scaling of individual body parts, a practice that would be impossible with most natural history specimens. We also discuss some practical considerations for how this method can be applied to other animal groups, some of which may be more challenging to model.

Using 3D modelling to build conservation tools for estimating mass remotely in wild animals

Duncan Irschick

Estimating body condition is important for ecologists and conservation biologists, as an animal’s body condition - often depicted as body mass - can dictate mortality, reproductive opportunities, and migration patterns. While estimating body condition is feasible for small animals that can be straightforwardly captured, such as reptiles, birds, or insects, this is not true for terrestrial and aquatic megafauna (e.g., elephants, sharks), for which capture and weighing is expensive, and potentially dangerous to the scientists and animals involved. The integration of 3D modelling, machine learning, and 2D-3D projection provides a powerful new toolkit for conservation biologists and ecologists. By creating accurate 3D models of living animals and using them to estimate body volume and surface area, and then relating those variables to mass, one can obtain accurate estimates of body mass. Through integrating this paradigm with 2D-3D projection, such as through camera traps or drones, one can estimate condition non-invasively and seamlessly, and at a high level of accuracy. Finally, the role of machine-learning is growing, as it has the potential to enable vast amounts of data to be analyzed quickly and accurately. I cover this process through our laboratory’s on-going efforts to build a pipeline for terrestrial aquatic and terrestrial megafauna of critical conservation importance. I also explain some possible avenues for the future through integrating advances in AI, photography, and 3D modelling.

If cognitive abilities confer an advantage, how do we measure that in wild birds?

Sara Isgate, Katherine Johnson, Josiah Southern, Kim Rosvall

As environments become increasingly altered by anthropogenic influence, wild organisms must cope with change or face elimination. Previous work suggests cognitive attributes may confer an advantage, but standardized methods to assess this in the wild remain underutilized. Here, we capitalized on the parental drive to feed nestlings and used two operant puzzles to evaluate cognitive performance in adult tree swallows (Tachycineta bicolor). Testing occurred from May through July across a range of times and ambient temperatures. Each puzzle was temporarily affixed to the front of the birds’ nest box during the chick rearing period. One puzzle assessed differential choice, prompting birds to perch upon one of two levers to open an obstructive door occluding the nest box entrance. The other puzzle assessed inhibitory control via a transparent barrier designed to encourage detour reaching. We presented all birds with both puzzles, counterbalancing the order of presentation. Via focal observations and post hoc scoring in BORIS, we observed marked among-individual variation in cognitive performance. Ongoing analyses will assess how cognition intersects with environmental

and demographic attributes to better understand why some individuals solve problems more effectively than others. More broadly, our findings will help advance the use of operant conditioning assays in a changing world.

Light and vision on the high sea surface

Tom Iwanicki, Rebecca Helm

The ocean surface is a massive, biodiverse, and often overlooked habitat at the frontline of human impacts, notably marine debris and plastic, and a mechanistic understanding of light and vision at the surface is critical for conservation strategies. Very little is known about the visual ecology at the air-sea interface and the mechanisms animals use to forage, mate, and avoid predators in this sundrenched environment. The impact of consuming plastic may be profound, seabirds are particularly vulnerable to ingesting plastic which can lead to reduced body condition and potentially death. Not all plastic is equal; albatross on Midway Atoll were found to disproportionately consume red and pink disposable lighters. Animals adapted to live at the sea surface (broadly defined as 'neuston') use a suite of distinct color pattern strategies, notably blue pigmentation and reflectance, presumably for countershading camouflage. Some features of neuston pattern may appear similar to marine debris resulting in inadvertent consumption of plastics by birds and fishes. We used calibrated full-spectrum photography to quantify the color and pattern of neuston and marine debris modeled through the eyes of select birds and fishes. These data will support the development of a risk assessment tool for endangered, threatened and protected species which we can leverage to ensure current policies are consistent with states and federal protection laws including the Endangered Species Act.

3D modeling and analysis of dueling flight trajectories of the long-legged fly

Aaron Jackson, Samuel Fabian, Jamie Theobald

Pursuit behaviors in flies have been studied for many years, focusing largely on methods of target tracking and interception. In pursuit, speed is the defining characteristic for success, right? Speed is very important for catching up to targets or achieving their immediate survival goals such as evasion, predation, or territorial dueling, especially in flying species. Flying insects will commonly collide in the air, especially at higher speeds. Long-legged flies are one of a list of examples of flies that utilize high-speed pursuit tactics. We hypothesized that dueling long-legged flies would achieve maximum speeds in pursuit of their target in addition to having higher average speeds than solo-flying long-legged flies. We tested this hypothesis using twin high-speed cameras, producing a 3D view of them dueling or flying in their natural environment. We plotted the relationships of turning and acceleration kinematics over speed and time. We found that the average speed and accelerations for dueling and solo flies were not significantly different with dueling flies only having a wider range in these kinematics. Additionally, we found that dueling flies do not achieve their maximum speed due to a maintained tangential acceleration at 20 m/s2. Therefore, we reject our hypotheses and support the idea that dueling flies will exhibit a wider range of speeds and accelerations to improve their maneuverability in space.

Disentangling the neural mechanisms of migration from reproduction in White-crowned Sparrows

Maddie Jackson, Jason Strickland, Jonathan Perez

Photoperiod serves as a reliable cue used by many organisms to time seasonal life history events, such as migration and reproduction. Artificial photostimulation, used to simulate spring conditions, has been widely used in the laboratory to stimulate migratory and reproductive physiology. However, few if any studies have been able to isolate the neural mechanisms of migration from reproduction due to this shared reliance on photoperiod as a stimulatory cue. To disentangle the neural mechanisms between these two life history stages, we utilized a dim green light paradigm with Eastern White-crowned Sparrows (Zonotrichia leucophrys leucophrys) as a model. Birds were separated into three groups: control on short winter photoperiod (8L:16DvDG; n=8), long days on dim green light (18DgL:6DvDG; n=8), and long days on bright light (18L:6DvDG; n=8). Both green and bright groups significantly increased fat deposition and displayed migratory restlessness behavior compared to controls. However, only the bright light group experienced gonadal recrudescence. Further, we will present comparative transcriptomic analysis of the hypothalamus, cerebellum, hippocampus, and pineal gland identifying changes unique to the migratory life history stage.

Prioritizing external engagement in science and conservation: A versatile hands-on activity

Molly Jacobs, Lily Green

Community engagement is critical to the short- and long-term success of many scientific and conservation projects, but it can be difficult to convince funders, boards, and other scientists to prioritize engagement goals on par with purely scientific goals. Manomet Conservation Sciences is a science and conservation organization that works across the western hemisphere, from the Arctic to the southern tip of South America. Cultivating trust and long-term relationships with many different communities is key to the success of this work. In 2023-2025, Manomet convened an external engagement working group of staff from across the Americas to gather best practices. This working group developed a framework for approaching external engagement. From this framework, we developed a simple but effective activity using building blocks to start conversations and demonstrate the importance of engagement work in science. The activity is easy to adapt to specific research programs and geographies, and works well with groups of scientists and science-adjacent professionals ranging from students to boards of directors. Here, we will demonstrate the activity, and share the resources SICB attendees will need to implement it as part of their own external engagement work. We will also share some of the community engagement lessons learned from more than five decades of international conservation science work.

Investigating impact of gene presence on mutation and selection across codons in eukaryotes

Isha Jain, Stevie Clemens, Alex Cope, Abigail LaBella

Why are synonymous codons that code for the same amino acids used at unequal frequencies across the genome? One reason is that synonymous codons influence cellular translational and transcriptional dynamics. Therefore, we know that codon usage is shaped by both neutral and selective forces and that the balance between these two forces varies between species. We are investigating the factors shaping this balance. Leveraging the Ribosomal Overhead Cost version of the Stochastic Evolutionary Model of Protein Production Rates (ROC-SEMPPR) to disentangle the effects of natural selection from mutation biases on a comprehensive dataset of 1,154 sequenced yeast genomes, we hypothesize that species-specific genomic features and gene presence significantly shape the mutation-selection equilibrium. We are testing whether the presence or absence of genes and variations in species characteristics correlate with codon-specific mutation and selection rates. Through data visualization and statistical modeling, this work aims to analyze the extensive metadata associated with these genomes. This approach will reveal how genomic and biological features drive codon shifts, enhancing our understanding of codon evolution in eukaryotes. The findings will refine the application of codon usage metrics in evolutionary studies by accounting for species-specific and gene-specific variations in translational selection. This research addresses fundamental questions about the dynamics of codon evolution and its impact on gene expression, contributing to a deeper understanding of translational dynamics across diverse eukaryotic lineages.

Experimental approaches to triggering maternal hormone allocation: A comparative test in bluebirds

Anna James, Hunter Strickland, Leigh Bailey, Kendall Terry, Hana Walker, Anna Merritt, Jasmeen Kaur, Cameron Nixon, Alexandra Bentz

Across taxa, mothers can communicate information about environmental conditions to their offspring via hormone-mediated maternal effects, potentially shaping offspring phenotype in adaptive ways. For example, in many avian species, females allocate higher levels of testosterone (T) to egg yolks in response to heightened social competition, which can impact offspring traits

like growth and aggression. While the relationship between yolk T and social stimuli is well established, few studies have tested it through direct experimental manipulation. Most studies manipulate the broader social environment by increasing group size or breeding density rather than directly targeting social interactions. Simulated territorial intrusions offer a way to experimentally replicate social challenges at the individual level, but there is little consensus on the methodological standards needed to reliably elicit maternal hormone responses. Here, we compare three methodologies for conducting simulated territorial intrusions using Eastern bluebirds (Sialia sialis), a species known to elevate yolk T in response to social competition. We examined how the number, duration, and timing of simulated territorial intrusions impacts yolk T levels and early postnatal growth in offspring. These data will help identify effective and efficient approaches for altering a female's social environment, thereby allowing us to isolate the effects of social interactions on maternal hormone allocation, all of which can provide insights into how maternal effects shape offspring development across generations.

Prey type and prey size affect the feeding behavior of blind snakes (*Afrotyphlops spp.*)

Emma James, Bruce Jayne

Unlike other snakes, blind snakes (Scolecophidia) usually consume large numbers of very small prey such as ants and termites, but their secretive habits and small size have impeded studying their feeding behavior. Hence, we videotaped feedings of two large Afrotyphlops (A. schlegelii; A. lineolatus) to test how the size of ant larvae (0.2-107 mg), ant pupae (2-101 mg) and beetle larvae (10-460 mg) affected handling times and feeding behavior. Prey handling times of ant larvae, ant pupae, and beetle larvae ranged from 0.07-2.04 s, 0.16-5.40 s, and 0.88-88.83 s, respectively, and all these quantities increased significantly with increased relative prey size. Both snakes ate some (compressible) prey with diameters that exceeded their maximal gape. The frequencies of maxillary retractions during swallowing were rapid, averaging approximately 3.6 and 2.4 Hz for ants and beetles, respectively, but they did not change substantially with relative prey size (R2 < 0 .06). However, the number of maxillary retractions increased significantly with increased relative prey size. Beetle larvae were usually consumed from posterior to anterior, and they were commonly decapitated. Our observations of Typhlopids decapitating beetle larvae and previous findings that Leptotyphlopids detach the abdomen from the thorax of termites suggest the interesting possibility that the capacity to dismember prey may be widespread in Scolecophidians, although different methods of dismembering are used by these two families.

Individual variation in behavioral strategies for coping with heat in altricial nestlings

Emmy James, Sydney Anglin, Evelyn Rees Many, Kim Rosvall, Elizabeth Derryberry

Behavior can act as a powerful tool for managing heat. As temperatures rise due to climate change, thermoregulatory behaviors such as panting and shuttling to cooler microsites are increasingly important for survival. Yet few studies have described how much individuals vary in these behaviors, particularly in altricial young that may be especially vulnerable to heat. We examined among-individual variation in thermoregulatory behaviors in 12-day old nestling tree swallows (Tachycineta bicolor). Using heat packs, we experimentally elevated nest temperatures by about 4°C and scored two behaviors: time spent panting and movement toward cooler microclimates within the nestbox. As expected, chicks in heated nests spent more time panting; however, individuals varied greatly in time spent panting, with up to four-fold variation among siblings in the same nest and 32-fold variation across nests. Heated chicks also changed positions more frequently than controls, rather than remaining continuously at cooler microsites. These strategies are not without cost: chicks that spent more time panting also lost body mass. Because body mass at this age is the strongest predictor of future survival and fecundity, this variation may have lasting fitness consequences.

How does crowding shape variation in thermoregulatory behavior in altricial young?

Emmy James, Sydney Anglin, Omayah El-Salim, Ellis Kelsey, Evelyn Rees Many, Kim Rosvall, Elizabeth Derryberry

Heat waves are increasing in frequency and intensity, prompting animals to deploy thermoregulatory behaviors like panting or movement to cool microclimates. However, the use of these thermoregulatory responses may be constrained when space used for dissipating heat is limited. We examined this issue in free-living tree swallows (Tachycineta bicolor) by experimentally enlarging or reducing brood size at twelve days post-hatch. We used heat packs to simulate a moderate, realistic heat challenge with date-matched controls, and we filmed chick behavior for the duration of the trial. We scored two behaviors associated with thermoregulation: panting and movement throughout the nestbox, which may confer access to cooler microsites. We expect chicks in enlarged broods to rely heavily on panting to cool off if movement within the box is limited due to crowding. Enlarged broods may alternatively exhibit increased movement throughout the box if chicks are not able to maintain the same position for as long, due to having more nestmates. With these findings, we seek to characterize sources of among-individual variation in thermoregulatory behaviors. Future work will test the consequences of these strategies to better understand how behavioral variation under competition may influence fitness outcomes in a warming world.

Molecular modulation in response to environmental perturbations

Jordan James Bond, Kwasi Connor

The fermentative pathway, fumarate-reductase, is a conserved mitochondrial ATP-generating metabolic process that can be found across many genera of facultatively anaerobic organisms. The major end-product of this pathway is succinate, a widely regarded oncometabolite. In cancer biology, succinate accumulation has been shown to drive proliferation and ATP production by promoting protein succinylation. Interestingly, the intertidal mussel Mytilus galloprovincialis also generates large amounts of succinate when it closes its shell valves during aerial exposure at low tide, activating the fumarate-reductase pathway. Therefore, we predicted that mussels use succinate to tune proteins related to energy production and growth in fluctuating environments. Investigating this paradigm in mussels, we subjected individuals to simulated tides (i.e., daily aerobic/anaerobic cycles)varying in the level of air temperature. Following acclimation, we analyzed gill tissue for targeted and global succinylation. Our findings elucidated a molecular network that synchronized the environment with metabolism. Key aerobic and anaerobic enzymes were identified with a succinylated modifier, highlighting the link between aerobic and anaerobic metabolism. Our analyses of global succinylation and targeted gene-expression unveiled novel observations of the architecture of facultative anaerobiosis in fluctuating environments. Understanding the nuisances of this conserved mechanism will aid in conservation efforts, while supporting further studies of non-model systems under hypoxia.

Mud crabs may use low-contrast AoLP cues to detect objects in visually noisy tidal creeks

Madison Janakis, Daniel Speiser, Maryia Sikirzhytskaya

Tidal creeks are highly productive and ecologically vital environments that serve as nurseries for many species and as feeding grounds for many others. Despite their ecological importance, very little is known about the visual ecology of these environments. Tidal creek animals inhabit an environment where it can be difficult to visually detect objects. For instance, these habitats can be spectrally narrow and have high levels of caustic flicker, which respectively lower chromatic and achromatic visual contrast. Animals can use the angle of linearly polarized light (AoLP) to reliably detect objects under these light conditions. We investigated how the Atlantic mud crab, Panopeus herbstii, uses different aspects of light to distinguish objects against their background in spectrally narrow and visually noisy environments. We recorded the cardiac responses of mud crabs as a proxy for their perception of overhead looming cues that varied in AoLP contrast or achromatic contrast. We found that crabs responded significantly to overhead looming stimuli even when

their achromatic contrast was low. We also found that mud crabs are able to visually detect stimuli differing in very small e-vector angles using polarization sensitivity (down to 3° differences in e-vector). High contrast sensitivity to both achromatic and AoLP cues may be useful to animals like mud crabs that live in environments where light scattering creates a hazy visual scene.

Global fluxes and biogeographical patterns in biocrust nitrogen fixation

Shloka Janapaty, Lars Hedin, Erwan Monier, Anna Chan

Recent studies suggest that biocrusts—soil-dwelling photoautotroph communities—perform a major portion of biological nitrogen fixation. However, global-scale patterns in their biogeochemical activity remain largely unexamined. More fundamentally, the field has yet to attempt a theory of how biocrust nitrogen fixation is organized across biogeographical scales and the first-principle forces that govern these processes. Such a theory must exist to model the global nitrogen budget and land carbon sink in the face of climate change. Here, we present a global estimate of biocrust contributions to terrestrial nitrogen fixation and investigate global-scale biogeographical patterns in biocrust nitrogen fixation using a dataset of ~400 observations from literature. Using a statistical bootstrapping approach, we estimate that biocrusts are responsible for 15 Tg of fixed N per year, ~1/4 terrestrial N fixation. Our analysis also reveals substantial variation in biocrust nitrogen fixation rates along an aridity gradient. Whereas carbon uptake rates decrease with aridity, nitrogen fixation increases. Notably, the N:C uptake ratio—a proxy for photosynthetically acquired carbon invested in nitrogen fixation—is two orders of magnitude higher in semi-arid biocrusts than non-dryland. To explain this pattern, we propose several hypotheses centered around the observation that a biome-level tradeoff exists between water availability and photosynthetically-driven nitrogen fixation. We subsequently develop a mathematical model that allows biocrusts to vary their nitrogen fixation rates in the context of nutrient limitation and ecological disturbance.

Sexual dimorphism of SF1 neuron presynaptic distribution in SC/PAG during developmental stage

Geo January, Jennifer Hoy

When hunting for prey, mice use their visual systems to find and orient to potential food sources, such as crickets. This orienting behavior they exhibit while searching for moving prey is similar the human's ability to orient to moving visual stimuli. Previous findings of our lab have found sex and age-related differences in this behavior related to visual motion detection in mice. We hypothesize these differences to be related to the projections of the SF1 neurons from the ventromedial hypothalamus (VMH) to the peri-aqueductal grey (PAG) and the superior colliculus (SC). However, there is a lack of understanding of neural basis that causes an age- and sex-dependent difference in visual orienting behavior. To address this question, we explore whether the projection of SF1 (Steroidogenic factor 1) neurons are distributed differently in different brain areas such as SC and PAG according to sexes and ages. We thus utilize confocal imaging to visualize and quantify the SF1 neurons' presynaptic terminals in both SC and PAG in different sexes of NR5A-Cre/tdTom mouse, in which the florescent labeling, tdTomato is expressed in SF1 neurons, at adolescence and adulthood. This project will provide critical evidence of sexual dimorphism of brain development in visual orienting behavior.

Suffocation via gills? The physiological struggle of Panulirus argus & Maguimithrax spinosissimus

Morgan Jarrett, Mark Butler IV, Yannis Papastamatiou

The size and shape of respiratory organs, typically in the form of gills for water breathing ectotherms (WBEs), are vital to the efficiency of oxygen diffusion and often unique to each species. Due to the limiting oxygen conditions in seawater, WBEs have evolved gill morphologies based on their life history and environment that maximize oxygen uptake. Gill surface area (GSA) and metabolic rate scale as a power function with body mass, whose difference in exponents can indicate whether an individual is being geometrically oxygen limited (< 1 =limited). This study will focus on understanding the constraints of the gills on oxygen supply in two decapod crustaceans: the Caribbean Spiny Lobster (Panulirus argus) and the Caribbean King Crab (Maguimithrax spinosissimus). Here we establish the first body mass and GSA scaling exponents for these species, and compare these values to the metabolic scaling exponents. We found that the GSA scaling exponent for these organisms are 0.809 and 0.702 for lobsters and crabs, respectively. These values indicate that the gills could be causing geometric constraints on oxygen supply, but metabolic rate exponents will further contextualize if the oxygen demand is able to be met by the gills as these organisms grows. This research will provide better context as to how these organisms' physiology and morphology may limit them as seawater conditions continue to warm and oxygen becomes more limiting.

Oligodonty, polidonty, and variation in the dental formula in Felidae, with possible implications

Steven Jasinski

Felids (Carnivora: Felidae) are known to take reduction in number of teeth to an extreme among mammalian carnivores. Little to no work has been done understanding inter- and intraspecific variation of the upper second premolars among non-Lynx felids. Here, 33 of the approximately 40 species of modern cats were studied to determine inter- and intraspecific dental variation. In addition to P2, variation was also found in the presence/absence of M1 and the number of incisors. Within subfamilies (Felinae and Pantherinae), felines show more variation in the presence/absence of P2, but pantherines show more variation in M1. Loss of some incisors (usually loss of 1 or 2) was present among felines, but not among pantherines. Among felid lineages, P2 variation was diverse; commonest in the Lynx lineage, followed by the Caracal lineage. M1 variation was highest in the Panthera lineage. Some of this variation may be due to lack of a tooth germ in the lamina, damage/resorbtion of a tooth germ, fusion to a neighboring germ, and/or from retention of the eruption process of a completely formed tooth, or even ancestry, as there is also the possibility of linkages between phenotypically active and inactive traits. Inactive traits may become phenotypically active on occasion, affecting their frequencies among taxa. Higher frequencies may provide clues to the possible evolutionary loss of these teeth among non-Lynx felids.

Comparing Bladderwort trap morphology: adaptations for suction feeding in aquatic species

Melissa Jauregui, Ulrike Muller

Bladderworts (Utricularia spp.) are a diverse genus of over 200 carnivorous aquatic and terrestrial plants that use suction traps to capture microscopic prey. Hydrodynamic theory predicts that suction feeding is ineffective at very small sizes, supported by studies on larval fish, yet bladderworts operate near this limit. Studies on adult fish show that mouth size and shape strongly influence suction performance. In bladderworts, the trap entrance (funnel) varies widely, from long tubes to short nozzles. Although trap mechanics have been studied extensively, little work has examined comparative morphology, particularly funnel shape and size across species. To address this, we mapped funnel shapes from illustrations of more than 100 species in a taxonomic monograph, with multiple scorers digitizing the same set of images. We hypothesized that more derived species would show hydrodynamically optimized funnels, short and slightly contracting, with a larger outside than inside opening. Our findings support this: ancestral terrestrial species typically have long funnels with diverse shapes, from expanding to straight or contracting. In contrast, derived aquatic species consistently exhibit short, slightly contracting funnels. These observations align with the hypothesis that aquatic bladderworts possess traps better suited to generating strong suction flows. This morphological study will guide hydrodynamic experiments with mechanical models to test how funnel shape and length affect suction flow. Next, we will validate our illustration based data against fresh trap specimens.

From field to physiology: understanding overcompensation under stress

Julia Jehn, Ken Paige

Overcompensation, where plants boost growth and reproduction after herbivory, has long challenged traditional ideas about plant–herbivore interactions. Early studies showed that damage can enhance fitness in certain lineages, and later research identified endoreduplication, the duplication of DNA without cell division, as a key mechanism. By increasing ploidy, plants gain greater metabolic capacity and flexibility, supporting improved growth, stress tolerance, and defense. This discovery connected a cellular process to an ecological phenomenon and opened new perspectives on how plants respond to multiple stressors.

My work extends this foundation through both field studies with soybeans and greenhouse experiments with Arabidopsis. I investigate how drought interacts with overcompensation by combining chlorophyll measurements, soil moisture monitoring, and clipping treatments. These studies test whether limited water affects plants' ability to recover after tissue loss, with implications for ecological theory and crop resilience. My next steps focus on a finer scale by quantifying organelle abundance, such as mitochondria and plastids, paired with metabolomic profiling. By linking organelle-level changes with overall plant responses, I aim to identify physiological and genetic pathways that enable plants to adapt and sometimes thrive under stress. In particular, the proline cycle and its role in drought tolerance represent a key pathway of focus, offering insight into how plants integrate metabolic shifts with stress resilience.

Physiological shifts in female bowhead whales over historic oceanographic and anthropogenic regimes

Jen Jelincic, Josh Reed, Matthew Rogers, Leslie New, Danielle Dillon, Nadine Lysiak, Alyson Fleming, Daniela Mello, Piper Thacher, Autumn Gray, C. Loren Buck, Kathleen Hunt

Long-lived marine mammals such as bowhead whales (Balaena mysticetus) provide rare opportunities to examine physiological responses to past environmental and anthropogenic pressures. Using baleen plates from six adult females, we reconstructed up to 18 years of longitudinal profiles per individual for eight analytes: corticosterone, cortisol, dehydroepiandrosterone and its sulfated form (DHEA(S)), progesterone, testosterone, triiodothyronine (T3), and bulk carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$). These records spanned three distinct periods: the 1850s–1870s, marked by commercial whaling and a warm Pacific Decadal Oscillation (PDO) phase; 1940s–1960s, a cold PDO phase with Arctic stability and multiple La Niña events; and 1970s–1980s, which included a major PDO shift and strong El Niño events. We identified 1–8 putative pregnancies per individual, with variation in gestation length (13–21 months), calving interval (8 months to >4 years), and apparent pregnancy or calf loss. During pregnancy, all hormones were elevated except T3. The 1940s–1960s were physiologically distinct, with significantly lower progesterone and DHEA(S), suggesting altered pregnancy dynamics during Arctic stability. By contrast, the 1970s–1980s showed increased progesterone despite continued T3 decline, possibly reflecting energy balance changes. Concurrent increases in $\delta^{15}N$ and $\delta^{13}C$ indicate shifts in foraging ecology, including baseline enrichment, prey composition, or habitat use. These findings highlight baleen as a biomonitoring tool and reveal reproductive plasticity and physiological responses of female bowheads to environmental change.

The early evolution of high-frequency hearing in reptiles

Kelsey Jenkins, Rachel Fleming, Juan Daza, Hans-Dieter Sues

In reptiles, the middle ear is characterized by a single bone: the stapes. Reptiles that detect high frequencies typically have a slender stapes. Conversely, Permian stem reptiles are often characterized by stockier stapes and are thought to detect low-frequency sounds via bone conduction. As a result, stem and early crown reptiles were placed into one of two hearing categories: low-frequency vs. high-frequency. Based on gross observations of the stapes and outer ear region of fossils, it was suggested that tympanic hearing independently evolved in each major lineage of reptile (Lepidosauria, Archosauria, Testudines). However, the stapes of stem reptiles are morphologically diverse, suggesting a wider range of hearing abilities than previously appreciated, which has direct implications for how we interpret the early evolution of hearing in reptiles. To explore the function of pan-reptilian stapes, we used harmonic response analyses (a type of finite element analysis) and morphometric analyses. We found that the evolution of a slender stapes and tympanum in crown reptiles was facilitated by the formation of the annular ligament, increasing stapedial mobility. Our results indicate that an array of hearing abilities were present in the ancestors of modern reptiles, and that the common ancestor of reptiles could likely hear higher frequencies than previously appreciated.

Effects of thyroid hormone and dexamethasone on Xenopus metamorphosis

Lauren Jesmain, Ravi Pavana, Elizabeth Walsh, Rachel Jorgensen, Alex Schreiber, Jerianne Stephens

Amphibian metamorphosis is accompanied by rises in endogenous glucocorticoids (GC) and thyroid hormones (TH) that may interact to modulate development of diverse tissues. We treated Nieuwkoop and Faber (NF) stage 54 prometamorphic tadpoles with TH (3nM T3) and the pharmacological GC analogue dexamethasone (DEX, 2uM) for 4 days, individually or in combination, and measured the effects on various morphological parameters. Interestingly, compared with TH treatment alone, TH+DEX significantly accelerated gill resorption, tail resorption, olfactory nerve shortening, and snout-vent shortening. By contrast, TH+DEX did not significantly influence growth of the brain or limbs compared with TH alone. These findings suggest that GCs preferentially accelerate developmental programs associated with cell death and resorption over cell proliferation and growth.

Phenotypic differences across the native and invasive ranges of the western mosquitofish

Hanna Jewell, Rachel Berg, Julian Torres-Dowdall

Our predictions of the potential impacts of global environmental change on biodiversity are limited by our understanding of how organisms will respond to such changes, but are crucial as climatic changes are realized. Species with wide latitudinal ranges provide a valuable opportunity to study how organisms adapt over long time periods to existing environmental variation. When those same species are introduced into new regions, their invasive populations create parallel evolutionary experiments in which a small gene pool is rapidly exposed to novel environments. Together, native and invasive latitudinal range studies allow us to better understand the extent of phenotypic variation and the relative time scales that it is realized under. Thus, studying both native and invasive latitudinal ranges can offer insight into potential climate change responses. Gambusia spp. provide such a study system. However, there has been little effort to compare and connect the patterns of phenotypic variation in their native and invasive ranges. Here, we report our findings on the phenotypic variation that exists within the both native and invasive ranges of the western mosquitofish. We found that responses in traits including fecundity, reproductive allocation, and size differ in both strength of response and direction in the native and invasive ranges, providing insight into how organisms may respond adaptively or maladaptively to climate change.

The effect of changing floral density on pollinator networks in a subalpine meadow environment

Ruby Jewett, Alden Sears

Plant-pollinator networks shape flowering plant populations across the world. Ecosystems face increasing challenges that decrease floral density and threaten to restructure plant-pollinator networks. The responses of these networks will play a critical role in the fates of plants. Pollinators make foraging decisions to optimize the foraging cost/benefit ratio based on factors including energy expended and gained. The loss of a single generalist plant species disproportionately impacts the pollinator network, decreasing visitation rates to surrounding plants. However, it is unknown how the concurrent decline of multiple flower species might affect the pollinator community and network. Understanding the impact of floral density on pollinator networks is critical for

predicting the effects of ecosystem change. We applied clipping treatments to thirty-six eight-by-eight meter plots to create gradients of floral density for four wildflower species. Pollinator observation data was used to quantify pollinator community variation across plots and calculate network metrics to understand the impact of floral density on the pollinator network. Our findings suggest that changing floral density affects pollinator composition, total pollinator visits, and visitation rate, and has no effect on nestedness or specialization. This has implications for the ability of plant-pollinator networks to withstand future threats because these relationships have the potential to increase or decrease plant resilience, an outcome that will help determine the fate of plant populations as they respond to environmental change.

A riddle wrapped in a mystery inside an enigma: what are hydrothermal vent animals looking at?

Sonke Johnsen, Alyvia Martinez Zoroya, Umut Ayoglu, Jonathan Cohen, Heather Bracken-Grissom, Tamara Frank

The visual ecology of deep-sea hydrothermal vent communities has remained puzzling since the sites were discovered in 1977. First, because the water can reach temperatures greater than 400 C, the vents emit substantial infrared radiation. However, previous light measurements at vents have also shown unusually high levels of visible radiation that has been attributed to either triboluminescence or bioluminescence. Finally, the eyes of the alvinocarid shrimp that dominate Atlantic vents sites are enormous but highly modified to the point where it is unclear whether they see at all. Thus it remains an open question whether visual cues are at least partially responsible for recruitment to these ephemeral communities. We visited the Lucky Strike vent field (depth 1700 m) on the mid-Atlantic Ridge near the Azores and examined them for the presence of bioluminescence in three ways. First, we collected each animal species found on the vent and tested them for light emission. Second, we used low-light video to test whether plankton impinging on vent chimneys emitted light, as is seen in other benthic habitats. Finally, we performed multiple bioluminescence transects right above the vents and at 750 m depth. All three tests showed no triboluminescence and almost no bioluminescence at this site. Given the lack of other sources of visible light, the possibility for infrared vision is explored.

Individual and collective podial ground reaction forces measured in locomoting sea stars

Amy Johnson, Olaf Ellers, Matthew McHenry

Measurements of ground reaction forces have offered critical insight into the mechanics of terrestrial locomotion, but the extent to which these forces explain underwater legged locomotion of animals that may use hundreds of appendages is unclear. Therefore, we measured ground reaction forces of individual or groups of sea star podia (tube feet). We designed a sensitive underwater force beam from acetate sheets and measured its deformation with lasers to quantify forces simultaneously in the travel and vertical directions during sea star locomotion across the force platform. The platform was scaled such that one or a few podia stepped on it at a time. Simultaneous filming from the side and below allowed us to link force measurements with body and podial kinematics. Many force traces resembled classic terrestrial stepping forces, with horizontal breaking and accelerating forces and vertical lifting forces. Other patterns were distinct: some podia stepped without accelerating or breaking forces, or contributed negligibly to vertical lifting forces, while others pulled briefly upward when adhering. In an underwater setting where flow may threaten dislodgement, occasional adherence during locomotion may be essential. In general, horizontal and vertical forces were of similar magnitude. We also found that a single podium out of hundreds of podia may support 10% of a sea star's weight, forces varied systematically along rays, and closely adjacent podia created complex aggregate forces.

Post-metamorphic neurogenesis in the nudibranch Berghia stephanieae

Emma Johnson, Zahraa Salloum, Harshada Sant, Jorge Perez-Moreno, Paul Katz

Individually identifiable neurons are the hallmarks of brains in many invertebrates. The developmental origins of many identified have been determined in the fruitfly, Drosophila melanogaster, and the nematode, Caenorhabtis elegans. The brains of gastropod molluscs contain individual neurons that can be reliably identified across individuals based on gene expression and soma location, however their developmental origin is not known. In the gastropod Berghia stephanieae, the number of neurons in the brain increases ten-fold after metamorphosis. Many of the newly born neurons are individually identifiable. In this project, we have attempted to determine when neurons recognizable by neuropeptide expression are born. 5-Ethynyl-2'-deoxyuridine (EdU) was pulsed on at varying times during larval or juvenile development. The brain was later examined using in situ hybridization chain reaction (HCR) with probes labeling the genes coding for neuropeptides and markers of neurogenesis. We found that the hox-like gene, Prox1, which is a common marker of neurogenesis, was expressed by cells in the cerebral and pleural ganglia of adults. In addition to the brain, we plan to examine peripheral neurons in the rhinophores and oral tentacles. In gastropod embryos, neurons are born in the epithelium. We expect to find neurogenesis limited to the periphery in juveniles as well. By determining when and where neurons are born and differentiate, we hope to understand the origin of identified neurons in gastropods.

Birds of Mordor: severe wildfires alter behavior-fitness relationships in a ground-nesting songbird

Jacob Johnson, Yiran "Ryann" Su, Thomas Hahn, Andrew Sih

As fire regimes accelerate worldwide, understanding how animals cope with the after-effects of fire is increasingly critical. We studied interactions between behavior and performance indices from 2023-2025 in the Dark-eyed Junco (Junco hyemalis), a ground nesting songbird, examining how the interplay of behavioral type and individual performance shifted within and between fire-affected and unburned study sites, as well as how time-since-fire impacted these relationships. Using the aftermath of the record-breaking 2021 Dixie Fire as the background for a natural experiment, we compared individual territorial aggression with key performance indices of territory quality and body condition in both burned and unburned habitat throughout Lassen National Forest. Our findings suggest that territorial aggression had a much stronger relationship with performance indices in postfire habitat compared to unburned habitat, suggesting that burned environments may favor individuals with highly aggressive behavioral types via competition for rare high-quality territories. We likewise found much higher variance in territory quality in postfire study sites, with a corresponding increased variance in behavioral performance for postfire birds. We highlight how extreme environments may reveal a functionality behind variable behavioral types that can otherwise be experimentally elusive, and provide potentially useful information for conservationists, who may benefit from being aware of shifting territoriality and social dynamics in songbirds living in fire affected areas.

Outer retinal ribbons: bipolar cell dendrites join the synaptic dialogue

Laurence Johnson, William Grimes, Konan Sakuta, John Ball, Wan-Qing Yu, Wei Li, Jeffrey Diamond, Steven DeVries, David Berson, Jordan Renna

The transmission of visual information through the retina is supported by the ribbon synapses found in the terminals of rod and cone photoreceptors and bipolar cells. Synaptic ribbons enable bipolar cells to engage in fast, sustained glutamatergic signaling, sending outer retinal inputs from rods and cones to amacrine and ganglion cells in the inner retina. Using serial block-face electron microscopy (SBEM), we have observed ribbon synapses in the dendrites of bipolar cells, forming a previously unrecognized synaptic layer. Here, we seek to determine the cell types that express these ribbons, what circuits they modulate, and in which species they are present. Connectomic reconstruction revealed that dendritic ribbons are present in both ON and OFF bipolar cells

in a type specific manner in mouse, macaque, and human retinas, with their distribution varying across species. These synapses commonly contact horizontal cell axon terminals and rod bipolar cell dendrites, suggesting a potential role in modulating rod-driven signals. Our findings reveal an additional layer of processing in the outer retina, and the presence of these structures across species suggests an evolutionarily conserved role for shaping photoreceptor input and supporting scotopic vision in mammals.

Optimizing regeneration success of larval clones in the brittlestar *Ophiopholis aculeata*

Maclaren Johnson, Jonathan Allen

Brittlestars are among the most abundant animals in the ocean, occurring in benthic habitats at densities up to 3000m-2, but their reproductive potential remains poorly understood. The daisy brittlestar, Ophiopholis aculeata, exhibits multiple modes of larval cloning via 1) autotomy of the distal tip of larval arms and 2) release of posterolateral arms at settlement. Larval cloning modifies an already complex life cycle and potentially increases the reproductive capacity of echinoderms. Our first goal was to assess the frequency of regeneration success for both cloning modes at three different temperatures (12°C, 15°C and ambient temperature of ~18°C) for a population in Casco Bay, ME. Our second goal was to compare these regeneration frequencies with prior studies of a population from Friday Harbor, WA. We found that arm pairs are more likely to regenerate than autotomized arm pieces and that lower temperatures increase the frequency of regeneration success in arm pairs. Arm pieces of WA larvae were much more likely to regenerate than ME larvae but ME larvae were more likely to drop their posterolateral arms. Lastly, we treated both clone types with 20mM LiCl to upregulate Wnt signaling during regeneration, but found no evidence that this treatment increased the likelihood of successful outcomes. We hope to further develop O. aculeata larval cloning as a model system for studying regeneration and life history tradeoffs in echinoderms.

SQUEAK: a scalable RFID based station for individual-level monitoring of small mammals

Madison Johnson, Liam Stanley, Ben Olsen, Albert Bae, Tracy Burkhard

Many of the most interesting questions in ecology and evolution require individual-level data; however, for many species, especially small, nocturnal mammals, conventional monitoring methods like telemetry or semi-natural enclosures are laborious, expensive, or limited in their application and insights. Moreover, popular capture–recapture techniques inherently disrupt natural spatial activity patterns and behavior. Here, we introduce the Station for the Quantification of the Uncaged Ecological Activities of Kritters (SQUEAK). The SQUEAK is a low-cost and highly customizable system that pairs open-source tools (Raspberry Pi, CAD software) with RFID technology and trail cameras to noninvasively monitor free-living mice and other animals. Focal animals are captured, subcutaneously injected with a small (1.25x7mm) and battery-free RFID tag, then released. Focal animals are likely to encounter the SQUEAK during normal foraging activity; the SQUEAK automatically detects these encounters and records individual identity and time of visit. In this study, we validate the SQUEAK in both laboratory and field settings, finding that it reliably records animals across a range of velocities (>85% accuracy max velocity) and weather conditions. Finally, we demonstrate two of its potential applications in ecology: building social networks and studying animal personality. Our system increases the tractability of studying small mammals and other elusive species; further, its compatibility with a variety of accessory sensors allows for a wide range of research applications.

Fun-sized HybSeq: Advancements in target capture sequencing for plant conservation genetics

Matt Johnson, Madison Bullock

The use of targeted DNA sequencing, especially from universal probe sets, has been adopted widely for phylogenetic studies. There are many advantages to HybSeq, including the highly repeatable generation of sequence information from hundreds of low-copy nuclear loci from both fresh tissue and herbarium specimens. However, applications of "HybSeq" at and below the species level have been limited by cost and availability of appropriate analytical methods. Here we describe two methodological advancements to make targeted sequencing projects within plant species feasible. We developed a protocol for miniaturizing high throughput sequencing library preparation, drastically reducing sequencing costs. For data analysis, we developed HapPySNP, a workflow for generating microhaplotypes from targeted DNA sequences that extracts more genetic diversity information per locus than SNPs alone. We describe applying our methods to assessment of genetic diversity of two range-restricted endemic flowering plants and their more widespread congeners using Angiosperms353 data from hundreds of samples.

Tobacco exposure effect on skeletal muscle DNA following superoxide dismutase inhibition

Sam Johnson, Amber Schlater, Sophia Ansello, Jadyn Lind

Tobacco exposure is a known major contributor to carcinogenesis. Specifically, nitrosamines are the cancer-causing agents, in part due to increased reactive oxygen species (ROS). The electron transport chain naturally creates ROS and free radicals, but their buildup creates oxidative stress that leads to altered cellular membranes, proteins, and DNA. Certain enzymes prevent free radical buildup and convert them into useful metabolic byproducts. One such enzyme is superoxide dismutase (SOD). It converts free radicals into hydrogen peroxide and molecular oxygen. This study investigates the effects on skeletal muscle DNA damage following the inhibition of SOD in the presence of a nitrosamine, using mouse C2C12 skeletal muscle cells. We used these cells for their similarities to human cells. We cultured our cells in high-glucose DMEM for two weeks before inducing differentiation with HIT media for 7 days. Following this, we exposed the cell lines for 24 hours to one of three treatment conditions: control, nitrosamine (NNN at 5 μM), or nitrosamine with SOD inhibitor (NNN+LCS-1 at 10 μM). We assessed enzyme activity to determine results and are awaiting a comet assay to assess DNA damage. Neither LDH nor COX produced statistically significant results for treatment groups compared to control. Future research should include increased treatment groups as well as varying NNN concentrations to better gauge the effects of exposure on enzyme activity and DNA damage.

Urban Hearing: A study of the relationship between air pollution and hearing sensitivity

Shae Johnston, Kelly Ronald, Natalia Gonzalez-Pech, Chisom Okogbue, John Wenderski, Liam Hanlon

The growth of urban centers poses a significant ecological challenge. Urbanization is strongly linked to air pollution, which includes particulate matter (PM)2.5, particles 2.5 micrometers and smaller. Nanoparticles, a subset of PM2.5, are small enough to bypass blood-gas and blood-brain barriers, potentially via sensory nerves such as olfactory and auditory. Hearing loss is associated with air pollution in humans and model species, but whether environmental nanoparticles alter hearing sensitivity remains unknown. Songbirds are unique because they persist in urban areas at higher rates than other taxonomic groups, have notably thin blood-gas barriers, and are highly sensitive to airborne contaminants. This study tested the impact of iron oxide nanoparticle (IONP) exposure on hearing in house sparrows (Passer domesticus). Birds were captured from locations around Holland, MI, USA, and auditory brainstem response (ABR) tests were conducted before and after exposure in a pre versus post test design. Birds experienced either chronic (50 hours over 10 days) or acute (2 hours, single) aerosolized IONP exposure. We predicted that IONPs would reduce hearing sensitivity, with stronger effects under chronic exposure. Our findings contribute to understanding how nanoparticles influence songbird hearing, which is significant as North American songbirds have declined sharply in recent decades. These results also highlight potential implications for air quality standards relevant to both humans and wildlife.

Understanding antibody dynamics in the wild

Anna Jolles, Brianna Beechler, Ricardo Reyes Grimaldo, Jan Medlock

The dynamics of adaptive immune responses against infectious diseases in natural host populations are poorly known because time series of antibody

titers within individual hosts are hard to collect for most species. We measured antibody responses to a suite of 10 respiratory pathogens in a herd of African buffalo in Krueger National Park, South Africa. We sampled the study herd every 2-3 months for 3 years, resulting in a serological time series, which we utilized to (i) estimate the duration of immunity for our focal pathogens, (ii) test for positive (synchronized) or negative (prioritization) correlations in the timing of the loss of immunity, and (iii) evaluate demographic, environmental and physiological factors that might affect the timing/rate at which immunity to each pathogen is lost. We demonstrate that antibody longevity is extremely variable across pathogens. For the acute pathogens we studied, correlations in the timing of antibody loss were overwhelmingly positive, indicating synchronization. By contrast, the three chronic pathogens we studied displayed opposite (negatively correlated) patterns. The loss of antibody protection was driven by seasonal variations in body condition and forage availability. Metabolic and behavioral host factors and associations in the incidence of some of the pathogens are likely to contribute to these patterns. This study is one of the first to describe variation in antibody dynamics against a range of different pathogens in a natural mammalian population, addressing a critical empirical data gap that is foundational to construct meaningful disease dynamic models for infection risk forecasting and management.

Urban influence on butterfly wing morphology: A study of pollution's reach

Ashley Jones, Kainen LaPlante, Carl Grobe

Pollution is known to affect organismal growth, but its specific impact on morphological traits such as wing size in butterflies remains underexplored. Cabbage White Butterflies are ideal for studying environmental effects of pollution, as they have short life cycles that allow us to detect how they adapt to the changes pollution creates. In this study, we investigated whether butterfly wing length and width varies with proximity to urban environments, which should have higher pollution levels impacting food availability. We hypothesized that butterflies from urban areas would exhibit smaller wings due to developmental stress from air pollution, reduced food quality, and other urban environmental factors that could impair larval growth. Using iDigBio.org to collect digital specimen images, we selected 40 butterflies. These samples included 20 urban butterflies (from the UK, US, and Japan) and 20 rural butterflies (collected approximately 45km away from city samples). Sample collection year ranged between 1979 and 1986. Wing measurements were taken using ImageJ and geographic distribution was visualized with QGIS. We performed a two-sample t-test to compare wing dimensions between urban and rural butterflies. Our results showed no significant difference ($p>0.05$), possibly due to the small sample size. While inconclusive, this study lays the groundwork for larger-scale analyses, which could enhance our understanding of how urbanization affects organismal development and might parallel developmental impacts in human populations.

The impact of priority effects on strain level composition in a core honeybee symbiont

Korin Jones, Yulin Song, Sabrina Rinaldi, Nancy Moran

Dispersal is understood to be an influential process in host-associated microbial community assembly. Few experimental studies, however, have specifically investigated the role of dispersal timing and how the resulting priority effects impact microbiome composition. The species composition of the honeybee gut microbiome is largely consistent across individuals, hives, and localities. However, strain composition varies, among hives and among individual bees within a hive, a potential consequence of priority effects. Here, we targeted a core honeybee symbiont, Snodgrassella alvi, to understand if priority effects influence strain-strain dynamics. We selected two strains that differed in presence of a Type VI Secretion System (T6SS), as the T6SS can influence strain-strain competition. We additionally included a T6SS knockout strain to understand if observed outcomes were due to T6SS possession. We sequentially inoculated microbiota-deprived, newly emerged bees with two strains of S. alvi carrying different fluorescent markers. Initial strains were given either 1 or 5 days of priority before the second strain was introduced. By counting colony-forming units from gut homogenates, we found five days of priority led to the exclusion of secondary colonists regardless of T6SS possession. Additionally, a T6SS-lacking strain that was routed during simultaneous co-inoculations persisted when given 24 hours of colonization priority. These results provide empirical evidence of the relative roles of dispersal timing and bacterial weaponry in determining strain composition in the honeybee gut microbiome.

Quantifying differences between ornamentation of paper nautilus (Argonauta) shells across species

Megan Jones, Kathleen Ritterbush, Nicholas Hebdon

Paper nautilus (Argonauta) are open-water octopus with a unique feature. The females biomineralize an egg case that forms a rigid hull they swim with throughout their life. Lacking an outer covering of protein like typical mollusk shells, Argonauta egg cases are potentially more susceptible to ocean acidification. These egg cases grow with a delicate ridged along the flanks and venter, creating patterns that vary across species and morphotypes. Here, we investigate ornamentation variance within and between species.

We use 3D surface scans to create digital models of Argonauta egg cases across three different species: Argonauta nodosa, A. hians, and A. argo. We use a log spiral fit analysis to characterize ornamentation, including rib amplitude and wavelength with respect to accretionary growth. Generally, rib coarseness corresponds to a narrow range of egg case aspect ratios within species (and along ontogeny), but the relationship between ornament and shape varies markedly between species. Characterizing the ornamentation on Argonaut egg cases will aid study of fluid dynamics, growth, and material properties of these unique structures. We discuss possible hydrodynamic consequences of these features, and speculate that certain ornament-morphotype associations provide advantages for locomotion in different marine habitats. Finally, we present streamline observations from computational fluid dynamics simulations on key specimens to refine the framework of further tests.

Developmental mode and anuran functional trait evolution: inferences from novel comparative methods

Menna Jones

Ongoing comparative methods development enables the exploration of increasingly complex evolutionary trends and interpretation of their underlying biological scenarios. Methods may accommodate trends that are not only random, directional, and bounded, but also heterogeneous across time, space, and defined evolutionary regimes. However, statistical assumptions are often overlooked when building these models, questioning the soundness of biological interpretations drawn from them. Fair relative model evaluation of a suite of candidate models requires that models share both a method of likelihood calculation, and a state space upon which they are defined. Despite this, violations of these criteria are widespread in studies of continuous trait evolution and require addressing. Here I introduce a novel set of discrete, multi-regime comparative models designed to alleviate the aforementioned issues. This includes the first discrete-space Ornstein-Uhlenbeck (OU) model, as well as implementations of both reflected and absorbing bounded Brownian motion. I will use these models to explore the influence of reproductive mode development on functional trait evolution across Anura. I expect that for key traits, direct-developing lineages will be more loosely bounded than biphasic individuals, reflecting relaxed constraints of potentially conflicting pre-and post-metamorphosis functions.

Environmental stressors exacerbate disease by impacting constitutive and induced coral immunity

Nicholas Jones, Sydney Dutton, Lauren Fuess, Erin Shilling

Coral reefs are immensely biodiverse ecosystems, providing countless economic services. However, these important ecosystems have faced rapid decline in recent decades due to mass mortality of foundational hard coral species. This mortality is largely driven by rising sea surface temperatures and disease, and these changing environmental conditions have been known to exacerbate coral disease susceptibility. Here, we evaluated the impacts of environmental conditions on host susceptibility to an emergent coral disease,

Stony Coral Tissue Loss Disease (SCTLD). Statistical modeling was used to identify environmental covariates of disease susceptibility and indicated two main drivers of susceptibility: temperature and chlorophyll-a concentration (i.e., nutrient enrichment). To experimentally validate the impacts of these factors on immunity, we exposed fragments of Montastraea cavernosa to a combination of heat and nutrient treatments for one month. At the conclusion of this period, corals were exposed to Vibrio coralliilyticus, a known coral pathogen, and their immune activity was evaluated with a suite of biochemical assays. Our results suggest that temperature strongly influences baseline immunity; corals exposed to increased temperature had lower constitutive activity of most immune metrics. In contrast, nutrient enrichment primarily impacted response to disease, with corals exposed to low and high levels of nutrients demonstrating reduced induced immunity. Our results are an important step towards an improved understanding of environmental impacts on disease with strong implications for future management.

Impacts of warming on the stress response of Arizona tiger salamanders (Ambystoma mavortium)

Rachel Jones-Lord, Catherine Propper, Amanda Carter

Amphibians are declining globally, with 40.7% of species threatened by disease, habitat loss, and climate change. A common mechanism linking these threats may be physiological stress, as chronic elevation of corticosterone (CORT) can impair immunocompetence, reproduction, and survival. Despite this, research on amphibian stress responses is limited. We tested how climate change – specifically warmer temperatures – may act as a chronic stressor in the amphibian, Ambystoma mavortium. We measured the interplay between warmer temperatures and CORT using two studies: a field study that took advantage of Arizona's diverse thermal gradients, and a controlled lab study that directly manipulated temperature. CORT was collected using minimally invasive dermal swabs and quantified using ELISA. We hypothesize that warmer conditions will elevate baseline CORT and exaggerate acute stress responses in salamanders from both field and lab studies, relative to cooler sites and controls. Our results will provide insight into how A. mavortium and other amphibians are responding to thermal stressors and, more broadly, how physiological stress may impact their ability to cope with other stressors in the future. If elevated temperatures increase CORT, this could suggest that physiological stress is a common mechanism driving amphibian population declines. Ultimately, this work will help advance our understanding of amphibian resilience under climate change and inform conservation strategies aimed at mitigating population declines.

Environmental and hormonal regulation of septate junctions in the renal tubules of larval mosquito

Sima Jonusaite, Molly Cummings, Sydney Looney

Relatively little is known of the regulation of renal structures, the Malpighian tubules (MTs), of freshwater (FW) larval mosquito Aedes aegypti in response to increased environmental salinity occurring due to climatic and anthropogenic factors. We recently reported salinity-induced changes in the expression of epithelial paracellular transport regulating septate junction (SJ) proteins in the MTs of A. aegypti larva which occurred with altered SJ permeability.

This study examined how larval tubule SJs are affected by the brackish water (BW) rearing and a diuretic neuropeptide leucokinin-VIII (LKVIII), known to increase SJ permeability to Cl- in the tubules of adult A. aegypti. We found that LKVIII stimulated fluid secretion by tubules isolated from FW- and BW-reared larvae but had salinity-dependent effect on tubule SJ permeability to [3H] PEG-400. Specifically, the tubules from FW-reared larvae showed a significant decrease in PEG-400 permeability whereas BW tubules were more permeable to PEG-400 in response to LKVIII. In addition, salinity increased tubule SJ protein mRNA abundance but the actions of LKVIII led to upregulation of select SJ components in FW and downregulation in BW.

Taken together, data provide first evidence of the regulation of larval A. aegypti tubule SJ molecular structure and permeability by LKVIII. This likely serves to fine tune the function of larval MTs under varying salinity contributing to the ability of this disease vector to cope with environmental changes.

Tricking bees with tripwires: can bumblebees update their concept of self size?

Katherine Jordan, Yashvi Monani, Stacey Combes, Wilsaan Joiner

An accurate mental representation of one's body size can be crucial in avoiding collisions when navigating through complex environments. Several animals, including cats, dogs, and insects, have demonstrated self-size representations. Among insects, these representations are fixed in some species, but can be updated in others. Bumblebees are holometabolous, so they do not interact with the environment until they are fully grown. However, foragers transport heavy loads of nectar and pollen, necessitating adjustments to changes in body mass and inertia; thus, updating their body representations could be beneficial. Previous studies have shown that bumblebees yaw (rotate around the vertical axis) to avoid collisions when flying through narrow apertures. This turning behavior depends on the ratio of the individual's wingspan to the aperture width, indicating that bumblebees have an internal representation of their own size. However, whether this self-size representation is plastic remains unknown. We quantified the turning behavior of bumblebees flying through narrow apertures, then added invisible tripwires to reduce actual aperture width and cause collisions, in an attempt to induce bees to update to a larger self-size representation. We quantified bees' turning behavior over two days with tripwires in place, and then during a final day with tripwires removed, to determine whether bees can update their self-size representations. Our findings may provide insight into the plasticity and sensory mechanisms involved in internal representations of size.

Environmental zinc induces embryonic-lethal changes to fertilization envelope in *Mnemiopsis leidyi*

Elias Joseph, Orianna Duh, Yinghui Wang, Allison Edgar

Heavy metals pose significant ecological and developmental threats to animal life. The effects of heavy metal exposure on reproductive outcomes, like inhibition of reproduction and increases in abnormal development, have been well documented across many aquatic and marine phyla including Echinodermata, Mollusca, and Chordata. Ctenophores are abundant and ecologically significant zooplankton in many marine environments. Zooplankton are critical components of marine food webs. This study investigates the impact of zinc, copper, and nickel on the reproduction of a model ctenophore, Mnemiopsis leidyi. We found that low-level zinc exposure causes a specific developmental phenotype wherein embryos develop normally but are unable to hatch from the fertilization envelope. There are no other disruptions to development, the cydippids are fully formed but cannot emerge and manually hatched cydippids grow normally. This phenotype is brought on by acute exposure at the moment of fertilization and not remedied by the removal of the pollutant past that critical window. The concentrations of zinc that produce this and other developmental outcomes that inhibit recruitment in ctenophores are lower than levels that may be considered safe. Zinc pollution from industrial, urban, and agricultural sources may contribute a greater reproductive risk to many animals and to the stability of marine food webs than previously considered.

Fantastic fastening feet: regional variation in form and function of gecko adhesive microstructures

Sarah Juan, Shahrzad Dehghani, Hana Arabi, Aaliyah Roberts, Utkarsh Patil, Ali Dhinojwala, Peter Niewiarowski, Austin Garner

The subdigital pads of many geckos possess fibrillar micro- and nanostructures (setae and spatulae) that induce adhesion to virtually any surface, primarily via van der Waals interactions. Setal morphology is suspected to be critical to their adhesive functioning, as variation in shape and size can theoretically impact the ability of setae and their spatulae to generate intimate contact with a surface. Previous work demonstrated that setal shape and dimensions not only vary between species, but also along a single digit of an individual. The morphometrics of setae (e.g., length, diameter, density, resting angle) vary as a function of their anatomical position on the digit and each subdigital scale (scansor). Numerous studies have measured forces generated by individual setae and setal arrays and made setal morphological descriptions in isolation, yet few studies have attempted to experimentally bridge the gap between setal form and function. Here we explored this connection by measuring shear

adhesive stress (adhesive force per unit area) of scansors isolated from three anatomical positions (proximal, intermediate, distal) along the subdigital pads of Tokay geckos (Gekko gecko). We then used scanning electron microscopy and image analysis to measure setal morphometrics and infer connections between morphology and performance. Our work here enhances our understanding of fundamental form-function connections in the gecko adhesive system, with clear application to the development of next-generation gecko-inspired adhesives.

Generalizing thermoregulatory effectiveness metrics across space and time

Bryan Juarez, Eric Gangloff

Thermoregulatory effectiveness (E) measures an animal's ability to behaviorally regulate its body temperature relative to environmental temperatures. Current approaches use data on operative temperatures, body temperature, and a species' preferred temperature range to estimate E. Here, we seek to expand our statistical toolkit for estimating E and associated statistics. Current approaches sometimes carry limitations which we demonstrate using empirical data and simulations. For example, the most commonly applied methodology does not recognize spatial or temporal structure in operative temperatures; this yields the unreasonable assumption that all animals have access to operative temperatures available in all spaces and at all times. Additionally, skewness in operative temperatures causes the average environmental deviate (de) to be unrepresentative of the central tendency of operative temperatures. Such skewness results in statistical bias that can make the central limit theorem inapplicable and downstream inferences unreliable. Despite these challenges, we show how a mathematical reframing of the thermoregulatory process allows us to account for spatial, temporal, or other structures in the data through generalized linear mixed models. We also discuss how de (and associated measures) can be estimated with little to no bias, using medians or z-scores, and present novel diagnostics to quantify bias in existing datasets. Overall, our goal is to expand user options when estimating thermoregulatory effectiveness and we hope to inspire future methodological advances in thermal ecology.

In my prime: influence of parity on parental behavior strategies

Makenna Juergens, Nikolas Monte, Kathryn Wilsterman

Parental behavior is a highly variable trait influenced by several factors such as environment, genetics, and learned experiences. Mammals have previously been "primed" to exhibit parental behaviors, either through exposure to young or treatments with "parental" hormones, such as estrogen or prolactin. In uniparental species of small rodents, such as the North American deer mouse (Peromyscus maniculatus), only one parent provides care to offspring. Despite the fact that it is widely accepted that only the female parent provides care for offspring in this species, male deer mice have been successfully "primed" (i.e. activation of paternal neural pathways) for parenthood in previous studies by pup distress signals. We hypothesized that, when primed for parenthood by previous litters, deer mice will wean heavier pups than when individuals are nulliparous, especially with the male parent present in the cage. To test this hypothesis, we compared maternal behavior and pup developmental milestones across the duration of lactation for two litters, both between and within individuals. These data will provide further insight into the potential priming effects of pregnancy and pup rearing on parental behavior and pup development in subsequent litters.

Ground Effect in Undulatory Locomotion and Surface Pumping

Sunghwan Jung

Many organisms, such as apple snails and giant larvaceans, utilize undulating appendages to generate unidirectional flows for efficient filter-feeding and/or locomotion at the air-water interface. This undulatory motion is used for particle collection that avoids the capture of larger organisms, and for locomotion that provides stable and continuous propulsion on the fluid surface. This study investigates a bio-inspired undulatory thin-beam capable of dual functionality: horizontal pumping and surface locomotion. First, we characterize the pumping performance by measuring the resulting flow fields and identify optimal operational parameters for maximum efficiency. Second, we analyze the same mechanism for its capacity to generate thrust for surface propulsion. Our results demonstrate that this single, bio-inspired mechanism can be optimized for both particle collection and locomotion, providing a framework for understanding various behaviors of animals near the water surface.

Long-term physiological benefits from growth-period training persist into a sedentary adulthood

Derek Jurestovsky, Stephen Piazza, Jonas Rubenson

It is well known that exercise influences musculoskeletal structure in growing animals. Less clear, however, is whether growth-period exercise produces long-term physiological benefits into adulthood. We hypothesize that growth-period exercise produces higher metabolic and mechanical capacity and decreases movement effort, and that these effects persist after a non-exercise washout period in adults. 30 two-day old guinea fowl were assigned to a sedentary control group or an exercise group (treadmill training 30 min/day, five days/week for one year). Following the training period, birds were singly housed in large pens for a six-month washout (non-training) period. Birds were tested for maximal mechanical (jumping) and metabolic (running) capacity, and submaximal (running) metabolic cost at 12- and 18-months. The exercise group had a significantly higher maximal metabolic capacity and were more economical at 12 months ($p < 0.05$). The higher metabolic capacity persisted into adulthood despite a 6-month sedentary period (18-month time point, $p < 0.05$). No between-group differences in maximal jump performance were observed. These results suggest that growth-period exercise leads to dramatic and long-term changes in exercise capacity and movement effort. It may be that intense play behaviors in juveniles enhance evolutionary fitness by providing long-lasting effects on adult physical activity. Future work in this area will focus on the mechanisms underlying the changes in metabolic capacity, and may ultimately have important implications for human health.

Into the Microverse: Differential immune response to environmental microbes in an anthozoan anemone

Hannah Justin, Shivani Patel, Adam Reitzel

Viruses are the most abundant biological entities in Earth's oceans. Climate change has expanded the geographic range of marine microbes, including viruses, with direct impacts on ecosystems and their residents. Nematostella vectensis, an estuarine burrowing anemone, is an emerging invertebrate model for answering a diverse suite of biological questions related to host-microbe interactions. N. vectensis's repertoire of immune pathway genes and wide geographic distribution of genetically distinct populations lay the groundwork for insightful investigations into genetic diversity and its impact on host immune responses. Recent work has outlined interesting variability in host gene expression following exposure to lab-cultured bacteria among individuals from N. vectensis populations collected along the North American Atlantic Coast. However, there is a knowledge gap regarding N. vectensis exposure to other environmental microorganisms, specifically marine virus-like particles (VLPs). To bridge this gap, we exposed N. vectensis clone-lines collected from Florida, North Carolina, New Jersey, and Nova Scotia field sites to 0.22 um-filtered and centrifuge ultraconcentrated VLP communities collected from a novel South Carolina field site for 24 hours, measuring differential gene expression in candidate immune response pathways between populations and individual variation therein. This work aims to expand our understanding of the role of genetic variation in host immune responses to novel microbial communities and better predict adaptability of N. vectensis to VLP exposure.

Linking mechanics to performance in infant mammalian suckling

Elska Kaczmarek, Harlow Smith, Ani Smith, Dylan Anderson, Maressa Kennedy, Hannah Shideler, Skyler Wallace, Thomas Stroud, Christopher Mayerl

As the word implies, suckling uses intraoral suction to draw milk into the mouth. Infant mammals generate suction by moving their flexible, muscular tongues in a wave, acting as a peristaltic pump. However, to generate suction, they must also form a seal around the nipple. While several decades of study have focused on the mechanics of the pump, little work has investigated the biomechanics of the seal and how these interact to generate organismal performance. Our goal was to characterize the relationships between tongue kinematics, suction, and milk flow in piglets. One might expect greater tongue depression to cause greater suction and milk flow. While mechanistically true, we did not observe this as an axis of performance. Instead, greater tongue depression correlated with less suction and milk flow. When the tongue sealed strongly around the nipple, milk was acquired, but more suction built up and limited tongue depression. In contrast, a weak seal caused little suction generation and milk flow, but large tongue depression. We found that premature infants struggle to acquire milk even though they depress their tongue as much as full-term infants and that this mismatch is explained by their inability to maintain a strong seal. This emphasizes the ability to seal around the nipple as an important, understudied axis of performance and highlights the need for methods to directly quantify seal strength.

Lake Malawi Cichlids outperform neotropical species in benthic feeding

Chloe Kaelin, Khalil Russell, Peter Wainwright

Cichlid fishes have undergone extensive trophic diversification in the neotropics over many millions of years, but have generated similar ecological diversity in Africa's Lake Malawi in only a fraction of the time. Previous studies show that the morphological diversity of cichlids in Lake Malawi is less than that found in the neotropics and suggest that time may explain the difference. We contrasted the level of performance achieved by benthic-feeding trophic specialists in the neotropics and Lake Malawi. We experimentally measured suction and benthic feeding performance in seven species from the neotropics and two from Lake Malawi. Benthic trials consisted of a gelatin and crushed fish pellet mixture pipetted onto a glass surface and allowed to dry, while zebra fish fry were used as evasive prey during suction feeding experiments. Among the neotropical species, feeding ecology matched relative feeding performance, with a benthic aufwuchs feeder having the highest benthic feeding performance and a piscivore having the best performance on zebrafish. Both species from Lake Malawi far exceeded the best neotropical species in benthic feeding but had intermediate performance on zebrafish. Our results suggest that the adaptive radiation in Lake Malawi has generated species with benthic feeding abilities that surpass those of species in the neotropical radiation and have managed to escape the trade-off between elusive and benthic prey feeding that is apparent in the neotropics.

Fringe and flow dynamics: modeling baleen whale filtration

Shirel Kahane-Rapport, Karly Cohen, Cassandra Donatelli

Filtration is a fundamental challenge in engineering, solved by organisms through the evolution of specialized structures that separate particles from fluid. Baleen whales meet their immense energetic demands by processing tens of thousands of liters of seawater daily using baleen. Baleen is a dynamic, hierarchical structure, composed of straight keratinous plates that wear down to form a matted fringe of variable spacing and diameter. This complexity, combined with the animals' inaccessibility, makes in vivo study of baleen filtration difficult and presently has no human-designed analog.

We investigated how variation in fringe spacing and diameter influences flow patterns using six model configurations. Digital particle image velocimetry captured flow fields which were analyzed in MATLAB. Models with variable fringe diameters and arrangements had thicker boundary layers than models with uniform fringe structures. Thicker boundary layers generated stronger trailing edge vortices, driving particles into a larger zero flow area behind the model. The stronger vortex and larger stagnant zone caused particles to fall out of suspension; in a living whale, these particles would fall toward the throat pouch. Our results indicate that baleen fringes primarily direct rather than trap particles, shaping flow to enhance particle movement.

This study represents a first step toward experimentally modeling baleen hydrodynamics and provides insight into biological filtration principles. Understanding these mechanisms may inspire the design of novel, clog-resistant engineered filtration systems.

A timeline of mesogleal cells appearing in symbiotic and aposymbiotic Cassiopea polyps and buds

Charlotte Kahn, Cody Miner, Mark Martindale

Cassiopea, or upside-down jellyfish, are scyphozoans in the phylum Cnidaria. Similar to coral, they have a photoendosymbiotic relationship with dinoflagellates. Cassiopea take in dinoflagellates through their oral cavity, and the symbiont cells are then phagocytosed by host cells in the gastrodermis. These symbiocytes can then migrate to the mesoglea, which is a collagenous mesenchymal layer between the ectoderm and endoderm. This happens through a process called epithelial – mesenchymal transitions, or EMT. We have found that aposymbiotic polyps (polyps without dinoflagellates) also contain phagocytic cells within their mesoglea, meaning that either EMT in Cassiopea can occur without cells being symbiotic, or non-symbiotic mesogleal cells are originating without EMT. I am exploring the timeline in which mesogleal cells (amoebocytes) appear in symbiotic and aposymbiotic polyps and buds by staining polyps with phalloidin and Hoechst. When we do this, we can visualize cells on a confocal microscope and see when mesogleal cells appear. This can help us answer the question of where mesogelal cells originate from. It is likely that non-symbiotic cells are able to migrate from the gastrodermis to the mesoglea, which we hope to test by labeling gastrodermal cells. We can then isolate the mesoglea to see if any labeled cells are asymbiotic, which would indicate that host cells are able to undergo EMT without a symbiotic relationship.

Abundance and size distribution of two coral macroborers in Mo'orea, French Polynesia

Ethan Kahn, Zoe Fu-Chen, Ellie Fox, Natalie Loftus

Bioerosion by boring organisms is a key process that can structure growth and survival of coral reefs. Vermetidae (Gastropoda) and Leiosolenus spp. (Bivalvia: Mytilidae) are two tropical suspension-feeding macroborers, and their local distributions are related to nutrients and particulate matter in the water column, though the details remain unclear. We surveyed these two groups on Porites lobata-like coral at nine sites in Mo'orea, French Polynesia, from within the bays to out on the reef flats. By capturing a range of environmental conditions, particularly nitrogen enrichment and wave speed, we investigated the effect of environment on macroborer abundance and size. We fit GLMMs to identify predictors of density for these two groups and found that proportion of live coral, depth, wave speed, and nutrient levels all affected density of Leiosolenus clams, but mostly did not have a significant effect on density of Vermetidae snails, possibly due to small sample size. We found that Leiosolenus is associated with live coral cover, deeper water, higher agricultural inputs, and lower wave speed, which points to a niche inside the bays and away from high wave exposure. Our data do not allow us to make strong conclusions about where Vermetidae are most abundant. High densities of Leiosolenus at sites within the bays are potentially related to feeding mechanisms, food particle availability, or competition with other macroborers.

Body-size bias in occurrence-based biodiversity datasets

Leah Kahn, Noel Heim, Craig McClain, Pedro Monarrez, Isaac Trindade-Santos, Thomas Webb, Jonathan Payne

Analyses of large, occurrence-based biodiversity datasets have greatly increased our understanding of biodiversity and evolutionary patterns. However, biodiversity data have known biases toward organisms that are large, charismatic, and/or useful to humans. These biases can limit our ability to accurately interpret evolutionary and ecological processes from

biodiversity patterns. Here, we use body-size data from extensive databases developed for fossil and extant marine animals to assess body-size bias in three commonly used occurrence-based natural history databases: the Paleobiology Database (PBDB), the Ocean Biodiversity Information System (OBIS), and the GenBank sequence database. By referencing these occurrence databases against comprehensive taxonomic lists from Sepkoski's compendium of fossil marine animal genera and the World Register of Marine Species (WoRMS), we determine the presence or absence of taxa in each database and model the probability of sampling as a function of body size. Our analyses include data for 23,311 fossil genera and 62,733 extant species, and sequence data for 70,344 species. We consistently find that taxa with small body sizes have a lower probability of being sampled. Bivalves, gastropods, and ray-finned fishes show significant associations between body size and probability of sampling across all three occurrence databases. Our findings underscore the importance of considering body-size bias when using occurrence data to study biodiversity, ecology, and evolution, both past and present.

Evolution of the undulating membrane in amphibian sperm

Ariel Kahrl

Amphibians have some of the most diverse fertilization environments of all vertebrates, ranging from internal fertilization in some salamanders and caecilians to external fertilization in anurans which can take place aquatically, in terrestrial or aquatic foam nests, on land, arboreally on leaves, and many other diverse and understudied environments. This diversity in fertilization modes has also led to a rapid diversification of sperm size and the components of the sperm across amphibians. Additionally, the morphology of amphibian sperm exhibits novel structures, such as an undulating membrane which runs along the flagellum. Within the undulating membrane is an axial fiber, and a membrane that connects the fiber to the axoneme. The axial fiber is larger in internal fertilizing species and species with more terrestrial fertilization (rather than aquatic), suggesting that this structure is required for navigating higher viscosity media. These components also evolve at different rates, likely in response to differences in the selective pressures from different fertilization modes. Specifically, the axial fiber evolves at almost 10x the rate of the undulating membrane width and very conserved axoneme width.

Does dewlap display intensity vary across social contexts in anole lizards?

Khushi Kakadia, Riya Vankamamidi, Michele Johnson

Across animal taxa, many species exhibit elaborate visual displays to communicate with each other, particularly during aggressive and reproductive encounters. Male and female Anolis sagrei (brown anole lizards) communicate through extensions of their colorful throat fans, called dewlaps. Dewlap extensions - in combination with pushups, headbobs, and other modifying display elements - are used by males and females in interactions with others of the same and other sex. While we know this structure plays a crucial role in sexual and social behavior, whether the intensity of dewlap display (i.e., the degree to which the dewlap is fully extended) differs among these contexts has not yet been examined. In this study, we measured dewlap extension in male-male, male-female, and female-female interactions in standardized laboratory trials. These trials were filmed, and the number, duration, visual intensity, and area of each dewlap extension were extracted from the recordings. Preliminary results indicate no difference in the number, duration, or visual intensity of dewlap extension across different social contexts. These results support our understanding that the same animal behaviors may have different meanings in different social environments.

New methods for quantifying 3D muscle architecture in embryos: A case study in corn snakes

Madison Kalter, Anthony Pellicano, Vladimir Grubisic, Brian Beatty, Daniel Blackburn, Julia Molnar

Muscles and bones interact with each other over the course of an animal's life, and the influence of muscle forces on the skeleton may be greatest during embryonic development. However, due to the difficulty of measuring embryonic muscle using traditional dissection-based methods, muscle architecture is known in only a few model species (chicks, mice, and humans). In this study, we investigated two methods for 3D visualization of muscle fascicle development in the jaw muscles of embryonic corn snakes (Pantherophis gutattus). In the first method, specimens were embedded in paraffin wax, sectioned, stained, and imaged using an Axio Observer microscope, and image slices were aligned in Amira software. In the second method, specimens were fixed, stained with monoclonal antibody MF20 using double immunohistochemistry, and imaged using a Nikon C2 confocal microscope. While both methods produced high resolution 3D images of muscle fibers, the thin sections required for histological staining resulted in missing data between the slices, disrupting the path of the muscle fibers. In contrast, antibody staining allowed imaging of the entire jaw muscle group in a single image stack, suitable for quantifying muscle volume, fascicle length, and fascicle orientation using fiber tracing algorithms. This protocol will broaden the scope of species and developmental stages that can be analyzed, revealing more about how muscles and bones interact with each other both evolutionarily and developmentally.

Molecular (RNA) foundations of habituation in aneural systems

Cedric P Kamaleson, Nimra Khan, Saad Bhamla, Saumya Sarkar

Learning in living organisms is characterized by its ability to detect and process external stimuli, thereby facilitating decision-making, adaptability, and behavioral plasticity. Identification of molecular engrams underlying memory and cognitive adaptation is an active area of research, with particular focus on habituation, the simplest and most widespread form of learning, defined as a cognitive process in which an organism diminishes its response to a repeated, non-threatening stimulus. Although learning via neuronal plasticity is typically associated with higher organisms, evidence indicates that cognition can occur even without essential neural components. A striking example is the ciliate Spirostomum ambiguum, which exhibits habituation by attenuating its contractile response to repeated mechanical stimulation, demonstrating an aneural form of learning. In this investigation we aimed to molecularly characterize habituation, with special focus on RNA as the putative molecular engram. To achieve this, we carefully designed a stimulus-delivery apparatus that allowed us to train Spirostomum populations under controlled conditions, thereby inducing short-term memory acquisition and habituation. We then performed temporal measurements of differential RNA expressions, spanning bulk, nascent, and non-coding RNA species. Our observations indicate distinct and rapid shifts in RNA production during habituation, which may be attributed to the transcripts/RNAs functionally linked with short-term memory acquisition. These RNA dynamics suggest a mechanistic role in regulating behavioral plasticity and shaping the emergent organismal phenotype, underscoring their potential as drivers of learning.

Arboreal activity, canopy cover and body mass shape pelage patterns in squirrels

John Kamerer, Edu Guerra, Emma Carney, Sharlene Santana

Coloration is an important morphological feature, as it facilitates thermoregulation, communication, and concealment. Sciuridae (squirrels, chipmunks and marmots) displays remarkable pelage diversity, including variation in patterns, countershading, and pigment intensity/distribution. We conducted a family-wide study of pelage traits to investigate if there is a relationship between coloration traits and geography, habitat, and predator avoidance in sciurids. Using a standardized protocol, we collected museum specimen images to generate data on pattern (stripes, spots, none, etc.), countershading (contrast between dorsal and ventral color), and position/sharpness of color transitions. Additionally, we used literature to collect morphological and ecological data, including relative tail length (proxy for degree of arboreality), body mass, habitat preference, and nesting behavior. Phylogenetic analysis reveals that species with lower body mass are more likely to have stripes. Species in closed habitats, as well as those that nest in trees, have increased countershading. Also, dorsoventral color transition is nearer the ventrum and sharper in more arboreal species. These findings indicate that concealment is an integral driver in pelage evolution in Sciuridae; however, variation across all

pelage traits also has a strong phylogenetic signal. While we did not find evidence of convergent evolution in pelage coloration traits of Sciuridae, we did find that locomotion strata, habitat, and body size are ecologically relevant to predicting aspects of pelage coloration.

Are aquatic invertebrates reliable sentinels of cyanotoxins?

Roberto Kannapell, Megan Schulz, Misty Peacock, Anthony Lapsansky

Aquatic invertebrates frequently serve as biosentinels of freshwater health. These animals accumulate toxins over time, allowing researchers to identify both brief and persistent forms of pollution. Cyanotoxins, toxins produced by freshwater cyanobacteria, pose an escalating threat to freshwater habitats; however, it remains unclear whether invertebrates can signal these forms of habitat degradation. Liquid chromatography mass spectroscopy (LCMS) is considered the "gold-standard" for quantifying cyanotoxins, but the varying tissue types of animals (i.e., matrix effects) can impede accurate quantification and precise comparisons between species. We quantified cyanotoxin concentrations in animal tissues collected from local lakes during periods of high microcystin – a widespread cyanotoxin. In some samples, predatory invertebrates contained 10-fold greater microcystin concentrations than their prey, while in other cases the opposite was true. To explore these conflicting results, we tested whether there is a significant effect of phylum on microcystin recovery. We spiked tissue samples from different phyla with specific amounts of microcystin produced by our laboratory grown culture of Microcystis aeruginosa. Then, we quantified the microcystin concentration in each sample using LCMS to determine whether the percent recovered varied significantly between groups. This information will help to determine whether aquatic invertebrates reliably signal deterioration of freshwater habitats by microcystin.

Morphologically driven swimming dynamics of the longnose skate

Alexandria Kaplan, John Michael Racy, Megan Vandenberg, Adam Summers, Bart Boom

Skates propel themselves using winglike pectoral fins that generate undulatory waves along the body. We hypothesize that their skeletal morphology, parallel rows of fin rays composed of mineralized radials, enhances locomotion by passively directing undulation through stiffness. Stiffness decreases distally down each fin ray, and the space between parallel fin rays reduces stiffness along the anterior to posterior axis of the fin. We compared swimming in a live longnose skate (Raja rhina) to the passive motion of a deceased specimen driven by a vertical linear actuator. We used motion tracking to quantify frequency, wavenumber, and amplitude. We investigated whether an undulatory wave can be passively generated without muscle activation, and at what frequencies it most closely resembled live swimming. Our results revealed: 1) for live swimming, small increases in frequency were able to significantly increase swimming velocity. 2) Frequencies of maximum amplitude responses for the live and deceased skate were similar. 3) The swimming skate had a preferred range of frequencies and wavenumbers within the range of the dead skate's response. 4) Undulatory waves were still generated in the deceased skate. These results indicated that morphology alone supports wave propagation without active muscle input. Musculoskeletal structure constrains and optimizes the swimming frequency and wavenumber, highlighting the role of passive mechanics in undulatory swimming in the longnose skate.

Evaluating iPhone photogrammetry for assessing oral morphological complexity using extant turtles

Priyank Kapur, Zariel Zamudio, Megan Vandenberg, Brenlee Shipps

Previous studies have found a strong correlation between the dietary patterns of vertebrate species and the complexity of their oral morphology, but specimens must be digitized into 3D models before this complexity can be analyzed. Photogrammetry offers a straightforward and relatively low-cost method for creating the high-quality models necessary for morphological analysis, yet despite its popularity, a gap persists regarding the implementation, efficacy, and accuracy of photogrammetry compared to more traditional methods, such as micro-CT scanning. In this study, we explore a reliable, widely accessible tool to quantify a biologically meaningful trait. We digitized 19 extant turtle skulls, ranging from 1.5 cm wide Terrapene carolina to 11 cm wide Macrochelys temminckii, using the ultra-wide lens of modern iPhones and the photogrammetry software Abound. We then isolated the occlusal surface of these renderings to conduct an Orientation Patch Count (OPC) analysis, which quantifies the oral morphological complexity of each specimen. Finally, we compared our results with OPCr values obtained using micro-CT scanning and traditional photogrammetry techniques involving DSLR cameras. Our initial findings suggest that models created using an iPhone and Abound software produce results comparable to those obtained using micro-CT scans, regardless of specimen size. These findings highlight the potential for widespread adoption of accessible and affordable photogrammetry methods in paleobiological research, broadening the accessibility of 3D data collection and analysis.

Biofluorescence is a Widespread and Highly Variable Phenotype in Plethodontid Salamanders

Michael Kardos, Dasara Slova, Jasper Kopfinger, Sarah Woodley

Biofluorescence, or the absorption and reemission of light by living organisms, has been discovered in most salamander families including the plethodontids, the most diverse family containing over 60% of all salamander species. Despite this variety, most studies of amphibian biofluorescence have included only one or two species of plethodontids. With such limited representation, no studies have attempted to survey this family for phylogenetic patterns in biofluorescence or to unravel the evolutionary history of this phenomenon. In this study, we used a combination of microcopy, histology, and imaging techniques to characterize biofluorescence in eight genera and twelve species spanning the plethodontid family tree. We found evidence of biofluorescence in all twelve species but the sources, localization, and patterns in sexual dimorphism varied widely between species. While biofluorescent pigment-containing cells were scattered diffusely in the skin of almost all species, more derived species also possessed one or multiple types of biofluorescent skin glands. Although biofluorescence was male-biased in Plethodon, we discovered female-biased biofluorescence in Desmognathus and Aneides and no sexual dimorphism in other species. With so much variation in the sources and patterns of biofluorescence across the plethodontid tree, it is likely that this phenotype has evolved multiple times and has experienced strong selective pressures. Together, our results suggest that biofluorescence is a phylogenetically complex trait in plethodontids and may serve unique functions in different species.

Facultative migrants show seasonal variation in metabolic capacity while HPA activity remains stable

Jessica Karr, Ryan Wilgenkamp, Thomas Hahn, Jessica Malisch, Jamie Cornelius

Individuals with greater metabolic flexibility are expected to exhibit higher survival during challenging fluctuations in low temperature, and therefore may be capable of decreasing metabolic capacity as a tradeoff to allow for earlier breeding success. Although variation in weather can impact timing of breeding and stress responses for songbirds, it is unknown how thermogenic capacity relates to the timing of breeding at high elevation sites characterized by unfavorable spring weather conditions. Here we describe changes in thermogenic capacity and baseline corticosterone of mountain white-crowned sparrows (MWCS) in the Sierra Nevada from migratory arrival to breeding. Thirty-eight male MWCS were captured from May to July at Tioga Pass, CA over two years. Thermogenic capacity was measured as summit metabolic rate (Msum) within one hour of capture following a blood sample. Twenty-seven individuals were then recaptured at least 14 days later and resampled. Our findings suggest that there is high variation in early season MWCS Msum and males show large variation in metabolic rates during the onset of breeding in the population. Furthermore, Msum declines by an average of 13% from May to July, while baseline corticosterone levels remain low throughout the season. These results indicate that MWCS invest in thermogenic capacity that may help them cope with extreme conditions and then reallocate resources during the breeding season without influencing basal HPA activity.

Genomic analysis reveals constraint and lability of taste receptor genes in the Mexican tetra.

Ama Karunarathne, Joshua B Gross

The Mexican cavefish (Astyanax mexicanus) provides a powerful model for investigating the microevolutionary dynamics of sensory adaptation. Gustation in cavefish is underpinned by an expansion of extraoral taste buds. These taste buds harbor receptors for sweet (T1R2/ T1R3), umami (T1R1/T1R3), and bitter (T2R) stimuli. These gene families, however, remain uncharacterized across cavefish populations. We used a robust in silico pipeline combining NCBI keyword searches, TBLASTN, Hidden Markov Model profiling, conserved domain detection, and AUGUSTUS-based manual gene prediction to identify and compare T1R and T2R repertoires across four Mexican cavefish populations (Surface, Pachón, Tinaja, Molino). Interestingly, all populations contained four conserved T1R genes (T1R1, T1R2a, T1R2b, T1R3), located on homologous chromosomes. In contrast, T2R repertoires varied substantially from 11 to 21 different family members (i.e., Surface = 17, Pachón = 21, Tinaja =16, and Molino = 11 T2R genes). The majority of T2R genes were clustered on chromosome 11 and exceeded the number of T2R genes in the zebrafish genome (n = 6) in all populations. These caves differ significantly in ecological and nutritional profiles, shaped in part by distinct bat populations and their guano inputs. This environmental variation likely drives differential T2R diversification, enhancing bitter detection for food discrimination and toxin avoidance. This study enables cross-population comparisons of chemosensory gene families and provides a basis for linking ecological pressures to molecular adaptation in extreme habitats.

Superfetation: a mechanism facilitating polyandry

Mayank Kashyap, David Reznick, Joseph Travis

Understanding patterns of multiple paternity is central to evolutionary biology, particularly in uncovering how sexual selection shapes reproductive strategies and species diversity. Variation in multiple paternity is influenced by a range of male and female traits, which in turn affect both the intensity and timing (pre- or post-copulatory) of sexual selection. One such trait, superfetation, the ability of females to carry overlapping broods at different developmental stages, has been hypothesized to promote polyandry in live-bearing fishes (family Poeciliidae). Theory suggests that superfetation increases the likelihood that temporally overlapping broods are sired by different males. While previous studies have provided some support for this idea using field-collected females from Poeciliopsis retropinna and P. turrubarensi (both have superfetation), these inferences were limited by coarse temporal resolution, uncontrolled mating opportunities, and incomplete pedigree reconstruction. In this study, we use controlled laboratory matings in Heterandria formosa, a species with superfetation and Poecilia reticulata, a closely related species lacking this trait, to examine how superfetation influences patterns of polyandry. Leveraging genomic data from wild-caught individuals bred under controlled conditions through the grand-offspring generation, we reconstruct multigenerational pedigrees to quantify multiple paternity. This framework allows us to test whether superfetation is associated with increased polyandry and to explore how multiple paternity correlates with male and female sexual traits.

Evolution of centromeric repeats and characterization of the epigenetic marker CENP-A in cnidarians

Amanda Katzer, Andy Baxevanis

Centromeres consist of constitutive heterochromatin that is highly repetitive and gene-poor. While some elements of constitutive heterochromatin are conserved across species, others show significant divergence, reflecting the dynamic nature of these genomic regions. Despite their critical roles, little is known about the evolutionary pressures and mechanisms shaping these heterochromatic regions compared to overall chromosomal organization and conservation. Cnidarians are excellent models for studying constitutive heterochromatin because they are sister to the bilaterians, contain most of the histones and histone variants found in bilaterians, and diverged before many of the genome duplications observed in animal species. However, the only consistent marker of centromeres in animals is an epigenetic marker, centromere protein A (CENP-A), which is a variant of histone H3. We have analyzed the genomes of Hydra vulgaris, Nematostella vectensis, Hydractinia symbiolongicarpus, and Podocoryna americana, identifying putative centromeric regions based on available genome sequence data, and have identified one copy of CENP-A in each species. CENP-A has low expression across broad cell types, except in H. vulgaris. Further, there is notably high expression of CENP-A in the male germ line cells of H. vulgaris. Similarly, in H. symbiolongicarpus, there is high expression of CENP-A in its i-cells and sperm cells. Current work is focused on characterizing CENP-A binding sites to understand the repetitive sequences in the centromere and compare the evolutionary histories of centromeres in cnidarians.

Bioinformatic analysis of opioid receptors in the tobacco hornworm, *Manduca sexta*

Gurleen Kaur, Tarnampreet Kaur, Alicia Rice, Megumi Fuse

Leucopyrokinin (LPK) is a neuropeptide initially isolated from the cockroach but is part of the larger PBAN/pyrokinin peptide family in insects that have numerous roles including pheromone biosynthesis and muscle contraction. When injected into mice, LPK has been shown to induce antinociception (analgesia) mediated through opioid receptors, even though it has a different structure and sequence from opioid peptides in vertebrates. We have shown the effects of LPK on antinociception in the hornworm, Manduca sexta. The active fragment of LPK reduced sensitization of the defensive strike response in M. sexta, in a dose-dependent manner, using a touch assay with von Frey filaments. The response, however, was not blocked by the opioid-receptor inhibitor, Naloxone, as it was in mice. To explore the molecular basis of these findings, we are assessing whether insects have opioid receptors through a bioinformatics approach looking at insect genomes. This analysis includes retrieving vertebrate opioid receptor sequences from databases as reference queries, and conducting BLAST (Basic Local Alignment Search Tool) searches against the annotated genomes of a variety of insects including M. sexta. Our preliminary results coupled with the bioassay results suggest that when administered in insects, LPK may use an alternate pain-inhibiting pathway other than the opioid pathway noted in mice.

Impacts of the freshwater salinization syndrome on olfaction of an ecotoxicological model amphipods

Jaskirat Kaur, Jamie Cochran, Andrea Durant

The salinization of freshwater systems is a significant threat to freshwater organisms because of alterations in salinity and pH, and by mobilizing other contaminants such as heavy metals (e.g. copper). This phenomenon is termed as freshwater salinization syndrome, whereby these potent salt and heavy metal cocktails can have synergistic toxic effects. The amphipod crustacean, Hyalella azteca, is an important model for sediment and water toxicity testing. Although H. azteca have a high tolerance to heavy metals and road salts (i.e. NaCl) compared to other ecotoxicological models, we test the hypothesis that exposure may impair the olfactory system, potentially disrupting critical behaviors such as foraging. We investigated the individual and interactive effects of environmentally realistic levels of copper and road salt on the amphipod sense of smell. Using a T-maze behavior arena and a chemosensory navigation model, our findings show that while amphipod survival rates remain unaffected by road salt and copper, significant differences emerge in their abilities to locate attractive and aversive stimuli when comparing individual stressors and their combination. Additionally, ionotropic olfactory receptor expression is significantly altered across treatments, suggesting differential impacts on the olfactory sensilla that likely underlie observed differences in foraging behaviors. These findings highlight the importance of integrating subtle, sublethal measurements of olfactory system function into broader endpoints of toxicity thresholds, as these changes could have long-term consequences for population success.

Experimental insights into maternal hormone effects during critical development windows

Jasmeen Kaur, Ryan Paitz, David Miller, Alexandra Bentz

Females communicate non-genetic information about the environment to their developing offspring to generate potentially adaptive phenotypic plasticity. For example, birds often allocate more testosterone to their egg yolks in response to competitive environments, and these offspring typically grow faster and display more aggression. However, the mechanisms by which maternal hormones cause lasting phenotypic change remains unclear. Maternal hormones are rapidly metabolized, and most previous studies sample outside the critical period of hormone exposure. Here, we experimentally elevated yolk testosterone in house sparrows (Passer domesticus) to assess its effects on the early hormone environment and embryo physiology. In 2023, eggs were injected with testosterone or a vehicle control and we quantified the concentration of yolk hormones at embryonic day 3 and 5 using liquid chromatography with tandem mass spectrometry (LC/MS/MS). Results suggest that testosterone manipulation may also affect metabolite concentrations, indicating broader effects beyond the target hormone. In 2024, injected eggs were artificially incubated, and embryonic heart rate was measured at day 5 using infrared monitoring. We also piloted a non-invasive method to track circulatory development. Embryos from testosterone-injected eggs had significantly higher heart rates than controls. These data allow us to gain a deeper understanding of how early exposure to testosterone shapes offspring phenotype.

Low cost, Configurable VR Platforms for Behavioral Biology

Pavan Kaushik, Jamie Theobald

Mechanistic understanding of behavior requires field context and laboratory control, and Virtual Reality is increasingly seen as the bridge. Yet most existing systems are expensive, custom-built, and difficult to deploy outside specialized facilities. We present a DIY, open-source platform constructed from off-the-shelf components and 3D-printed parts. For about $250 per cube, the system delivers ~4π steradian visual input for walking and flying animals ranging from Drosophila to adult locusts. By networking multiple cubes, researchers can investigate collective interactions. Real environments can be reconstructed by 3D-scanning habitats or importing satellite terrain, allowing faithful recreation of field scenes with the ability to perturb them arbitrarily. Because some species are ephemeral or exhibit state-dependent behaviors that are difficult to reproduce in the lab, the system can also operate off-grid, enabling in situ experiments with mechanistic precision. While the hardware is compatible with a range of display systems, we further introduce Holocube, an open-source Python module for displaying arbitrary, perspective-corrected, rapidly updating visual scenes. Developed primarily for behavioral experiments, Holocube now supports many additional applications. It coordinates 3D immersive displays, precisely timed visual stimuli, closed-loop feedback, and emerging extensions. Together these tools provide a low-cost and versatile system for conducting sophisticated sensory and collective behavior experiments.

Maximum primary muscle fiber size in larval reef fishes as an indicator of early life experience

Kathryn Kavanagh, Robert Drew, Nicole Whelpley

Muscle fiber size is known to be plastic in response to developmental environment. In tropical marine fishes, muscle fibers are functional within days of fertilization in order for the young larva to begin to feed and avoid predation. A key developmental event in fish larval muscle development is when the differentiated myoblast cells fuse by joining cell membranes, resulting in multinucleated large cells or myocytes. As they elongate along the anterior-posterior axis, they are termed the primary muscle fibers. These fibers continue to add cells, increasing in cross-sectional area over time. The primary muscle fiber thickness reaches a maximum size at which time new adjacent fibers start forming, creating the mosaic stage in trunk muscle cross-sections. For numerous reasons, it is impossible to directly know the environmental experience of individual or even cohorts of larval marine fish throughout their pelagic stage, therefore an indirect indicator is needed. We propose that maximum primary muscle fiber size could provide an indicator of larval environmental experience of the individual. A review of larval swimming studies suggests that the relationship between environment and larval muscle phenotype can have functional implications for locomotory performance. Understanding how the environment affects larval phenotypes can help predict effects of ocean warming on populations.

Thermal sensitivity of metabolic rate influences landscape energetics of desert tortoises

Ellen Keaveny, Isabella Burger, Thomas Radzio, Talisin Hammond, Katelyn Rock, Melissa Merrick, Ronald Swaisgood, Eric Riddell

Environment, physiology, and behavior influence the energy balance of organisms, particularly amid warming climates, with cascading effects on fitness. Those that burrow underground are often assumed to be buffered from challenging temperatures, minimizing their energetic and hydric costs. Yet, the degree to which burrow-use mitigates these costs may be context-dependent, especially across age classes which may vary in their sensitivity to rising temperatures. We measured the thermal sensitivity of metabolic and evaporative water loss rates of hatchling, juvenile, and adult desert tortoises (Gopherus agassizii) using flow-through respirometry to quantify differences in energetic and hydric costs across age classes. Juvenile tortoises have a 51% higher thermal sensitivity of metabolic rate compared to adults (0.1215μL/min vs. 0.0803μL/min). We incorporated the thermal sensitivity of metabolic rate into mechanistic niche models and found that environmental factors as well as age class-specific differences in metabolism and evaporative water loss influence energy and hydric balance of desert tortoises across the landscape. Such predictions are informative for conservation in prioritizing current suitable habitats and identifying future areas of conservation for translocations that minimize physiological costs as the climate continues to change. Our results also identify physiological variation across age classes as a critical factor shaping vulnerability to environmental change.

The effects of larval diet on male butterfly eyes

Chloe Keck, Emilia Stachl, Daniel Speiser, Carol Boggs

Vision is an integral component of mate detection and recognition in many species. For instance, many butterfly species rely heavily on vision during mating; specifically, species that exhibit patrolling behavior first initiate mating after visually detecting prospective mating partners. Speyeria mormonia males patrol for mates and make the initial approach during mating. Our study aims to build upon our understanding of how butterfly vision, and thus potential mating success, is impacted by resource limitation. We examine the effects of larval dietary restriction on eye morphology in adult male S. mormonia and determine differences in visual performance in adults. We conducted a dietary restriction experiment in which S. mormonia larvae experienced intermittent bouts of starvation during their final larval instar. Upon adult eclosion, we dissected the eyes of adult males to isolate the corneas. The corneas were photographed and the number and size of the facets of the ommatidia were analyzed. The number and size of facets correspond to visual acuity. By comparing eye morphology of adult male S. mormonia adults experiencing larval dietary restriction to those that received larval hostplant ad libitum, we aim to understand how the larval diet impacts visual acuity, and thus mate detection. These results will help elucidate the link between larval hostplant availability and adult male fitness in butterflies.

CritterGripper: a new tool for rapid and damage-free mechanical testing of bending organisms

Ryan Keleher, Mallory Mongeon, Eric Tytell, Yordano Jimenez

Ex vivo mechanical testing is a powerful way to investigate in vivo performance. One method is the oscillatory bending apparatus. In this device, two ends of a whole organism––or part of it––are mounted. A motor at one end bends the body, and a sensor at the other end measures bending torques. A major challenge to performing these experiments is quickly and consistently mounting the preparation while minimizing damage to biological tissues. We designed a new gripping system that enables rapid mounting of elongate organisms onto the oscillatory bending apparatus. The new design combines

custom 3D-printed components, magnets, trigger clamps, memory foam, and rough tread tape to create a rapid-mount system that is also user-friendly. This tool firmly clamps the sides of the organism, in our case fish, using clamps lined with memory foam and tread tape, which conforms to the local body shape and secures the body through frictional forces on the scales. Compared to some previous mounting methods, the new gripping system has reduced student training time (from days to hours), preparation time (10x faster), and tissue damage (from 20% to 0%). In our application, the simulation of fish swimming, this tool enables more physiological tests across multiple body regions before muscle tissue death. This tool has the potential to facilitate the rigorous mechanical description of diverse organisms of various body shapes and sizes.

Temperature spikes and marine heatwaves trigger rapid larval growth in *Pisaster ochraceus* sea star

Ciera Kelley, Sophie George

Marine heatwaves (MHWs) are increasing in intensity, frequency, and duration, resulting in large ecological shifts in rocky intertidal systems. MHWs have been linked to a 90% decline in the keystone species Pisaster ochraceus in the Pacific Northwest. This study focused on the effect of MHWs and temperature "spikes" on the larval stage of this species. Larvae were reared in control ambient (CA) temperatures of 11.0-16.0 (including spikes), constant control (CC) temperatures 11.0-11.7 , and MHW temperatures that rose to 20°C over 12 days and remained high for 40 days before returning to ambient conditions. Morphological measurements and development of larvae from each treatment were obtained weekly. Linear regression revealed strong correlations between total length and total width and stronger correlations between total length and preoral process length for CA and MHW treatments. PCA revealed that younger (15-22dpf) MHW larvae occupied a different morphological space than CA and CC larvae. Over time (29-36dpf) although differences were still significant, the morphological space of CA larvae approached that of MHW larvae. On the contrary, the morphological space occupied by CA and CC larvae diverged over time. Juvenile structures appeared earlier for MHW larvae followed by CA and CC larvae. This study shows that MHWs and temperature spikes can trigger rapid larval growth and development, potentially impacting settlement and recruitment into the benthic habitat.

Hearts racing! A novel method for evaluating heart rate in hummingbirds.

Kiley Kellum, Alejandro Rico-Guevara, Claudia Moreno, Oscar Vivas

Hummingbirds have long fascinated biologists due to their small sizes and extreme physiological and biomechanical adaptations. One of such adaptations is the incredibly efficient cardiovascular system that enables hummingbirds to sustain the high metabolic rates necessary for fueling their energetically demanding flight. While previous studies have shown that hummingbird heart rates can range from ~30 bpm during torpor to >1200 bpm during flight, it is unlikely that these are the actual limits of sustained hummingbird heart rates due to the immense difficulties associated with quantifying heart rate in such small animals. To date, very little is known about the hummingbird heart and the mechanisms that contribute to its great range of cardiac variability. Given this challenge, we present a novel method for measuring respiratory and heart rates in Calypte anna at different activity levels, with the aim of expanding upon our understanding of the extreme cardiac adaptations observed in these birds. Using a non-invasive photoplethysmography sensor and customized signal processing approach employing short-term Fourier transforms, we calculate respiratory and heart rates from 14 individuals in different active states. This technique is validated with data collected using a commercially available electrocardiogram measuring the same physiological parameters from two individuals under anesthesia. The preliminary data obtained from this new method show that Calypte anna can sustain heart rates >1500 bpm, greatly exceeding previous estimates.

Mutant symbionts: a novel mechanism for gene editing in *Vibrio fischeri*

Kayla Kelly, Brian Pipes, Michele Nishiguchi

Studies of the symbiosis between sepiolid squid and their Vibrio bacterial symbionts benefit from the ability to genetically alter the bacteria, often through the introduction of plasmid DNA vectors. However, traditional methods of plasmid construction are time and labor inefficient. The Ligase Cycling Assembly (LCA) provides a more efficient method for assembling multiple DNA fragments into a plasmid, yet a limitation of this approach is the oligomerization of plasmid constructs, which reduces accurate assembly. To address this, we created three blunt ended plasmid fragments and assembled them using LCA. We documented the rate of plasmid multimers formed via sequencing, and then tested modified LCA strategies to reduce oligomerization, which includes altering the ratio of fragments in an assembly reaction and sequential assembly strategies. The stability of the concatemer structure was assessed through extended culturing and resequencing, demonstrating the extent of effects of homologous recombination. This work highlights improvements to the LCA method that enhances correct plasmid assembly with applications for examining specific genes that regulate symbiont competency. Future uses in associations such as the squid-Vibrio mutualism and other symbiotic models will provide insight into the mechanisms that are responsible for the molecular cross talk between partners and the importance of beneficial microbes to life on Earth.

Mind over malaria: exploring the pathology of cerebral avian malaria

Tosha Kelly, Kenedi Lynch, Christine Lattin

Malaria threatens avian biodiversity worldwide, including wild birds, zoo populations, and birds in captive breeding programs. Although malaria parasites have been detected post-mortem in the brain of avian hosts, the pathology of cerebral malaria in birds remains largely unexplored, leaving huge knowledge gaps in our understanding of how frequently wild birds experience cerebral malaria, its survival rate, and how it impacts avian hosts. To explore the pathology of cerebral malaria in wild birds, we inoculated house sparrows (Passer domesticus) with the common avian malaria parasite Plasmodium relictum (n = 56 birds; 6 were sham controls, 16 were exposed-but-resistant, and 34 became infected). At peak parasitaemia, we collected blood samples and cerebellum tissue, then used qPCR to compare the expression of genes in blood and brain that may indicate cerebral malaria pathology; specifically, we assessed the expression of genes that would indicate possible sequestration of malaria parasites in the brain, endothelial dysfunction of the blood-brain-barrier, and neuroinflammation. Cerebellar expression of two cytokines (TNF-α and IFN-γ) differed between treatment groups and blood IFN-γ expression was positively correlated with the amount of gene expression of malaria parasites in the brain. While preliminary, our results may inform treatments against cerebral malaria in wild and captive birds and help develop pre-mortem diagnostic techniques.

How does panting effort relate to hematocrit in altricial young?

Ellis Kelsey, Emmy James, Kim Rosvall, Elizabeth Derryberry

As global temperatures rise and heat waves become more frequent, animals must increasingly deal with heat. Panting enables heat dissipation through evaporative cooling but also results in water loss that can accelerate dehydration under high temperatures. Here, we examine how time spent panting influences hydration state, measured via hematocrit, in nestling tree swallows (Tachycineta bicolor). We experimentally elevated nest temperatures by approximately 4°C using heat packs, and we filmed chicks to record their behavior during the four-hour heat challenge. Immediately after the trial, we collected blood samples to measure hematocrit as a proxy for hydration. Larger chicks tended to have higher hematocrit, and chicks in hotter nests also had higher hematocrit, consistent proportionally lower water content in the blood. By linking water balance and behavioral thermoregulation, our study highlights the individual consequences of coping with ecologically relevant heat.

Liver morphological alterations in fathead minnows exposed to micro- and nanoplastics

Brandon Kenaya, Amira Abuhmoud, Miranda Jasinski, Sarah Magid, Gregory Grabowski, Levi Storks, Rachelle Belanger

Rising plastic use has accelerated the release of microplastics (< 5 mm) and nanoplastics (< 1 µm) into aquatic ecosystems, negatively affecting liver morphology and reducing the capacity of organisms to digest and detoxify. Microplastics are very harmful to the liver of fish because their small size allows them to get embedded in the digestive tract, causing blockage of the absorption of key nutrients. Further, nanoplastics are even more dangerous because they are even smaller and can enter the bloodstream, make their way to the liver, and cause metabolic disruption. To investigate the impacts of micro- and nanoplastics on the liver of fathead minnows, we exposed male and female fathead minnows to polystyrene MPs (30 µm) and NPs (0.5 µm) for 28 days at concentrations of 0 mg/L (control) and 1 mg/L. The liver of these fish was removed, and hematoxylin and eosin staining was performed. Fish livers were evaluated for edema of hepatocytes, dilated sinusoids, and hepatic congestion. This research provides critical insights into how micro- and nanoplastics disrupt liver structure and function in fish, underscoring the urgent need to regulate plastic pollution and prevent long-term impacts on aquatic food webs.

An investigation of female harassment in the forked fungus beetle *Bolitotherus cornutus*

Clara Kendrick, Charlotte Greene, Clara Stahlmann Roeder, Vincent Formica, Edmund Brodie III

Due to differing reproductive strategies between the sexes, males evolve strategies of coercion to gain access to more mates. Female harassment, defined as repeated attempts to copulate, can be costly to females. Intensity of female harassment can be dependent on the social context and therefore create unexpected variation in female fitness that can potentially influence variation in selection on female traits. This study investigated the cost of courtship and male aggression on fecundity in the forked fungus beetle Bolitotherus cornutus in two different population age structures. We found no variation in female fecundity due to courtship, male aggression, or male population age structure. We offer three alternate explanations for this trend: (1) females minimize courtship costs by convenience mating, (2) the cost of courtship is offset by nuptial gifts, and (3) rather than fecundity, females suffer a longevity cost.

Mosquito *Aedes japonicus* interaction with fly poison plant *(Amianthium muscitoxicum)*

Ray Kennedy, Irving Upshur, James Moloney, Simone de Montigny, Chloe Lahondere

Aedes japonicus is a mosquito species invasive to the U.S. that can carry pathogens such as St. Louis encephalitis, West Nile Virus, and Japanese encephalitis, for which no methods of control currently exist. This study investigates the relationship between this mosquito species and the fly poison plant (Amianthium muscitoxicum) to inform the potential development of attractive toxic sugar baits (ATSBs).

In the wild, we observed Ae. japonicus landing on the neurotoxic fly poison. Here, we investigated if Ae. japonicus is a pollinator of the plant, and Ae. japonicus' ability to sugar-feed on the plant. Pollination and phytophagy by Ae. japonicus was explored through plant visitation assays, forced feeding assays, and scent collection to determine VOCs that could be attractive to the mosquitoes.

We found seventy percent of Ae. japonicus consumed nectar from A. muscitoxicum, while five percent were found with pollen, indicating Ae. japonicus nectar-feeds and can pollinate fly poison. Mosquito nectar consumption varied as the fly poison scent changed throughout the blooming stages. We also found that the consumption of fly poison nectar decreased Ae. japonicus survival within the first 5 days post-consumption. Overall, these results support the strong potential for this system to be an effective ATSB for this mosquito species due to its harmful effect on survival.

Iron augmentation in shrew enamel is associated with taller and sharper dentition

Nina Kent, Tristan Stayton, Joseph Guillen

The Mammalia order Eulipotyphla includes multiple families of small (< 5 kg) mammals, including the Soricidae (shrews), which can be further separated into three subfamilies. These subfamilies are distinguished by the presence of either red or white teeth. Red-toothed shrews, (subfamily Soricinae) possess red teeth, the hue deriving from the presence of iron in their dental tissue, whereas white-toothed shrews (subfamily Crocidurinae and subfamily Myosoricinae) lack this trait. Despite an existing recognition of this distinction, the functional and biomechanical implications of these iron-augmented teeth are not yet fully understood. We photographed 200 shrew skulls in four views across multiple red and white-toothed shrew taxa. We digitized landmarks and curves on these photographs in tpsDig2. Principal component analyses and phylogenetic ANOVA were conducted in RStudio, revealing statistically significant differences in the shape and sharpness of red-toothed and white-toothed taxa, with red-toothed shrews exhibiting relatively taller and sharper teeth, particularly in the molars. These patterns support the hypothesis that iron-augmentation might enhance tooth strength and hardness, potentially enhancing durability and thus allowing taller and sharper teeth throughout a shrew's lifespan.

Using vibrissae to investigate reproductive and foraging histories of Steller sea lions

Mandy Keogh, Angela Gastaldi, Michael Rehberg

We developed methods to measure progesterone concentrations and stable carbon and nitrogen isotope signatures (expressed as δ13C and δ15N values) in vibrissae from female Steller sea lions (Eumetopias jubatus). Our initial study found yearly progesterone concentrations were greater in years a pup was produced compared to years when no pup was observed, and we proposed a yearly progesterone concentration of 30 pg/mg or greater to classify a reproductive year as producing a pup. We applied this method to vibrissae collected from 11 free-ranging Steller sea lions with dependent offspring. Steller sea lions were remotely sedated, satellitetagged and sampled in the fall of 2018 and 2019 in Prince William Sound and Kodiak, Alaska. We found seasonal patterns in both δ13C and δ15N values suggesting the vibrissae represented between 2+ and 6+ years of growth. Using the δ15N values we identified reproductive years (summer-summer) and determined the yearly progesterone concentration for each female. Using the yearly progesterone concentrations, we classified each year as likely producing a pup (≥ 30 pg/mg) or likely not producing a pup (< 3 0 pg/mg). We will also use the variation in δ13C (-18.20 – -13.64 ‰) and δ15N (13.88 – 18.78 ‰) values to explore if foraging varies with reproductive state in these Steller sea lions.

Cue, distraction, trap? Testing jumping spider responses to avoidable & unavoidable vibratory noise

Ciara Kernan, Damian Elias

Animals reliant on vibroacoustic information must contend with anthropogenic noise. Many have evolved alongside the multimodal din of wind, rain, or crashing waves and may have developed strategies to deal with not only these but also novel noise sources. On the other hand, animals using certain environmental cues to glean information about habitats—for instance, navigating towards low-frequency river vibrations—could face sensory traps via novel sources of similar vibrations, like roads or railways. To investigate the effects of substrate vibrations on jumping spiders, we allowed spiders to move freely between quieter and noisier conditions at different amplitude levels. We tested the hypothesis that spiders use broadband vibrations as either positive or negative habitat cues, predicting that they would avoid very high-amplitude vibrations, but might show a preference for lower-amplitude vibrations over silence. Because environmental noise can have a variety of biological impacts even in the absence of aversive behavior, we also investigated the effects of inescapable vibrational noise on foraging. We presented spiders in noisy or quiet conditions with a visual prey stimulus and quantified their predatory behavior. Preliminary findings indicate resilience to vibrational noise, a pervasive potential stressor: spiders lacked a strong aversive response to even high

amplitudes and showed minimal evidence of being distracted or confused during visually directed foraging. However, sex-specific noise responses potentially influence both movement and foraging behavior.

Morphological variation among invasive island populations of brown anoles (*Anolis sargei*)

Gavin Kerr, Chris Norris, Sydney Wayne, Anthony Gilbert, Daniel Warner

Islands that are severely impacted by gulf storms or hurricanes are frequently re-colonized by species that were present prior to extirpation. Many species that colonize these islands are faced with new ecological conditions that either vary between islands, or that differ substantially from the mainland. Such environmental heterogeneity can act as a driver of trait values through both natural selection and/ or phenotypic plasticity. In 2013 and 2022, Anolis sagrei were collected from two populations on small spoil islands in the Tomoka River, Florida. These islands varied extremely with respect to temperature, moisture, and canopy cover, and are subjected to repeated disturbances. We selected males and females from each island population from both time points. We measured external morphological traits and dissected individuals to measure the morphology of various organs. We then compared these measurements within and between the islands and time points to quantify spatial and temporal variation in morphology. We hypothesized that the environmental drivers of phenotypic variation are consistent across time, leading to consistent trait values within islands regardless of year. By testing for repeatable environment-phenotype associations, our results will demonstrate how strong and persistent ecological conditions might impact morphology and provide insight into the processes that shape phenotypic variation in populations.

Machine learning detects suckling behavior in accelerometer-equipped northern fur seal pups

Sarah Kerr, Carey Kuhn, Cory Williams

The Eastern Pacific Stock of northern fur seals has declined dramatically over the last half-century and pup production at the largest colony continues to decline. Although the exact cause(s) of the current decline remain uncertain, food limitation in proximity to major rookeries may be contributing to low pup growth rates, survival, and recruitment. Lactation is the most energetically expensive phase of the annual cycle and, as central place foragers, females are restricted to forage within the locality of the pupping colony when nursing their young. Although lactating females are likely susceptible to local prey depletion, costs may be borne by pups if mothers prioritize future reproductive potential over current investment in reproduction. Here, we develop a new tool for investigating reproductive trade-offs in fur seals – the use of accelerometry in pups to measure suckling behavior. Combining behavioral observations with accelerometry data, we used extreme gradient boosting models, a type of supervised machine learning, to classify four behaviors (high activity, low activity, suckling, and resting) with moderate to high success (F1 scores >0.7). Comparing pup suckling patterns to female rookery attendance based on satellite telemetry revealed predicted suckling behavior corresponded with maternal rookery attendance. Overall, our study reveals accelerometry is useful for measuring suckling patterns in free-living fur seals and we suggest this approach is likely to be effective for assessing reproductive tradeoffs in mammals.

Fish out of water: the neural circuitry of hypoxic spreading depolarization

Zain Khalid, James Strother

Prolonged hypoxia can produce severe and irreversible tissue damage, and mechanisms for sensing and surviving hypoxia are found in a diversity of vertebrate animals. Fish may encounter hypoxic environments under various circumstances, including algae blooms, heat waves, and stagnating waters. Fish can detect low oxygen in their environment and may navigate away from such conditions. However, when hypoxic conditions are more widespread, it may be necessary for the animals to tolerate a hypoxic environment. In cases where this is not possible, hypoxic environments can cause large-scale mortality events. While the physiology of respiration and behavioral responses to hypoxia have been well-studied in fishes, less is understood about the changes in neural activity that occur during severe hypoxia. In zebrafish larva, we used whole-brain calcium imaging to record neural activity throughout the brain during hypoxia exposure while simultaneously recording heart rate. In response to prolonged environmental hypoxia, we observed a wave of spreading depolarization throughout the CNS similar to that observed in mammalian models. Interestingly, whole-brain calcium imaging also allowed the identification of a stereotyped sequence of depolarization events in specific reticulospinal neurons preceding brain-wide depolarization. This suggests that neural circuitry during hypoxia plays an important role in triggering hypoxic spreading depolarization and ischemic cell death. Understanding the neural circuitry activated during hypoxia may provide key insights into how animals cope with severe environmental stressors.

Cellular changes in crayfish hepatopancreas from microcystin-LR and glyphosate exposure

Mona Khalil, Antonillamarein Hanna, Brandon Kenaya, Amira Abuhmoud, Sarah Magid, Miranda Jasinski, Kendra Evans, Rachelle Belanger

Aquatic environments are frequently exposed to both natural and anthropogenic stressors, that can negatively impact the ecosystem health. Chemical pollutants, in particular, raise concern because of their persistence and widespread distribution. We investigated the individual and combined effects of the widely used agrochemical Roundup® (active ingredient glyphosate) and the algal toxin microcystin-LR (MC-LR) on crayfish hepatopancreas cells using flow cytometry and morphological analysis. Assessing exposures to both glyphosate and algal toxins in combination enables evaluation of potential additive morphological effects of these stressors. Crayfish (N= 6per treatment) were exposed for 7 days to 10 µg/L MC-LR, 10 µg/L glyphosate, or a combination of 10 µg/L MC-LR and 10 µg/L glyphosate). We found that exposure to MC-LR and glyphosate decreased fluorescein diacetate labeling and increased propidium iodide labeling, indicating reduced cell viability and elevated apoptosis. These data were compared with morphological analyses of hematoxylin and eosin–stained hepatopancreas tissues. Histological analysis showed that hepatopancreas tubules of exposed crayfish displayed epithelial degeneration, increased vacuolization, and dilated lumens, although combined exposure to MC-LR and glyphosate did not produce additive effects. Taken together, our findings emphasize that monitoring and regulating environmental contaminants is critical for maintaining the health of freshwater ecosystems and the organisms that rely on them.

The anal gills of marine fly larvae function similarly to euryhaline fish gills

Elissa Khodikian, Shrinidhi Prabhakaran, Andrea Durant

While insects have generally failed to establish themselves in seawater, perhaps the best examples of 'marine' insects are the euryhaline larvae of few mosquitoes and chironomid midges. These salt-tolerant larvae drink seawater to achieve water balance, and the need to rid themselves of excess salt was likely the catalyst for the evolution of novel salt-secreting glands in the excretory system. The external anal gills (or papillae)—critical for ion absorption by species with freshwater-restricted larvae—are significantly smaller in euryhaline larvae. We test the hypothesis that the anal papillae support active salt secretion to achieve water balance when larvae are reared in seawater via a reversal in ion-transporting machinery required for ion uptake in freshwater—an analogous strategy to the euryhaline fish gill. This is based on our recent findings of very high ion pump (Na+/K+-ATPase and H+-ATPase) expression in gill epithelia that function as batteries to energize ion flux. By combining morphometric analyses, 3D organ reconstructions, immunohistochemistry, RNA sequencing, and ion flux measurements, we characterize the cellular mechanisms enabling hypo-regulation of hemolymph osmolality in seawater. We confirm that the anal gills of marine larvae absorb ions in dilute freshwater, and we measure high Na+ efflux rates at the gills in seawater. Lastly, high expression of Rh proteins for ammonia transport in the gill epithelium suggests a dual function in nitrogenous waste excretion in seawater.

Sequencing stress: using omics approaches to identify novel markers of stress in marine vertebrates

Jane Khudyakov

Physiological stress causes alterations in catecholamines, corticosteroids, thyroid, and other hormones in vertebrates. While glucocorticoids have been used extensively as stress markers in wildlife studies, hormone measurements may be impractical in marine vertebrate species and do not provide adequate information on the downstream impacts of stress on animal health and survival. Stress-associated hormones exert their effects, in part, by altering expression of genes encoding metabolic enzymes, hormone receptors, nutrient transporters, and other key proteins in target tissues. Therefore, measuring changes in target gene activity - the abundance of gene transcripts and their protein products - is an alternative approach for detecting stress and predicting its tertiary physiological effects in marine vertebrates. Using both experimental manipulations and correlative studies and omics approaches, we have identified genes and proteins that are responsive to stress hormones and reflect their circulating levels in northern elephant seals and bottlenose dolphins, as well as potential markers of health in sharks and seabirds. I will discuss insights from our omics datasets, such as the similarities and taxon- and species-specific differences in tertiary stress responses and the potential of gene and protein markers to predict health and survival of marine vertebrates.

Eight years of whale watch data finds humpback whale behavioral trends

Eman Khwaja, Kathryn Kavanagh

Understanding the factors influencing humpback whale (Megaptera novaeangliae) behavior is important for research and conservation. This study uses data from whale watch vessels in the southern Gulf of Maine to examine whether temporal (diel, seasonal, and interannual) and environmental factors (recorded wind and sea condition) can predict the likelihood of observing humpback whale surface activity on a given trip. Results using GLM suggest that environmental variables had a limited impact on the likelihood of observing feeding activity, i.e. wind, waves, and rain did not predict occurrence of whale feeding behavior. However, surface feeding activity showed temporal variation with a trend of increased surface feeding during the spring, with a 25% decrease in the summer and 41% decrease in the fall, supporting speculations that whales have an immediate focus on replenishment post- migration. Surface active behavior was 62% higher during the fall than the spring, supporting anecdotal reports of increases in pre-migratory surface activity and social behavior. Surface active behavior also increased by 6% for every unit increase in wind speed. Significant interannual variability in both types of behaviors may suggest shifts in prey availability or ecological changes. This study reinforces the value of whale watch data as an investigative tool and highlights the need to take temporal and environmental factors into account in analyses.

Morphology and gene expression in the olfactory cavity of salamanders across varying life histories

Karen Kiemnec-Tyburczy, John Reiss

The transition of tetrapods from water to land was one of the major transitions in vertebrate evolution, requiring sensory systems to adapt to a new physical medium. Olfaction, in particular, presents a unique opportunity to study how structural and molecular features evolve in response to different environments. To investigate these changes, we examined the olfactory systems of six species of lungless salamanders—a diverse clade that includes both biphasic and direct-developing lineages. Our study focused on the genera Ensatina (E. eschscholtzii), Desmognathus (D. amphileucus, D. aureatus, D. wrighti, D. ocoee), and Plethodon (P. shermani). Using histology and microcomputed tomography, we compared the architecture of the olfactory organs, finding broadly conserved cavity morphology but a notable epithelial reduction in D. aureatus, which has highly aquatic adults. At the molecular level, in situ hybridization revealed conserved mRNA expression patterns of key olfactory genes in all species examined: Gαolf in the main olfactory cavity (MOC), Trpc2 in the vomeronasal organ (VNO), Gαo throughout the MOC and VNO, and no detectable expression of Gαi2. Interestingly, Trpc2 expression extended beyond the VNO into the MOC in some biphasic species but remained VNO-specific in direct-developers. Despite the striking variety of developmental modes and habitats in this group, olfactory organization has remained largely conserved across major clades that diverged over 50 million years ago.

Effects of urbanization on innate immunity, metabolites, and behavior of an urban-adapted bird

Denyelle Kilgour, Claudia Gerecke, Elyssa Cabey, Nicole Karugu, L. Michael Romero

Urbanization changes land use at a rapid rate, presenting wildlife with challenges and stressors that can impact their health and behavior. However, some species can cope with the stressors they encounter and exploit novel city resources. Previous research has often focused on the physiological stress response to understand how urban wildlife, particularly birds, adapt to these environments. However, no consistent patterns have emerged. This inconsistency may stem from individuals adjusting their responses to local conditions and interactions between the stress response and other physiological systems. We collected samples from house sparrows that represent a subset of the interconnected physiological systems and behavioral traits these urban birds may employ to cope with urban stressors at twelve sites around the Boston metropolitan region, which vary in degree of urbanization. Specifically, we analyzed how a measure of innate immune function, blood metabolites, and behavior varied in response to the amount of human development and mean human population density within their approximate home range. Our preliminary analysis found no significant effects of the mean percentage of impervious surface or human population density, suggesting that this urban-adapted species may not be sensitive to these habitat characteristics or may be compensating for their effects through other physiological or behavioral systems.

Range expansion of tropical ghost crabs and its effects on the native ghost crab, *Ocypode stimpsoni*

Dain Kim, Yongsung Park, Sojung Kwon, Taewon Kim

Global warming-induced northward range shifts of tropical marine species into temperate waters pose potential threats to native ecosystems via intensified interspecific competition for critical resources, including habitat, prey, and reproductive opportunities. Notably, the native ghost crab Ocypode stimpsoni inhabits semi-terrestrial zones and has been designated as a protected marine species in South Korea. Recently, newly discovered tropical ghost crab species (O. sinensis and O. ceratophthalmus) have been found co-occurring with this native species. To evaluate the impact of these cryptic species on native populations, we hypothesized that O. stimpsoni would exhibit differences in the vibrational and genetic characteristics of courtship behavior between native monospecific populations and populations where the native species co-occurs with newly discovered cryptic species. We predicted that: (1) vibrational courtship signals, particularly repeated pulse rate patterns, would differ between monospecific and co-occurring populations, and (2) genetic diversity, would be higher in monospecific populations. To test this hypothesis, we conducted biotremological analyses of vibrational signals during waving behavior and performed a population genetic analysis to assess genetic differentiation between monospecific and co-occurring populations. However, the biotremological and genetic results revealed no population differentiation among all populations, leading to the rejection of our hypothesis. Our findings suggest that populations of O. stimpsoni, exhibit high genetic connectivity, likely due to the continuous influx of individuals facilitated by ocean currents and larval dispersal.

Does clade age dictate phenotypic diversification dynamics of marine-derived freshwater fishes?

Jonathan Kim, Devin Bloom, Melissa Rincon-Sandoval, Ricardo Betancur-R, Aline Paiva Morais de Medeiros

The Australasian freshwater ichthyofauna is unique because the majority of its actinopterygian representatives are thought to be derived from marine ancestors. Analogous to island radiations of terrestrial fauna, the repeated

colonization of freshwater habitats in Australia-New Guinea (AUG) may have offered ecological opportunity for diversification. Species richness and ecomorphology varies greatly among AUG clades. Lineages also vary in timing of colonization, suggesting different evolutionary trajectories between stem invasions. In this study we explore diversification patterns for signatures of adaptive radiation stemming from invasions of the continental freshwaters of Australia and New Guinea. We test the hypothesis that early arriving lineages experienced reduced competition and greater ecological opportunity for diversification. We assembled a morphometric dataset of linear traits associated with movement and feeding for over 1000 species of bony fishes from both marine and freshwaters of AUG. Our analyses show that some freshwater representatives occupy a large ecomorphological space in comparison to nearby marine relatives, such as silversides (Order: Atheriniformes) and eel catfishes (Family: Plotosidae). In contrast, other clades with largely marine and euryhaline representatives, such as Pleuronectiformes and Syngnathiformes, show little variation in body shape between freshwater and marine taxa within the broad Indo-Pacific region. Our results suggest that diversification proceeds in both predictable and contingent modes, and that freshwater invasions can accelerate rates of phenotypic evolution within marine-derived freshwater lineages.

Investigating the role of NRG/ERBB signaling in proportional heart growth

Oliver Kim, Bradley Davidson

During heart development, distinct regions of the organ proliferate at different rates to achieve the overall correct size and shape. In vertebrate hearts, this proportional growth is partially governed by NRG/ERBB signaling, but extensive gene and isoform diversity has made it difficult to fully characterize the contributions of this pathway. Here, we address this deficit by investigating heart growth in Ciona robusta, an invertebrate chordate with a compact genome and simple heart structure. Where vertebrates possess four NRGs with many isoforms, we identified just two candidate NRG orthologs in C. robusta. Further, scRNAseq data indicates that both Ciona NRG orthologs and both Ciona orthologs to the cognate ERBB receptors are expressed in the heart. Notably, one of these receptors, EGFRa is expressed in a line of progenitors that drive heart growth. Based on these findings, we hypothesized that NRG/EGFRa signaling modulates the proliferation of these cardiac progenitors. To test this, we generated a dominant-negative form of C. robusta EGFRa. We also used pharmacological ERBB, MAPK, PI3K, and PLC inhibitors to disrupt NRG/ERBB signaling and downstream pathways. Although disruption of NRG/ERBB signaling did not significantly alter progenitor number, we did detect decreased proliferation in a specific, distal progenitor population. These preliminary results lay the groundwork for further analysis of NRG/ERBB signaling in C. robusta heart growth.

Comparative phylogeography reveals genetically distinct Appalachian populations of boreal songbirds

Abby Kimmitt, Teresa Pegan, Kristen Wacker, Andrew Jones, Benjamin Winger

Genetic diversity within a species across its breeding range can have direct effects on a species' long-term survival, such that patterns of genetically distinct populations can inform conservation practices. Most conservation genetics studies focus on a genetic diversity in a single species, however, comparative population genomics and phylogeography can provide evidence of whether co-distributed species share patterns of spatial genetic differentiation and diversity. In this study, we sequenced over 900 low-coverage whole genomes to examine genetic population structure and genetic diversity in 12 species of co-distributed migratory birds that breed across the boreal forest belt as well as the Appalachian forests. We found that 11 out of 12 species exhibited shared patterns of genetic structure, such that populations in the geographically small range of the southern Appalachians were subtly distinct from the widespread population across the boreal forest belt. Despite the difference in geographic range between these populations, we did not find that standing genetic diversity significantly differed between these populations. We argue that comparative phylogeography can use genetic diversity patterns to inform ecosystem-level based rather than species-level conservation, as we show that conservation of the Appalachian forests would likely protect distinct genetic diversity in several migratory birds.

The Power Problem: Hawkmoth flight muscle work loops do not yield the required power for flight

Casey King, Ethan Wold, Travis Tune, Simon Sponberg

In order to fly, insects must overcome high aerodynamic forces via thoracic muscles that power the wings. Other costs like inertial power can be reduced through resonant coupling to elastic structures in the exoskeleton. Nevertheless, flight muscle must provide the animal's aerodynamic power at least in the absence of storage and return of energy with the external environment. Manduca sexta hawkmoths are large agile fliers that push the limits of high frequency flapping flight with synchronous (neurogenic) flight muscle. However, prior measurements of the mass-specific power output of the main downstroke muscle (DLM), which are typical of high performance muscle, only account for 15.5% of the total aerodynamic power required for flight. Conservatively accounting for the contributions of other flight muscles, Manduca produces 29.7% of the required power. In experiments at maximum power conditions, which exceed those measured during flight, Manduca produces 52.3% of the power. Building on prior work loop methods, we developed techniques to account for the missing power. First, we removed the abdomen from the specimen and further dissected the thorax to ensure force measurement from the DLM alone. Second, we increased the number of stimulus locations and iterated over different current and voltage stimulus regimes. We find that these procedural alterations do not improve the experiment suggesting missing physiological, mechanical, or aerodynamic adaptations in hawkmoth flight.

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The sand dollar *Dendraster excentricus*: a new model to explore novelty in neural circuits

Isabella King, Eric Edsinger, Willem Weertman

Decoding how neural circuits function and evolve is no small task, but studying how disparate nervous systems produce similar behaviors may offer unexpected insights. Cephalopods possess complex hierarchical nervous systems with a centralized brain adjacent to their decentralized nerve ring, cords, and ganglia of their arms, whereas echinoderms lack a centralized brain but have an independently evolved nerve ring with ganglia and radial nerves. Both groups, however, possess numerous specialized appendages on "multi-arm" axes that serve analogous locomotor and sensory functions. This study focuses on how Dendraster excentricus, the Pacific sand dollar, can be used as a novel research model to investigate neural circuit evolution, given its unique secondary bilateral symmetry that is superimposed on the ancestral pentaradial structure observed in sea urchins. We used time-lapse videography in lab and field settings to generate behavioral ethograms of D. excentricus and applied deep learning tools to analyze locomotion. These datasets, along with microCT and confocal imaging, enabled us to compare body movements and coordination of tube feet and spines across individuals. Our findings revealed distinct locomotor behaviors in D. excentricus that suggest directional control and spatial awareness, despite its decentralized neural anatomy. This research contributes to the understanding of how morphological and ecological divergence shape neural circuit functionality and provides a comparative framework for studying the evolution and function of nervous systems in marine invertebrates.

Gestational glucocorticoids do not impact fence lizard offspring cell migration

Taryn King, David Ensminger, Sandra Khalaf, Tony Chao, Summernatsu Hennen, Nathan Tsai, Alexander Payumo, Matthew Chu

Many species experience stressors such as heat stress, competition, predation, and anthropogenic disturbances, with many of these expected to increase in the future. Chronic exposure to these stressors can cause physiological issues such as cell deterioration and impaired replication, leading

to disrupted growth patterns and reproductive difficulties. However, limited knowledge exists about how gestational stress, or maternal stress, impacts offspring cellular dynamics. Here, we investigated the impact of maternal stress on offspring cellular movement in Western Fence Lizards. Gravid wild female lizards were collected and randomly assigned to either control or corticosterone (CORT) treatments. As the primary reptilian glucocorticoid, CORT enables targeted manipulation of a fundamental aspect of the stress response. Eggs were collected and incubated until hatching, where after 7 days, offspring were collected for tissue sampling. Isolated dermal fibroblasts were seeded into 0.2% gelatin-coated plates and grown to 100% confluency. A scratch assay was conducted using a 200ul pipette tip and fibroblast migration was measured through imaging at 40x magnification, in 8-hour increments until complete wound closure. Preliminary analysis indicates that maternal CORT did not influence offspring fibroblast movement speed. Although maternal stress in related species has been shown to influence hormones, heart rate, and growth, this finding would suggest that wound healing may exhibit less plasticity than these traits, though further research is needed to elucidate the physiological basis of these differences.

The breakdown of mitonuclear communication during extreme hypertrophic muscle fiber growth

Stephen Kinsey, Dylan Orcutt, Emily Helder, Pierre Le Pabic

Mitonuclear communication is critical for cellular function. A key form of mitonuclear crosstalk is the stimulation of nuclear gene expression by mitochondrial production of reactive oxygen species (ROS). We took advantage of the extreme hypertrophic growth and associated organelle distribution shifts that occur in blue crab swimming muscle to evaluate disruption of mitonuclear communication. As the animals grow, fiber diameter increases from 600 µm in adults. To compensate for diffusion limitation during this large increase in fiber size, mitochondrial distribution shifts from uniform in juvenile fibers to exclusively peripheral in adult fibers, while nuclear distribution shifts in the opposite manner, from exclusively peripheral to uniform. Thus, the large adult fibers have a population of peripheral nuclei in close contact with mitochondria and a population of central nuclei that are spatially separated from mitochondria, presumably disrupting mitonuclear communication in these central nuclei. We found that ROS produced by peripheral mitochondria failed to penetrate the fiber more than a few microns, meaning the central nuclei likely are not exposed to these important mitochondrial signals. To determine the consequences of the presumed mitonuclear communication breakdown, we collected samples that isolated the peripheral and central nuclei by mechanically skinning the fibers and examined gene expression in each nuclear population. This model offers the potential for novel insights into cellular communication.

Tracking demographics in the aggressive intertidal sea anemone *Anthopleura elegantissima*

Nathan Kirk, Riley Bellows, Itzel Delgado Lopez, Thandiwe Venema, Elle Hopkins, Rowan McLachlan

The intertidal sea anemone Anthopleura elegantissima forms clonal aggregations that aggressively defend themselves against conspecifics, resulting in injury to the combatants. Although individual aggressive interactions have been described, less is known about the long-term effects of these behaviors on the outcome and how dynamic population sizes are. To help address these knowledge gaps, in July 2022 we started a long-term demographic study by semi-permanently marking 72 colonies in close proximity to each other across separate 2 field sites on the Oregon Coast and have since extended this work to 3 new locations. We have collected individuals from each colony to determine their aggression, sex and gonadal status and have determined how colony sizes change over time using image and video analysis. The marked colonies range in size from 55 to 1206 individuals and 57% colonies have decreased in size (avg=-16.5+/- 115) although there was no correlation between the total number of individuals and magnitude of change; some colonies disappeared completely over the three-year period. We hypothesized that aggression and the ability to win competitive interactions may lead to advantages in the field and have been partnering anemones from different colonies in controlled pairwise aggression assays. There was no significant correlation between the ability to win a fight in the lab and the colony size change likely indicating other factors besides aggression contribute to persistence.

Natural and experimental temperatures affect both avian parental behavior and offspring development

William Kirkpatrick, Sarah DuRant

Climate warming exposes parents to rapidly shifting environments, which can affect parental care behaviors. In cavity nesting birds, parental behavior can be separately influenced by average environmental temperature and thermal variation with implications for offspring phenotype. However, we know little about the interactive impacts of adult behavioral shifts and the thermal environment on post-hatch development in offspring. We collected observational data in a 208 box nestbox system across 5 field sites to examine Eastern Bluebird (Sialia sialis) and Tree Swallow (Tachycineta bicolor) behavior and offspring physiological development from 2020-2024. During 2023-24, we modified some Eastern Bluebird nests to experience modified thermal conditions in an experimental study, either increased average temperature or thermal variation. We quantified adult breeding behavior and nest temperatures using thermal loggers. Our observational results suggest that average temperature negatively correlates with offspring mass. Tarsus length was best predicted by incubation constancy (the percentage of time mom spends on the nest) and species. Eastern Bluebirds chicks had longer tarsi when adults invested more time on the nest, but the opposite was true for Tree Swallows. Our experimental results supported our observational data as offspring mass remained negatively correlated with average temperature even though mothers increase constancy as temperatures rise. Both observational and experimental adults reduced constancy in more thermally variable nests.

A common genetic pathway underlying nectary and carpel development in a Ranunculid species

Avery Klein, Anthony Garcia, Verónica Di Stilio, Saya Natsuume

The Ranunculales represents the order sister to the core eudicots, and as a result, occupies a phylogenetically important position for comparative studies. Within the Ranunculales, the large Ranunculaceae family contains species with floral traits ancestral to the eudicots, such as unfused carpels, while simultaneously showing independently evolved innovations, such as nectariferous petals. These floral structures are important for pollination, but their genetic underpinnings remain known in only a few model organisms. In particular, the STYLISH (STY) gene family regulates nectary and stigma development in Aquilegia coerulea, but its function in other Ranunculaceae is unknown. To study the potential conservation of STY function within these organs and inform our understanding of the origin of nectaries, we aim to determine STY gene function in Myosurus minimus, a member of the Ranunculaceae distantly related to Aquilegia that also has nectaries, free carpels, and spurs. We used virus-induced gene silencing to silence M. minimus homologs and will characterize the structural changes resulting from STY misexpression using scanning electron microscopy. We expect to observe loss of nectaries and stigmas in STY silenced plants, suggesting STY function in carpels and nectaries is conserved across Ranunculaceae. By analyzing STY function in M. minimus, we aim to provide insight into the origins of angiosperm floral innovations and identify genetic networks that may have been co-opted for these novel structures.

Star Meadow: Assessing historic populations of the threatened sunflower star in a video archive

Julia Knopf, Willem Weertman, Jason Hodin

Eelgrass is a foundational biome that provides critical habitat for numerous species in the Pacific Northwest. Modern evidence supports that sunflower stars (Pycnopodia helianthoides) use eelgrass as a nursery. In Puget Sound, sunflower star populations experienced a nearly 90% decline beginning in 2013–2014, resulting from an unprecedented sea star wasting disease (SSWD) outbreak. Despite being a dominant predator, sunflower star populations were not monitored in any systematic way. Washington State Department

of Natural Resources (WDNR) surveys marine vegetation trends through the Submerged Vegetation Monitoring Program (SVMP), with a primary focus on eelgrass. The SVMP video archive is ~6000 hours of submerged footage throughout the Salish Sea in Washington state and dates back to 2000. This work describes the design of a computer vision system to scrape sunflower stars from the archive and appropriately account for variable video footage quality. Working with a 1% sample of the full archive, we developed three computer vision models: a clean-dirty filter, an optical character recognition model, and a sunflower star detection model. We demonstrate the combined use of these models, with human verification of sunflower star detections, to put historic sunflower stars present in the archive on a map. These studies provide a unique window into the past, from healthy sunflower star populations that predate SSWD and spanning the declines, with implications for both sunflower star and eelgrass restoration.

Fluid stigmergy: animal collective organization in fluid environments

Hungtang Ko

Collective behavior defines the lives of many animal species on Earth. Yet, how swarm intelligence and group coordination arise despite individuals' limited sensory capabilities remains a captivating question. In this talk, I explore Fluid Stigmergy, a framework highlighting the role of fluid environments in animal self-organization. In air and water, animals exploit fluid forces both passively and actively. Fire ants leverage surface tension to form floating rafts; honeybees manipulate airflow to transport pheromone signals; and fish use hydrodynamic cues to sense schooling mates. These examples demonstrate how fluid media expand animals' sensory reach and enable implicit communication. By focusing on interactions between organisms and their fluid environment, this perspective reveals novel pathways to collective organization and underscores the importance of interdisciplinary collaboration across fluid mechanics, biology, and robotics.

Phylogenomics of Cumacea (Pancrustacea: Peracarida), a model for Antarctic adaptation

Kevin Kocot, William Farris, Victoria VanderBrandt, Sarah Gerken

Cumaceans are diverse peracarid crustaceans that are ubiquitous in marine soft sediments and play important roles in benthic food webs. Because many Antarctic species have close temperate relatives, cumaceans represent a promising system for comparative genomic investigations of adaptation to extreme cold. However, relationships among major lineages remain unresolved, limiting ecological and evolutionary investigations. To address this, we sequenced transcriptomes from nearly 100 species spanning most families, including the rarely collected family Gynodiastylidae. Phylogenomic analyses followed a routine pipeline including inference of single-copy orthologs using OrthoFinder and PhyloPyPruner. Maximum likelihood analysis of a preliminary dataset composed of 233 genes totaling 65,006 amino acid positions with 27% missing data supported monophyly of the order and a deep division between taxa with a free telson and those with a fused pleotelson, consistent with earlier studies. Unexpectedly, Bodotriidae was recovered paraphyletic, with Cyclaspis and Eocuma recovered as early-branching, and a clade including Atlantocuma and Vaunthompsonia grouping with Nannastacidae + Leuconidae. Placement of Gynodiastylidae, previously only represented by a single COI sequence, is being re-evaluated with transcriptome-scale data. While transcriptome-quality samples are lacking for Pseudocumatidae and Ceratocumatidae, genome skimming of ethanol-preserved specimens will expand our taxonomic coverage. This ongoing work represents the first large-scale phylogenomic study of Cumacea and provides a framework for testing hypotheses of diversification and cold adaptation in this ecologically important group.

Mechanical design of spicule-reinforced connective tissues: Features affecting breakability

Mimi Koehl

Many animals from different phyla have, embedded in their pliable connective tissues, small bits of stiff material called spicules. Earlier work showed that spicules increase the stiffness of connective tissues and that spicule-reinforced tissues exhibit stress-softening behavior. This study focuses on the breakability of spiculated tissues. The fracture mechanics of spicule-reinforced connective tissues from various cnidarians and sponges, as well as of model spiculated ""tissues"", were measured to elucidate the effects of spicule size, shape, and packing density within a tissue. Models had a pliant matrix with viscoelastic properties mimicking cnidarian mesoglea, but the type and volume-percent of spicules embedded in the material was varied. Spicules increased strength (breaking stress), but decreased extensibility ([breaking length]/[undeformed length]) and toughness ([work to break]/[x-sectional area]) of pliable tissues. The strength of model ""tissues"" with small spicules increased, while those with large spicules decreased with greater volume-percent of spicules. High-speed movies of the fracture process and microscope analysis of fracture surfaces revealed mechanisms responsible. Spicules make tissues stronger by blunting the crack tip (reducing local stress in the tissue), increasing the area of the fracture surface (raising work required to break the specimen), and reducing resilience of the tissue (lowering transfer of strain energy from the tissue that drives the advancing crack). However, spicules make tissues less extensible and tough via local strain amplification in the matrix.

Freshwater ponds provide insights into dynamic host-microbe interactions across a landscape scale

Kevin Kohl, Emily Hardison

Across landscapes, organisms are facing compounding challenges due to anthropogenically-induced global change, such as pollution and rising temperatures. Host-microbe associations play critical roles in conferring organismal resilience to these environmental stressors. For example, our group has shown that associations with microbes increase tadpole survival under heat stress. In aquatic animals, these environmentally-acquired microbes are subject to their own independent ecological and evolutionary trajectories in response to environmental stressors (temperature, pollution). Thus, understanding and preserving host-microbe partnerships may be particularly important for maintaining resilient ecosystems. We have been elucidating the dynamic and interconnected microbial ecology of temperate ponds: small water bodies (less than 2.5 hectares) that harbor great biodiversity of aquatic life and serve important ecosystem services. Ponds also occupy small catchment areas on the landscape, and thus serve as localized indicators of human activity. Through widespread and repeated environmental sampling, we are uncovering geographic and environmental drivers of pond microbial communities. Then, using laboratory experiments, we experimentally investigate how variable microbial communities confer increased organismal resilience. For example, we have shown tadpole inoculated with microbial communities preconditioned with salt (NaCl) exhibit greater survival when exposed to acute salt stress. In this regard, ponds and their resident micro- and macro-organisms are emerging as powerful models to understand how landscape conditions, especially anthropogenic influences, impact host-microbe interactions across different geographic and temporal scales.

Integrating complex environments to reveal integrated phenotypes by cryptic developmental plasticity

Tiana Kohlsdorf, Leandro Lofeu

Phenotypic integration can be studied at different biological levels and is often interpreted from developmental and/or functional perspectives. Increasing literature recognizes the role of developmental plasticity revealing new complex and integrated phenotypes, which likely express interactions between development and function because the animal performs ecological tasks while develops in a given environment. In this talk, we present an approach designed to investigate the cryptic plastic potential for revealing novel phenotypes in specific developmental environments. This framework introduces the concepts of Parental Developmental Environment (PDE) and

Experimental Developmental Environment (EDE). The PDE corresponds to the prevailing environmental conditions for a population in which a given phenotypic range is expressed, whereas the EDE represents a novel set of environmental conditions that differ from the PDE and enable cryptic developmental plasticity to reveal new phenotypes, thereby expanding the phenotypic space. We illustrate application of this approach in studies using Anostomidae, a fish family of neotropical distribution. Specifically, we integrated several environmental signals in complex developmental environments and raised fish in different experimental conditions (EDE). We evaluated plastic responses under a multi-trait and multi-level approach that combined morphological data with gene expression and applied analyses as diverse as modularity and FEA. We identified novel phenotypes arising through developmental plasticity in Anostomidae, and confirmed expansion of the phenotypic space by plastic phenotypes revealed through manipulations of EDEs.

How do worms use roots to climb: insights from the biomimetic simulations

Prathyusha Kokkoorakunnel Ramankutty, Harry Tuazon, Ivy Li, Saad Bhamla

Living organisms often employ diverse strategies to climb trees and plants in their habitats for survival. Here, we explore how a flexible invertebrate, the California blackworm (Lumbriculus variegatus), uses plant roots to maneuver and climb. These worms live in aquatic environments and are capable of entangling with one another to form highly dense entangled worm blobs. They exhibit climbing behavior when interacting with free-floating plants like duckweed in their vicinity. The dangling roots of the duckweed provide support for maneuvering and entangling, which helps the worms climb. The assembly of the duckweed and worms acts like a floating raft, enabling the worm to achieve faster collective locomotion. Drawing inspiration from this mechanism, we model the ensemble of California blackworms and duckweed as a system of active and passive polymers, respectively. Within a coarse-grained computational framework, we model the worm as a flexible active polymer endowed with self-propulsion and a chiral head motion [1], and the duckweed as a polymer of finite stiffness, either anchored or free at one end. Our simulations demonstrate that passive-polymer stiffness, intrinsic curvature of root tips and worm activity govern the climbing process. Our study reveals how blackworms manipulate environmental structures for survival, offering insights into locomotion that can inform the design of bio-inspired robots across diverse terrains.

[1] Science 380, 392 (2023)

Chemosensory gene expression in Southern Torrent Salamanders across sex and life stage

Asher Kolden, Karen Kiemnec-Tyburczy

Chemoreception is critical for salamanders, mediating behaviors such as courtship, kin recognition, and foraging. At the molecular level, the sensory cells in the salamander nasal cavity are highly tuned to sense target ligands using specialized seven-transmembrane G-protein-coupled receptors (GPCRs) but expression of these receptors has only been investigated in a handful of amphibian taxa. The Southern Torrent Salamander (Rhyacotriton variegatus), a species of conservation concern in California, remains uncharacterized in terms of olfactory gene expression despite its reliance on chemoreception for survival. Because the family of olfactory receptors (ORs) are primarily coupled with the G-protein Gαolf and vomeronasal receptors (V1Rs, V2Rs) coexpressed with the ion channel Trpc2, these genes can serve a proxies for the localization of these major receptor gene families in the main olfactory epithelium and vomeronasal organ of R. variegatus. To investigate the expression of Gαolf and Trpc2, we conducted in situ hybridization on nasal tissue collected from larvae, adult males and adult females. We found that Gαolf expression was widespread in the main olfactory cavity of larvae and adults, while Trpc2 expression was largely restricted to the vomeronasal organ in both life stages. By comparing expression patterns across sexes and developmental stages, this study provides the first molecular characterization of the olfactory system in Torrent Salamanders and contributes to broader understanding of the expression of these receptor gene families in urodeles.

Environmental DNA surveying of insect pollinator communities in young, changing floral environments

Cameron Kolthoff, Alex Torson, Kendra Greenlee, Julia Bowsher

Land use changes in the United States are one of the leading threats to insect biodiversity. In the prairie region of the United States, a way to combat this habitat loss has been through prairie enhancement using wildflower garden plots or strips. In this project, we are tracking changes in insect pollinator and plant communities across two sites containing six treatments planted in proximity. These treatments include commercially available seed mixes and custom mixes, containing a variety of native perennials, annuals, and exotics. Plantings of wildflower species rapidly shift composition within the initial years (1-3 years) and within a season. Because of these quick changes, similar shifts in an associated pollinator community could be expected as well. Thus, we are monitoring insect pollinators on a biweekly basis throughout the season over multiple years. To facilitate the degree of sampling required, we are using environmental DNA (eDNA) metabarcoding of insect DNA from floral washes as a minimally destructive method for fast sampling of young plantings.

Our initial observations of flowering data indicate a similar flowering community between sites and general temporal differences for species of flowering plants, with the presence of early and late season species. Due to these observed temporal differences in plant availability, we hypothesize that the pollinating insect community will be similar across sites but will change across the season.

Motor control of the Drosophila melanogaster antennae

Emily Kophs, Marie Suver

Animals actively sense their surroundings to respond appropriately to environmental cues and stimuli. This dynamic acquisition of sensory information is enabled by active positioning of sensors and helps guide behavioral responses to evolving and unpredictable environments. Yet how these active movements are controlled during behavior and coordinated with ongoing sensory acquisition is not fully understood. In the fruit fly Drosophila melanogaster, the antennae are crucial sensors for extracting important information from the environment including mechanosensory, olfactory, and auditory signals. Just four distinct muscles command movement of the antennae, and this work is aimed at elucidating the motor circuits controlling these muscles. We recently characterized the complete set of antennal motor neurons used by Drosophila for actively positioning the antennae. Using genetic tools to stochastically label subsets of these neurons, together with optogenetic manipulations in flying and nonflying flies, and connectomics data, we are elucidating the role of specific motor neurons for coordinating active antennal movements and their role in flight behavior.

Population genomics of Spea spadefoot toads in southern USA

Syrmalenia Kotronaki, Heidi Seears, Amber Rice

The New Mexico spadefoot toad, Spea multiplicata, is an American species found in southwestern United States and central Mexico. In some parts of the United States, its distribution overlaps with the range of its congeneric S. bombifrons. Depending on local conditions, some populations consist of one species (allopatric), while other populations consist of both species (sympatric). We explored the population genomics of both sympatric and allopatric S. multiplicata from the Arizona- New Mexico border. Using double digest restriction-site associated DNA sequencing (ddRADseq) data and a reference genome, we surveyed the genetic diversity of 175 S. multiplicata individuals collected from eight sites, and elucidated patterns of genetic structure. We investigated whether sympatric populations are more genetically differentiated relative to allopatric and allotopic populations. We detected reduction in gene flow between different populations, which is consistent with has been found in previous studies. S. multiplicata has undergone both ecological and reproductive character displacement. Our findings support the hypothesis that character displacement causes post-mating isolation between the populations that are in sympatry with S. bombifrons and those are in allopatry.

More than skin deep: the microbiome influences ectoparasitic infection and host behavior in guppies

Rachael Kramp, Faith Rovenolt, Jason Walsman, Will Rogers, Kevin Kohl, Wouter van der Bijl, Jessica Stephenson

Infectious diseases are a growing risk to public health and biodiversity. Incorporating understudied factors of hosts will help create a framework for holistically studying infectious diseases. Recent research has revealed one such understudied factor: the host-associated microbial communities, i.e., the 'microbiome'. Here I use a uniquely experimentally tractable fish-parasite system (guppy Poecilia reticulata-ectoparasitic flatworm Gyrodactylus turnbulli) to answer how the microbiome influences host physiology related to fitness and infection severity. I used three microbial manipulation treatments: conventional conditions, probiotic condition, or sterilized "microbially-disrupted" condition, to rear guppies until adulthood. Next, each fish was infected with parasites for 15 days to test how the microbiome affects infection dynamics. Additionally, I tracked each fish's activity and social behavior. There were striking differences in infection severity, fish growth rate, and male orange coloration between microbial treatment groups. Those raised in microbially-disrupted water had reduced infection intensities. Fish in conventional and probiotic-treated water grew larger and faster than microbially-disrupted fish, yet all treatment groups had similar body condition. Remarkably, males had greater orange in the probiotic treatment compared to other treatments. Using structural equation modeling, I found that the microbiome treatment directly affected infection severity and growth rate, but not indirectly through affecting host length. Lastly, microbially-disrupted fish appeared less social than the other treatment groups with foreign treatment groups. These results demonstrate that the host-associated microbiome plays a crucial role in host fitness and parasite infection.

How squirrels twist their ankles: XROMM analysis provides 3D insights into hindfoot reversal

Duyi (Tina) Kuang, Stephanie Pierce

Many arboreal mammals can rotate their hindfeet up to 180°, enabling head-first descent and upside-down hanging. Although this extreme range of motion (RoM) has been well-documented in diverse mammalian taxa (e.g., squirrel, opossum, kinkajou), the underlying mechanism remains unclear. To understand the skeletal basis of this movement, we performed ex vivo cadaveric XROMM on four gray squirrel (Sciurus carolinensis) specimens, manipulating the hindfoot through its full range of poses to quantify joint motions. We show that complete hindfoot reversal results from coordinated motion across multiple tarsal joints. During inversion, the tibio-astragalar joint contributes only minimally (~5°), while the astragalocalcaneal joint permits the calcaneus to pivot around the astragalus by ~80°, with articular surfaces translating ~4mm. The transverse tarsal joint contributes an additional ~55°. Notably, although the astragalocalcaneal joint exhibits limited rotations during ankle flexion-extension and abduction-adduction, ankle inversion requires simultaneous extension (~20°) and adduction (~35°). Dissections further reveal that the lateral ankle ligaments of gray squirrels have a long slack length that enables this wide RoM, highlighting the importance of soft tissues in shaping joint kinematics. Our findings show that the astragalocalcaneal joint is specialized for hindfoot reversal in tree squirrels — one evolutionary solution to the locomotor demands of arboreal life. Comparative sampling across terrestrial and arboreal mammals will help clarify how skeletal morphology and soft tissue architecture support varied arboreal strategies.

Topography of photoreceptor classes in the retina of hogfish (*Lachnolaimus maximus*)

Isabelle Kuhn, Vanessa Moreno, Lorian Schweikert

For many animals, the visual sensory system is critical to survival and thus, is often shaped according to ecological need. In the marine realm, this is reflected in spectral sensitivity, or the capacity to detect distinct wavelengths of light as determined by opsin expression across photoreceptor cells of the retina. The Caribbean hogfish (Lachnolaimus maximus) is a color-changing reef fish species that may depend on vision for behaviors including social signaling and defense. To investigate this, we examined retinal topography of photoreceptor classes in retina of hogfish (N = 5 fish) using anti-opsin immunohistochemistry. The distribution of short-wavelength-sensitive (SWS1) cone photoreceptors, long-wavelength-sensitive (LWS) cone photoreceptors, and rod photoreceptors were mapped across the retina to determine spatial differences in 1) rod to cone photoreceptor proportion; 2) SWS1 to LWS cone photoreceptor proportion; and 3) the photoreceptor complement associated with the acute zone of spatial vision. The findings of this study, connecting retinal form and function, provide new insight into the visual ecology of this species and, consequently, a greater understanding of the use of vision in their world.

Chick meal size and parent feeding responses in Leach's storm petrels (*Hydrobates leucorhous*)

Kayla Kulzy, Liam Taylor, Robert Mauck, Patricia Jones

In long-lived species, individuals must balance short-term offspring investment with long-term self-prioritization to maximize lifetime reproductive success. Many seabirds are long-lived and rely on ephemeral pelagic resource patches when rearing young, which creates a cost of high-risk foraging trips and may necessitate biparental care. Leach's storm petrels (Hydrobates leucorhous) are procellariform seabirds with extensive pair bonds and single-egg clutches. Parents return to the burrow at night to regurgitate lipid-rich oil to chicks for the 67-day rearing period. Using weigh bridges in burrow entrances combined with radio frequency identification, we recorded the entry and exit masses of individual parents to determine meal sizes delivered to chicks. We demonstrate that entry weight of the adult and duration since that adult had last fed the chick were important predictors of meal size allocated to a chick. If both parents fed the chick in the same night, the order in which the adult feeds was also correlated to meal size. The combination of this novel technology and unique life history allows us to accurately quantify how much adults chose to invest in their offspring in a given year.

Are honey bees' pollen baskets viable for plant germination?

Alex Kurtt, Shawn Steffan, Anna Edlund, Fernando de la Torre, Juan Zalapa

Pollen acts as both a gamete for plant reproduction and a vital nutrient for bees. Adult honey bees (Apis mellifera) mix pollen with nectar, enzymes, and microbes to create 'bee bread,' the primary diet of developing larvae. This pollen represents a surplus that has been diverted from plant reproduction and then re-appropriated as food for bees. Pollen destined for honey bee hives is stored in a forager's 'pollen basket' (corbicula), and while the pollen will eventually become food, the point at which pollen grains become non-viable (incapable of germination) is largely unknown. This study investigated the changes in pollen viability after collection and manipulation by honey bees for two species of plants: Allium tuberosum and Solidago rigida. Pollen viability was measured by culturing pollen grains on species-specific pollen germination media. Bee-collected pollen was contrasted against fresh pollen directly from floral anthers (the untreated control), de-ionized water-soaked pollen, and 10% sucrose solution-washed pollen (a nectar substitute). Our data show that between a plant's anther and a bee's hive, foraging honey bees may often manipulate corbicular pollen such that its viability is greatly reduced.

Mitochondrial-supported thermogenesis in crosses between highland and lowland-adapted deer mice

Shady Kuster, Jada Joseph, Adam Chicco, Daniel Sloan, Kathryn Wilsterman

High elevations are a model system for studying local adaptation because they place cold stressors on animals in hypoxic (low O2) environments. These challenges have been hypothesized to select for efficient O2 use and increased thermogenic capacity based on mitochondrial function. Highland deer mice (Peromyscus maniculatus) demonstrate metabolic adaptations across many biological levels in comparison to lowland conspecifics. We focused on two critical sites for thermogenic performance: the gastrocnemius and brown adipose tissue. We bred reciprocal crosses of deer mice sourced from high and low elevation environments and acclimated them to cold normoxic (5°C, 17% O2) or cold hypoxic (5°C, 12% O2) conditions for eight

weeks. We measured both whole-animal and mitochondrial aerobic phenotypes to assess the efficiency of O2 use. Our results recapitulated known highland and lowland phenotypes, but reciprocal hybrids tended to show similar whole-animal and mitochondrial aerobic performance despite carrying different mtDNA haplotypes. Cold hypoxia induced a higher maximal VO2, but in mitochondria from two regions of the gastrocnemius, hybrids differed from pure lines by failing to show hypoxia-induced decreases in O2 consumption. Overall, we demonstrate that having some highland ancestry across the genome is usually sufficient to produce highland-adapted aerobic phenotypes and that mtDNA does not seem to differentially affect aerobic traits. These findings may explain why some highland populations seem to show such high lowland-associated allele frequencies.

Inter-arm connectivity of the intramuscular nerve cords is conserved across octopus species

Adam Kuuspalu, Melina Hale, Eden Anne Bauer

Each octopus arm is extensively innervated, notably containing a central nerve cord and four small intramuscular nerve cords (INCs). The INCs are thought to contain proprioceptive circuits. Recently, Kuuspalu et al. (2022) (Curr Biol. 32, 5415-5421) found an unexpected uniform crossover pattern of INCs connecting arms two arms apart in Octopus bimaculoides. Comparative work in species of squid and cuttlefish did not find the same organization (Kuuspalu et al., SICB2024 Neurobiology and Neuroethology [abstract]). Here, we ask whether the anatomy of O. bimaculoides is present in other octopus species. We examined oral INC anatomy, the focus of Kuusapulu et al. (2022), in a lesser-studied octopus, Octopus mercatoris. O. mercatoris are found along the western coasts of Mexico and Florida, with a mantle reaching ~16-18 mm in length compared to ~10-17 cm in O. bimaculoides. Animals were obtained from the Marine Biological Laboratory (Woods Hole, MA). Frozen specimens were cryosectioned, then arm anatomy was visualized with immunofluorescence staining and confocal imaging. Results yielded evidence of oral INCs passing between arms to connect arms two arms apart as in O. bimaculoides, suggesting this pattern may be a feature of octopuses. In the future, we hope to investigate the development and function of this oral INC patterning, and to compare these results more broadly across coleoid cephalopods. Funding: ONR N00014-22-1-2208.

Responses to climate warming: repeatable direction but species-specific magnitudes

Alycia Lackey, Sophia Anner, Shayna Earl

Responses to climate warming are influenced by life history complexity, plasticity, and local adaptation, but whether these responses are predictable across taxa and environmental gradients remains poorly understood. While earlier phenology and reduced survival are common responses to warming, the extent to which such responses are repeatable—across species or even within species—is a key open question. We address this question using two fly species, Rhagoletis pomonella and R. suavis, which diverged ~3mya and differ in host use, genomic background, and life-history trait optima. Despite these differences, the species overlap in geographic ranges and experience shared climatic and seasonal selection gradients. Critically, the transition from overwintering pupae to reproductive adults is highly sensitive to environmental conditions, making their complex life cycles a key mediator of climate responses. Using a realistic simulated warming experiment, we tested the repeatability of phenological and survival responses across species. Both species emerged earlier under warming, but R. pomonella showed a larger shift than R. suavis. Yet, greater phenological plasticity did not buffer R. pomonella from higher survival costs compared to R. suavis. Our results highlight how species facing similar selection pressures can show divergent responses to warming. Improving climate response predictions will require a deeper understanding of the roles of plasticity, evolutionary history, and physiological constraints shaping response.

Small but keen: The large and acute eyes of a tiny alien arachnid

Brendan Lan, Sonke Johnsen

Of the known eye designs that have evolved, camera-type eyes provide the highest visual performance for their size and have independently evolved across animals from humans to deep-sea polychaetes to arachnids. Here we examine the spatial acuity and morphology of the eyes in Caddo agilis, a 3 mm long arachnid harvestman (Opiliones) with one pair of proportionally massive 0.5 mm diameter camera-type eyes. Previous work on C. agilis has noted its large eyes but did not explore its vision or behavior. We show that C. agilis are predatory, highly visual hunters that will strike at moving bars on a screen. Although absolute eye size is generally a reliable predictor of acuity, we found that C. agilis has significantly higher acuity than predicted by its eye size. Using behavioral trials, we have measured its acuity to be at least 0.87 cycles per degree, similar to a rat despite the rat having 11x the eye diameter. Natural selection can increase acuity beyond what is predicted by eye diameter through the lengthening of their eyes into a tubular shape, developing foveal pits, or decreasing photoreceptor diameter. We have found that C. agilis eyes are not tube-shaped and are currently using microscopy techniques including microCT to determine what morphological adaptations its eyes possess that allow them to overperform in acuity.

How does insulin-like growth factor 1 relate to adult and nestling body size across latitudes?

Samuel Lane, Gabrielle Names, Ádám Lendvai, Isaac Rush, Lindsey Willingham, Bethany Bespoyasny, Taylor Fossett, Alexander Hoxie, Hailey Freeman, Anuj Ghimire, Jeffery Kittilson, Jennifer Grindstaff, Heather Mathewson, David Westneat, Britt Heidinger

In endotherms, body size is expected to decrease in response to climate warming as a modern extension of Bergmann's rule. This rule predicts body size increases with latitude because larger individuals have more efficient heat retention in cold environments but are less able to dissipate heat in warm environments. When phenotypic traits are sensitive to the same hormonal mechanisms, changes in hormone levels are predicted to facilitate rapid phenotypic responses to changing environmental conditions. One hormonal mechanism that is well-positioned to regulate rapid phenotypic change is insulin-like growth factor 1 (IGF-1). IGF-1 is a protein hormone that influences growth rate and body size across varying environments. Specifically, IGF-1 is sensitive to a range of environmental stimuli including nutrient availability and temperature, both predicted to vary with latitude. Thus, IGF-1 is likely a key mechanism influencing body size and other life-history traits via micro-evolutionary changes, phenotypic plasticity, or both. To determine if IGF-1 promotes differences in growth and body size across different latitudes, we explored the natural variation in plasma IGF-1 in free-living adult and 10-day-old nestling house sparrows (Passer domesticus) along a latitudinal gradient in the central United States. We predicted that IGF-1 levels would be positively correlated with pace of growth (nestlings) and body size (adults) and that IGF-1 levels would increase with latitude.

Ecological opportunity and niche filling of insular reptile and amphibian radiations

Zachary Lange, Luke Frishkoff

Islands provide a natural laboratory for studying how ecological and evolutionary processes unfold, offering varied opportunities for species to diversify across niche space. In adaptive radiations, it is often assumed that lineages possess the evolutionary capacity to fill unoccupied niches. However, it remains unclear whether different radiations exposed to the same ecological opportunities will exploit them similarly. In this study, we examine how reptiles and amphibians occupy vertical niche space from the forest floor to the canopy across four islands of varying size: Puerto Rico, Jamaica, Hispaniola, and Madagascar. To do so, we conducted ground-to-canopy and terrestrial transect surveys across a broad range of climates on each island. Our results show that reptiles consistently occupy the full vertical niche space on all islands, while amphibians remain largely restricted to lower strata. Near the forest floor, both groups show expected abundance patterns, with higher

densities on smaller islands. In the canopy, reptile abundances mirror terrestrial trends, but amphibians are consistently scarce regardless of island size. These findings suggest that ecological opportunity alone does not guarantee full niche exploitation. Some axes of niche space, such as the vertical niche axis, may be more evolutionarily accessible to some clades compared to others.

Optic flow during free flight in pigeons

Anthony Lapsansky, Douglas Wylie, Douglas Altshuler

Optic flow, the movement of wide-field image features across the retina resulting from self-motion, is thought to underlie flight control across diurnal animals. In birds, optic flow is encoded by nuclei within the Accessory Optic System (AOS) and pretectum. These nuclei receive direct input from the retina and project to the cerebellum, forming a subcortical pathway for processing optic flow and, potentially, controlling flight. The optic flow preferences of neurons within the AOS and pretectum are well described for at least some avian species and are hypothesized to match the natural statistics of optic flow experienced during their flight. However, data describing the optic flow produced by flight are lacking. We developed a head-mounted camera system to record high-speed video during free flight in pigeons (Columba livia), collecting data from 11 individuals and 36 flights from a distant release site to the pigeons' home loft. Optic flow varied substantially across the visual field, with greater velocities occurring below the horizon. Along the horizon, however, flow velocities closely matched the speed and direction preferences of neurons in the pigeon AOS, suggesting that AOS neurons act as matched filters to control flight. Additionally, these velocities balance the slow, repetitive eye movements previously documented in flying pigeons, providing further evidence that birds stabilize visual features during flight through oculomotor behavior.

Using orientation patch count to predict sexual dimorphism in M. terrapin

Alexandria Lardent, Brenlee Shipps, Jenny Zhan

The triturating surface of a beaked animal is the part of the beak that contacts food. Previous work has found a significant correlation between low triturating surface complexity and carnivory in turtles. We measure triturating surface complexity using orientation patch count (OPC), a function within the R package molaR, the result of which we then compare to the known diet of the species. The species Malaclemys terrapin is strongly sexually dimorphic. Females are significantly larger than males, which results in a proportionally larger skull and consumption of exclusively hard-shelled invertebrates. This is in contrast to the smaller male M. terrapin, which consumes both hard-shelled and softer prey. While it is known that diets differ between sexes, it is not known whether this difference is reflected in the complexity of their triturating surfaces. Using a sample of 33 M. terrapin specimens from MorphoSource, we used OPC to explore whether sexual dimorphism was reflected in this triturating surface. Though we anticipated that females would have a higher OPC than the males due to increased vascularity on the maxilla, our results indicate that male M. terrapin have higher OPC on average. This implies that although the titrating surface can reflect sexual dimorphism, our understanding of the relationship between apparent surface complexity, computed surface complexity, and variations in diet within populations is incomplete.

Departures from Mendelian Inheritance in Hybrid Rattlesnakes

Nicolas Largotta, Brenna Levine, Warren Booth, Gordon Schuett, Wolfgang Wuster

Hybridization between closely related species can generate genomic incompatibilities in the offspring, leading to departures from expected Mendelian inheritance. This phenomenon is particularly relevant in rattlesnakes, where species boundaries are porous and natural hybridization occurs in the wild. We investigated these dynamics in an experimental cross between prairie (Crotalus viridis) and mojave rattlesnakes (C. scutulatus), two species with strikingly different venom profiles. Using whole-genome resequencing, we analyzed a non-hybrid C. viridis mother and her four F1 hybrid offspring. We quantified genome-wide Mendelian incompatibilities in the mother–offspring pairs and estimated de novo mutation rates in the hybrids. Results of our study provide insight into how hybridization can disrupt Mendelian inheritance, with potential downstream effects on complex traits such as venom composition. More broadly, this work contributes to understanding the genetic consequences of hybridization in rattlesnake populations and the evolutionary processes shaping natural hybrid zones.

Evaluating tissue tropism in a neotropical migrant

Emilee Larisch, Victoria Wiley, C. Loren Buck

North American breeding bird populations have decreased by 29% since 1970; it is hypothesized that population declines may be related to environmental contaminants. The Purple Martin (Progne subis) is a migratory, insectivorous swallow that breeds in North America and overwinters in Brazil. Consequently, they are susceptible to mercury (Hg) exposure when molting due to deforestation and mining activities in Brazil. As upper trophic level consumers, they are vulnerable to the compounding effects of bioaccumulation and biomagnification of toxicants, including Hg. We collected feathers, organs, and whole body samples from 57 P. subis adults. To provide a comprehensive view of contaminant patterns in the body, organs collected include the brain, liver, pectoralis, gastrocnemius, heart, gastrointestinal tract, and lungs. We are quantifying Hg to investigate the body burden and tissue-specific patterns in P. subis using cold vapor atomic absorption. We hypothesize that Hg concentrations will be higher in the liver, heart, and muscles when compared to the lungs, brain, and gastrointestinal tract. We also predict that Hg concentrations in feathers will positively correlate with those in paired internal organs, enabling prediction of contaminant loads across the body from minimally invasive feather sampling. Because feather sampling is a widely used approach in bird ecotoxicology, our findings will refine its interpretation and improve understanding of tissue-specific Hg distribution in a declining Neotropical migrant.

From head to tail: patterns of scale diversity in centrarchids

Hana Larkins, Dylan Wainwright

Fish scales are ossified, overlapping plates that cover the body of ray-finned fishes and display remarkable morphological diversity within and across species. Scales of bony fishes are often grouped into two types: cycloid scales with smooth edges and ctenoid scales with spines that are separate ossifications. Scale types are conserved within species or higher taxonomic groups. Although functions of scale types are not fully understood, proposed roles include predator defense, biofouling, and hydrodynamics. Past work shows that bluegill sunfish (family Centrarchidae) have more than one scale type on different body regions, with cycloid scales on the opercle and ctenoid scales along the body and tail. To test whether this pattern is widespread in centrarchids, I examined scale type and morphology across body regions in 28 centrarchid species (70% of the family). I sampled scales from the opercle, mid-body, and peduncle of three individuals per species and imaged each region with gel-based profilometry to capture surface topography, scale morphology, and assign scale type. Preliminary results suggest that centrarchids commonly exhibit cycloid scales on the opercle and ctenoid scales on the mid-body and peduncle. Additionally, I found variation in the proportion of scale edges covered in ctenii, with scales near the tail approaching complete coverage. These findings support that multiple scale types within individuals are widespread across centrarchids, clarifying how scale morphology shifts along the body axis.

42 years of sea turtle tagging in a growing rookery on Florida's Gulf coastline

Jake Lasala, James Grimes, Kim Heuberger, Kristen Mazzarella

Long-term data sets and analyses are essential to long term conservation plans of a species. In ideal populations, observations of behavior can be partnered with census counts of individuals – thus allowing researchers to quantify how populations change over time. Unfortunately, marine turtles tend to be elusive, limiting availability. Mark-recapture studies of nesters allow researchers to identify reproductive parameters for their populations, including: size at sexual maturity, age at sexual maturity, clutch frequency, remigration rates, nest site

fidelity, and survivorship can all be estimated from analyzing long-term tagging data. Most studies focus on one nesting beach to make inferences about the population, but in this study, two long-term tagging groups in the Sarasota, Florida region have pooled resources to assess their nesting population from 1983-2025. These nesting beaches make up the largest loggerhead (Caretta caretta) rookery in the Gulf and the green sea turtle (Chelonia mydas) is rapidly growing. This project will quantify the number of nesting loggerhead and green sea turtles that comprise this established rookery on beaches in the Sarasota County, Florida region - identify their reproductive parameters and survivorship. These reproductive parameters can provide beach managers with necessary information to further monitor and protect future nesting populations.

Relative impacts of developmental temperature and parental care on juvenile behavior

Rikki Laser, Chloe Lee, Xingjian (Henry) Mu, David Grafals, Linnea Niemack, Kiran Kadakia, Alexander Ophir

Developmental plasticity influences behavioral phenotype across the lifespan. Parental behaviors are important for ensuring offspring survival and for shaping offspring phenotype, including how offspring care for young (i.e., alloparenting behavior). Likewise, developmental temperature impacts offspring phenotype, and acute exposure to ambient temperature impacts parental behavior. However, few studies have investigated how temperature and parental behavior jointly shape offspring behavioral phenotype. Prairie voles are small rodents whose parenting behavior affects later offspring alloparenting behavior. Additionally, temperature can affect prairie vole parenting behavior. To investigate this, we manipulated ambient temperature and recorded both the parental care offspring received as neonates and the alloparental behavior offspring later showed as juveniles. In this study, we explore the utility of using generalized linear models to understand the relative effects of developmental temperature versus parenting received on later offspring alloparenting behavior. Even though the literature has demonstrated that parenting behavior impacts alloparenting behavior, we found evidence indicating that developmental temperature shows a stronger impact on alloparental contact and licking/grooming behavior. This work demonstrates the importance of considering both social and abiotic factors in understanding developmental plasticity.

Fuel vs. fitness: driving forces behind locomotive performance in frogs

Audrey Laskey, Chase Kinsey

Locomotor performance is driven in part by adequate nutrition and may be modulated by training effects. Previous studies have focused on nutritional input, or training regime. However, there is little empirical evidence under controlled laboratory settings to suggest a relationship between both effects. Here, we evaluate the relationship of nutrition and training using the African Clawed Frog as a model system. Xenopus laevis frogs (n=28) were split into four treatments: exercise with controlled food intake, non-exercise with controlled food intake, exercise with unlimited food, and non-exercise with unlimited food. Each frog was placed in a custom-built flow tank and swam at 2000 rpm for 10 minutes daily over a period of 30 days. After 30 days, frogs were filmed performing an escape response in a 10-gallon tank. Videos were digitized in MATLAB and average maximum velocity calculated. Preliminary results of treatment groups with controlled food intake showed no difference in performance or mass between exercise and non-exercised groups. We expect the treatment group undergoing exercise with unlimited food availability to perform better than other treatment groups. The expected results, in conjunction with current preliminary results might suggest that increased locomotor performance is driven by an increase in nutrient consumption in conjunction with a training regime. Data from this study will provide insight into the physiological demands of locomotion in a prolific species of frog.

Reassessing the biomechanics of an invertebrate ear: tympanal ridges in a parasitoid fly

Brendan Latham, Andrew Reid, Norman Lee, James Windmill

The parasitoid fly Ormia ochracea achieves precise directional hearing on a micro-scale through a mechanically coupled ear. Studies in the 1990s identified a see-saw tympanal (eardrum) bridge, and this discovery inspired many bioinspired microelectromechanical systems (MEMS) microphone designs. Despite this progress, the role of the tympanal ridges, prominent morphological features of the ear, remains unclear. We apply advanced imaging and vibration analysis to reassess Ormia ear biomechanics. Micro-computed tomography (micro-CT) imaging provides high-resolution three-dimensional reconstructions and enables the creation of digitally modified models. These models are subjected to finite-element analysis under simulated acoustic stimulation to test how ridge morphology influences sound reception. Scanning laser Doppler vibrometry complements this approach by experimentally recording vibrational responses from across the entire tympanal surface, offering far greater coverage than earlier studies. The resulting data indicate whether the tympanal ridges support a travelling wave, as observed in diverse taxa from bushcrickets to the mammalian cochlea. By combining anatomical imaging, experimental recordings, and computational simulations, this interdisciplinary work addresses a long-standing question in insect hearing. The results advance understanding of tympanal function in Ormia and may inform new design principles for miniature directional microphones used in hearing aids and mobile devices. By comparing the potential for a travelling wave in this system with established examples in other organisms, this study contributes to understanding shared principles of sound reception across species.

Resurrecting ancestral dehalogenases to illuminate the origin of octocoral bioluminescence

Emily Lau, Joseph Thornton

Evolution tinkers with existing genetic material, producing novel phenotypes absent in ancestral lineages. However, the genetic mechanisms underlying the origin of novel phenotypes at the organismal level remain poorly understood, due to the difficulty of establishing causal relationships between genetic and phenotypic changes. Here, we use ancestral protein reconstruction, structural modeling, and biochemical assays to investigate the origin of bioluminescence in octocorals. Octocoral bioluminescence is produced by a biochemical reaction, whereby a protein called “luciferase” oxidizes a substrate called “luciferin”. Octocoral luciferases evolved by recruiting dehalogenases, an enzyme family with ancestral hydrolase activity. To understand the genetic mechanisms underlying the catalytic transition from hydrolase to luciferase activity, we first identified dehalogenase sequences from octocoral genomes and transcriptomes. We inferred a phylogeny of dehalogenases, then recombinantly expressed and tested extant sequences for luciferase activity to identify a clade of functional luciferases. We reconstructed the ancestral sequences prior to and at the origin of luciferase activity and identify several amino acid substitutions at the active site cavity, which may underlie the functional transition from hydrolase to luciferase activity. Currently, we are functionally testing these ancestral sequences and examining the effects of the amino acid substitutions on luciferase and hydrolase activity. The results of this research will provide a deeper understanding of the genetic mechanisms underlying the origin of octocoral bioluminescence.

Resolving the paradox of fish schooling: positional rearrangement enables energetic saving

George Lauder, Michael Calicchia, Yu Pan, Rui Ni, Yangfan Zhang

Recent experiments on fish schooling behavior have revealed a paradox. Measurements of metabolic energy use have shown that fish in schools reduce their energetic costs relative to swimming alone, particularly at higher speeds, but fish within the school are also constantly rearranging their relative positions. How can energy saving occur if fish do not maintain fixed positions? To understand the causes of energy saving when swimming in a school, we need to quantify water flow patterns within the school to determine if there are reduced velocity zones that could facilitate a reduction in swimming cost. We used a 3-laser imaging arrangement for particle image velocimetry to measure

within-school flow dynamics in groups of 8 giant danio (Devario aequipinnatus) swimming at speeds of 1.5 to 5 lengths/sec. We observed fish within the group in a wide variety of relative positions and quantified flow velocities (relative to free-stream velcocity) in regions near to swimming groups of fish. Fish pivoting and traversing laterally generated a reduced velocity region downstream of approximately 20%. Fish swimming in a staggered formation or in side-by side configurations also generated reduced velocity along the body of nearby or downstream fish. These results show that positional rearrangement can generate reduced velocity zones that fish in a school can take advantage of, reducing drag and locomotor cost.

DNA methylation and epigenetic potential of *Toll-like receptor 4* in house sparrows

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House sparrows (Passer domesticus) are one of the world's most cosmopolitan bird species, and epigenetic mechanisms affecting gene expression appear to facilitate their geographic distribution. In introduced house sparrow populations, DNA methylation compensates for reduced genetic diversity, and the most recently introduced individuals have the greatest variance in DNA methylation. Further, introduced house sparrows have higher epigenetic potential than native ones. Epigenetic potential, in this context, refers to an individual's ability to express differential DNA methylation based on genetic variation in potentially methylated sites. Together, these results suggest that house sparrows use epigenetic buffering as part of their response to novel environmental conditions. Here, we take a targeted approach to further investigate the relationships among DNA methylation, epigenetic potential, and gene expression of a microbial surveillance gene, Toll-like receptor 4 (TLR4). We screened DNA methylation, epigenetic potential, and gene expression among individuals from 10 native and introduced locations to test whether birds from introduced populations could more nimbly establish DNA methylation states on epigenetic potential sites to regulate gene expression. We hypothesize that higher epigenetic potential in introduced birds results in greater DNA methylation variability, increasing their variability in TLR4 gene expression. These results will further our understanding of how epigenetic mechanisms relate to the birds' ability to overcome the suite of challenges presented by biological introduction on as vast a geographic scale possible.

Long-fuse evolution of carnivoran skeletal phenomes through the Cenozoic

Chris Law, Leslea Hlusko, Jack Tseng

Climatic change is hypothesized to promote phenotypic diversification. While neontological analyses are often used to test this hypothesis, extant data only captures time-averaged signals of surviving lineages. More nuanced tests require paired and longitudinal climatic and organismal data. Here, we developed the most comprehensive phenomic dataset of pan-carnivorans to test hypotheses that Cenozoic climatic change influenced the evolution of the cranial, appendicular, and axial skeleton. We found support that a hierarchical progression of ecological diversification across the Cenozoic significantly influenced the establishment of modern carnivorans. Specifically, extinctions during the Eocene-Oligocene Transition released crown carnivorans from a constrained adaptive zone to interfamilial skeletal diversification. Intrafamilial skeletal diversification did not occur for another 20 million years until after the Mid-Miocene Climate Transition. Our work demonstrates the essential role of macroevolutionary data from the fossil record for revealing how major global climatic events steered the evolutionary trajectories of modern skeletal phenomes.

Effects of Acute Heat Stress on Megachile rotundata Development and Survival in Nondiapausers

Arnel Lawrence, Arun Rajamohan, Mehakpreet Kaur, Julia Bowsher

As extreme weather events such as heat waves increase due in part to climate change, it is critical to understand how acute thermal stress affects species vital to ecosystem function. Megachile rotundata (leafcutter bees) is a major managed pollinator used globally in alfalfa production and routinely experiences extreme temperatures within nest cavities. The goal of this study was to determine how acute heat stress affects development and biological aging in solitary bees.This study examines how acute thermal stress during late pupal development, when individuals are believed to be pharate adults, (45 °C for 1 hour versus a 25 °C control) impacts survival to adult emergence, developmental timing, and telomere length in non-diapausing M. rotundata, a life-history stage that remains relatively understudied. Following treatment, bees were housed individually and monitored daily to record emergence timing, emergence success, sex, and post-emergence behavior. Behavioral activity (flying versus crawling) was recorded to assess whether activity level influences telomere length. We predicted that acute heat stress would shorten telomere length and accelerate emergence relative to control conditions. Telomere length analyses are ongoing and will be examined in future work. Planned comparisons will also evaluate differences between non-diapausing and diapausing individuals from the same generation, and environmental conditions during collection will be incorporated into future analyses. Together, these results will provide insight into how acute thermal stress may shape developmental outcomes in a key solitary pollinator under climate change.

Stage dependent nest defense and predator recognition by nesting red-winged blackbirds

Shelby Lawson, Angela Zbaracki, Russell Campbell, Eleanor Fraser, David Kikuchi

Animals must rapidly assess threats to both themselves and their offspring, yet how prey evaluate predators that pose differing risks to adults versus young remains unclear. We tested wild red-winged blackbirds (Agelaius phoeniceus) across nesting stages using lifelike models of common nest threats: a brood-parasitic brown-headed cowbird, California scrub jay, California ground squirrel, Pacific gopher snake, and the venomous Western rattlesnake that the gopher snake mimics, as well as a neutral control. Our goal was to assess how blackbirds discriminate among predators of varying risk to themselves or their young, and how those responses shift over the course of breeding. Blackbirds showed stronger aggression toward predator models than the control, with overall aggression increasing as reproductive investment rose. In particular, responses to the gopher snake increased across stages, suggesting strategic escalation in defense as offspring neared fledging. This increase was not observed for the rattlesnake, despite its similar appearance. Responses to cowbirds declined after eggs hatched, aligning with reduced parasitism risk. Females were also more likely to return to the nest during the nestling stage, reflecting increased willingness to take personal risk to provision young. These results demonstrate that blackbirds dynamically adjust their antipredator strategies based on both predator identity and breeding context. Birds did not clearly distinguish between the snake species, but their shifting responses suggest flexible decision-making when balancing self-preservation with offspring defense.

Investigating acoustic behavior and geographic variation of a cryptic species: the striped cusk-eel

Xylo Lazrinth, Rachel Rodriguez, Thomas Quigley, Paul Forlano

Despite their abundance along the Eastern Seaboard, striped cusk-eels (Ophidion marginatum) remain relatively understudied due to their cryptic nature, which involves remaining buried throughout the day, and emerging at night for feeding and spawning. Advertisement calls consisting of chatters follow a crepuscular pattern and are produced by males throughout the summer reproductive season to attract females. Utilizing passive acoustic monitoring (PAM), we recorded striped cusk-eel advertisement calls from several sites in Brooklyn, NY and Long Island, NY during the summer of 2024 and 2025 using HydroMoth recorders. Daily calling patterns and individual

call characteristics, such as number of pulses and pulse repetition rate, were measured for each site and recording period. Due to challenges associated with identifying individual calls during overlapping choruses, call occupancy (total duration of calls/recording duration) was utilized to characterize calling activity for every hour of the day, from either four or ten minute samples. We observed spatial and temporal variations, with the biophony of two sites dominated by striped cusk-eel detections with differences in the call occupancy of dusk and dawn choruses. Variation in soundscape contributors, particularly vessel noise, may influence striped cusk-eel calling patterns and has previously been shown to disrupt acoustic communication in other species. Using PAM, this study offers valuable insights into striped cusk-eel acoustic behavior and provides a baseline for monitoring potential impacts of underwater noise pollution.

Genomic mechanisms of adaptation to high hydrostatic pressure in deep sea fishes

Katie Le, Mackenzie Gerringer, Amanda Byer, Jacob Daane

Hydrostatic pressure increases with ocean depth, exceeding one thousand times atmospheric pressure in hadal trenches. These pressures disrupt fundamental biochemical and cellular processes, posing physiological challenges for survival in the deepest parts of the ocean. To identify genetic and cellular mechanisms of pressure adaptation, we are combining comparative genomic and laboratory functional genetic approaches. As a model clade, we are focused on the order Perciformes (sensu stricto), a rapidly diversifying clade that has repeatedly colonized habitats exceeding 1,000m in depth, and including several hadal fish species inhabiting waters exceeding 7,000m. Using existing and new genome assemblies, we are generating a whole genome alignment encompassing multiple independent invasions of the deep oceans to look for patterns of convergent evolution in deep-adapted species. In parallel, we are developing a zebrafish model system of hydrostatic pressure. We built a pressure chamber that simulates the hydrostatic pressure conditions found at all ocean depths, and using this set-up we are using RNA-seq and ATAC-seq in zebrafish embryos to identify pressure-specific cellular stress responses. Further, we can use genome editing tools to test the function of evolved protein changes from Perciformes in an in vivo context. Together, this data will provide insight into the cellular mechanism of pressure tolerance that facilitates the colonization and survival of the deep sea.

Combined cytokine and pathogen exposure signaling induce antimicrobial peptide production in Xenopus

Emily Le Sage, Leon Grayfer, Jack Lubitz, Lillard Preschlack, Thomas Tao, Yiwen Su

Antimicrobial peptides (AMPs) are broad-spectrum, potent defenses found in all kingdoms of life. Amphibian species are among the most studied taxa for potential AMP therapeutics, yet the mechanisms orchestrating AMP production and secretion in this group are not well understood. Given recent evidence suggesting AMP defenses contributed to the recovery of some amphibian populations following disease-induced declines, greater insight into how AMP production is regulated will grant perspective on amphibian resilience. To this end, we examined whether AMP production was induced by exposure to the fungal pathogen, Batrachochytrium dendrobatidis (Bd), and proinflammatory cytokines that increase in the skin during Bd infection. In an exposure experiment, we found that injecting Xenopus laevis with recombinant tumor necrosis factor-alpha (rTNFa) prior to Bd exposure resulted in greater recovery of AMPs compared to animals treated with a vehicle control or a recombinant interferon-gamma. Further, AMPs isolated from rTNFa-treated and Bd exposed frogs were more effective at inhibiting Bd growth. Thus, Bd-targeting AMP production is induced by the paired signaling of proinflammatory cytokines and pathogen presence in Xenopus laevis. These results raise the hypothesis that population responses to Bd may vary due to differences in cytokine signaling and AMP production during Bd infections.

Halteres as sensors for postural stabilization in crane flies

Kristianna Lea, Madeline Ang, Jessica Fox

Halteres, the modified hindwings of flies, provide precise sensory feedback about inertial forces to the peripheral and central nervous system. Though most prior research has focused on their role as flight stabilizers, here, we show that they also sense perturbations outside of flight. Using wild-caught crane flies, we filmed body and haltere movements at high-speeds during rotational, vertical, and horizontal perturbations. In rotational movements, flies did not oscillate their halteres but maintained stable posture against a range of rotation speeds. When the halteres were removed, flies were less able to maintain a stable body posture at any rotation speed. In free fall, we observed multiple types of maneuvers of the haltere, and found that flies without halteres were significantly less able to stabilize their center of mass. Similar results were observed during short falls with substrate impact and in rapid lateral translations. Across perturbation types, we noted a distinct class of haltere behaviors: small oscillations. Flies that did these oscillations were as stable as flies that did large flight-like oscillations, suggesting that any input from the haltere can be sufficient to stabilize body motion. Taken together, our experiments suggest that crane flies use their halteres as organs of stability outside of their canonical role in flight behavior, and that any motions of the haltere are sufficient to provide the necessary information to resist external perturbations.

What about the thymus gland? Effects of thyroid hormone and dexamethasone on Xenopus metamorphosis

Benjamin Lee, Caroline Hamilton, Anas Shahood, Alessandro Grunstein, Alex Schreiber

Amphibian metamorphosis is accompanied by rises in endogenous glucocorticoids (GC) and thyroid hormones (TH) that may interact to modulate development of diverse tissues. Exogenously administered GC are known to suppress the vertebrate immune system and induce thymus gland involution, including in amphibian tadpoles. The effects of exogenous TH on tadpole thymus development remains uncertain, as well as its potential interactive effects with GC. Here we characterize changes in thymus gland gross and fine morphology during spontaneous metamorphosis, as well as in Nieuwkoop and Faber (NF) stage 54 prometamorphic tadpoles treated with TH (3nM T3) and the pharmacological GC analogue dexamethasone (DEX, 2uM) for 24-48 hours, individually or in combination. During spontaneous metamorphosis, thymus size transiently increases during climax, then become smaller. Thymus gland development is accompanied by both increased cell proliferation and apoptosis at climax, followed by a return to baseline levels. Thymuses of NF54 tadpoles treated with either TH or Dex for 4-5 days similarly decreased in size compared with controls, and TH+DEX treatment produced even smaller sizes. Whereas DEX or TH alone increased apoptosis, TH+DEX further increased apoptosis. Both TH and DEX individually increased cell proliferation, with TH inducing more than DEX. The findings suggest that changes in thymus development during metamorphosis are influenced by both thyroid hormones and GC.

Impacts of developmental and acute temperature on alloparenting behavior

Chloe Lee, Alexander Ophir, Rikki Laser, Kiran Kadakia

Early-life environments can shape the development of caregiving behavior. In rodents, alloparental care (i.e., juvenile caregiving toward unrelated pups) provides an important window into the emergence of social and thermoregulatory strategies. Although the role of social context in alloparenting has been relatively well studied, it remains unclear how developmental temperature influences the expression of juvenile caregiving behavior. To address this question, we raised prairie vole families (Microtus ochrogaster) either at room temperature or under a heated condition, then measured juvenile alloparenting behavior at both room temperature and the heated temperature. Juveniles decreased high contact and increased lower contact behaviors with pups under experiencing acute heat compared to acute room temperature. Developmental and acute temperature significantly interacted across behaviors. For example, females raised under the heated condition demonstrated

less high contact and licking/grooming behavior when tested under the acute heated condition compared to those raised at room temperature. In sum, both developmental and acute temperature conditions influenced alloparental behavior. These findings suggest that developmental temperature modulates juvenile caregiving behavior, highlighting a pathway through which early-life environments shape the expression of social and thermoregulatory strategies.

Pace length revisited: Quantifying leg compliance in human gait

David Lee

Walking legs are conventionally thought of as rigid struts despite experimental evidence that leg compliance is a key feature of human walking. In order to probe the stiffness of the human walking leg, we prescribed pace lengths from extremely short to extremely long and measured changes in radial leg stiffness, deflection, work, and vertical force profile. As pace length is increased from preferred, radial stiffness decreases to a horizontal asymptote that equals the stiffness of the running leg. As pace length is decreased from preferred, the radial leg becomes significantly stiffer at a pace length just 20% less, then becomes arbitrarily stiff as pace length decreases further. These data show that radial leg stiffness during walking can be modeled as a reciprocal function of excursion angle, which is directly proportional to pace length. Our simplified model of a radial leg with spring and actuator in series shows similar radial stiffness values during preferred walking and running, suggesting that these gaits are influenced by the same intrinsic musculoskeletal compliance of the leg. These observations might also be extended to bipedal robots designed to achieve walking and running on the same legs - or to prosthetic designs seeking to enable both gaits.

Oxtr SNP predicts social observation toward strangers in female prairie voles

Shang Lin Tommy Lee

The oxytocin receptor (OXTR) supports pair bonding in prairie voles, yet how natural Oxtr variation shapes the social interactions that precede a bond is unclear. A specific Oxtr SNP predicts nucleus accumbens (NAc) expression: C/C females have higher OXTR than T/T. We quantified behavior in C/C and T/T females during cohabitation with a novel wild-type male using a custom multi-animal pose pipeline (DeepLabCut, SLEAP, and idTracker) and a random-forest classifier to label social behaviors across time. We observed a significant genotype × time × spatial/orientational interaction on approach. In the first 15 minutes, C/C females stayed farther from the novel male yet oriented toward him more often, consistent with elevated "social observation." C/C females showed more social observation than T/T early in cohabitation, and the genotypes converged over time. In the Social Preference Test (SPT), we found a genotype × social zone interaction: C/C females spent less time with the stranger, whereas T/T females spent more. Comparing across contexts, C/C females exhibited longer durations of stranger-directed social observation than T/T overall, with a genotype × context interaction indicating a larger difference during cohabitation than in the SPT. Together, these results show that natural variation in Oxtr biases the temporal unfolding and "style" of early interactions with a novel male, underscoring the interplay of genotype, social context, and temporal dynamics in the formation of social bonds.

Characterization of *Caprella penantis* microbiome under seasonal temperature fluctuation

Zachary Lee, Jose Moscoso, Kent Hatch

Caprella penantis is an important organism responsible for cleaning decaying matter and predating on small invertebrates. Microbiome variation can facilitate host evolution and be the mechanism by which a species can become cosmopolitan, by expanding the breadth of niches hosts can occupy. The microbiomes of C. penantis have not been previously characterized. This study examined the microbiomes of C. penantis over time to test for the effects of temperature and seasonal variation on skeleton shrimp microbiome composition. The C. penantis microbiome was analyzed on three separate days, an early, middle, and late day. There were notably colder water temperatures on the days leading up to the early date compared to the other two dates, and as a result the early date had a significantly different microbial composition. We also observed a greater alpha diversity in microbial communities for the early sampling date. The C. penantis microbiome composition was very similar to Litopenaeus vannamei, the most commonly used shrimp in microbiome research. The main observable differences between the early and later dates was an increase in the relative abundance of Gammaproteobacteria, a class containing several opportunistic pathogens which can compete with other bacteria in the microbiome, potentially resulting in decreased microbial diversity, altered microbiome composition, and increased host vulnerability to infection and disease. This is the first instance where the C. penantis microbiome has been documented.

Heat-induced physiological stress effects in Eastern Bluebird nestlings

Lily Lehnhardt, Sarah Knutie, Jennifer Houtz

Climate change can cause an increased frequency of extreme weather events, such as heat waves, leading to physiological stress in homeothermic animals. The hypothalamic-pituitary-adrenal (HPA) axis releases glucocorticoid hormones like corticosterone as a physiological mechanism to mobilize energy during thermal stressors. Altricial birds are susceptible to heat-induced stress during development due to their inability to thermoregulate until they reach homeothermy. Increased temperatures can also lead to physiological changes like increased dehydration and decreased body mass that may negatively impact organismal fitness. I hypothesized that Eastern Bluebird (Sialia sialis) nestlings exposed to increased temperatures would show decreased body mass, higher corticosterone levels, and higher hematocrit levels due to dehydration. I quantified the physiological effects of increased temperature on nestlings by simulating a 10-day heat wave inside nest boxes from hatch day to day 10 of nestling development. I then assessed heat-induced physiological changes of day 13 nestlings, including body mass, corticosterone, and hematocrit percentages. There was no effect of temperature on corticosterone, body mass, or dehydration (% hematocrit) in Eastern Bluebird nestlings. Individual box microclimates may have impacted the internal nest box temperature and nestlings' responses.

Snapping for dominance: a machine learning approach to *Dulichiella* behavioral analysis

Shengwei Lei, Melody Young, Abhinav Vaduri, Jackson Savage, Daniel Rittschof, Sheila Patek

Specialized weapons often evolve either as damaging tools or as ritualized signals, yet empirical tests of their function in tiny crustaceans (<10 mm body length) remain scarce. Male amphipods, Dulichiella appendiculata, possess large snapping claws—reaching 30% of their body mass—that generate powerful water jets. To understand the behavioral usage of snapping claws during territorial contests, we used machine-learning tracking models to analyze 10 male dyads competing for bryozoans under laboratory conditions. The study addressed key questions: (i) How do snapping claws function behaviorally during territorial contests over bryozoan habitat? (ii) How does territorial competition influence movement dynamics, inter-individual spacing, and contest outcomes? (iii) What behavioral patterns distinguish dominant from subordinate individuals in their territorial defense strategies and weapon deployment? Motion trajectories aligned with time-stamped behavioral annotations revealed consistent behaviors. Amphipods first reached toward opponents before snapping, delivering successive snaps without visible injury to targets, suggesting that snapping serves purposes other than physically harming intruders. Movement tracking showed subordinate amphipods moved faster than dominants, with both individuals exhibiting sudden speed increases during contests. Subordinates often accelerated immediately before snap events, and inter-amphipod distance increased significantly following snapping, indicating that these disproportionately large weapons potentially serve as ritualized signals in miniature marine territorial systems. Understanding how these weapons function in territorial contests could reveal novel mechanisms of combat in miniature marine systems.

Heatwaves destabilize epidemics in guppies: how behavior shapes climate-driven disease outbreaks

Noah Leith, Carolyn Tett, Sadie Evanov, Tabea Schneider, Cameron Braswell, Vineet Nayak, Mariam Azizbekyan, Naomi George-Hall, Ashka Patel, Shannon Sneed, Emily Hardison, Niclas Kolm, Kevin Kohl, Jessica Stephenson

Increasingly frequent heatwaves are dramatically altering the risk of disease outbreaks in human and wildlife populations. A major challenge in predicting the epidemiological consequences of heatwaves is understanding how the thermal sensitivity of host behavior impacts transmission. We investigated how behavioral changes during heatwaves shape disease outbreaks using Trinidadian guppies (Poecilia reticulata) and their ectoparasitic Gyrodactylus worms. For individually housed guppies, we found that heatwaves early in infection consistently enhanced host resistance, while late heatwaves increased mortality. To test how behavior links these physiological impacts of heatwaves to parasite transmission, we conducted 30, 14-day experimental epidemics coinciding with either no heatwave, a heatwave over the first five days of the epidemic, or a heatwave five days after the epidemic began. Heatwaves destabilized transmission patterns especially when they happened early in an epidemic, ranging from rapid infection of all hosts to almost complete infection fade-out. Although transmission was slower among guppies that were artificially selected for high social responsiveness, evolutionary differences in behavior did not predict variation in transmission during heatwaves. To explore effects of heatwave-induced behavioral plasticity, we recorded daily behavioral videos and used individual tracking software to test if transmission correlated with temporal changes in guppy social and sexual networks. Overall, we provide a uniquely comprehensive test of how the epidemiological impacts of heatwaves may emerge from feedbacks between individual infections and transmission-relevant behavior.

Assessing the effect of Chytrid fungus on locomotor performance in *Xenopus laevis*

Anna Lennon, Laura Reinert, Louise Rollins-Smith, William Best, Chase Kinsey

Chytridiomycosis, a fungal infectious disease caused by Batrachochytrium dendrobatidis (Bd), is a contributor to declining amphibian populations. Chytridiomycosis disrupts ion exchange across the skin and may result in decreased locomotor performance. Although Xenopus laevis is relatively resistant to Bd, it may be a good model to study how Bd exposure could affect locomotor function. We hypothesized that locomotor performance in X. laevis would be affected by soluble factors released in Bd supernatants. Given the symptoms of lethargy and loss of righting response during infection in some species, we predicted locomotor performance would be negatively impacted. X. laevis were injected with Bd supernatant at varying concentrations and then filmed performing a swimming escape response with high-speed cameras at 4 hours, 24 hours, and 1-week post-injection. Although concentration had no significant effect on escape swimming velocity, velocity was significantly lower at 4 hours post-injection with improvement at 24 hours and 1-week post injection across all groups. Despite an initial decrease in performance, X. laevis quickly recovered. The lack of evidence for changes in locomotor function as seen in diseased frogs may be due to other physiological effects of chytridiomycosis independent of soluble factors released by Bd. Future studies should continue to explore the potential physiological effects of the Bd on locomotion.

The cephalic lateral line in gars (Lepisosteidae): unique tubule structures and development

Derrick Leong, Dohwui Kim, Zehua Zhou, Zachary Randall, Ingo Braasch, Juan Liu

Lepisosteidae (gars) present a valuable model system for investigating lateral line evolution by being an early-diverged actinopterygian clade and having the cephalic lateral line completely enclosed in the skull. Using X-ray-based computed tomography, we investigated the cephalic lateral line across all seven extant and one extinct species (Atractosteus simplex from the Eocene Green River Formation). An ontogenetic series of Lepisosteus oculatus specimens stained with phosphotungstic acid was also scanned. All species present similar canal pathway patterns in terms of branch location and canal length. Tubules, small branches of the canal, are characterized by unique, arch-shaped rows with reticulated secondary, accessory tubules in all species. The elongated snout is a region that consistently displayed the most regional complexity also across all gar species. Interspecific variations are primarily found in connectivity and complexity of tubules. The Eocene specimen displayed comparable canal pathways but showed both incomplete and fully connected arched tubules and minimal secondary tubules, which may reflect distinct evolutionary or ontogenetic stages. While the ontogenetic changes of tubules remain unclear, canal development shows snout-associated canals develop first, particularly the anterior segments of infraorbital, supraorbital, and mandibular canals. It is currently unclear whether this is because of differential temporal gene regulation and/or a functional adaptation of early foraging. Future work aims to understand the importance of these patterns, specifically in the lepisosteid snout.

Disabled and neurodivergent perception, community, and identity in the biosciences: A call to action

Taormina Lepore, Brooke Fitzwater, Alexandra Tissot, Kevin Neumann

Disabled people are important contributors and community members in the biological sciences, yet efforts have failed to consistently build truly welcoming and anti-ableist community spaces in biology classrooms, labs, field work, and conferences. We undertake this call to action on disabled and neurodivergent perception, community, and identity in the biosciences to bring attention to the disabled biologist community and to highlight areas of support for disabled scientists. Part of our process will involve discussing a critical narrative review of the literature as it is known, regarding disability identity and community within the biological sciences. The critical review component uses search terms related to disabled identity, biosciences, and biologists. We underscore areas of substantial disability dialogue in biology, such as education research, and provide recommendations accordingly, as well as areas of growth and improvement, such as conference spaces, field work, and academic departments. In sharing this call to action, we invite ongoing conversation on disabled and neurodivergent community and awareness in bioscience spaces, and we support ongoing work in building anti-ableist biology community spaces.

Phenotypic and proteomic signatures of copper stress and recovery in *Botryllus schlosseri*

Maxime Leprêtre, Dietmar Kueltz

This study establishes the copper tolerance range of the colonial marine tunicate Botryllus schlosseri. Furthermore, quantitative organismal phenotyping and quantitative proteomics were combined to characterize the B. schlosseri response to, and recovery from, acute copper exposure stress. Changes in the area of B. schlosseri colony systems and pigmentation provided sensitive, dose-dependent markers of exposure to, and recovery from, copper stress. Comprehensive quantitative proteomics using consistent data-independent acquisition (DIA) assay libraries revealed activation of detoxification, oxidative stress, and immune pathways during exposure to copper stress. In addition, quantitative proteomics uncovered enrichment of tissue remodeling and proliferative signaling pathways during recovery from copper stress. We identified 35 proteins whose expression closely mirrored phenotypic changes observed at the colonial system level. This specific proteome signature represents a comprehensive molecular underpinning of the organismal response of B. schlosseri to copper stress. In conclusion, this study establishes copper tolerance ranges of the invasive colonial tunicate B. schlosseri and explains the molecular underpinnings of stress-induced organismal phenotypes by identifying corresponding proteome signatures and their associated functional enrichments. Moreover, identification of copper concentrations that are stressful and highly disruptive on the molecular phenotype, yet readily recoverable from, lays a critical foundation for future studies directed at stress-induced adaptation and evolutionary trajectories of marine invertebrates in changing and novel environments. Funded by NSF grant MCB-2127516.

The evolution of same-sex sexual behavior: Using old theory to answer new questions

Brian Lerch

The evolution of mating preferences and consequences of sexual selection are among the oldest and richest subfields in evolution. However, until recently, the evolution (or absence) of perhaps the most fundamental of all mating preferences, the preference for mating with opposite-sex individuals, received little attention. There has been a recent explosion of literature on the evolution and expression of same-sex sexual behavior (SSB) in non-human animals. I make the case that many insights from classic theory on mate choice has strong connections to literature on SSB and that explicitly integrating this "old theory" on mate choice is tremendously informative for understanding SSB. I will review what is known about the expression and evolution of SSB. I begin with experimental studies on how varying social conditions such as density and sex ratio influence the plastic expression of SSB. I then explain why evolution may favor imperfect sex discrimination, how imperfect sex discrimination manifests empirically, and the origin of sex discrimination as a derived trait. Next, I turn to evidence for adaptive SSB, wherein the act of mating with same-sex individuals enhances fitness. I conclude by arguing that researchers should take care to not overstate the broader implications of their findings on SSB and that connecting such results on the evolution of "classic" mating preferences will lead to deeper insights for our field.

Increased oyster density ameliorates heat stress by slowing thermal diffusion

Sara Leuchtenberger, Emily Carrington

Intertidal oysters reach high aerial body temperatures that pose physiological challenges, including reduced growth, disease-tolerance and survival. The density of individuals in an oyster aggregation (farmed or wild) can alter key biophysical factors that modulate body temperature, potentially leading to within-group variability in growth and survival. We used a laboratory wind tunnel to evaluate the effect of oyster density, bed position and wind speed on oyster body temperature. Adult Pacific oysters (Magallana gigas) were stocked in ½ m2 aquaculture bags at densities ranging 50-500 and heated in wind treatments for 3 hours. We monitored the body temperature of live oysters on the top and bottom of the aggregation. Oyster temperatures declined with increased wind speed and if they were on the bottom of a bed with > 250 oysters/bag (linear model, p 250/bag, but were warmer on the top of the bag regardless of density (density x position interaction, $p < 0.001$). Our findings suggest that oyster density can modify in-bed thermal conditions, which may lead to variability in growth and survival. Additionally, the biomimetic "Robo-oyster" is a robust tool for measuring how bed heat transfer varies between different sites or environments.

More than one way to heat a cat: detangling the genomic complexity of body temperature in mammals

Danielle Levesque, Ana Breit, Dylan Barth, Diane Genereux, Mal Ballinger

Although all mammals are endotherms, there exists a surprising amount of variability in body temperatures ranging from ~28-40°C. It has been hypothesized that the ancestral mammal had a low and variable body temperature, and that the high and constant body temperatures of extant lineages evolved during the Cenozoic. To determine the potential causes and mechanisms of high body temperatures in mammals, we first built a quality controlled dataset of resting body temperatures for all eutherian mammals with publicly available genomic data (n=438), 156 of which had reliable and comparable data on resting body temperatures. We applied phylogeny-aware methods to screen for changes in rates of evolution and for areas of genetic convergence between species with similar body temperatures. Ancestral state reconstruction predicted a shared ancestor with a body temperature of around 35-36°C with several cold lineages (38°C, Lagomorpha, Artiodactyla, Mustelidae) diverging over time. No single, clear cause was linked with high body temperature in mammals and more shared genes with accelerated rates of evolution were found in colder species than in hot ones. The genomic complexity of body temperature evolution is consistent with its status as an emergent property of many underlying physiological and behavioral processes.

Contrasting invasion histories and genomic responses to urbanization in the spotted lanternfly

Brenna Levine, Nicolas Largotta

A major question in urban evolution is whether standing genomic variation provides the raw material necessary for rapid adaptation to the novel and heterogeneous selective pressures of cities. The spotted lanternfly (Lycorma delicatula), native to China, has invaded Japan, Korea, and the United States, where invasions have unfolded differently: spread has been rapid in Korea and the U.S., but far slower in Japan. Previous comparative mitogenome studies show that the Korean, U.S., and some Japanese sub-populations share the same haplotype and putative source populations, whereas sub-populations in other regions of Japan are founded by a different haplotype. These contrasting invasion histories provide a powerful framework to test how standing genomic variation contributes to evolution and persistence in human-modified environments. To address this, we generated whole nuclear genome sequences for 360 spotted lanternflies collected from urban and rural sites across the invasive ranges. With these data, we compare genetic structure and patterns of linkage disequilibrium among regions and scan for signatures of selection to assess the role of standing genomic variation in evolutionary responses to urbanization. The outcomes will provide new insights into how standing genomic variation mediates evolutionary responses to urban environments and inform strategies for monitoring and management of this destructive invader.

AI in wildlife monitoring: climate-driven behavior in boars, lizards, and ants

Ofir Levy

Artificial Intelligence (AI) is transforming ecological research by addressing one of the current field's greatest challenges: extracting meaningful insights from massive datasets. Camera traps, for example, provide long-term, noninvasive wildlife monitoring but generate millions of images, most of them empty or irrelevant. AI enables efficient processing of these data, opening new opportunities to discover how animals respond to environmental conditions across broad spatial and temporal scales.

I will highlight three strategies we have developed and applied. First, we use general-purpose models for broad tasks such as animal detection and classification. By combining MegaDetector with species-specific classifiers, we analyzed wild boar activity and uncovered distinct schedules for adults versus mothers with offspring. Second, we build custom models for targeted questions. Our study on lizard thermoregulation trained a sun-versus-shade classifier that not only achieved high performance but also revealed that the AI relied on environmental cues (e.g., ground brightness) rather than the animal itself—providing novel insight into model learning. Third, we tackle complex data such as time-lapse footage of desert ants. Here, we applied extensive pre-processing (stabilization, background subtraction, manual annotation) to enable successful training of object detection models.

Together, these approaches illustrate how we can leverage AI as a flexible toolkit to transform raw ecological data into targeted scientific knowledge, advancing integrative studies of animal behavior and climate adaptation.

The effects of paternal deprivation on juvenile social preference

Jiaxuan Li, Michaela Kihntopf, Kelci Cox, Shelby Olson, Patrick Monari, Catherine Marler

Biparental care in mammals plays a critical role in offspring development, influencing both reproductive success and long-term behavioral outcomes. Disruption of this care—such as the absence of a parent—can lead to substantial changes in offspring social behavior. To investigate how paternal deprivation shapes early-life social preferences, we used the three-chamber test in biparental rodent species California mouse (Peromyscus californicus). Fathers were removed on postnatal day 3, and offspring were tested on postnatal day 24-27 to assess their preference between age-matched opposite-sex peers and parents. Our results show that paternal deprivation significantly increased the ratio of entries into the peer chamber compared to controls, although there was no significant difference in the total time spent

in each chamber. These findings are consistent with previous work showing that paternal deprivation alters social behavior in adulthood and suggest that early-life paternal loss may accelerate offspring-led weaning or reduce the strength of the parent-offspring bond. This early shift in social motivation may reflect long-term changes in affiliative behavior. Ongoing analyses of oxytocin receptor (OXTR), dopamine D1 receptor (D1R), and dopamine D2 receptor (D2R) expression in the nucleus accumbens and the medial amygdala will help understanding the underlying neurobiological mechanisms. If paternal deprivation is found to alter these signaling pathways, it may suggest that early-life stress enhances social motivation toward peers by modulating neurodevelopmental trajectories.

Differences in wing melanization in north american and european Pieris rapae during summer

Jaina Liang, Dominic Lucia, Kristen Genet

Pieris rapae is a global species of butterfly in the family Pieridae which is invasive to Asia, North America and Australia. Because of environmental differences between North America and Europe we wondered if there would be a difference in melanization between the two populations of butterflies, as they use the melanin in their wings for varying purposes. We hypothesized that introduced North American populations would show greater melanization compared to native European populations due to latitude differences. There has been little work done to determine a quantified distinction between European and North American populations of P. rapae for the purposes of expanding basic science and providing data for future research. Therefore, we analyzed data on the proportion of melanization on the dorsal forewing and completed two sample T-test analyses to determine if differences were statistically significant. Using 616 specimens downloaded from iDigBio (from 1821-2016) , we found North American (n = 322) butterflies had significantly greater wing melanization than European (n = 294) Pieris rapae in the wing apex and anterior spot (M3) for both male and females, although there was more variation among North American than European butterflies which could be due to things such sexual selection and a wider range of climate.

From ocean to brain: a multi-scale approach to fish locomotion

James Liao, James Strother, Esra Gokturk

A comprehensive understanding of fish locomotion requires frameworks that transcend laboratory constraints. While laboratory experiments provide precise data, they often fail to capture natural behaviors expressed in ecologically relevant and spatially expansive contexts. We developed a multi-scale approach integrating field telemetry, mesocosm-based behavior, and in vivo neurophysiology. At the landscape level, acoustic tracking of 43 adult red drum (Sciaenops ocellatus) across 5610 km^2 of coastal Florida revealed individual variation in seasonal migration and tidal coupling, indicative of context-dependent behavioral strategies. Finer-scale behavior was resolved using dual tri-axial accelerometers affixed to the tail and operculum of wild red drum in an outdoor mesocosm. These sensors captured swimming speeds, resting, and maneuvering behaviors not captured by traditional dynamic acceleration analyses. To reveal the neural mechanisms driving locomotion, we developed a waterproof head-stage amplifier to record real-time brain activity with fine temporal resolution over extended periods in freely swimming fishes. Using fast-scan voltammetry, we aim to monitor neurotransmitter dynamics that underlie different physiological states during swimming, such as fear, arousal, and stress. This multi-tiered framework linking ecological behavior with internal state promises to advance the fields of movement ecology, conservation biology, robotics, and comparative neuroscience.

The unfolding interactions between environment and metabolism during early-life seabird development

Kayla Lichtner, Sarah Chapman, Tori Chace, Axel Uribe, Liam Taylor, Samuel Neirink, Robert Mauck, Patricia Jones, Mark Haussmann

Energetic efficiency is essential for organismal performance and survival. Mitochondria, the primary producers of cellular energy, demonstrate remarkable functional plasticity in response to early-life environmental conditions. However, the specific factors driving the emergence of diverse mitochondrial phenotypes remain poorly understood. This study explores how seabird parental provisioning influences mitochondrial respiration and DNA oxidative damage in nestling Leach's storm-petrels (Hydrobates leucorhous), and assesses the metabolic flexibility of nestlings during natural periods of fasting. At our field site on Kent Island, New Brunswick, burrow entrance scales were installed to quantify parental provisioning during the 66-day nestling period. Blood samples were collected from nestlings on day 16, 35, and 58 post-hatch to measure DNA oxidative damage (8-OHdG) and mitochondrial respiration. Using high resolution respirometry, this study provides an in-depth analysis of each nestling's energetic profile, highlighting various mechanisms of mitochondrial efficiency and flexibility during early-life development. Preliminary data suggests that mitochondrial respiration and mitochondrial working capacity change over the course of the nestling period. We will discuss the interplay between early-life nutrition and bioenergetics that may underlie the life history of this long-lived seabird.

Relationships between color and behavior in native and invasive anoles

Elena Liebl, Emily Stelling, Christine Lattin

Invasive brown anoles (Anolis sagrei) are currently displacing native green anoles (Anolis carolinensis) in the southeastern U.S. Inter-species behavior differences may have played a role in the brown anole's success, with possible links between increased melanin pigment and decreased neophobia (i.e., novelty avoidance). Both species also have colorful dewlaps they use for social signaling. Carotenoid pigments like those in dewlaps can indicate health and competitive ability, and may be linked to behavioral differences. However, much is still unknown about the relationship between individual variation in behavior and color in lizards. We compared variation in dewlap and body color in brown and green anoles with variation in neophobia, measured as anoles' latency to feed with novel objects present or to eat novel foods. The color of each anole's dewlap, back, and belly was assessed using standardized photo measurements converted to saturation, hue, and brightness. Behavior data suggest that both anole species were neophobic during novelty trials compared to control trials with no significant differences between species. A preliminary color analysis suggests that within brown anoles, there was no relationship between color and neophobia, but green anoles that were lighter in color were less neophobic. Our results suggest intriguing links between color and behavior in green anoles, but do not support the hypothesis that reduced neophobia aided brown anoles in their successful invasion.

Assessing Sample Storage Protocols for HAB Metabarcoding

Stephanie Lievano, John Andres, Ashley Reaume, Mousumi Mary, Michelle R. Gaither

Increasing water temperatures and nutrient loads can create conditions favorable for harmful algal blooms (HABs), which have been linked to economic impacts, fish kills, and health hazards. The Florida Fish and Wildlife and Research Institute (FWRI) monitors HABs by collecting water samples and conducting cell counts. In collaboration with community scientists they receive samples from across the state. These samples are stored at ambient temperature for up to 24 hours during transport. To ensure the efficacy of their protocol, FWRI, in partnership with the University of Central Florida, is investigating whether storage at ambient temperature impacts the plankton community composition of samples. In this study we collected water samples from a single location in the Indian River Lagoon and processed them across six time points (0, 3, 6, 12, 24, and 48 hours). Four replicate samples, along with one negative control, were filtered at each time point.The 0-hour time point was filtered on-site to represent community structure at the time of collection. DNA metabarcoding was employed using 18S V9 and 16S V3-V4 primer sets to characterize plankton communities. Analysis of Similarities (using Bray–Curtis dissimilarities) revealed significant differences in community composition

among time points ($P < 0.05$) in both the 18S and 16S datasets. However, other comparisons did not indicate significant differences. Here we discuss the data and its implications on statewide monitoring programs.

Investigating the role of complex sex-specific patterning in the striped killifish, *Fundulus majalis*

Isaac Ligocki, Sean Burke, Rachel Cuomo, Nicolas Walker

Complex patterns serve a wide range of functions across animal taxa. The striped killifish, Fundulus majalis, is a widespread coastal fish in North America. Male fish of this species possess vertical bars, while female fish possess horizontal stripes. We investigated whether individual decisions to associate with conspecifics were suggestive of a role of patterning in 1) predator confusion, or 2) communicating mate quality. If patterning in F. majalis serves to confuse predators, we predicted that individual fish would preferentially associate with same-sex conspecifics as "parallel" markings has been shown to enhance predator confusion effects. If patterning in F. majalis is under (inter)sexual selection, we predicted that female fish would preferentially associate with males that had more complex patterns that may communicate mate quality. Neither male nor female focal fish differed in their preference to associate with same- or opposite sex conspecifics. Female fish did not preferentially associate with males with more complex patterns, but larger focal females spent more time associating with stimulus males than smaller focal female fish. Collectively, the adaptive value of distinct, sex-specific patterning in F. majalis remains unresolved; future studies should focus on observing interactions between wild fish in natural settings to better understand the functional and adaptive value of patterning in this species.

A tale of tails: Biorobotic experiments test hypotheses of caudal fin evolution

Levi Lilienthal, Alex Spitzer, James Mannix, Cher Mei, John Long

In chordates, the synapomorphic post-anal caudal fin varies from small and pointed to large and flared. The propulsive consequences of these different shapes have been explored experimentally in fishes and self-propelled robotic models; however, few studies have tested adaptive hypotheses about caudal fins using the paradigm of evolutionary biorobotics, whereby propulsion is coupled with autonomous goal-directed behavior. With feeding behavior in mind, we tested the adaptation hypothesis that selection for navigating up a light gradient alters tail geometry. We predicted that swimming quickly and accurately towards the light, and then orbiting close to it, would favor mid-sized, symmetrical tails. We tested this prediction by evolving a population of ten Tadro-class biorobotic swimmers, outfitting individuals with stiff, flat caudal fins of variable 2D morphology, and selecting for enhanced autonomous phototaxic behavior. The starting population included extremes of size and symmetry, covering much of the range of the caudal fin morphospace of vertebrates. Under ten generations of selection, the population's median swimming speed and accuracy increased, behaviors that were correlated with asymmetric caudal fins possessing large ventral lobes. We suspect that because the Tadros swim on the surface, with their tails just barely submerged, dorsal lobes generate surface waves rather than thrust, leaving the work of propulsion to the ventral lobes. Thus, surface and substrate interactions may be key considerations for caudal fin adaptive hypotheses.

What's black, white, and red all over? Cell type specific gene expression in melanin pigmented feathers

Cody Limber, Richard Prum

Feather coloration is one of the most spectacular and well-studied traits in birds. Although there are a variety of color production mechanisms, melanin coloration is the most ubiquitous and produces some of the most spectacular within-feather patterns. Many studies have documented mutations associated with large changes in melanin pigmentation, but we still lack an understanding of the cellular mechanisms involved in creating feather patterns. We used single nuclear sequencing of developing feathers to look for transcriptional changes across cell types in different colored feathers. As predicted, we found differences in melanin production gene expression between black and white feather melanocytes. However, we also find transcriptional changes in keratinocytes, implying that cell type coordination is necessary for feather pigmentation. Finally, to our surprise, we found that pheomelanin and eumelanin production represent distinct melanocyte states with clear gene expression differences. This subfunctionalization requires few gene expression changes and provides a developmental mechanism for plumage color evolvability.

Muscle properties limit energy storage in tendon

David Lin, Austin Au, Bertrand Tanner

Tendon serves an important function to store and return mechanical energy, which augments performance during ballistic movements. It is generally thought that more compliant tendons are better suited to this function, but this hypothesis is difficult to test experimentally due to limitations in changing the compliance of tendon while it is coupled to a muscle. We created a hybrid experimental-simulation system in which muscle fibers can be activated while coupled to simulated tendons. We were able to measure the energy stored in the tendon while the muscle is transiently activated, mimicking the near isometric musculotendon condition of the plantarflexors during the initial phase of a vertical jump. In over 80 muscle fibers, we varied tendon compliance over a range of 0.02 to 0.4 Lo/Fo, where Lo was the length of the fiber at a sarcomere length of 2.7 um and Fo was the isometric force. We found that the energy stored in the tendon increased nonlinearly with increasing compliance, such that the slope of the energy versus compliance approached zero as compliance increased. The limited energy storage coincided with a decreased muscle force and increased muscle shortening as tendon compliance (and lengthening) increased, consistent with force-length and force depression properties. Thus, we concluded that although increased tendon compliance has the potential to store more energy, muscle properties limit the amount of energy muscle can produce.

Searching for palp-able differences between Rhagoletis fruit flies

Jessi Lin, Cheyenne Tait

The olfactory system facilitates important host fruit choice behavior in the Rhagoletis genus. Insects detect odors through two olfactory appendages, the antennae and the maxillary palps. The two co-receptors required to form olfactory receptor complexes, ORCO and IR25a, occur in both. We used fluorescent in-situ hybridization chain reaction to show the co-receptor genes are expressed in the palps and antennae of various Rhagoletis species. The presence of these co-receptor genes suggests that the appendages share similarities mechanistic similarities, as expected from work in other insects. Furthermore, we backfilled the maxillary palps with neurobiotin to trace the path of the olfactory sensory neurons present into glomeruli in the antennal lobe. Our results indicate that in the apple and hawthorn variants of Rhagoletis pomonella, an olfactory neuron on the palps projects to one previously determined valence-determining glomerulus, ventral posterior 1 (VP1). Also, there were more glomeruli overall that were backfilled from the palps neurons in the dogwood variant compared to apple and hawthorn. In addition, VP1 was not backfilled from the palps in dogwood flies. To further dissect differences between more distantly related species of Rhagoletis, we also performed backfilling of the palps in Rhagoletis juglandis and Rhagoletis juniperina. Our findings demonstrate that olfactory neurons on the palps likely play a role in host choice behavior, not solely the antenna as previously investigated.

Axial muscle multiarticularity in the sandfish lizard (*Scincus scincus*)

Jianfeng Lin, Henry Astley, Daniel Goldman

Elongate animals use undulatory body waves to locomote through diverse environments. Previous studies suggest that animals undulating in overdamped environments, such as the sandfish lizard (Scincus scincus), require higher joint torque and greater energy consumption in the central body region [Ding et al., 2012]. Multiarticular muscles that span multiple joints occur in both appendicular and axial systems of vertebrates. In legged animals, multiarticular muscles transfer power among joints to improve locomotor efficiency.

We hypothesize that axial multiarticular muscles similarly balance torque and energy along the body through power transfer. To test this hypothesis, we studied axial muscle multiarticularity in the sandfish lizard, which relies on axial muscles to undulate in sand. Through dissections, we quantified the spans of three major muscle groups: iliocostalis (IC, spanning 7 vertebrae, one-sixth of a body wave during sand swimming), semispinalis–spinalis (SSP, 6), and longissimus dorsi (LD, 4). Using microCT of a diceCT stained specimen, we further measured lever arms and cross-sectional areas at 25%, 50%, and 75% SVL. Muscle groups with longer lever arms for horizontal bending (LD and IC) also have larger cross-sectional areas, underscoring the role of axial muscles in overcoming environmental drag. By constructing a 16-link swimmer with each cable spanning 3 body sections, as observed in the iliocostalis, our simulations indicate that this arrangement balances muscle torque and energy along the body.

Scaling of avian sit-to-stand: passive mechanisms mitigate muscle work limits

Yuting Lin, Delyle Polet, Lars D'Hondt, Friedl De Groote, Mehran Moazen, John Hutchinson

Standing up from rest is a ubiquitous yet mechanically demanding behaviour in terrestrial tetrapods, yet the principles governing sit-to-stand (STS) across species remain unresolved. We combined empirical measurements with theoretical and predictive simulation models to examine STS in two phylogenetically distant ground birds—a large cursorial emu (Dromaius novaehollandiae, ~30 kg) and a small galliform pheasant (Phasianus colchicus, ~1 kg). A simplified single-muscle model revealed size-dependent mechanical limits to standing time: small birds are constrained primarily by vertical centre-of-mass displacement, whereas large birds approach a muscle work-capacity limit. Empirical STS speeds fell well below these bounds, though emus were relatively closer to their mechanical limit. We then explored likely neuromuscular objectives in STS using optimal control simulations with a simplified two-link model. Both species' optimal performances were best described by a combined cost of muscle activation and force-rate, but with distinct species-specific weightings. Full 3D musculoskeletal simulations showed that morphology determines how these objectives shape movement. Emus, limited by low relative ankle extensor capacity and long distal limbs, relied on tendon elastic buffering and passive horizontal-to-vertical momentum transfer to reduce muscle work demands and maintain efficiency. Pheasants, with shorter distal limbs and greater relative ankle capacity, used a primarily vertical, muscle-driven strategy with minimal momentum transfer. These results reveal how size and limb design constrain non-locomotor behaviours and suggest that giant theropod dinosaurs may have evolved alternative strategies to rise from rest—insights relevant to postural evolution and energy-efficient legged-robot design.

Not all monomorphisms evolve equally: female and male ornamentation in Tyranni passerines

Sara Lipshutz, Gabriel Macedo, Yuchen Chen

Across diverse taxa, female animals have ornaments such as conspicuous coloration. However, the evolution of female ornamentation and its contribution to sexual dimorphism are consistently understudied in relation to male ornamentation. We addressed this knowledge gap by investigating plumage ornamentation of females and males of 681 Tyranni species (Suboscines). We hypothesized that greater ornamentation is associated with stronger socio-sexual selection in both females and males, and that sexual dimorphism emerges only when selection pressures differ between sexes. Using phylogenetic models, we tested associations of ornamentation and sexual dimorphism with territoriality, mating system, parental care, migratory behavior, and climatic seasonality. After accounting for natural selection pressures such as vulnerability to predation, we found that females and males show similarly high ornamentation (low sexual dimorphism) in territorial and monogamous species with biparental care and in more seasonal climates. In contrast, males show more elaborate plumage than females in migratory and polygynous species with female-only parental care. Our findings suggest that when females and males are under similar socio-sexual selection pressures, they show similar ornament elaboration. Conversely, sexual dimorphism is greater when males face stronger socio-sexual selection pressures than females. Our study highlights that addressing the processes shaping female traits is key to understanding the evolution of sex differences and similarities.

Sea lions as sentinels: microbial and parasitic indicators for One Health monitoring

Emma Little, Julia Burco, Katherine Prager, Justin Sanders, Brianna Beechler, Holly Arnold

Understanding the drivers of microbial community variation in wild animals offers insights into both host health and ecosystem dynamics. The gut microbiome, as a key regulator of immunity and disease susceptibility, provides an especially valuable lens through which to study wildlife health. Here, we characterize the gastrointestinal (gut) microbial and parasite communities of California sea lions (Zalophus californianus) and Steller sea lions (Eumetopias jubatus) sampled lethally at dam sites within the Columbia River Basin, Oregon and non-lethally in Astoria, Oregon, and assess the influence of host species, sampling location, and health status. Preliminary results suggest sampling location significantly explains variation in microbial community composition, whereas host species does not. Core microbial communities are dominated by Firmicutes, Fusobacteria, Bacteroidota, Actinobacteriota, and Proteobacteria. Putative parasite presence varies between individuals, with Digenea, Filaroididae, Myxosporea, Eucestoda, and Anisakidae detected in 98.3%, 75.8%, 75.4%, 45.9%, and 16.1% of California and Steller sea lions, respectively. We also explore microbial associations with urogenital carcinoma, a cancer prevalent among California sea lions. DESeq2 analysis identifies 26 amplicon sequence variants that are differentially abundant in California sea lions with and without urogenital lesions, many belonging to the phyla Firmicutes and Bacteroidota. Overall, this work contributes to our understanding of host-microbiome-environment interactions and supports the use of pinnipeds as sentinels of ecosystem and wildlife health.

Limb specific control strategies and centralization in cockroaches running on complex terrains

Ellen Liu, Leo Wood, Simon Sponberg

In many behaviors animals' limbs have distinct functions e.g. object manipulation, thrust generation, burrowing. Limb-specific changes in control may promote stable locomotion and these functional differences may drive variation in control through neuromechanical coupling - defined as both mechanical and neural feedback acting between limbs. Coupling can be strong enabling a combination of limbs to respond together to a perturbation (global response) or weak resulting in local limb responses. We hypothesize limb-specific changes in the neuromechanical coupling to arise when increasing terrain complexity for Blaberus discoidalis as limb-specific coupling is known for individual leg perturbations. Alternatively, all limbs may converge to low or high couplings due to limited processing times at high step frequencies or other dynamical constraints. We used an empirical, model-free measure of centralization based on information theory where we compared variation in neuromuscular activation of the anterior femoral extensor muscle (measured with EMGs) with local and global limb states (individual and collective limb kinematics). When increasing terrain complexity, the middle limb's EMG became more informative of the global limb kinematics indicating an increase in coupling and a more centralized limb response. In contrast, the hind limb's control signal became more informative of its own local kinematics implying a more decentralized response, potentially more reliant on intralimb feedback. These opposing trends support our hypothesis that neuromechanical coupling variation is limb-specific. NSF DBI 2319710

Temperature-dependent germ cell proliferation dynamics prior to gonadal sex differentiation

Jingling Liu, Boris Tezak

In many reptiles, such as the red-eared slider turtle (Trachemys scripta), temperature during embryonic development determines sex, a process known as temperature-dependent sex determination (TSD). Cooler incubation produces males, while warmer produces females. Research has traditionally

focused on how temperature affects somatic cells of the gonad, which direct sex differentiation. However, recent work from our lab shows that temperature also directly influences germ cells (GCs), which can shape sexual fate. Warmer temperatures during the first third of development, before gonadal sex determination begins, increase GC numbers, and elevated GC numbers are associated with ovarian fate. The mechanism driving this temperature-dependent increase in GCs remains unclear.

We hypothesized that warmer temperatures promote higher GC-specific proliferation rates. To test this, we incubated T. scripta eggs under male-producing (cool) and female-producing (warm) conditions and injected embryos with the proliferation marker EdU at three early developmental stages. Samples were analyzed by immunofluorescence to compare proliferation rates in GCs and somatic cells across treatments and time points, with proliferation further validated by phospho-histone H3 immunostaining. Surprisingly, our results revealed no active GC proliferation during stages corresponding to early gonad formation. These findings suggest that temperature-dependent differences in GC number occur earlier, specifically during germ cell migration to the gonad. Ongoing experiments aim to determine whether these differences result from proliferation during migration, variation in GC death, or altered migration dynamics.

Unveiling the unexpected: the oldest freshwater otophysan and its macroevolutionary implications

Juan Liu, Don Brinkman, Alison Murray, Michael Newbrey, Zehua Zhou, Lisa Van Loon, Neil Banerjee

Otophysans, accounting for two-thirds of extant freshwater fish species, are characterized by enhanced hearing capability enabled by the Weberian apparatus between the gas bladder and inner ears. It has long been believed that they had a single freshwater origin before the breakup of Pangea, suggesting a nearly one-hundred-million-year gap in the fossil record known as ghost lineages. However, the discovery and integrative study of a new Late Cretaceous otophysan representing the first Mesozoic skeleton-based freshwater otophysan globally and North America's oldest, upends this traditional view. Using combined-evidence Bayesian phylogenetic analysis, the new fossil species is placed at the base of the Characiphysi, while other early fossil otophysans are also scattered near the root. Integrating fossil, morphological, and genomic data using fossilized birth-death model, this study estimates the divergence time around 154 Ma, reconciling molecular divergence time with the fossil record. Paleogeography and ancestral state reconstructions indicate a marine origin for the otophysans crown group, with minimum two transitions to freshwater leading to global diversification, contra the prevalent single freshwater origin hypothesis. Functional simulations of the new fossil's Weberian ossicles using dynamic finite element methods reveal that this fish likely had a fully functional Weberian apparatus with most sensitive hearing frequency 500-1000 Hz. The unique hearing capabilities of otophysans likely evolved alongside freshwater radiations, highlighting a complex evolutionary history marked by marine beginnings and freshwater conquests.

It's all about the bees: Cataloging native bees in urban and wild environments

Harmonie Lo, Danielle Velazquez, Jesse Cortez, Robert Schroeter, Alicia Fox

As a part of a multi-campus project (The BUZZ), Allan Hancock College (AHC), located in the central coast region of California, has participated in annual surveys of native bees on our two campuses and at Sedgwick Reserve. As we have continued our surveys, we have catalogued native bee genera that are unique and new to each of our study sites, as well as presence of rare bees. A new and unique bee in 2025 included the Red-legged Oil-digger Bee, Centris rhodopus, a bee typically found in desert/arid environments, at our campus student farm/community garden location. A rare bee included Anthophorula sp. in the native garden at Sedgwick Reserve's Field Station. A major goal of this project is to increase native plant diversity on campus for native bees (and other pollinators). We have accomplished this at two campus locations: 1) our student farm/community garden; 2) at an intended rock garden on our main campus. The latter was initially proposed to be a succulent garden, but we were able to plant native plants around the boulders and had an area cleared for a pollinator garden managed by biology faculty and students. We will continue to increase native plant abundance and diversity, and survey native bees in future years.

Selection on alligator ovarian physiology after generations of xenoestrogen exposure in the wild

Yeraldi Loera, Shane Campbell-Staton, Benjamin Parrott, Matthew Hale, Nicolas Rochette

Industrial pollutants are globally pervasive biological stressors, yet their evolutionary impacts on wildlife remain understudied. Nevertheless, severe environmental contamination events may serve as opportunistic natural experiments for investigating the mechanistic targets and adaptive responses underlying evolved resistance. We examined signatures of selection in a population of American alligators (Alligator mississippiensis) chronically exposed to pesticides following a severe spill in 1980 at Lake Apopka, Florida. Phenotypic, regulatory, and genomic divergence support site-specific selection to mitigate ovarian dysfunction following multigenerational exposure to endocrine-disrupting chemical pesticides (EDCs). Comparative ovarian morphology and regulatory reorganization throughout development reveals compensatory selection against maladaptive ancestral plasticity induced by precocious estrogen signaling. Whole genome sequencing identified multiple loci associated with fertility, hormonal homeostasis, and ovarian cancer as targets of site-specific selection. These results reveal the molecular mechanisms of compensatory adaptation in a highly conserved reproductive organ, highlighting industrial contamination as a driver of rapid evolutionary change in a long-lived, ecologically pivotal species.

Experimental framework to uncover the cryptic plastic potential and the expression of new phenotypes

Leandro Lofeu, Tiana Kohlsdorf

I reflect on an approach that integrates environmental complexity with multilevel phenotypes, aiming to investigate the Cryptic Plastic Potential as a source of novel phenotypes within specific developmental contexts. Central to this framework are the concepts of the Parental Developmental Environment (PDE) and the Experimental Developmental Environment (EDE). The PDE refers to the prevailing conditions of a population, under which a characteristic range of phenotypes is expressed. The EDE encompasses a novel set of environmental factors, distinct from the PDE, where cryptic developmental plasticity may generate new phenotypes, thereby expanding the phenotypic landscape. I outline this approach, illustrate it through an empirical case study, and discuss the opportunities it creates for future research.

Investigating gene expression patterns associated with dietary phenotypes in bats

Lalitha Loka, Harshal Wasnik, Nicholas DiVittorio, Wynn Meyer

The goal of this research is to study dietary phenotypes and their associations with variation in gene expression levels across different bat species. Changes in gene expression can frequently contribute to the evolution of phenotypic diversity. Our work presents an analysis of the expression levels of 4,173 genes that had identifiable orthologs within the transcriptomes of eighteen different bat species. We obtained RNA sequencing data from samples from liver tissue of the bat species from the Sequence Read Archive on the NCBI database and quantified these levels into transcripts per million (TPM) for each gene using SALMON. We have chosen to study bats due to the diversity of diet among their order. Six of the species represented were insectivores; seven were frugivores; two were nectivores; two were omnivores; one was a sanguivore. We performed phylogenetic principal component analysis using the TPM data for the top seventeen highest variance genes to reduce dimensionality while accounting for phylogenetic non-independence. By visualizing the data on the top few pPCs, we found that gene expression at these highly variable genes does not seem to be strongly driven by diet. However, that may not be the case for gene expression at other genes involved in dietary adaptation, presenting us with a clear direction for future analyses.

Investigation of a novel fighting structure in the sea anemone *Metridium senile*

Rowan Lopez, Sarah Arnold, Kennedy Bolstad, Leslie Babonis

Territory defense, self-protection, and prey capture are important factors that allow organisms to succeed in their environments. Cnidarians (sea anemones, corals, and jellyfish) use a wide variety of stinging cells to complete these different functions. The sea anemone, Metridium senile, has evolved an inducible fighting tentacle to defend its territory during intraspecific competition. These tentacles develop from feeding tentacles and contain a unique type of stinging cell not found in any other tissues in their body. Metridium farcimen, a sister species of M. senile, is unable to develop the fighting tentacle or the type of cnidocyte associated with it. To understand the evolution of fighting tentacles, we characterized the morphology and function of tentacles in M. senile and M. farcimen. We observed proliferating cells located only at the base of the fighting tentacle of M. senile but throughout the feeding tentacles of both species. Consistent with known differences in the types of stinging cells found in feeding and fighting tentacles, we also observed morphological and size differences between the apical sensory cones that mediate stinging cells firing. To characterize these tissues further, we generated transcriptomes for tentacles of both species and identified approximately 200 differentially expressed genes between the fighting tentacles and feeding tentacles of M. senile. Together, these experiments elucidate the development and evolution of species-specific tissue types.

Winners and losers in a warming ocean: a synthesis of reproductive resilience in coastal crabs

Paola López-Duarte

Reproductive phenology in coastal crabs is finely tuned to synchronize larval release with favorable environmental conditions, maximizing survival and population persistence. Anthropogenic warming is disrupting these cues, accelerating embryonic and larval development, and shortening the planktonic larval duration (PLD). These physiological shifts have two key consequences: altered larval dispersal that can weaken population connectivity, and an increased risk of trophic mismatch as crab larvae and their planktonic prey respond at different rates. This presentation draws from a synthesis of physiological, behavioral, and ecological responses to warming across multiple crab taxa. A comparative framework highlights differences between native species, which often possess narrower thermal ranges and restricted reproductive schedules, and highly plastic, introduced species. Traits including broad thermal tolerance, flexible reproductive timing, and adaptive energy allocation emerge as predictors of reproductive resilience in a changing ocean. The approach leverages invasion biology as a "natural experiment" to identify mechanisms that forecast which species are likely to persist or decline under climate stress. Climate-driven phenological shifts also challenge static, calendar-based management approaches and expose critical research gaps, including understudied taxa, geographic blind spots, and the need for multi-stressor studies. By integrating these insights, the synthesis advances a predictive framework for assessing reproductive resilience, with implications that extend beyond crabs to other marine ectotherms facing rapid environmental change.

From Field to Flight Tunnel: Studying Echolocation-Guided Bat Flight

Robert Lorence, Joshua Matthew Foley, Ben Westcott, Chi Nnoka, Yihao Hu, Rolf Mueller

Understanding the biomechanics of echolocation-guided flight in bats requires high-fidelity observations of both aerial maneuvering and acoustic signaling. We present a methods-driven framework that integrates enhanced field capture with laboratory-based kinematic and acoustic analyses. In the field, a modular ultrasonic lure was deployed alongside harp traps, enabling real-time adaptation of call structure to local bat populations and significantly increasing capture efficiency. Captured individuals were flown in a 12-m enclosed tunnel equipped with high-speed cameras and an expanded 32-microphone ultrasonic array. The cameras and microphones were hardware-synchronized via a custom data acquisition system, allowing simultaneous recording of flight trajectories and echolocation calls. Flight videos were manually tagged to extract key biomechanical parameters, which were analyzed in parallel with spectrographic characterizations of call structure. This combined dataset enables precise mapping of echolocation timing to in-flight maneuvering. While primarily intended for comparative studies of animal flight, these methods have also informed the design of bio-inspired aerial robots, such as flapping-wing "Batbot" prototypes. By integrating flexible field-capture strategies with synchronized, high-resolution laboratory measurement systems, this approach provides a robust foundation for investigating the evolution and mechanics of echolocation-guided flight across taxa.

Genome assembly of long-living freshwater teleost reveals gene families related to cellular stress

Kimberly Louisor, Trevor Krabbenhoft, Vincent Lynch

The genomic basis for longevity has long been studied in land mammals. Recent studies have identified partly overlapping mechanisms for longevity in aquatic and marine mammals. Catostomidae are a family of freshwater fish with a wide range of body sizes and lifespans, including the longest-lived freshwater teleost, Ictiobus cyprinellus. The family has large variation in phenotype and lifespan, as well as the multiple gene duplications as a result of the Cat4R whole genome duplication event around 65 mya. De novo genome assemblies of I. cyprinellus and its shorter lived relative Erimyzon oblongus were analyzed to begin understanding the genomic bases of longevity in Catostomidae. Using Danio rerio as an outgroup, overrepresentation analyses revealed differences in biological pathways and high copy number genes for the two catostomids. Many genes related to longevity were retained from the whole genome duplication I. cyprinellus as compared to E. oblongus. Comparing these results with previously assembled Myxocyprinus asiaticus genome, long lived species seemed to have retained more genes/pathways related to longevity compared to shorted lived species. Finally, E. oblongus appears to evolve more rapidly (synonymous substitution rate) than M. asiaticus and I. cyprinellus, likely due to a shorter generation time. These results are a foundation for future work investigating longevity in Catostomidae and provide additional phylogenetic perspective for studying aging and developing potential gene therapies for age related diseases (e.g., cancer) in humans.

The interplay between diversification dynamics and phenotypic evolution in salamanders and newts

Vivien Louppe, Anne-Claire Fabre

Life shows striking disparities in species richness across clades. Variation in speciation and extinction rates over time is a key driver of present-day biodiversity. Higher diversification rates (speciation minus extinction) are expected to increase richness via radiations and are often assumed to promote faster phenotypic evolution. Yet, non-adaptive radiations—marked by high diversification but limited phenotypic divergence—challenge this view.

Adaptive radiations have been shown to shape species and morphological diversity in anurans, but it remains unclear whether similar patterns occur in other amphibians. Here, we investigate links between diversification rates, species richness, and morphological diversity in Caudata, a clade remarkable for its species, phenotypic, ecological, and life-history diversity, as well as large disparities in richness across lineages.

We used the most comprehensive time-calibrated phylogeny of the group, including 763 salamander and newt species. To evaluate macroevolutionary processes underlying richness, we applied two branch-specific diversification models. We assembled a morphological dataset of 523 species, including body size and 3D geometric morphometrics of the cranium and mandible, and estimated rates of morphological evolution. We then tested relationships between morphological rates, morphological diversity, and diversification rates.

Our results reveal a central role of diversification rate variation in shaping salamander richness and emphasize the complex interplay between diversification dynamics and phenotypic evolution in Caudata.

Effects of early-life diet and gut microbiota on host resistance to parasites

Ashley Love, Suzannah Tupy, Victoria Simons, Anita Amiti, Sarah Knutie

Nutritional resources, such as lipids and protein, can affect the development of the host immune response and resistance to parasites. Gut microbiota can also mediate the effect of nutrients on host immune responses. To disentangle the effect of early-life diet and gut microbiota on host resistance to parasites, we used a factorial design in which we supplemented nestling tree swallows (Tachycineta bicolor) with dietary macronutrients (lipids, protein, or control) crossed with a disruption in the gut microbiota (antibiotic or no antibiotic). We then characterized nestling resistance to parasitic blow flies (Protocalliphora sialia) whose larvae feed externally on the blood of nestlings. After one week of the treatments, blood and fecal samples were collected from nestlings to quantify blood loss, inflammatory gene expression, and characterize the gut microbiota. Once nestlings fledged or nests failed, we collected nests to quantify the total parasite abundance for each nest. Nestlings with a disrupted gut microbiota crossed with a lipid diet had more parasites than nestlings from the other treatments. The abundance of some bacterial taxa were associated with nest ectoparasite abundance, however the strength and directionality of these relationships depended on whether nestlings were supplemented with a lipid or protein diet. These results suggest that dietary macronutrients can affect host-parasite interactions, but these effects may be dependent on gut microbiota composition.

Basal metabolic rate variation across reproductive state in the precocial rodent *Octodon degus*

Josephine Low, Yuta Sato, Tate Garcia, Carolyn Bauer, Annalise Di Cicco

Basal metabolic rate (BMR) varies by reproductive stage in female mammals. Small mammal studies in altricial species like mice and voles have found that BMR is high throughout reproduction and generally peaks during lactation rather than gestation. However, life history strategies fall along an altricial-precocial continuum, and precocial species are relatively less represented and understood. We studied a captive lab population of the precocial rodent species Octodon degus, which has an exceptionally long gestation period and large litter sizes relative to other precocial mammals. As precocial offspring are well-developed at birth and require less energy investment to reach independence, we hypothesized that late pregnancy is the most metabolically demanding reproductive state in Octodon degus. A cohort of adult female degus were evaluated for BMR and total evaporative water loss by open-flow respirometry at four timepoints: non-reproductive, early gestation, late gestation, and lactation. This study clarifies the relationship between life history strategy and energy investment during reproduction for the first time in Octodon degus as a representative precocial rodent species.

Steps to a bounce: Identifying gait transitions in sea stars

Graham Lucas, Olaf Ellers, Amy Johnson

Sea stars are known to use two gaits: a slower crawling and a faster oscillatory gait. The crawl is characterized by slower speeds and unsynchronized movement of podia (tube feet), while the oscillatory gait is characterized by faster speeds and synchronized movement of podia. Stress often stimulates the oscillatory gait, thus, sea stars are hypothesized to initiate the oscillatory gait to escape predators or to capture food. However, unlike the transition between a bipedal walking to running gait, determining when the transition to the oscillatory gait occurs is challenging, because sea stars use hundreds of podia to locomote. For instance, a human run is readily separated from a walk because during a portion of a running step neither foot touches the ground. We explore different methods of identifying the transition to the oscillatory gait from a crawl by using Fourier transforms and wavelets on the kinematic data, rather than attempting to track the relative movement of hundreds of sea star podia. We compare the success of these methods to our visual identification of the crawl to oscillatory gait transition.

Nutrient remix: Vibrio fischeri's shift from free-living to symbiotic life

Joaquin Lucero, Michele Nishiguchi

Vibrio fischeri forms a highly specific beneficial association with sepiolid squids, providing a powerful model to investigate microbial evolution and host specificity. To explore V. fischeri's breadth and adaptability, we are examining how V. fischeri shifts between free-living to host at the metabolomic level. Using an untargeted metabolomics approach, we focused on how V. fischeri utilizes host provided nutrients to reshape its metabolism to successfully colonize and persist within the Euprymna tasmanica light organ. We examined the metabolomic profile of V. fischeri ES114 (wild type to Hawaiian E. scolopes), 2B1 (ES114 evolved through E. tasmanica for ~500 generations), and ETBB-24 (wild type to Australian E. tasmanica) in E. tasmanica juveniles. Both free-living and host-associated bacterial samples were analyzed on a 5977C GC/MSD and collected data using Global Natural Products Social Molecular Networking (GNPS), an open-access web-based spectrometry tool. Our hypothesis predicted that host-associated V. fischeri will exhibit a metabolome reflecting reduced usage of broad environmental carbon sources and altered central carbon and amino acid metabolism, consistent with adaptation to host-derived nutrients. This analysis identifies the metabolites and pathways underpinning host-associated metabolic specialization. These results highlight the metabolic flexibility of V. fischeri during the transition from free-living to host-associated life history strategies, providing insight into how nutrient reprogramming supports persistence across beneficial host–microbe associations and the pathways necessary for microbial adaptation to novel host species.

Solving the species-boundary puzzle of clownfish hosting sea anemones Heteractina in Japan

Nina Luckas, Aurélien De Jode, Miranda Gibson, Estefanía Rodríguez, Benjamin Titus

The most famous mutualistic symbiosis, between clownfishes and their sea anemone hosts (Anthozoa: Actinaria), can be found throughout tropical coral reefs in the Indo-Pacific Ocean. From three distinct clades of Actinaria, ten described species of sea anemones have evolved symbiosis with clownfishes independently. Clownfish hosting sea anemones have only been described morphologically yet display a wide range of intraspecific phenotypic variation that can make in situ field identifications challenging. The exact number of host species is unknown.

Phylogeographic sampling of the anemone clade Heteractina was done along the Japanese archipelago. Here, Heteractis aurora, Radianthus crispa, R. malu and R. doreensis co-occur. Underwater photographs were used for morphological identification and to record phenotypic differences. Ultra Conserved Elements (UCEs) and Restriction Site Associated DNA sequencing (RAD-seq) data was analyzed to test species boundaries.

Phylogenetic analysis showed that two different clades are present in Heteractina. The first one comprising the species R. crispa and R. malu and the second one R. doreensis and H. aurora. Further analysis showed highly differentiated genetic clusters and sub-clusters with lower levels of differentiation, though some individuals exhibit a mosaic of morphological characters originally used to diagnose specific Heteractina species. Our research is examining if these mixed morphological characters are the result of phenotypic plasticity or genetic variation, which could make morphological characteristics an unreliable source for species identification.

Genomic analysis of a putative Barbary Lion: tracing ancestry to guide conservation

Lesley Lugardo, Joanna Kelley, Muh-Ching Yee, Matthew Glasenapp, Terrie Williams, Obed Garcia, Sarah Huse

Lions (Panthera leo) have suffered a drastic population decline over the last 150 years. Two of the six African lion subspecies have gone extinct in the wild as a result of habitat loss and human activity. One of these, the North African Barbary lion, is phenotypically distinct from other African lions, with fur around the ears and long dark manes extending from the chest down the front legs and abdomen. Historical documentation and genetic studies using lion mitochondrial DNA suggest there are captive lions with Barbary

ancestry. These captive lions might possess important genetic variation for conservation efforts aiming to preserve the genetic diversity of this subspecies. We generated whole-genome sequencing data for an individual that phenotypically resembled a Barbary lion using Oxford Nanopore technology. We combined this data with publicly available modern and ancient lion whole-genome sequencing data to reconstruct a Panthera leo phylogeny and evaluate the placement of the putative Barbary sample. We quantified phylogenetic discordance using multiple sequence alignments of single-copy orthologs. We also extracted the mitochondrial genome for the sample and compared it to the existing lion mitochondrial assemblies. Our insights into the ancestry of this lion provide critical information for captive breeding programs seeking to prevent inbreeding depression and maximize genetic diversity in North African lion populations.

Evolving in a warming ocean: how local adaptation can promote heritability of thermal responses.

Alexis Lundquist, Darren Johnson, Thea Cole

Ocean warming poses an ongoing threat to many species. To anticipate how populations will respond over multiple generations, we need to understand the genetic capacity of thermal responses to evolve and the processes that promote genetic variation. One potential source of such variation is local adaptation to environmental conditions. For example, if individuals inhabiting cooler waters tend to have cold-tolerant genotypes and individuals inhabiting warmer waters have warm-tolerant genotypes, then local adaptation could promote genetic variation in the population as a whole. We tested for local adaptation of thermal sensitivity in three populations of California Grunion spanning ~300 km. We collected the gametes and reared embryos and larvae in a common laboratory environment. Larvae were reared across temperatures reflecting their natural range, and we measured growth and mortality. Our results suggest significant local adaptation of thermal sensitivity. Biomass production exhibited hump-shaped relationships with the southern population experiencing a peak at 28.25°C, and the northern and central populations producing maximal biomass at 22.8°C and 23.5°C respectively. In addition, we found that local adaptation increased heritability for measurements of growth and survival, particularly at thermal extremes. Grunion experience gene flow at large spatial scales, and our results suggest that adaptation to local temperature conditions can increase overall heritability in thermal sensitivity. Local adaptation may thus increase the population-wide capacity for evolutionary adaptation to climate change.

Phylogenetic relationships and the evolution of fin and body shape in the surgeonfishes

Linnea Lungstrom, Mireille Farjo, Ryan Isdonas, Andrew George, Mark Westneat

Patterns of shape change in fishes are strongly associated with dietary ecology and locomotor mechanisms, and integration of shapes across the fish body plan affects these ecomorphological relationships and evolutionary rates across taxa. The surgeonfishes (Acanthuridae) show high diversity in the shape of the head, body, and propulsive fins (caudal and pectoral), suggesting that morphometric analysis of these functionally relevant traits could provide ecomorphological insight into surgeonfish evolution. Here, we developed a new multi-locus, time calibrated phylogenetic hypothesis for the surgeonfishes (19 loci, 80 acanthurid species and 45 outgroups). Detailed head, body, and fin geometric morphometric data were collected for all 80 surgeonfish species in the tree to visualize patterns of shape evolution across the family. Additionally, a novel three-state feeding trait axis was used to examine how shape evolution relates to diet. Naso was distinct from all other surgeonfishes in phylomorphospace, and head and body shape were significantly associated with diet. Additionally, species exhibited two alternative locomotor strategies related to fin shape: 1) a high aspect ratio (AR) caudal fin and low AR pectoral fins and 2) high AR pectoral fins and a low AR caudal fin. Using novel phylogenetic comparative methods to measure correlations between shapes, we found the caudal fin had the highest evolutionary rates and covaried with both body and pectoral fin shape, likely due to dietary and locomotor demands, respectively.

Central processing of the lateral line encodes flow direction relative to the center-of-mass

Elias Lunsford, Martin Carbo-Tano, Claire Wyart

From shifting visual scenes to tactile deformations and fluid motion, animals must interpret patterns of sensory flow around their body to construct stable internal models and produce adaptive behavior. Understanding of how such transformations are encoded within the brain remains incomplete. To tackle this question, we leverage the lateral line of larval zebrafish as a tractable sensory system sensitive to fluid motion that is used to steer navigation. By presenting stimuli to individual neuromasts along the body, we used high-resolution calcium imaging to map hindbrain responses. Our findings reveal a simple, yet powerful principle centered on an egocentric framework: the direction and location of local flow is encoded relative to the animal's center-of-mass. This simple representation enables the brain to register complex flow patterns and provides a robust basis for subsequent behavioral action selection. Sensorimotor neurons within the medial octavolateralis nuclei (MON) that encode flow toward the center-of-mass broadly project to form bilateral connections onto reticulospinal neurons that coordinate forward locomotion while MON neurons that encode flow away from the center-of-mass displayed a more selective and unilateral projection profile to command neurons for turns. Our discovery represents a shift from purely somatotopic encoding toward an integrative representation of axial position and directionality combined. This study advances our understanding of how complex mechanosensory inputs select appropriate motor outputs via simple egocentric neural maps in the hindbrain.

Aposematic color patterns are a dominant phenotypic axis Nymphalid butterflies

Moritz Lürig

Butterfly wing patterns mediate visual communication through warning signals, mimicry, mate attraction, and camouflage. In nymphalid butterflies, this diversity emerges from permutations of a conserved ground plan—deterministic in origin yet highly multidimensional in form. Capturing this complexity at scale has long limited tests of how visual signals interact, constrain one another, and evolve. We tackled this challenge using computer vision–derived features in a phylogenetically explicit framework, assembling the largest comparative dataset of wing color patterns to date, covering ~one-third of all known nymphalid species. We asked whether chemical defense maps onto a distinct phenotypic axis, whether aposematic signals are expressed consistently across sexes and wing surfaces, and whether their origins shaped evolutionary tempo. Defended species clustered tightly along the dominant axis of morphospace defined by high-contrast warning patterns, with strong phylogenetic signal. Independent validation on moths confirmed that this axis separates aposematic from non-aposematic forms across Lepidoptera. Consistent with theory, aposematic species showed reduced differences between dorsal and ventral surfaces, between sexes, and among individuals. Rate analyses revealed repeated origins of aposematism linked to non-linear shifts in the tempo of wing pattern diversification.Together, our results highlight aposematic coloration as the dominant organizing dimension of nymphalid wing evolution, structuring expression, consistency, and macroevolutionary dynamics of other visual signals.

Ozone as an oxidative stressor in *Botryllus schlosseri* laboratory cultures

Brenda Luu, Yanyu Zhang, Jens Hamar, Monica Urias, Maxime Leprêtre, Dietmar Kueltz

Botryllus schlosseri, a colonial tunicate, is an emerging model organism for studying aging, self-recognition, and full-body regeneration. As a chordate closely related to vertebrates, it provides a convenient model to assess oxidative stress responses of intact marine organisms. Ozone, an oxidant commonly applied in recirculating aquaculture systems (RAS) to reduce bacterial and fouling organisms, has poorly characterized impacts on tunicate health. Before integrating ozone into RAS for laboratory Botryllus cultures, it is critical to identify tolerance ranges of Botryllus and evaluate ozone effectiveness for biosecurity purposes. To do so, two range-finding experiments

were conducted. First, a four-week ozone exposure experiment with stepwise weekly increases in ozone dosage (measured in mV) across three genotypes was performed. Second, a one-week acute LC50 experiment was conducted with a single genotype. Heterotrophic plate counts at the end of the first experiment compared bacterial loads under ozone treatment and a control. Contrary to our initial hypothesis of high sensitivity, Botryllus colonies continued to grow exponentially despite elevated ozone dosages during the first experiment. Results from the acute exposure revealed that Botryllus tolerated ozone-induced oxidative stress better with gradual acclimation. Ozone was effective in eliminating bacterial growth in the treatment tank. These results establish B. schlosseri as an intriguing model for studying molecular mechanisms underlying oxidative stress responses and conditions for safe ozone sanitation of laboratory tunicate cultures. Funded by NSF Grant MCB – 2127516.

Investigating reproductive and stress physiology as a mechanism for avian brood parasitism

Kathleen Lynch

Avian brood parasites lay their eggs in the nest of other species rather than provide parental care to their own offspring. The proximate mechanisms associated with this behavior are less understood as compared to the ultimate mechanisms. We have investigated whether modifications in reproductive and stress physiology are involved in the loss of parental care in the brown-headed cowbird (Molothrus ater), a brood parasitic species ubiquitous across North America. We have compared reproductive and stress physiology between closely related blackbird species that are parasitic and non-parasitic to identify whether these mechanisms exhibit stark differences across these closely related species. We find that in comparison to parental blackbird species, the non-parental brown-headed cowbirds exhibit greater sensitivity to secretagogues that initiate hypothalamic-pituitary-gonadal (HPG) activity but not hypothalamic-pituitary-adrenal (HPA) activity. We also observed species differences in how reproductive state affects response to restraint stress, indicating reproductive and stress physiology interact with one another. We are examining negative feedback in the HPA system of these related species and the density of corticosterone receptors in the brain that may mediate species differences in HPA resiliency. Overall, we observe clear differences in HPG and HPA function between parasitic and non-parasitic blackbird species. I will discuss how these species differences in physiology may play a role in the stark disparities these species display in parental care.

PAX6 evolution in Gnathostomes relative to life history

Leigha Lynch, Sofia Barajas, John Phillips

PAX6 is a key transcription factor that regulates neurogenesis of the brain and development of the eye. Previous research has demonstrated that there is considerable PAX6 genetic variation both within and among clades of vertebrates, however which factors influence the evolution and diversification of this gene is unclear. Using previously published PAX6 sequences from 276 species of gnathostomes, we tested if variation within this gene correlated with relevant life history variables: trophic level, activity pattern, diel pattern, degree of sociality, and migration. First, we tested for differences in branch length per life history variable using a ML phylogeny of PAX6. We found no significant differences, suggesting that there is little convergence in genetic variation across clades relative to life history. We also analyzed discrete character evolution using a Mk model and the ML phylogeny of PAX6 as a phylogenetic framework. We found that aquatic, semiaquatic, and nocturnal species consistently had the shortest branch lengths within their respective clades. This suggests that activity and diel pattern-related selective pressures select for the conservation of PAX6. This is consistent with previous research by our lab which found that PAX6 in clades containing aquatic and nocturnal taxa are undergoing positive selection within the gene.

Lepidoptera occupancy is correlated with plant diversity in solar panel arrays

Sofia Maass, Tristan Hoerschelmann, Dmitry Kutcherov, Sushant Potdar, Grace Hirzel, Kiana Kasmaii, Ethan Royal, Andrew Ruegsegger, Jennifer Ogle, J.D. Willson, Erica Westerman

Pollinator communities are shaped by their surrounding habitat through the availability of both larval host plants and adult nectar plants. When humans modify landscapes during shifts in land use, we change the availability of these plant resources for pollinators. However, little is known about how conversion of land to solar arrays impacts pollinator communities. To assess the effect of solar array conversion on Lepidoptera communities, we compared Lepidoptera abundance and occupancy in solar array facilities relative to adjacent control sites in Arkansas and Kansas in 2023-2025. We conducted three transect surveys, covering areas both in sun and shade, at each site once per season (Spring, Summer, and Fall). Additionally, habitat data such as solar facilities, crops, and trees within 1 km, plant diversity, and the percent native plant species were recorded. Lepidoptera were sighted in all 60 of our sites. However, we found a negative correlation between solar installation and Lepidoptera family occupancy, with the families Lycaenidae and Pieridae being the most negatively correlated with solar installations. These two families were also the most positively correlated with vegetation diversity. Across all families, vegetation diversity had a stronger correlation with occupancy than the percent of native plant species. These results show that solar facilities with greater plant diversity may be able to offset some of the negative effects of the solar facilities on Lepidopteran pollinators.

Striking diversity: contrasting benthic feeding kinematics across four reef fish families

Maresa MacKenzie-del Toro, Peter Wainwright

Feeding on substrate-bound prey characterizes nearly half of reef fish species and is a source of considerable functional diversity. Recent studies have begun to clarify the mechanisms used by these fishes, but comparisons between major lineages are lacking. We described feeding kinematics in 22 species from 4 prominent families of benthic feeders: Acanthuridae, Chaetodontidae, Pomacanthidae, and Siganidae. We used 1000 Hz video to track head and jaw movements during feeding on substrate-bound prey. For each strike, we quantified five prominent motions of the jaws and head. We found distinct kinematic patterns in most families. Pomacanthidae exhibited the highest kinesis, with large ranges of motion in jaw rotation, head elevation, upper jaw protrusion, and lower jaw protrusion, while Chaetodontidae were characterized by very small mouth gapes and diversity in upper and lower jaw protrusion. Pomacanthidae and Chaetodontidae did not overlap in multivariate kinematic space, but the two families formed a bounded continuum of strike kinematics. Acanthuridae and Siganidae overlapped in kinematic space but were distinct from the other two families. Acanthurids and siganids showed large mouth gapes but little additional kinesis. We suggest that variable reduction in jaw and skull kinesis is a major axis of diversity in benthic-feeding reef fishes, with herbivory associated with the least skull mobility.

Generative AI and the undergraduate classroom: sharing strategies, challenges, and surprises

Jason Macrander

The rapid emergence of generative artificial intelligence (GAI) tools has created both opportunities and uncertainties in undergraduate teaching. As faculty, regardles of institution or instrucitonal level, we are navigating shifting landscapes of student use, institutional policies, and evolving best practices, while also reflecting on how GAI reshapes their own approaches to instruction. Although this talk will not present fixed answers (and any session that says it does should be approached with caution), it will instead serve as a space for conversation and exchange of ideas, as well as audience participation. My own experiences will change over the coming semester as I plan to share my own personal experiences integrating GAI into classroom teaching. I will highlight the challenges, benefits, and surprises encountered, and share practical resources for those seeking to explore GAI in their own courses.

Participants will be invited to share their perspectives and strategies, fostering a collaborative discussion about how educators can adapt, respond, and learn from one another in real time as GAI continues to develop.

The evolution of temporal complexity in *Habronattus* jumping spider courtship

Abhinava Jagan Madabhushi, Aaron Kuebel, Areej Khan, David Morris, Nathan Morehouse

The complexity and diversity of animal signals have long captivated biologists. Traditionally, researchers have focused on individual signal components within displays, overlooking their temporal arrangement. However, temporal structure may encode important information such as species/group identity or social skill, making it a key aspect of displays. We explicitly incorporate this temporal view of animal displays into our investigation of visual signal evolution in jumping spiders of the genus Habronattus. These spiders exhibit elaborate courtship sequences that differ dramatically in both display traits and their temporal arrangement between species. We evaluated the courtship displays of 12 species from across the genus and here discuss in-depth analyses for a subset of three species: H. geronomoi, H. americanus, and H. dossenus. To quantify behavioral complexity, we annotated distinct signal components and species-specific courtship motifs. We then compared measures of temporal and combinatorial complexity across species. We found that species differ in courtship complexity primarily due to differences in the variety of signal components. However, complexity did not increase factorially with number of signal components, indicating species do not employ all possible temporal arrangements. Therefore, varying usage of signal components and specific syntaxes may have been selected to convey information. Our approach highlights temporal complexity as an important dimension of signal design, opening novel avenues for understanding animal communication and signal evolution.

Comparisons of skeletal muscle fiber-type proportions in the feeding and locomotor systems

Samantha Magrini, Renee Demarest, Jesse Young, Lisa Cooper

Changes to skeletal muscle in the locomotor and feeding systems during ontogeny are not fully understood, including how muscles adapt to new performance constraints throughout growth (e.g., weaning). For example, muscle fiber types vary in force production relative to resistance to fatigue. How ontogeny impacts fiber type proportions in these systems remains uncertain.

Here we present the fiber composition of eight feeding muscles and four locomotor muscles, in 4-month-old pigs. 1x1x1cm muscle samples were collected from six individuals, snap frozen, stored at -80°C, then embedded, cryosectioned (10µm), and stained for NADH-TR. A sample of five 1x1.5mm areas from each muscle sample were imaged at 40x magnification, and all whole cells were counted and assigned to Type-I, Type-IIa, or Type-IIb.

Preliminary results suggest that muscles of the feeding system contain a higher proportion of Type-IIb fibers, especially the extrinsic tongue muscles (mean: 45.73%). Type-IIb fibers generate short, powerful, and rapid movement, which we suggest are necessary in feeding for bolus movement and swallowing. Conversely the forelimb muscles appear to have a higher proportion of Type-I fibers (mean: 42.59%), indicative of their weight bearing capacity, and need for fatigue resistance.

These findings provide preliminary data for broader studies to determine patterns of growth in the feeding and locomotor systems, and how they compare as systems that are both functional at birth in these precocial species.

Biodiversity in the Southern Ocean: morphological and molecular insights focusing on Pycnogonida

Andrew Mahon, Kenneth Halanych

Antarctica, one of the most rapidly changing places on the planet due to global climate change, hosts an impressive diversity of marine organisms. Sea spiders (Pycnogonida) are marine chelicerates found throughout all oceans, ranging from intertidal to abyssal depths. Though cosmopolitan, sea spiders are particularly abundant in the Southern Ocean and are considered one of the Antarctic region's flagship groups of benthic biodiversity. However, high levels of phenotypic plasticity within individual species, genetically distinct populations, and cryptic species complicate accurate identification efforts, particularly in the Antarctic. Additionally, studies from multiple regions around the continental shelf of Antarctica support defined ecoregions. This presentation will discuss current efforts in describing the overall biodiversity of sea spiders in continental shelf waters surrounding Antarctica. We will present a number of new species currently being worked on and show how both morphological and molecular tools are helping with their descriptions. Observations of these creatures in continental shelf communities in this remote part of the world are helping the scientific community better estimate patterns of diversity in Southern Ocean ecosystems, providing a baseline for how they will change over time in response to climate variations.

Coastal resilience and pollution, opportunities for pre-undergraduate and community engagement

Anabela Maia, Cassandra DeBlois, Amanda Solano, Jillian Nash, Zulay Izazaga, Alexander da Silva, Julia Gandrud

Science, Technology, Engineering, Arts and Mathematics (STEAM) lesson plans commonly used in the classroom are often not responsive to current community issues and fail to engage students. We have been developing STEAM educational activities around the topics of coastal resilience and water quality informed by students and community members. We have been incorporating artistic expression in all our science activities and we have partnered with art educators and artists. One of our goals is to remove any accessibility barriers by publishing the documents in English, Spanish and Portuguese, the most common languages in the Rhode Island region. The other goal is to create documents that allow teachers to easily incorporate these activities within their existing lesson plans by providing student activity sheets and, whenever possible, offering assistance with the materials. Lastly, we have been working to adapt these activities to be deployed at community events. We have found that these activities at community events, such as paddling events, are great conversation starters and help us engage in other workforce development efforts. So far, we have created activities on "Mapping my waterways", water filtration, water quality assessment using diatoms and we are in the process of creating activities around water sensors. Our activities are hosted on multiple websites and freely accessible and we are also divulging them next to educators and community members.

Analyzing the pleiotropic effects of a transcription factor in Drosophila melanogaster

Jalen Major, Zoya Wani, Farnam Ghaemmaghami, Richard Meisel

Mating behaviors often evolve under sexual selection and are governed by complex gene regulatory networks. Genes within these networks can have widespread pleiotropic effects that can weaken the response sexual selection thereby constraining adaptation. However, we lack a mechanistic understanding of how genes within these networks interact to limit the adaptive response to selection. To address this gap, we are studying the Drosophila melanogaster gene speed date (spdt), which encodes a transcription factor that may regulate the expression of an odorant binding protein, Obp56h, which in turn affects male copulation latency. We artificially elevated spdt expression in neurons and used RNA-seq to measure gene expression in the head and body of male and female flies. We are analyzing these data to test the hypothesis that spdt regulates Obp56h and has downstream pleiotropic effects.

Comparison of androgen-related mRNA and protein in the brain and gonad of *Lythrypnus dalli*

Alyse Maksimoski, Grace Cain, Heather Ray, Devaleena Pradhan

Sex steroid hormones such as androgens are known to be systemically regulated by the gonads, however, they can also be locally synthesized in the brain. Both sites of action for these hormones function to initiate sex- and

context-appropriate behaviors, yet the exact mechanisms of sex steroid-mediated behavior remain largely understudied. Implementation of histological techniques are key to uncovering these complex neuroendocrine mechanisms, yet to date there are few validated for use in non-model species. Bluebanded gobies, Lythrypnus dalli, are marine fish that are capable of rapid bidirectional sex change to adapt to their dynamic social environmental needs. This makes them an extremely versatile and ideal species to investigate the neuroendocrine processes of sexual development at multiple levels of biological organization. We aim to detect gene and protein expression patterns of 11β-hydroxysteroid dehydrogenase (the enzyme that synthesizes the primary androgen 11-ketotestosterone) and androgen receptors in both the brain and gonads of L. dalli by coupling in situ hybridization with immunohistochemistry. The identification of gene and protein expression within and between the brain and gonads may provide unique insight into anatomical locations where androgen-related genes are transcribed and those downstream proteins synthesized to maintain reproductive sex in a bidirectionally sex changing fish. These data may potentially aid in future investigations using inexpensive, quantitative techniques to bolster our understanding of phenotypic plasticity, endocrinology, and sexual development across vertebrates.

Quantifying body temperature of birds in the wild with subcutaneous PIT-tags and low-cost readers

Traysea Malama-Auger, Dai Shizuka, Maria Stager, Akshiti Bhat, Angela Brierly, Eli Bridge

Body temperature is a fundamental measure of physiological performance in endotherms that correlates with important organismal functions such as metabolic rate. Temperature-sensing transponders have recently allowed for the measurement of body temperature in freely moving birds. We adapted and tested this method to measure body temperature in the wild using feeders equipped with Arduino readers and a modified program to read both external leg radio-frequency identification (leg) tags as well as temperature-sensing passive integrated transponder (thermal) tags. Our study aimed to 1) compare performance between leg and thermal antennas, 2) evaluate survivorship for subcutaneously tagged birds, and 3) decode the Arduino output from proprietary subcutaneous tags. We present our working perch design, antenna fabrication dimensions, and subcutaneous injection site. We show that subcutaneous implantation of PIT tags does not affect survival. We present data on interspecific variation in tag detectability by comparing readings of RFID leg tags and temperature-sensing PIT tags to ensure the efficacy of our methods, and how to correlate tag output with temperature for data analysis and interpretation. Our study was conducted on four species: white-breasted nuthatch (Sitta carolinensis), black-capped chickadee (Poecile atricapillus), downy woodpecker (Dryobates pubescens), and red-bellied woodpecker (Melanerpes carolinus).

Landscape context drives viral dynamics in honey bees and mediates spillover across pollinators

Allison Malay, Ken Fedorka

Pollinators host diverse viral communities, yet ecological drivers of infection risk across species and management drivers affecting honey bee colonies remain unresolved. We hypothesized that viral loads in honey bee colonies are jointly shaped by landscape context, husbandry practices, and host immunity, while landscape and community factors mediate viral spillover to other pollinator species. To test this, we surveyed 43 apiaries in Central Florida, quantifying eight husbandry practices, five landscape features, transcription of four immune genes, and infection intensities of four widespread viruses. We predicted that landscapes supporting higher pollinator densities would increase viral richness, and indeed, colonies surrounded by greater floral resources and open water showed elevated viral loads and coinfections. Management interventions targeting Varroa destructor had variable, unintended effects on honey bee viral dynamics, while immune gene expression tended to be negatively associated with viral loads, suggesting that robust immune responses can mitigate infection. Extending this framework, we sampled other Hymenopteran species across land-use gradients to test whether landscape and species richness mediate interspecific viral transmission, predicting that viral prevalence and intensity would increase in landscapes with higher pollinator diversity. Viral screening supported this prediction, revealing shared infection patterns among non-honey bee species. Together, our results demonstrate that viral dynamics in pollinators are shaped by interacting management and ecological factors operating across both colony and community scales.

Molgula tailless evolution: a failure to converge and extend

Mahi Malik, Ashley Subijanto, Billie J. Swalla

Ascidians are invertebrate chordates, with tadpole larvae that metamorphose into sessile adults. Molgulidae are a clade of ascidians where tailless larvae have evolved multiple times independently and our lab is interested in understanding the molecular mechanisms underlying the evolution of taillessness. There are two closely related Molgulidae species that are sympatric in Roscoff, France: Molgula oculata, a tailed ascidian and Molgula occulta, a tailless ascidian. The tailless M. occulta, have 20 notochord cells that do not converge and extend, called a “notoball”, and have evolved multiple larval pseudogenes. During embryonic development, convergence and extension are critical for the notochord cells to line up in a single row, and then tail extension occurs by swelling of the notochord cells and deposition of a cartilage matrix. Bioinformatic analysis has been done on many developmental genes involved in notochord formation in ascidians and most genes are highly conserved between M. oculata and M. occulta. We have identified the gene and the promotor binding sites in some of the notochord genes that are differentially expressed between M. oculata, M. occulta and hybrid embryos and report their genomic organization here.

Muscle work is more sensitive to changes in stimulation during strain perturbations at higher speeds

Carissa Mallonee, Monica Daley, Kiisa Nishikawa

It has been suggested that animals use different control mechanisms during walking versus running, relying more on neural control at slower speeds and more on mechanical control at faster speeds due to the longer time delays associated with neural control. In a previous ex vivo study using data from perturbed running in guinea fowl, we found that strain and the strain x stimulation interaction had greater effects on muscle work output than stimulation alone, supporting an important role for mechanical control at faster speeds. In the present study, we used in vivo data from intact and reinnervated guinea fowl during perturbed walking to investigate contributions of stimulation and strain to work, peak stress, and velocity at peak stress. Representative level and obstacle strides were selected for ex vivo ‘avatar’ experiments on mouse extensor digitorum longus muscles (n = 7). Intact and reinnervated (23 ms earlier) stimulation onset were used with each in vivo strain trajectory. To compare walking and running, we performed a 4-way mixed model ANOVA. We found that for obstacle strain trajectories, stimulation had a greater effect on all work loop variables in running strides than in walking strides (Tukey’s HSD, $p < 0$ .05). These results suggest that, in contrast to expectations, muscles are more sensitive to stimulation at fast speeds when strain changes rapidly, as occurs during perturbations. Supported by NSF DBI-2319710.

Context-specific division of labor roles and the disruption of coordinated behavior via oxytocin

Candice Malone, Aidan Yim, Catherine Marler

Oxytocin (OXT) signaling is known to impact coordinated, close-range behaviors (e.g. following, contact, huddling) in rodents. However, it is unknown if OXT impacts spatially-separated coordinated behaviors. The biparental, monogamous California mouse (Peromyscus californicus) coordinates spatially-separated tasks to accomplish spatially-separated goals such as resource acquisition, territorial defense, and parental care. Using this unique species, we investigated how division of labor changes across the social life span and whether OXT can alter division of labor in the primiparous stage. We manipulated OXT systems via intranasal or intraperitoneal injections of an agonist, antagonist, or vehicle after the first litter of pups were born. Behavioral analyses of the pairs during their pre-pair, post-pair, and primiparous stages in a nonsocial (foraging) and social (territory intrusion) challenge were conducted. Our results indicate that during social challenges, mice

use more sex-delineated roles, with males spending time near the intruder and females spending time at the nest. In contrast, nonsocial challenges are divided more equitably between the sexes. Division of labor also increases as time demands increase, such as during the primiparous life stage. Under the influence of OXT antagonists, division of labor tactics were disrupted, as evidenced by an increase in time spent foraging together with neglect of the nest. These results indicate a new role of OXT signaling in the coordination of spatially-separated tasks, not just proximal synchrony.

Midnight Pass: Monitoring the recovery of seagrass

Caralise Maloy, Jose Moscoso, Emily Lancaster, Samantha Levell, Samuel Bedgood

Estuarine habitats are vulnerable to change caused by natural and human events. Midnight Pass was historically connected the Gulf of Mexico to Little Sarasota Bay, Sarasota. The pass was closed in 1984 due to human intervention and coastal development. It was recently reopened after 40 years by hurricanes Helene and Milton; this shifted the area from low flow to high flow with a direct tidal connection to the Gulf of Mexico. The previous seagrass habitat was smothered by sand from adjacent barrier keys. We have monitored the recovery of seagrass at four semi-permanent transects monthly at Midnight Pass since its reopening in October of 2024. Two of these transects are near the pass and experience high tidal flow, while the other two are farther from the pass and experience lower flow. Each month we collect data on seagrass presence and growth, water chemistry, eDNA samples, sediment samples, and fish and invertebrate seine surveys. This study is ongoing and will continue to provide data that can be referenced as seagrass beds and ecological communities change and recover at Midnight Pass.

Joints: form, function, and the future of comparative biomechanics

Armita Manafzadeh

Slithering, sprinting, swimming, soaring – virtually all vertebrate animal motion relies on the joints that hold our skeletons together. However, despite our ability to repair torn ACLs and replace faulty hips in humans, we have a surprisingly poor understanding of how joints work at a basic level. Disentangling how the structure of joints relates to their function is essential to explaining the anatomical basis of adaptations, attributing functional diversity to differences in morphology versus behavioral plasticity, and anticipating how animals will move and migrate through risky and ever-changing environments. In this lecture, I will discuss how integrating methods and approaches from disparate fields like paleontology, computer animation, and cartography empowers us to illuminate (1) how joints work and (2) where they come from, both evolutionarily and developmentally. In the process, I will share explorations of joint form and function from across the vertebrate body plan (from skulls to toes) and phylogenetic tree (from sharks to humans).

High dietary protein quantity and quality each increase reproduction, in grasshoppers

Evangeline Mandell, Rebekah Sein, Natalie Alonzo, John Hatle

Dietary protein quantity and quality can play integral roles in reproduction and health of animals. Eating high quantities of protein promotes reproduction but also can lower self-maintenance (e.g., anti-oxidants). These costs may be mitigated by low-quantity protein diets that have high-quality protein (e.g., meets the needs of the animal by matching amino acids to the species' egg yolk protein). Here we test effects of dietary protein quantity and quality on reproduction and somatic storage in lubber grasshoppers. Using previously developed artificial diets, we reared grasshoppers on eight isocaloric diets, with all possible combinations of protein quantities (16P or 8P), qualities (High or Low), and lettuce (0.66 g or 0.33 g). The percentage that oviposited was increased by protein quality ($P < 0.001$; 48%) but not quantity ($P=0.14$). Total reproductive mass was greatly increased by 16P ($P < 0.001$; 80%) and high-quality protein ($P < 0.001$; 149%). Similarly, age at first oviposition was strongly reduced by 16P ($P < 0.001$; 19%) and high-quality protein ($P < 0.001$; 24%). In contrast to reproduction, somatic fat body mass was decreased by 16P ($P < 0.001$; 59%) but increased by high-quality protein ($P=0.004$; 53%). Lettuce amount had little effect. Overall, high-quality dietary protein increased both reproduction and somatic storage, while high-quantity protein increased reproduction but decreased somatic storage. Samples from these same individuals will be tested for anti-oxidant activity to test whether protein quantity or quality improves self-maintenance.

Bats actively modulate wing temperatures to minimize heat loss during flight

Kate Manges Douglas, Brooke Quinn, Sharon Swartz, Andrea Rummel

Bats are the only mammals capable of flight, an energetically costly form of locomotion. Flight not only imposes high energetic costs and generates endogenous heat, but it also exposes bats to pathways of heat loss that most mammals do not encounter: convection and radiation to the night sky. Bat wings are an integral structure for heat exchange and likely a major component of thermoregulation, given their large surface area. Here, we collected thermal images of the wings taken before flight, immediately after flight (a proxy for in-flight temperatures), and after recovery to assess temperatures in both the musculoskeletal structures and membranes of the wing as well as to model heat loss from the wings. We predicted that more proximal membrane regions of the wing would be least variable in temperature across all activity levels and that more distal regions would be more variable in temperature and experience greater heat loss. We found that the distal regions of the wing dropped in temperature during flight and experienced greater amounts of convective, radiative, and total heat loss than proximal regions. While wing temperatures were influenced by ambient temperatures, heat loss values were not. We suggest that heat flux is actively minimized during flight as means of energy conservation and to maintain function of the physiologically active wing components.

Small bodies & sparse data: Acoelomorpha species discovery at the limits of resolution and sequencing

Regine Manglicmot, Matt Hooge, Brian Leander

Acoela (Xenoacoelomorpha, Acoelomorpha) are a poorly sampled and rarely documented group of meiofaunal marine invertebrates found across intertidal and subtidal systems worldwide. Despite their broad distribution, no species records existed from Canada until now. We report the first confirmed occurrences of acoels in the country, supported by new nuclear 18SrRNA data and high-resolution microscopic imaging. Although we do not attempt to revise taxonomic groups or contest the currently accepted acoel phylogeny, we document novel sequences and body-wall musculature patterns among Canadian specimens. These images of actin-stained musculature are compared to those previously described from other regions, revealing unexpected variation that may have evolutionary significance and are an important step in collecting morphological data for future species descriptions. Our findings highlight how undersampled areas, even within North America, still harbour hidden biological diversity despite its known global distribution. Documenting this "invisible biodiversity" is essential for establishing accurate baseline diversity estimates, which are critical for detecting and understanding biodiversity loss driven by climate change and anthropogenic pressures. This work contributes essential genetic and morphological data to an underrepresented lineage and demonstrates the integration of species discovery, morphology, and molecular data in uncovering invisible biodiversity.

Applying the avatar method to dissect strain-frequency interactions in dynamic skeletal muscle work

Katelyn Manross, Caitlin Bemis, Kiisa Nishikawa

The ability of muscles to respond rapidly to perturbations is critical for maintaining stable locomotion in unpredictable environments. In vivo studies of guinea fowl have shown that muscle force can become decoupled from neural activation, suggesting that intrinsic muscle properties play a key role in stabilizing movement. These properties appear to be influenced not only by muscle length and activation but also by frequency of stretch-shortening cycles. This suggests that muscle may function as a tunable, active material in which complex interactions between strain and stimulation determine force

production. To test this, we applied four synthetic perturbation sizes, based on in vivo stretch-shortening cycles recorded during galloping in rats , to ex vivo mouse extensor digitorum longus (EDL) muscles (n = 18) at four frequencies (1, 3, 5 and 7 Hz), and three stimulation onsets (-10%, 0%, +10%). The results revealed significant effects of interactions among perturbation size, frequency and stimulation onset across most measured variables, indicating that the muscle's response depends on strain and activation. The results support the hypothesis that muscle behavior is context dependent, rather than fixed by simple parameters. Such complexity poses challenges for conventional Hill-type models, which typically do not account for frequency-dependent viscoelasticity or the role of activation timing. Predicting muscle performance in perturbed environments will require models that incorporate length- and activation-dependent viscoelastic properties. Supported by NSF DBI-2319710.

Using metabolomics to assess the effects of heat on an altricial songbird.

Evelyn Rees Many, Emmy James, Elizabeth Derryberry

Heat management strategies are crucial for organismal fitness. Metabolic activity is sensitive to fluctuations in temperature, with warmer temperatures often corresponding to an increase in metabolic activity. Managing metabolism is important for thermoregulation, particularly for altricial young, which may be especially vulnerable to heat. However, quantifying metabolism with metabolic chambers is challenging for altricial young, which cannot be separated from parents for long periods of time. Metabolomics offers a compelling alternative but remains largely understudied in altricial young with respect to heat. Here, we investigate the effects of elevated temperature on the metabolic activity of nestling tree swallows (Tachycineta bicolor) using metabolomics. We placed heat packs in the nests of twelve-day old chicks for four hours and then collected blood samples from each nestling. We centrifuged samples to extract plasma, then extracted metabolites for analysis. We expect to detect both treatment effects of elevated temperature on metabolic profiles as well as individual variation in metabolomic responses to heat. This work will provide insight into the thermal sensitivity of altricial chicks and help characterize the effects of heat on the avian metabolome, highlighting possible pathways for thermoregulation. In doing so, it will also establish whether metabolomics is a useful approach to capturing the consequences of individual variation in responses to heat.

Dietary consequences of invasive *Sargassum* on *Pugettia gracilis*

Gabriela Marcial, Katie Dobkowski

Along the west coast of North America, kelp forests significantly drive marine productivity and sustain biodiversity. In the Salish Sea, bull kelp (Nereocystis luetkeana) provide nursery grounds for various fish and invertebrates. However, these forests are increasingly threatened by abiotic and biotic forces. Climate change and invasive seaweeds such as Sargassum muticum endanger bull kelp, compromising the habitat and food that marine herbivores rely on. Pugettia gracilis, the graceful kelp crab, depends on bull kelp beds for a nutrient-rich food source, shelter, and reproduction. Yet, with the spread of Sargassum, herbivores like P. gracilis are forced to expand their diets to include non-native macroalgae, and the ecophysiological impacts of this shift remain unclear. In this study, we quantified the consequences of an invasive Sargassum diet on P. gracilis' molting rate, fecal mass, and body mass. Laboratory feeding experiments with 28 juvenile P. gracilis revealed that diet alone did not significantly affect our three metrics, but crab size did. Interestingly, crabs fed Sargassum changed carapace color from dark brown to orange. Our results suggest that Sargassum may become part of a more generalist diet in P. gracilis if bull kelp beds disappear. Though Sargassum may not directly limit crab development, it could influence traits such as carapace color on a short-term scale, potentially serving as a bioindicator of diet in kelp crabs under changing ocean conditions.

Testing for functional regionalization in the snake vertebral column

Miranda Margulis-Ohnuma, Bhart-Anjan Bhullar, William Ryerson, Armita Manafzadeh

Snakes navigate diverse ecosystems all over the world using their characteristic limbless mode of locomotion. While functional research typically takes a holistic approach to snake vertebral motion, considering the snake precloacal vertebral column to act as a homogenous series of repeated units, snakes—like their limbed ancestors—have morphological regionalization along their vertebral columns. Here, we investigate the apparent contradiction between theorized homogenous joint function and known regionalized joint morphology by quantitatively comparing the range of motion (ROM) of intervertebral joints along the snake body. Using ex vivo marker-based XROMM of fully intact ball pythons we find that, despite clear differences in vertebral morphology, ROM is very similar among joints sampled from the cervical, anterior thoracic, posterior thoracic, and sacral regions of the spine. Bilaterally, the combination of zygosphene and prezygapophysis of each vertebrae creates an osteological slot within which a process formed by the zygantrum and postzygapophysis slides during motion. Visualization of these osteological interactions highlights previously unappreciated integration between the zygapophyseal and zygosphene-zygantrum joints. Covariation of zygosphene and prezygapophysis angles relative to zygantrum and postzygapophysis angles along the vertebral column allows the process/slot relationship to maintain uniform constraints on ROM despite overall morphological change. These ROM results from intact cadavers resemble osteological ROM estimates generated from bones alone, suggesting that robust inferences about intervertebral ROM can be drawn from the snake fossil record.

The Modifying effect of context on endocrine modulation of behavior

Catherine Marler

What are the advantages of working with unconventional animal model systems? One distinct benefit is that we can explore natural examples of behavioral plasticity; understanding this plasticity and the mechanisms underlying it has driven much of my research. A central question my lab and I have asked is how the endocrine system influences on behavior and physiology are shaped by the social and physical environments. The importance of context for understanding the meaning of endocrine signals within the body frequently have been ignored. Both the production of testosterone and oxytocin and effects on behavior are highly dependent on both the internal and external environments of individuals. These environments are created by the physical location of the individual, their past mating experiences, and the absence or presence of familiar and unfamiliar conspecifics. I will describe laboratory and field research from my lab with the monogamous, biparental and territorial California mouse, Peromyscus californicus, that help us to make sense of the many stimuli that a biparental and territorial species needs to integrate in order to adapt to a dynamic environment. Endocrine mechanisms that can influence reinforcement and reward of experiences and alter the salience of social cues can dramatically influence the expression of behavior.

Effects of unpredictable food and variable cold on the winter phenotype of house sparrows

Chelsi Marolf, Sampath Kumar Anandan, David Swanson

Climate change is altering winter thermal landscapes in temperate regions, with more frequent extreme weather events and more variable temperatures superimposed on warming average temperatures. Such variability could modify resource predictability and promote trade-offs between thermogenic and other self-maintenance costs. We measured the combined effects of variable cold temperatures and food unpredictability on whole organism metabolic rates, body, and organ masses in house sparrows (Passer domesticus). In early summer, we captured birds in South Dakota and acclimated them to one of three temperature treatments: thermoneutral (25°C), stable cold (3°C), or variable cold (mean of 3°C, ranging from -10°C to 16°C). We included an unpredictable feeding treatment with food removed for four hours per day. We expected the stable cold/ad lib group to display the highest summit metabolic

rate (Msum, maximum cold-induced metabolic rate), while food restriction and variable cold temperatures were expected to limit thermogenic acclimation or increase basal metabolic rate (BMR) due to potential costs of flexibility. Birds on ad lib food in warm and variable cold groups increased Msum more than birds with unpredictable food. Pectoralis mass was higher in both cold treatments, but birds in variable cold, whether food restricted or not, had higher BMR and liver mass than other treatments. These data suggest that an unpredictable environment may be more costly or otherwise limit the maintenance of a winter metabolic phenotype.

Exploring the state of intersectional queer and neurodivergent identities in the biosciences

Jess Marquardt

In the past few years, diagnosis as well as self-identification rates of neurodivergent individuals have increased. Similarly, the percentage of the U.S. population that identifies as LGBTQ+ has more than doubled in a little over a decade. While neurodivergent and queer people are important current and future members and contributors to the biosciences community as students, researchers, faculty, and staff, they are still underrepresented in biological community spaces. Feelings of exclusion, invisibility, and lack of belonging have been reported. These alienating environments often lead to people from these backgrounds leaving the biosciences. A narrative review of the literature for the last 25 years was undertaken regarding neurodivergent and queer identities within the biological sciences. The review looks at identity, intersectionality, sense of belonging, and education research. The resulting manuscript informs on the question: how do we continue efforts to increase awareness, build inclusive community, and support diverse learners and future scientists, especially with intersectional queer and disabled identities?

Testing light environment induced plasticity in *Bicyclus anynana* butterflies through mate choice

Hannah Marr, Brooke Kester, Erica Westerman

Behavioral plasticity allows animals to flexibly respond to changing environmental conditions, often leading to shifts in critical behaviors such as mate choice. In butterflies, mating preferences are typically shaped by both genetic and environmental factors, but the extent to which visual environments during development influence adult mating behavior remain largely unexplored. Here we assess whether light environment during development influences female visual mate preference in the buttefly Bicyclus anynana. Previous studies have shown that females prefer males with two UV-reflective spots over those with four on their dorsal forewings. However, these studies assume a consistent, full sun, visual environment. To test the effect of developmental light environment on adult mate preference, we used a split-family design and reared caterpillars in three different light conditions, a green light-transmitting cage (simulating deep shade), a UV-blocking cage, and a control cage with full spectrum light. After pupation, we assess female preferences by presenting them with a choice between males marked with either two or four eyespots. Preliminary results suggest that there may be an effect of light environment on mate choice as well as development time. Butterflies reared in the green light-transmitting environment tend to take longer to develop. While female preference appears to differ across lighting environments. These findings suggest that variation in developmental light environment can shape sexually selected traits and mating behaviors.

Hemolymph circulating through insect antennae is critical for development of robust tactile sensing

Lucas Marsh, Adam Puchalski, Kostya Kornev, Artis Brasovs, Yutaka Kinoshita, Nyx Mashkow

Equipped with the stirring muscles only at the pedicel-scape pair, the muscle-free antennae of many insects can be twisted and bent on the insects' demand, even if the pedicel-scape pair is set motionless. We hypothesized that the hemolymph circulating through antennae provides pressure that facilitates twisting and bending and offers a feedback control channel for tactile sensing in non-flying insects. In a series of experiments on live cockroaches, we investigate this hypothesis. In physiological experiments, we measured hemolymph pressure along the antenna. This was accomplished by puncturing the antenna and letting hemolymph flow out and form a droplet. Photographing the drop, we then developed an image processing protocol employing the Young–Laplace equation of capillarity to evaluate the pressure. By puncturing antennae at different locations along the antenna axis, we were able to evaluate the pressure distribution and estimate the pressure level. A comparative analysis of pressure distribution among different Blattodea species was conducted to reveal the differences between flying and non-flying species. This physiological analysis was augmented with a morphological study employing histology and scanning electron microscopy. We identified the key antennal structures supporting hemolymph circulation, measured the cuticle thickness, area of trachea, nerves, and antennal vessel from the base to the tip. These data allowed us to evaluate the critical features enabling fast tactile sensing in Blattodea.

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Scaling Puppy Mountain: A complex performance landscape for scale-biting pupfishes with AI landmarks

Christopher Martin

The physical interactions between organisms and their environment ultimately shape speciation and adaptive radiation, but biomechanical performance landscapes are rarely measured among closely related species. My lab estimated a performance landscape for biting in an adaptive radiation of Cyprinodon pupfishes endemic to San Salvador Island, Bahamas, including a scale-eater and molluscivore. We used high-speed video to film strikes on gelatin cubes by 3 pupfish species and their hybrids and then compared strike kinematics to gel volume removed per bite. We developed an automated landmarking pipeline using SLEAP to measure six landmarks across over 100,000 frames. We discovered that gel-biting corresponds to a surprisingly complex performance landscape in pupfishes with two distinct performance optima for the interaction between peak gape and peak jaw protrusion in the best supported model. One performance peak was accessible to all species, characterized by small peak gape and minimum jaw protrusion. A second performance peak for large peak gape and maximum jaw protrusion was only accessible to scale-eaters and their hybrids, suggesting anatomical adaptations in this species enabling two different strike modes. An unexplained performance valley separated these peaks. This two-peak performance landscape only partially corresponds to the two-peak fitness landscape measured in the wild. Overall, we reveal a new bimodal non-linear biomechanical model for biting that connects morphology to performance to fitness in a rapid radiation of trophic niche specialists.

A simulated short-term heat wave alters ovarian steroidogenesis pathways in a eurythermal pupfish

Olivia Martin, Victoria Miller, Nola Weston, Isabel Villafuerte, Sean Lema

The frequency of extreme heat wave events has been increasing in freshwater and marine habitats with climate change. Effects of such heat wave events on fish reproduction, however, are largely unclear, despite the sensitivity of reproduction to temperature. Here, we examined how a simulated heatwave impacted reproductive status and endocrine physiology in the pupfish Cyprinodon nevadensis amargosae, a species with one of the highest thermal limits for reproduction among fishes. Adult pupfish in mixed-sex groups were maintained under ecologically-relevant fluctuating temperatures that cycled diurnally from a morning low of 20-21°C to an afternoon high of 31-32°C. After 54 d, a subset of fish was exposed to a simulated heatwave for 6 d by elevating daily maximum and minimum temperatures by 6°C. Female pupfish, but not male pupfish, exposed to the heat wave showed a lower gonadosomatic index (GSI). That lower GSI was paralleled by reduced abundances for FSH and LH receptor mRNAs in the ovary, a reduction in mRNA levels encoding several steroidogenic enzymes including cholesterol side-chain cleavage enzyme cyp11a1, 3βhsd, and ovarian aromatase cyp19a1a, and lower plasma 17β-estradiol. In contrast, the male testis showed an increase in star mRNAs, but no change in mRNA abundances for FSH or LH receptors or

steroidogenic enzymes. These observations suggest that steroidogenesis in female pupfish may be impaired by elevated temperatures associated a heat wave event.

Physiological and morphological divergence in Lestes damselflies across a freshwater oxygen gradient

Peter Martin, Alisha Shah

How and why species segregate along environmental gradients has long fascinated ecologists. In temperate regions, waterbodies commonly fall along a hydroperiod gradient, from ephemeral pools to permanent lakes. Lestes damselflies (Zygoptera: Lestidae) segregate along this gradient due to differences in hydroperiod and predation. Temperature and oxygen also change predictably along the gradient: ephemeral pools are warmer and more hypoxic than permanent lakes. For most aquatic ectotherms, variation in temperature and oxygen should play a role in shaping physiological tolerances and morphology. But these abiotic factors have never been explored in the context of segregation along the hydroperiod gradient. We predicted that ephemeral pool inhabitants should have higher tolerance to warming and to low oxygen than permanent lake inhabitants. To test for differences in physiological tolerances, we conducted two experiments, using L. dryas, an ephemeral pool specialist, and L. vigilax, a permanent lake specialist. We first measured CTmax, maintaining average oxygen levels. We then remeasured CTmax with reduced oxygen access by removing multiple gills from individuals. To test for morphological differences, we measured gill area relative to body size. Although the two species differed in CTmax, there was no significant change in CTmax in either species when oxygen access was restricted through gill removal. Preliminary analyses suggest, however, that L. dryas, which live in oxygen-poor ephemeral pools, have larger gill surface area compared to L. vigilax.

Effects of autumn warming on energy stores and survival of overwintering dragonflies

Rosemary Martin, Alisha Shah

In ectotherms, metabolic rate scales non-linearly with temperature, meaning that small increases in temperature can have disproportionally large effects on energetic demand. In temperate regions, many organisms increase food uptake in autumn to store energy to survive the winter. Autumn temperatures are warming faster than other seasons, which could profoundly impact the balance of energy use and storage. While the impacts of warming autumns on terrestrial insects have been given much attention, few studies have focused on aquatic insects. Here, we investigated the effects of autumn warming on the overwintering energy stores of dragonfly nymphs. Many overwintering aquatic insects remain active and continue to feed throughout the winter, which contributes to their energetic balance. However, the relative importance of energy accumulation during the autumn remains unclear. During warmer autumns, feeding could either keep up with metabolic and storage demands or be outstripped. We subjected nymphs of six dragonfly species to warm or cool autumn conditions in the lab. We took lethal sub samples of larvae before and after the treatment and compared levels of lipids, protein, and carbohydrates. We also recorded survival through to the spring. Preliminary results show that overwinter survival was higher in the group that experienced autumn warming indicating that, in contrast to many terrestrial insects, warming could be beneficial for aquatic insects.

Ants, plants, fur, wind, and fire

Chris Martine, Abigail Motter, Kaitlin Henry, Rebecca Beneroff, Diamanda Zizis, Melody Sain

Despite being a well-studied and economically important group, Solanum is still rife with mysteries and surprises. The Australian bush tomatoes of S. subgenus Leptostemonum, particularly the ca. 45 species in the “S. dioicum + S. echinatum Group,” continue to be a model of adaptive radiation linked to reproductive biology characters. Already established as an ideal clade for studying sexual system evolution given the presence of andromonoecy, cosexuality, and functional dioecy, our recent undergraduate-driven work in the group has generated new inferences in reproductive biology including seed dispersal strategies (censer and trample bur dispersal), plant-insect interactions (extraf loral nectaries), and clonal spread (specialized storage roots).

Machine Learning to quantify indicators of decline, resilience, and revival in coral reef ecosystems

Jackson Martine, Mason Gorrondona, Jeri Fox, Tristan Taranto, Isabelle Stiver, Hanna Bjerkness, Dipanjan Saha

Understanding the stressors coral reefs face is increasingly critical as the ocean’s climate continues to change. Individual indicators of decline and resilience in coral ecosystems, such as algal coverage, fluorescence, environmental parameters, and biodiversity, are well researched. However, little is understood about how their combined impacts indicate whether or not a reef will recover. We aim to identify indicators that a coral reef ecosystem will revive and experiment with methods of quantification using machine learning to create a predictive model of coral reef resilience.

Beyond fermentation: microbial amino acid production in large herbivores

Anejelique Martinez, Paul Koch, Anna Behrensmeyer, Seth Newsome

Herbivores consume a nitrogen-limited diet that create a stoichiometric mismatch between the macromolecular composition of their forage and their protein-rich bodies. Extensive research on wild herbivores has revealed how their specialized gut microbiomes ferment dietary fiber into short-chain fatty acids that provide energy to the host. Less is known about the role of gut microbes in synthesizing amino acids that the host could use to build proteins for growth and maintenance. Recent field and laboratory studies on small mammals show that symbiotic gut microbes convert carbon from dietary carbohydrates into essential amino acids (AAESS) that are assimilated by the host to synthesize proteins. We used amino acid carbon (δ13C) and nitrogen (δ15N) isotope analysis to evaluate gut microbiome contributions to the structural tissues of a community of large mammals in Amboseli National Park, Kenya, that have diverse diets and digestive physiologies. δ13C analysis indicates that grazers relying on low-protein diets use a higher proportion of microbially synthesized AAESS to build structural proteins, particularly in foregut fermenters adapted for fermentation and nitrogen recycling. δ15N analysis further reveals that higher microbial contributions elevate apparent trophic position in foregut relative to hindgut fermenters by adding an intermediate bacterial trophic level in the gut. These findings show that microbially synthesized AAESS are essential for herbivore protein metabolism, especially in grazers that persist on protein-poor diets.

Multi-material 3D printing as a tool to understand the role of soft tissue in dermal fish armor

Lorenzo Martinez, Karly Cohen, Cassandra Donatelli

Poachers (Agonidae) are a family of benthic fishes covered head to tail by heavily mineralized, and overlapping armor. While the plates themselves have been well described, less is known about how they connect and function as a protective system. In many biological armors, soft connective tissues are critical as they provide flexibility, absorb energy, and may enhance defensive performance. We examined the connective tissues within poacher armor using histology and explored their mechanical contributions to stiffness with simplified models. We 3D-printed models consisting of PLA scales joined by angled TPU segments, and fabrics embedded mid-print to mimic the relation between hard and soft tissues. We performed 3-point bend tests on models varying in TPU segment angle, fiber orientation, and fabric embed depth. Our results show that increasing TPU segment angle halves the work required to bend the models and increases the effect of fiber orientation. This suggests that the connective tissues between scales have large contributions to the mechanics of highly dense armor systems, especially when there is high overlap. Our histological sections revealed that on the sides of the body, the connective tissues are more extensive, while along the top and bottom the

scales are joined by tightly organized collagen bundles. We show a standardized and expandable framework for testing armor structure mechanics and provide insight into how bony armor can still be flexible.

Segmenting super sniffers: A comparative study of nasal turbinal morphology in domestic dog breeds

Lorenzo Martinez, Nicholas Hebdon, Kelly Diamond

Domestic dogs (Canis lupus familiaris) have been artificially selected for many purposes such as tracking, fighting, herding, and companionship. While breeds such as bloodhounds or beagles are classified as scent hounds, the mechanisms allowing superior olfactory abilities compared to other breeds are not yet known. The canid snout houses thin and tortuous turbinate bones that support mucous covered epithelium where particle filtration occurs and olfactory transduction begins. These two functions are associated with two structurally distinct subdivisions of the turbinal structures, the maxilloturbinals and the ethmoidal turbinals, respectively. We predict that breeds classified as scent hounds will have proportionally higher ethmoid turbinal surface area compared to non-scent breeds, as this may increase olfactory receptor neuron counts allowing for a wider range of chemosensitivity. In this study, we used µCT scans of dog skulls to create quantifiable segmentations of the canid nasal morphology. We compared turbinal cross-sectional area investment across the snout, proportional to snout length, across breeding groups. As expected, the posterior snout shows proportionately higher cross-sectional area across breeds, favoring olfaction rather than respiration. Our results also show regional spikes in cross-sectional area investment that differ between groups which may help explain observed differences in olfactory ability. These findings contribute to our understanding of functional mammalian nasal morphology and provide a basis to explain why some snouts support super sniffing.

The dynamics of water column formation of sandgrouse birds during take-off

Maria Martinez, Nami Ha, Saad Bhamla

Sandgrouse birds (Pterocles namaqua) absorb water using their ventral feathers and deliver ~25mL of water to their young. Their feathers are hydrophobic, but they can absorb 10-30g water/g feather to the maximum due to their barbules that reversibly form L-shaped structures with a single coil upon wetting. In addition to the reconfiguration of barbules, we hypothesize that water column formation during take-off would help to enhance water absorption by leaving droplets on ventral feathers after pinch-off. Based on our hypothesis, we investigate the water column formation of sandgrouse birds through online videos, fieldwork, and laboratory experiments. First, the online videos and the fieldwork data conducted in the Kalahari Desert of South Africa in December 2024 show temporal variations in water column height and the estimated take-off speed. Second, we film the water column formation using a dead sandgrouse bird using high-speed imaging in the laboratory by varying the take-off speed. This research would contribute to revealing the fluid dynamic principles underlying the sandgrouse's water column formation.

Integrating food physical properties and processing demands to predict multivariate diet in lizards

Selena Martinez, Graham Slater, Keegan Melstrom, Anna Wisniewski

Lizard dentitions and diets are often described as "simple" relative to more complex mammalian teeth and diets. However, lizards show striking diversity in both tooth shape and diet, possessing dentitions ranging from conical to molariform and consuming items as varied as algae, beetles, and goats. Traditionally, lizard diets are discretized (e.g., carnivore, omnivore, herbivore). Recent studies model diet evolution using frequencies of food items in stomach contents, yet these approaches assume diet is a categorical regime and may then be difficult to apply to the fossil record. Furthermore, these frameworks overlook a fundamental principle: that teeth do not "see" food items by "man-made" groupings. A tooth, ultimately, is a tool. Therefore, morphology may be more reflective of food items' mechanical properties than class membership. Here, we apply a Bayesian multilevel modeling approach to test whether dietary item importance rankings can be predicted from lizard dental morphology. We develop two ranking schemes: one based on the relative importance of food types, and another based on the material properties of those items. Our results show that taxa do not group by traditional diet categories in multivariate dental morphology space. This suggests mechanical properties may better reflect dietary adaptation than class-based labels. We discuss the implications for reconstructing diet in the fossil record and highlight the challenges and potential of quantifying niches not represented in modern ecosystems.

The hills have eyes: ecological drivers of ocular morphology in Pycnogonids

Alyvia Martinez Zoroya, Sonke Johnsen

Sea spiders (Pycnogonida) are marine arthropods found worldwide, from intertidal zones to deep-sea hydrothermal vents. Pycnogonids typically possess two pairs of simple eyes set on an ocular tubercle (OT), leading to speculation that they have 360-degree vision. However, their actual visual fields remain unknown. The OT displays substantial morphological diversity, as it can appear elongated, horizontal, pointed, or domed. The eyes may be positioned in different locations ranging from the tip of the tubercle to closer to its base. Additionally, the eyes vary in size, shape, and pigmentation, with some species lacking eyes entirely. Such diversity suggests that sea spider eyes may be shaped by environmental pressures, yet no study has systematically tested how morphology varies across depth ranges and associated light environments. To investigate these patterns, eye and tubercle morphology were quantified across 20 species representing six families from shallow, mid-depth, and deep-sea habitats. High-resolution three-dimensional reconstructions generated with micro-computed tomography (micro-CT) were used to measure eye and OT geometry. Examining the unusual eye morphology of pycnogonids will help clarify the adaptations that enable their success in diverse seafloor habitats and contribute to broader studies on the ecological pressures shaping the evolution of expanded visual fields in arthropods.

Investigating the biological effects of perchlorate exposure using mice model

Marcelino Mashanda, Michael Minicozzi

Perchlorate is a highly soluble anion widely used in rocket fuel, fireworks, explosives, and fertilizers. Due to its persistence in the environment, perchlorate has been detected in groundwater, surface water, soil, and agricultural products, raising public health concerns. Perchlorate disrupts thyroid hormone synthesis by competitively inhibiting iodide uptake, and although its systemic effects in mammals remain less understood, they are of growing concern. This project addresses the research question: How does chronic perchlorate exposure from maternal drinking water (100 ppm) affect thyroid, liver, and testicular development in offspring? To investigate this, laboratory mice will be exposed beginning in utero and continuing through weaning for 120 days, with control groups receiving standard drinking water. At study completion, animals were perfused, and tissues collected and stained with hematoxylin and eosin. We predict that the thyroid will have smaller and more follicles. We predict that lipid accumulation and inflammatory infiltration will be present in the liver. Within the testes, we predict reduced Leydig cell size and disorganization of seminiferous tubules. By examining organ specific consequences of perchlorate exposure in vivo, this study extends understanding beyond cell culture and non-mammalian models. Results can influence drinking water regulations limiting persistent pollutants to protect human health.

Coupling antenna morphology with its mechanical properties in Blattodea and Coleoptera

Nyx Mashkow, Lucas Marsh, Kostya Kornev, Adam Puchalski

Insect antennae are multifunctional fiber-like organs that are important for many species of cockroaches and long-horned beetles. The antenna is partitioned into scape, pedicel, and flagellum. Scape and pedicel may have some steering muscles, but the flagellum segments (flagellomeres) are annulated and muscle-free. Functionality and mobility of antennae are

enabled through key morphological and structural traits. Using scanning electron microscopy (SEM), we conducted a thorough comparative analysis of antennal morphology in Blattodea, examining sexual dimorphism characteristics through the comparison of sensilla and flagellum shapes. Sectioning was performed to study the internal morphology, evaluating the flagellomere diameters and cuticle thickness to show that males possess a higher quantity of sensilla. We also investigated similarity between species that wasn't fully dependent on how closely species are related. We conducted micro tensile tests to compare the mechanical properties of antennae of different species of Blattodea and Coleoptera. Surprisingly, the flexible cockroach antennae and the stiff, long-horned beetle antennae demonstrate a J-type force-elongation curve, suggesting that the flagellomere connectors contribute significantly to the mechanical properties. The breakup of the antennae of Blattodea and Coleoptera is very different, pointing to the importance of the materials organization in connectors revealed by SEM. This analysis sheds light on a possible evolutionary scenario of antennal adaptation during the transition from flying to non-flying behavior in these insects.

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Sex, assumed: histories, politics, and futures

Megan Massa

Last year's Moving Beyond Binary Sex Categories session laid bare the limitations of a binary sex model. As we begin to reconceptualize sex across origins towards a more accurate scientific paradigm, it is crucial to understand how social, linguistic, and political assumptions influence our scientific imaginary to avoid reinscribing the same limitations. Here, I detail the politico-social histories in development of the scientific study of sex, connecting this lineage to recent political interpretations and usages of scientific findings. I also examine the multiple invocations of "sex" within the scientific realm across species and origins before posing crucial considerations when developing alternative scientific paradigms.

Should I speak up? Impacts of noise pollution on bird song structure

Brigitta Mathews, Riley Crawford, Annika Dank, Jasper McCutcheon, Cvetana Ilic, Chris Templeton

Anthropogenic noise pollution has a variety of negative effects on animals, with acoustic masking posing particular challenges communication. Some songbirds have been observed to combat noise pollution by changing their song rate, duration, frequency, or amplitude, with different species employing different strategies. We tested whether Swainson's thrushes (Catharus usulatus) and brown creepers (Certhia americana) adjust their singing behavior or song structure under different traffic noise regimes. Brown creepers sing high frequency songs that are less likely to be impacted by traffic noise masking than the lower frequency thrush songs. We show that Swainson's thrushes, but not brown creepers, adjust their song structure and singing behavior when faced with road traffic noise, with similar patterns occurring both across the population survey and when specific individuals are confronted with realistic levels of experimental traffic noise playback. These results help confirm that noise pollution impacts singing behavior in birds and has differential impacts on different species depending on the natural singing behavior.

Collective invasion dynamics of bacteria in complex environments

Arnold Mathijssen, Ran Tao, Suya Que, Albane Thery

Bacteria have the remarkable ability to swim upstream [1,2]. This motion against flows can cause not only respiratory, gastrointestinal, and urinary tract infections, but also the contamination of medical devices and hospital equipment. However, it remains unknown how bacteria navigate upstream through these microstructured environments with narrow channels and wide cavities. Here, combining microbiology experiments with nanofabrication and mathematical modeling, we reveal how Escherichia coli invade in four stages: The (I) break-out from colonized cavities against the current, (II) propagation upstream in narrow connectors, (III) infiltration of new cavities, and (IV) colonization with biofilms under flow. Surprisingly, we find that wider channels with faster counterflows are actually more prone to invasion, but these incursions can be inhibited effectively with sharp corner designs. Next, we explore the serial invasion of multiple cavities in a row. We discover that instead of colonizing these nodes one by one slowly, the bacteria rapidly swim all the way upstream and form biofilm streamers there to take possession of the entire channel three times faster. These results shed new light on pathogen motility in host-relevant shear regimes, and they offer solutions that can be implemented directly in biomedical devices.

[1] B Torres-Maldonato et al., PNAS, 2024, 121, 50 e2417614121

[2] D Cao et al., 2024, arXiv 2408.13694

Two genomes, one metabolome: mitochondrial–nuclear interactions in metabolic regulation

Omera Matoo

Studies exploring the role of genetic variation in determining organismal metabolome (complete set of metabolites) has largely focused on nuclear(n) DNA. Yet, because mitochondria serve as central hubs of energy transduction, variation in the mitochondrial (mt) DNA, along with its epistatic interactions with nDNA, may play a critical role in shaping metabolism. To investigate this, we used a panel of four novel (mtDNA); nDNA genotypes generated by substituting divergent mtDNA from closely related Drosophila sister species- Drosophila melanogaster and Drosophila simulans. Previously, we have shown that in one specific genotype (simw501);OreR the genetic incompatibility, due to negative epistatic interaction between mitochondrial encoded tRNATyr and nuclear-encoded tyrosyl–tRNA synthetase, resulted in bioenergetically compromised phenotype (high reactive oxygen species, lactic acidosis and mitochondrial dysfunction). In the current study, we utilized untargeted metabolomics to test the hypothesis that mitochondrial-nuclear incompatibility will result in a metabolomic phenotype reflecting metabolic remodeling. Our data indicate changes in distinct biochemical pathways in (simw501);OreR compared to matched genetic controls: (1) downregulation of metabolites involved in Kreb's cycle, b-oxidation and protein synthesis, (2) upregulation of metabolites to increase glycolytic flux and maintenance of total adenylate pools, and (3) upregulation of protective metabolites involved in membrane integrity, protein stabilization and antioxidant responses. These findings underscore the critical, yet nuanced, role of intergenomic interactions between the mtDNA and nDNA in shaping the metabolome.

Microbial considerations for moving corals farther for restoration

Shayle Matsuda, Ross Cunning

Ocean warming is driving increasingly severe bleaching events, including the 2023 mass bleaching in the Florida Keys that decimated Acropora cervicornis, a primary species used in Florida coral restoration. As restoration programs expand and move corals across broader ranges, individuals encounter novel thermal regimes, taxa, and microbial communities. Because the coral microbiome forms a critical first line of defense against stress and disease, understanding its response to novel microbial environments is essential for predicting restoration outcomes. We experimentally tested the microbial flexibility of A. cervicornis in a controlled ex situ setting, deliberately exceeding current restoration distances. Corals were exposed to a gradient of microbial novelty: (1) housed with one other Caribbean coral species, (2) co-housed with two Caribbean and two Pacific species, and (3) placed in five aquarium "ecosystems" containing diverse assemblages of fishes, corals, and invertebrates. We characterized microbiome composition and community structure over time and assessed whether exposure to novel microbial pools promoted microbiome shifts (i.e., switching or dysbiosis) and how these shifts related to survivorship. This work begins to identify microbial risks and opportunities associated with coral movement across microbial landscapes. Our findings provide insight into microbiome plasticity and resilience in Acropora cervicornis, highlighting key microbial considerations as corals are moved into increasingly heterogeneous environments for restoration.

Genetic basis and evolutionary consequences of soft- and hard-tissue integration in cichlid jaws

David Matthews, Andrew Conith, Craig Albertson

One of the major focuses of evolutionary developmental biology has been understanding the genetics and evolution of variation in skeletal morphology. One important finding is that skeletal development is highly responsive to forces exerted on bones, including internal musculoskeletal forces. If we can elucidate the molecular mechanisms guiding this process we will gain insight into the developmental and evolutionary consequences of cell-cell signaling between different tissues. To achieve this we use twenty species of Lake Malawi cichlids, as well as F2 hybrids between two trophically divergent species, to examine how variation in jaw tendons and muscles affects the shape of the oral jaws across levels of biological organization. We performed regular and contrast enhanced CT scanning to capture bone and soft tissue morphology. We then utilized 3D and linear morphometric measures to characterize the association between jaw shape and muscle/tendon volume. In both data sets we find that there is a high correlation between soft tissue volume and hard tissue shape, particularly among tissues that are physically connected. Finally, we ran a QTL analysis among the hybrids to look for genomic intervals affecting both hard- and soft-tissues, which would indicate underlying pleiotropic effects. Our results suggest that tendons in particular may play an outsized role in the evolution of bone morphology, and provide an initial insight into the genetic and developmental mechanisms driving this effect.

Variation in immune response of female cat fleas(Ctenocephalides felis)against a bacterial infection

Margalit Mauricio, Lisa Brown, Ashley Lynch

A central challenge in immunology is determining why two hosts exposed to identical infections in the same environmental conditions exhibit different outcomes. One might show mild symptoms and recover, while the other faces severe illness or death. Cat fleas (Ctenocephalides felis) are an important vector for bacterial transmission, as they carry chronic infections that they transfer to their host via bite or defecation. In this study, we examined the capacity of females to overcome a systemic bacterial infection in their hemocoel. Specifically, fleas were injected with an ampicillin-resistant, GFP-expressing strain of Escherichia coli using a Nanoject III Automatic Nanoliter Injector. After two hours, we recorded survival at 2-, 4-, 6-, 8-, 10-, and 24-hours post-injection. At each time point, dead fleas were removed, homogenized, plated on selective media, and the resultant colony-forming units were used to determine the bacterial load upon death. After 24 hours, the bacterial load in living fleas was quantified. Data were collected as survival rates and colony counts to measure bacterial load. Our data showed there is no correlation between time of death and infection load, but that dead fleas have much higher infection loads than live ones. This suggests that infection outcome is determined by how long it takes the individual flea to mount an effective bacterial response and that hosts die if a certain threshold is reached.

How long do acclimation responses persist in three thermal traits in a field-caught leaf beetle?

Alexander Mauro, Adèle Piveteau, Hanna Kissener, Alfredo Escanciano Gomez, Aksel Johan Fosse, Gwenaëlle Deconninck, Cameron Ghalambor

Predicting the vulnerability of organisms to climate warming is a goal of thermal biology. Much of this research has compared projected temperatures to measures of an organism's thermal tolerance. More recently models have also incorporated the capacity of the organism to mount an acclimatory response – plastically alter thermal traits in response to thermal change. Beneficial acclimation results in improved tolerance, but the magnitude and duration of these responses vary among species and traits. Further, acclimation responses pose a challenge for researchers studying field-caught individuals: if the duration of the response persists beyond the time an individual is captured and measured for a thermal trait, then the acclimation effect will bias the measurement. Yet, how long such carry over effects last and how they vary for different thermal traits is largely unknown. Here, we investigated how acclimation to simulated heatwave conditions alters the thermal physiology of the leaf beetle, Bromius obscurus, and if the observed acclimatory responses would persist after a 24hr common "incubation period" to a benign temperature. We found that 1) a 7day simulated heatwave lowered thermal preference and standard metabolic rate but did not shift CTmax and 2) the incubation period negated the observed acclimation responses. Our results underscore the importance of a common incubation period prior to thermal measurements in field-caught individuals and highlight the benefit of measuring multiple thermal traits.

Characterization of critical thermal limits and metabolic rates of Mediterranean geckos

Eli Maynard, Allyson Fenwick, Christopher Goodchild

Mediterranean geckos (Hemidactylus turcicus) are native to the Middle East but have spread worldwide, including regions that should be too cold for survival. Critical thermal limits have been measured for U.S. populations along the Gulf Coast and south Texas, but not points further north. At the University of Central Oklahoma campus geckos have been found outside on building walls in temperatures far below published critical thermal minima. We conducted a two-year study to characterize seasonal variation in thermal limits of adult and subadult geckos. Current data suggest the window of critical thermal limits has shifted lower by about half a degree, with persistent differences between subadults and adults. Additionally, we measured annual variation in organismal metabolic rates (VO2). We are now coordinating with collaborators to use standardized methods to explore regional differences in critical thermal limits across multiple U.S. populations.

Dynamic transposable element landscapes shape cnidarian evolution

Ayanna Mays, Aide Macias-Muñoz, Feresa Cabrera

Transposable elements (TEs) are repetitive genetic elements that insert themselves and move locations in a genome causing genome expansions as well as structural rearrangement and can lead to genetic variation that drives diversification. Because TEs are inherited genetically, broad comparative analyses of TE activity within and across groups can give insight into the evolutionary history of phylogenetic relationships. The diversity of life history strategies, environment habitat, and phylogenetic position of Cnidaria makes it an ideal group to carry out a comparative TE analysis. We characterized TEs in 26 Cnidarian genomes aiming to find lineage specific TE trends that may explain the diversity found within the group. There was a positive correlation between genome size and TE load. Lineage specific TE trends were found in the Hydra clade within Medusozoa, while TE activity in other groups appeared to be independent of lineage. Most species displayed recent expansions of TEs. In Hydrozoa, DNA transposons were dominant while LINE elements were dominant in the Anthozoan, Scyphozoan, and Cubozoan genomes. Recent, independent expansions of LTR families across some groups highlight the dynamic nature of TEs. The rapid proliferation of TEs in individuals allows their successful continuation and creates genetic variation in groups which may be useful for adaptation, act as a tool for diversification, and lead to broad-scale evolution.

Effects of metal anti-predator screens on sea turtle embryo orientation

Alden Mazo, Jadyn Sethna, Kristina Williams, Joseph Pfaller, Chelsea Miles

Sea turtles rely on Earth's magnetic field for navigation and migration. Previous research has suggested that incubating embryos align predictably relative to magnetic north, which may affect subsequent magnetic orientation. Metal screens are a common method for protecting loggerhead sea turtle (Caretta caretta) eggs from predators in the Southeast USA. However, it is not yet known if using metal screens to protect eggs has a negative effect on the orientation of developing embryos. At our study site on Wassaw National Wildlife Refuge, GA, USA, we compared orientation angles (relative to magnetic north) of embryos developing under metal anti-predator screens (n=10 clutches) and plastic control screens (n=10 clutches). Our results indicated that at 75% development there was not a significant difference in embryo orientation angles between groups (metal vs. plastic), nor was there

significant directional embryo orientation across eggs within either group. In addition to comparisons between treatment groups, our analysis of nest effects found no significant orientation in any of the 20 focal nests. Our findings are inconsistent with previous research suggesting that sea turtle embryos align predictably relative to the Earth's magnetic field. These results suggest that metal anti-predator screens do not have a negative effect on embryo orientation.

Punk Rock SciComm: a guide to reaching people with art, community, & zines

Sarah McAnulty

In dark times, a punk rock approach to science communication is warranted.

Empowering scientists to effectively reach people with accurate and actionable information is critical in a time when our federal institutions are crumbling and online information sharing systems are under threat. Science communicators must overcome disinformation campaigns, suppression from social media algorithms, and increasing structural barriers to reach an overwhelmed populace. This is an incredibly challenging task, and becoming more challenging with each passing month. A diverse set of science communication methods can break through the noise.

Our recent work in Philadelphia begins with deep connections with local communities. These projects circumvent siloed media structures to reach people across divides. We put science content directly in the paths of people's everyday lives via events, murals, street art, zines, and other unconventional approaches.

In this talk, I will discuss many examples of how to reach people with science, along with tips for making projects successful in your neighborhoods. Attendees will receive a toolkit for creating science communication projects that they can create in their towns.

Managing risk with gut resilience in house sparrows

Kailey McCain, Lynn Martin, Elizabeth Sheldon, Kevin Kohl, Aaron Schrey, Cedric Zimmer, Melissah Rowe, Roi Dor, Jorgen Soraker, Henrik Jensen, Kim Mathot, Thinh Vu, Blanca Jimeno, Kate Buchanan, Massamba Thiam, Jim Briskie, Ho Thu Phuong

As organisms expand into new environments, they confront not only new resources but also heightened risks, particularly through increased exposure to parasites. Range expansions and biological invasions provide powerful natural experiments for examining how organisms respond to such ecological pressures. The house sparrow (Passer domesticus), one of the world's most widespread and successful invaders, offers an ideal system to explore how shifts in gene expression support survival and persistence in newly colonized habitats. We hypothesize that sparrows mitigate the risks of novel food exposure through physiological mechanisms that promote gut resilience, enhancing barrier integrity and immune function in the face of parasitic risk.

We conducted mRNA sequencing on duodenal tissue from 24 adult male sparrows across four native and four non-native populations. A differential gene expression analysis identified 558 genes with significant expression differences between population types, with 232 upregulated and 326 downregulated in non-native sparrows. Notably, the majority of the genes significantly up-regulated in non-natives are involved in processes supporting gut integrity, namely epithelial turnover, cytoskeletal modifications, and cellular anchoring. These functions are critical for maintaining barrier structure, enhancing nutrient absorption, and preventing microbial invasion. These results support the idea that non-native sparrows exhibit physiological shifts that promote gut resilience, helping them manage the risks associated with novel ecological conditions.

Brood size and sex ratio effects on testosterone levels of nestling tree swallows

Orion McCluskey, Jennifer Houtz

Environmental conditions during development can have significant effects on physiological traits and fitness in wild organisms. The role of abiotic factors, such as temperature, is well studied in altricial birds but social aspects, such as offspring sex ratio and brood size, can also have drastic effects on nestling developmental trajectory. For example, developmental environment can influence hormone levels such as testosterone which mediate behaviors such as begging and aggression which may be important in a larger brood. I tested the effect of brood size on plasma testosterone levels in nestling Tree Swallows (Tachycineta bicolor). I hypothesized that a larger brood size would lead to higher levels of testosterone. I quantified nestling plasma testosterone levels from varying brood sizes. Nestlings from a brood size of 5 had significantly higher levels of plasma testosterone in comparison to those from a brood size of 6. This research suggests that social aspects of development including brood size may have physiological and fitness implications for organisms. Future work includes consideration of brood sex ratio via molecular sexing.

Effects of temperature stress and predator-prey interactions on microbial evolution

Meg McConnell, Brenton Milton, Skylar Godwin, Rebecca Zufall, Karissa Plum

As environmental conditions change over time, so do the selective pressures populations may be exposed to. While previous studies have investigated how individual pressures impact evolution, few have considered the interaction of multiple stressors together. Thus, we aim to investigate how populations respond when they face multiple selective pressures together. In particular, we studied the molecular basis of adaptation in populations evolving under temperature stress and predator-prey coevolution. Using experimentally evolved populations of the ciliate Tetrahymena pyriformis and the bacteria Pseudomonas fluorescens, we tested how gene expression is altered as a result of adaptation to coevolving prey, temperature, and a combination of the two. Four lineages of T. pyriformis were grown either with or without coevolving prey and either at 26° or 30°C. RNAseq analyses reveal that the evolved populations have many differentially expressed genes relative to the ancestor. We predict that the populations evolving under stress of both temperature and coevolving prey will exhibit the largest number of differentially expressed genes. Further analyses of the genes that undergo changes in expression will reveal what genes and pathways are involved in adapting to the different combinations of stressors. These results will deepen our understanding of the molecular mechanisms behind adaptation in complex environments.

Predator call exposure during avian embryogenesis alters resulting nestling behavior and physiology

Raena McCown, Kristen Navara

Embryonic development in hard-shelled eggs has long been viewed as an isolated and independent experience. However, growing evidence suggests that avian embryos can perceive and respond to acoustic cues, producing lasting behavioral, physiological, and morphological changes after hatch. To test the impact of predator-associated acoustic signals, we investigated the developmental programming of Eastern Bluebirds (Sialia sialis) in a field study spanning 120 nest boxes across three sites in Athens, Georgia (February–August 2025). Experimental clutches were exposed to predator calls (Cooper's Hawk, American Crow, American Kestrel) during days 10–12 of incubation, while controls were unmanipulated. Offspring were measured for growth (tarsus, mass, wing length), begging behavior, and corticosterone responses at key developmental stages, with standardized predator-playback trials at day 14 to assess fear responsiveness.

Preliminary results reveal significant differences in hatch success and skeletal morphology: experimental broods exhibited reduced hatch success and decreased tarsal diaphysis symmetry compared to controls ($p < 0.001$). These findings demonstrate that acoustic cues during embryonic development can influence not only survival but also early skeletal growth. Our work highlights the potential for predator-induced acoustic programming to shape avian fitness, adding to a growing recognition that the environment during embryogenesis profoundly influences phenotypes and may contribute to adaptive responses in wild bird populations.

Activity and environmental preferences of invasive crayfish under aquatic and terrestrial conditions

Noelle McDonald, Robin Chambers, Emily Hardison, Jessica Diaz, José Goyco-Blas, Noah Leith, Kevin Kohl

Behavior plays an important role in the ability of an invasive species to disperse to new environments, compete with native species, and establish stable populations. Displacement by non-native species is leading to a global decline in crayfish diversity. The White River crayfish (Procambarus acutus) is an invasive species in parts of the United States and Europe. Understanding its invasive potential requires knowledge of the factors shaping its behavior under diverse physical and visual environments. Here, we conducted behavioral assays on 27 adult P. acutus from the same egg clutch to investigate their activity levels, willingness to interact with novel objects, and preference for white, black, or clear portions of their enclosures under aquatic and terrestrial conditions. Individual crayfish activity levels were consistent between aquatic and terrestrial test conditions and did not differ by sex, which suggests that activity varies on an individual level. In contrast, preference for different visual environments differed between the aquatic and terrestrial test conditions. Specifically, crayfish spent more time in black portions of tanks under aquatic conditions, but greater time in white environments under terrestrial conditions. Our results have implications for understanding behavioral phenotypes, dispersal, and invasion potential of crayfish under different conditions. Further, our results suggest that repeatable individual variation in behavior (i.e. personality) should be considered when modeling the behavior and invasion potential of crayfish.

Evolution of reduced plasticity in copepod sex determination across changing environments

Caitlin McDonough-Goldstein

Plasticity in sex determination is theorized to be an evolutionary mechanism that increases reproductive success across changing environments. The zooplankton copepods are an intriguing system for testing this hypothesis as they live in rapidly changing aquatic environments, have species across the genotypic to environmental sex determination spectrum, and have frequent reports of intersexuality. In this study, we examined the genetic and environmental contributions to sex determination across three populations of E. carolleeae adapted to different salinities. We found that all populations tended to have an even sex ratio in their optimal environment. Most notably, the brackish water population (ancestral state) had a significant increase in male bias when moved to freshwater environments that was not correlated with changes in survival to adulthood. Neither freshwater population (either from natural range expansion or experimental evolution in the lab) had a significant change in sex ratio in response to salinity. Thus, we find the plasticity in sex determination in the brackish water ancestral state is lost in the freshwater populations. Based on our results, we hypothesize that sex determination is influenced by body condition, and that the brackish water population - which lacks a history of adaptation to freshwater - was more strongly impacted by fluctuating salinity in their environment. Our research provides insight into how plasticity in sex determination can influence species survival in changing environments.

Reconciling sex across taxa to facilitate comparative analysis of reproductive trait evolution

Caitlin McDonough-Goldstein

Sexual reproduction has been an enduring component of scientific questions towards understanding the distribution and evolution of diversity across Eukaryotes. The complexity of ways that organisms are sexual presents tremendous opportunities as well as challenges, for biologists. High among them is navigating the many different meanings, assumptions, and nuances in how sexual terminology is used across fields and how entrenched social and cultural associations can influence their study. Language is also critically important in this area of research because communication of scientific concepts of sex can have real consequences for individuals marginalized with respect to their sex, gender and sexuality. Here we explore the justifications and critiques of the language used across different biological fields to categorize types of reproduction, types of sexually reproducing individuals, types of mechanisms to determine sexual phenotype, and the types of systems that include these individuals. We discuss the limitations of our language to capture the variation among these different “types” and the (in)compatibilities across different taxa and questions of interest. We aim to trace the complex, shifting, and intertwined definitions of sex and the implications for renewed efforts to create a database that will facilitate comparative analyses on the sexual traits across eukaryotes.

Nutrition drives feeding behavior and local distribution of a weapon-bearing insect

Isaac McEvoy, Shawn Wilder, Zachary Emberts

Metabolically expensive behaviors are common throughout the animal kingdom. For example, males of many species use sexually selected weapons to physically exclude rivals from desirable mates or resources. Diet is an essential component for these contests, as individuals must obtain the necessary nutrients to maintain these weapons and fuel the physical demands of combat. Not all food items are equal in their nutritional content or quality. Weapons may be associated with different dietary requirements or preferential access to certain food resources. Here, we use the giant mesquite bug to examine how weaponry influences feeding preferences and local distribution. Males of this species readily engage in combat using their enlarged femurs and distinct tibial spines on their hind legs. Individuals may choose between a variety of feeding sites and types of food, including fruit and new leaf growth on velvet mesquite trees. In the lab, males with large weapons prefer feeding on fruits, while small males and females prefer feeding on leaves. This feeding preference matched local distribution in natural populations, as males with large weapons were more frequently found on fruits. We also found that fruits and leaves vary in their nutritional composition across all investigated elements. These results suggest that diet selection for specific nutrients by weapon-bearing individuals may influence where they are distributed within their environment.

The evolutionary consequences of life cycle complexity on sensory systems

Carissa McGouran, Ronald Bonett

Animals that inhabit different ecological and or developmental niches across ontogeny are considered to have complex life cycles. Transitioning environments across ontogeny poses a host of challenges for these animals, one of which is detecting stimuli across shifting environments. Animals can overcome these physical constraints by transforming (i.e., metamorphosing) sensory structures to accommodate changing habitats. We review how sensory systems are modified in animals that experience life cycle complexity, paying particular attention to what broad trends emerge. We then lay out a variety of evolutionary hypotheses and a framework of how to test these hypotheses using an integrative approach to combine phylogenetic, developmental, and functional methods

Hot & cold: extreme water temperatures elicit varied personality expression in smallmouth bass

Kelsey McGrath, Katrina Whitlow

Temperature is an environmental stressor for smallmouth bass (Micropterus dolomieu). Metabolic rates, muscle contraction speed, and kinematic performance generally increase with rising water temperatures up to a thermal limit, which is relatively low in these sensitive ectotherms. Additionally, temperature changes may influence the display of fish’s personality traits (boldness/shyness) and therefore predator-prey interactions. This study investigated the influence of water temperature on the expression of personality in smallmouth bass from the St. Joseph River. We aim to elucidate how temperature-dependent metabolic rates impact individual boldness in smallmouth bass. Experiments were conducted across four temperature regimes: 15°C, 20°C, 25°C, and 30°C, representing ecologically relevant thermal variations. The fish were acclimated to and remained at these temperatures for 1-6 weeks before the experiment began. Individual boldness was assessed by measuring the

latency to explore, frequency of interaction with novel objects, and time spent in a standardized refuge. Time spent interacting with the objects was consistent over all temperatures, but more erratic behaviors (such as crashing into their tank walls) were seen at 15°C and 30°C. Fish at the midrange temperatures (20°C and 25°C) showed shelter seeking behaviors by spending time within the refuge. These preliminary findings suggest that ecological interactions will vary across temperature regimes. Further quantification of these responses will contribute to a better understanding of future adaptability of smallmouth bass.

Potential additive effects of dehydration and heat stress on physiology and damage in zebra finches

Margaret McGrath, Kevin Pham, Nathan Boudreau-Kim, Natalie Gassman, Haruka Wada

Understanding the ramifications of heat stress can help us predict populations' response to climate change. However, heat stress is often studied independently of other ecologically relevant stressors, such as dehydration, underestimating the role of combined stressors on physiological responses. This study seeks to understand how chronic dehydration modifies the physiological response to a non-lethal heat stress in a model songbird. Towards this goal, we gave female zebra finches a progressive water-restriction treatment over 8 weeks, with controls given ad libitum access to water. Following treatment, all individuals were exposed to three hours of heat (41.5°C) for two consecutive days. We collected blood samples to quantify glucose, beta-hydroxybutyrate, corticosterone, arginine vasotocin, and DNA damage in blood cells throughout the experiment. To determine heat-induced damage, we are in the process of quantifying oxidative damage in metabolically expensive tissues, as well as aquaporin abundance in the kidney. While dehydration and heat alone did not cause changes in blood concentrations of glucose, beta-hydroxybutyrate, and corticosterone, the combination of chronic dehydration and a non-lethal heat stress elicited elevations in all three variables. Hematocrit was not affected by dehydration or heat stress. Elevated metabolites and corticosterone suggest that dehydration may alter the physiological response to heat stress in zebra finches, which can affect how individuals respond to elevated temperatures due to climate change.

Let's Stick Together: Investigating micro-multicellular phenotypes across 1,000 isolates of *S. cerevisiae*

Macie McGraw, Helen Murphy

The common brewer's yeast, S. cerevisiae, is found around the world, from domestic populations in beer-brewing and wine-making, to wild populations living in tree bark and soil. Isolates of this yeast have been found to be obligately single-celled, obligately multicellular, or have a plastic multicellular response. These different growth forms make it an ideal system to understand the selective pressures that may favor the evolution of multicellularity. In yeast, multicellularity can be facilitated by the kin-recognition associated surface protein Flo11, which forms covalent bonds between cells, as well as the lectin-like surface protein Flo1, which binds reversibly and non-covelently to cells' mannose residues. Reversible Flo1-mediated binding is known as "flocculation," and is often selected for by brewers. In order to understand which micro-multicellular phenotypes are associated with which ecological niches, we screened a global panel of 1,011 of S. cerevisiae isolated from a wide variety of environments. To quantify the degree of obligate multicellularity, all strains were grown in rich medium, imaged in a 96 well plate, and particle sizes were calculated in ImageJ. To screen for isolates exhibiting a plastic response to glucose limitation, strains were also grown in low-dextrose media. Results show that strains isolated in different ecotypes exhibit different degrees of obligate micro-multicellularity, with most extreme phenotypes found in bioethanol production. Strains isolated from alcoholic beverage environments exhibited the largest plastic response in glucose-limited conditions. Next steps will include screening for Flo1 vs. Flo11 adhesion using a deflocculation buffer to get a fuller picture of how ecotype shapes micro-multicellularity.

Labriform mode of fish swimming creates strong suction thrust

Chase McGuire, Nils Tack, Bradford Gemmell

Pectoral fins are integral for the locomotion of many fishes. Fishes rely on these pectoral fins as a primary or supplemental source of propulsion, maneuvering, braking, and station keeping. The labriform swim mode relies solely on the pectoral fins for routine locomotion and is common in many reef fish species. In labriform MPF swimming, oscillations of the paired pectoral fins are used in drag-based (longitudinal rowing motion) or lift-based (dorso-ventral flapping motion) swimming modes. In lift-based labriform motion, the pectoral fins peel away from the body at the dorsal apex of pectoral fin motion to initiate two propulsive strokes, in contrast to a power stroke followed by the drag-inducing recovery stroke seen in drag-based labriform swimming. For this study, fishes in the family Acanthuridae and Labriforme were recorded swimming at natural speeds in a recirculating flume in an effort to quantify the velocity and pressure fields of their pectoral fin motion with high-speed videography and particle image velocimetry (PIV). Preliminary data suggests a previously undocumented negative pressure dominated suction thrust associated with the peeling motion of pectoral fins away from the body. Early findings of this research offer novel insights on the potential for effective thrust generation in MPF swimming while offering insights into the growing fields of soft robotics and bio-inspired vehicle design.

Waterbending chameleons: evaporative water loss shifts with acute temperature and humidity changes

Madison McIntyre, Graham Alexander, Krystal Tolley, Christopher Anderson

The ability to hydro- and thermoregulate to maintain performance in environments with extreme daily, seasonal, and annual temperature and humidity fluctuations are critical resilience strategies underlying survival of organisms. Ectotherms, and particularly squamates, are ecologically diverse groups with the potential to provide examples of adaptation and/or acclimation to environmental extremes. While short-term (acclimation) responses to temperature variation is well-studied, organismal response to changes in humidity remains relatively unexplored. We collected total evaporative water loss (TEWL) data from three chameleon taxa that naturally inhabit disparate environments with exposure to varying daily environmental temperatures and humidities. We placed individuals in a temperature and humidity-controlled respirometry system with nine low, medium, or high humidity and temperature combinations (20%, 50%, 80% RH; 15°C, 25°C, 35°C temperature) and collected three samples per individual over a 144 minute period per combination. Our preliminary results illustrate short-term acute exposure to increasing water vapor pressure deficit increased chameleons TEWL rates. Notably, two taxa (two Bradypodion melanocephalum populations from a 1000 m elevation gradient) absorbed water when exposed to moderate humidity and temperatures, suggesting a physiological mechanism by which water can be absorbed from the air. Such a mechanism may explain how individuals are able to maintain hydration status throughout the year and particularly during extended periods of low precipitation.

Humidity and the evolution of avian hyperthermia tolerance

Andrew McKechnie, Bianca Coulson, Marc Freeman

Early work on endothermic homeothermy suggested body temperature (Tb) is a non-adaptive constant, a paradigm that led to most hypotheses of thermal physiological adaptation in endotherms during the 20th Century focusing on traits such as metabolic rates rather than Tb. However, evidence for adaptation in Tb is accumulating. One environmental variable correlated with avian Tb is humidity, with southern African birds occupying humid lowlands having normothermic Tb and higher maximum hyperthermic Tb compared to species occupying drier habitats. Both theoretical modelling and empirical data support arguments, originally put forward by Wesley Weathers, that greater hyperthermia tolerance should be under positive selection in habitats where evaporative heat dissipation is impeded by high atmospheric humidity. In red-billed queleas (Quelea quelea), an African species with extreme hyperthermia tolerance (Tb = 48-49 °C), individuals exposed to high experimental humidity

become poikilothermic at air temperature > 44 °C, reiterating the role of hyperthermia in tolerance of hot, humid conditions. Most of Earth's avian biodiversity occurs in tropical latitudes and we propose that, for many species, the best metric for modelling sensitivity to extreme heat events is wet bulb temperature (TW). The maximum TW tolerated by an Afrotropical forest frugivore was 31.7 °C (close to a recently-proposed upper limit for humans), and exposure to environmental TW exceeding this value is predicted to increase substantially in coming decades.

Diversity and integrative taxonomy of Southern Ocean Solenogastres (Mollusca, Aplacophora)

Emily McLaughlin, E. Tremayne, M. Carmen Cobo, Kevin Kocot

Solenogasters occur in all oceans and depths, yet remain one of the least studied classes of Mollusca, with most of the group's diversity thought to be undescribed. Of the 314 described species, 105 are from the Southern Ocean, a fauna considered among the best studied in the world thanks to Salvini-Plawen's extensive 1978 monograph. However, most of these species were described from a single specimen or sampling event, making their distribution and intraspecific morphological variation largely unknown. The goal of this project focuses on narrowing this knowledge gap and improving the understanding of the diversity and evolution of Southern Ocean Solenogasters. This is being achieved by integrating historical records with new morphological and molecular data from ~800 specimens collected during five recent cruises. This includes redescription and extending distributions of previously described species, along with the description of new species using an integrative taxonomic approach. Of ~110 morphospecies, >40 are new species. I will demonstrate our integrative taxonomic workflow by focusing on three new species from the currently monogeneric family Syngenoherpiidae. Molecular phylogenetic results showing that the currently established systematics need revision will also be presented.

Extraocular muscles as a unique lens for understanding muscle function

Emily McParland, Jayleann Serrano Hernández, Marina Espinosa, Thomas Roberts

Much of what we know about the muscular basis for movement comes from studies of locomotor muscles. These studies have revealed "design principles" that explain how morphological evolution underpins muscles' ability to power movements that vary in speed, force, and precision. Extraocular (EO) muscles direct vertebrate eye gaze and provide a unique window into form and function of skeletal muscles that are uninvolved with locomotion. Working in three distinct constantly co-contracting pairs, these muscles guide fast saccades (up to 700 degrees/s) that allow animals to rapidly process visual input. The same six muscles also guide slow, controlled smooth pursuits (as slow as 30 degrees/s) that follow an object in motion. This dichotomy is well-characterized in other contexts ranging from marketing to neuroscience, however, it is less understood in a biomechanical framework. Here, we leverage existing eye tracking, morphological modeling, and in vivo EO muscle force data to understand the mechanical performance of human and monkey EO muscles. Calculations indicate that the force required to accelerate the eye is less than 1% of measured in vivo maximum isometric force, about 40% of maximum velocity, and less than 20% strain range. We hypothesize that the primary external load derives from a given muscle's antagonist. EO muscles provide a unique lens to understanding skeletal muscle mechanical function outside the scope of locomotor muscle.

Take-off behavior of the flying lizard *Draco dussumieri*

Niya McWhirter-Hall, Jake Socha, Pranav Khandelwal

Gliding animals undertake complex aerodynamic and morphological adjustments to execute a transition from perching to gliding. Flying lizards begin a glide using a leaping take-off, but their take-off behavior has not been characterized. Here, we quantify take-off from a vertical trunk in field recordings of the flying lizard, Draco dussumieri. Using two cameras (GoPro Hero4 Black; 240 fps), we recorded 24 glides performed by 14 individuals. Our analyses show that D. dussumieri employ a highly stereotyped take-off behavior. From a vertically head-up posture on the tree, the lizard pivots horizontally, initiated using a single hind leg. It then repositions itself using small front leg steps, and finally lowers the neck while taking a step forward using the original hind leg to push off and become airborne. During or just after push off, the lizard deploys the canard in 96 ± 30 ms (N = 14) and the wing membrane in 125 ± 29 ms. On average, the entire take-off from perching to complete wing deployment took 188 ± 49 ms. These observations highlight the sequence of events during take-off that leads to the Draco lizard achieving an aerodynamically effective gliding configuration. Moreover, they reveal a two-stage deployment of aerodynamic surfaces, with canard initiation before wings, in contrast to single motion wing deployment observed in other gliding mammals.

Spatial transcriptomics reveals molecular pathways underlying neural regeneration in larval lampreys

Cole Meador, Hilary Katz

In mammals, spinal cord injuries typically lead to irreversible neurological deficits. In contrast, larval sea lampreys (Petromyzon marinus) exhibit striking regenerative capacity following spinal cord transection. To investigate the molecular mechanisms that support this recovery, we utilized spatial transcriptomics to characterize region- and time-specific gene expression in the lamprey spinal cord before and after injury. Transcriptional profiles from rostral and caudal tissues at 1- and 3-weeks post-injury were compared against uninjured controls. Differentially expressed genes were ranked by the product of significance and the sign of log2 fold change and subjected to functional enrichment analysis using Enrichr, drawing from the GO Biological Process 2021, Reactome 2022, KEGG 2021, and ARCHS4 TFs Coexp gene sets. This analysis revealed distinct spatiotemporal patterns of pathway activation above and below the injury site. We observed differential regulation of regenerative and inhibitory signaling networks including an upregulation of genes related to both the FGF and Notch signaling pathways in rostral tissue when compared to caudal tissue at 1-week post-injury. Our findings highlight key molecular processes that likely contribute to successful neural regeneration in lampreys and provide insight into potential therapeutic targets for spinal cord injury in humans. Building on these results, we are currently investigating two conserved pro-regenerative transcription factors, ATF3 and c-JUN, using fluorescence in situ hybridization (FISH) to validate our spatial findings and quantify colocalization.

3D Reconstruction of deep sea octopus neuroanatomy could reveal unique chemoreceptive abilities

Tyler Mears, Robyn Crook

In the frigid darkness of the deep-sea thousands of pearl octopus(Muusoctopus robustus) migrate to hydrothermal springs to reproduce.This "Octopus Garden" off the California coast forms the largest knownaggregation of octopus on Earth. M. robustus exhibits a characteristic,upright reaching behavior using their front two arms (L1 and R1), and ithas recently been quantified that they use these arms by far the least forlocomotion. In this project we aim to describe the completely unknownneuroanatomy of M. robustus arms, to find if the L1 & R1 arms could bespecialized for distance chemoreception or display other differences inanatomy that reflects the unusual ecology of this species. Micro-CT andsynchrotron scanning of whole, fixed specimens will allow us to gainnew insights into the neuroanatomy of a deep-sea octopus. Findingunique neuromuscular features in their arms may provide insights intohow this species navigates over long distance to find the hydrothermalsprings they depend on and will shed light more broadly on the diversityof arm neuroanatomy that has been optimized for the many niches thatextant octopods occupy.

Deformable 3D models for quantifying body condition in southern right whales

Joshua Medina, Ruby Gaetani, Fredrik Christiansen, Duncan Irschick

This study provides new methods for accurately assessing mass and body condition in large marine mammals, with a focus on Southern right whales (Eubalaena australis). Traditional methods for estimating mass and body condition in cetaceans are often invasive or impractical due to their size and

transitory nature. Combining recent advances in UAV-based photogrammetry and 3D modeling, we introduce a new framework for estimating surface area, volume and mass in a non-invasive, high-resolution manner. 3D whale models were developed using morphometric parameters to simulate varying body lengths as well as varying stages of body condition and lactation. These models were used to generate synthetic whale data that covered a wide range of varying body shapes. These synthetic data were then compared to real whale data from 1,100 body volume measurements taken from UAV images of 40 female Southern right whales.

By integrating synthetic data modeling with real-world photogrammetry data, this work offers a more precise method for monitoring energy allocation and reproductive investment in baleen whales. The approach holds particular value for understanding the health and recovery of whale populations affected by historical exploitation and current environmental pressures. Long-term monitoring of body condition provides critical insight into maternal investment strategies, ecosystem productivity, and anthropogenic stressors.

The impacts of agricultural land use on leukocyte counts of overwintering shorebirds in California

Madison Meeuwsen, Ben Sonnenberg, Kenneth Glynn, Jamie Cornelius

The widespread decline of migratory shorebirds is a growing global concern, but identifying the drivers of these declines remains challenging. Wintering ground habitat may be critical for successful management of shorebirds and one California state initiative promotes the use of rice fields as habitat alternatives for migratory and resident waterbirds. Here, we examined potential downstream effects of habitat quality on the immune response of three shorebird species: dunlin (Calidris alpina), long-billed dowitchers (Limnodromus scolopaceus) and least sandpipers (Calidris minutilla). Birds were captured in Central CA at both interior and coastal locations and were sampled for body condition and peripheral blood. Ratios of lymphocytes to heterophiles (HLR) were analyzed across years and sampling locations within California as one assessment of health. We predicted a higher mean HLR (indicative of an active immune response) in shorebirds overwintering in the central valley of California during drought years and in birds sampled inland compared to coastal locations. Our results show weak support for between year differences, but HLR was higher in the wet year of the study, which was opposite to our prediction. There were no HLR differences between coastal and inland populations of dunlin. These preliminary data indicate the potential for differential immune response across years and habitats, but more sampling is required to investigate the suitability of rice fields as replacement habitat for wintering shorebird populations.

Jaw muscle volume, architecture, and leverage as predictors of bite force in turtles

Ammara Mehkri, Edwin Sun, Rohan Sundaran, Julia Molnar

Vertebrate feeding mechanics are affected by musculoskeletal traits such as width and height of the skull and size, architecture, and leverage of jaw muscles. Bite force in reptiles is closely related to jaw adductor muscle volume; however, an ontogenetic study in musk turtles showed that muscle architecture is also highly correlated with bite force. To investigate the relationship between musculoskeletal traits and bite force among turtles, we studied jaw and muscle anatomy in eight species with different ecologies and feeding strategies for which bite forces have been recorded in the literature. Using contrast-enhanced micro-CT and fiber tracing software, we non-destructively measured volume and mean fascicle length of the external mandibular adductor muscles (superficialis, medialis, and profundus). Muscle volume and leverage generally correlated with bite force, though exceptions were observed. For example, leverage of external adductors in the Asiatic softshell turtle (Amyda cartilaginea), the species with the highest proportional bite force of our sample, was 40% greater than in the loggerhead sea turtle (Caretta caretta), which had the smallest bite force. Muscle fiber length did not consistently correlate with bite force across species. This contrasts with ontogenetic studies in the musk turtle (Sternotherus), where muscle architecture influences performance. Thus, musculoskeletal morphology can predict bite force in turtles, but factors such as sex, captivity, and ontogeny should be considered as well.

Jump of the water monkey

Rita Mehta, Alegra Negrete

Many aquatic vertebrates leap out of the water to catch prey, escape predators, or cover greater distances. Silver arowana, Osteoglossum bicirrhosum , sometimes referred to as “water monkeys”, are predatory fish inhabiting the Amazon Basin that are known to jump out of the water to catch prey. In the wild, silver arowana have been observed to consume small arboreal mammals, insects, and birds. To better understand arowana jumping abilities, we re-examined jumping behavior in captive bred juvenile arowana following a previous study for which the kinematics of feeding in and out of water were carefully evaluated. In this subsequent study, we examined maximum jump height, accuracy, number of jumps in short succession, and fatigue, the phenomenon of tiring or a decline in performance after successive jumps. Jump accuracy and fatigue were tested at various prey heights. We examined 603 trials across 5 individuals. The proportion of successful prey capture trials was variable when arowana were challenged with prey at new heights. At the lowest prey height (12 cm) arowana tended to overestimate but produced jumps in tight succession. Arowana were more accurate when prey was held at 16 and 20 cm but took longer rests between jumps.

Deep-sea echinoderms collected from wood falls in the Monterey Canyon, California

Dylan Meier, Camilla Alves Souto

In 2011, researchers from the Monterey Bay Aquarium deployed 28 wood bundles at 3,100 meters in the Monterey Canyon. They contained 10 species (California fan palm, stone pine, ginkgo, tree poppy, island ironwood, California torreya, spicebush, redwood, coast live oak and tree fern) with various physical structures. After two years, the bundles were recovered and associated organisms were sorted. We aimed to identify and describe the echinoderms collected on this expedition. Preliminary identifications relied on morphological characteristics. Twenty crinoids, recovered from eight wood species (excluding tree fern and stone pine), and most abundant in island ironwood (Lyonothamnus floribundus). Seventy-six ophiuroids were found in all wood species, most abundantly in Torreya californica. Amphiura carchara (Amphiuridae) found in nine wood species (excluding redwood), Ophiacantha bathybia (Ophiacanthidae) in eight species (excluding spicebush, oak and tree fern), and Ophiambix aculeatus (Ophiomyxidae) in four species (California fan palm, ginkgo, redwood and spicebush). Bundles of branching woods supported a richer diversity of macroinvertebrates than solid trunk logs, likely because of their increased surface area and shelter. In contrast, redwood and tree fern hosted few echinoderms, possibly due to inhibitory chemical compounds. Remarkably, only O. aculeatus has previously been linked with wood substrates, and this study represents its first documentation off the continental U.S. coast. Ongoing work includes detailed species descriptions and molecular analyses to refine identifications.

What does it DO? Turning control and modulation of the dorsal oblique muscle in Manduca sexta

Elena Meigs, Ethan Wold, Jean Baptiste Bwirayesu, Simon Sponberg

Many control muscles operate indirectly by altering the biomechanics of joints that other muscles directly actuate. The dorsal oblique (DO) is an indirect flight muscle present in most hovering insects but absent in some closely related non-hovering species. It is smaller than the main indirect power muscles yet does not directly attach to the wing hinge like steering muscles, making its function unclear. Prior work showed variation in DO activity between wingstrokes and it may act analogously to the fly’s pleurosternal muscle to indirectly modulate resonant mechanics of the thorax-wing joint. Here, we investigate whether the DO plays a role in turning control in Manduca sexta hawkmoths, which rapidly modulate hovering flight. We recorded from the bilateral DOs and indirect power muscles in ventrally-tethered moths and induced turning behaviors with a visual stimulus. We find that left-right timing differences in DO spiking activity covary with left-right timing differences in the power muscles that help control turns. This demonstrates similar spike timing coordinated responses across all power muscles. However, the DO on each side maintains a consistent phase relationship with the ipsilateral upstroke and downstroke

muscle suggesting that it may shape strain propagation across the thorax and into the wing hinge in a consistent way even during turns. These findings clarify the role of the DO in the moth's motor program as a potential resonance modulator.

Glucocorticoid regulation as a predictor of nest abandonment during a cold snap

Nicole Mejia, Conor Taff, Maren Vitousek

Climate change-driven shifts in breeding range and timing expose species to variable weather conditions during critical reproductive periods. As a result, organisms must be able to cope with rapidly changing conditions through physiological responses. The hypothalamic-pituitary-adrenal axis facilitates this physiological flexibility through the upregulation of glucocorticoid hormones into the bloodstream. Acutely elevated glucocorticoids tend to increase investment in immediate survival and self-maintenance; this is often accompanied by a downregulation in reproductive investment. Cold snaps represent a significant threat to breeding tree swallows (Tachycineta bicolor), and previous work has shown that cold-exposed females show only a minor increase in baseline glucocorticoids but dramatically increase their glucocorticoid stress response. This could enable them to avoid the immediate costs of elevated glucocorticoids while heightening sensitivity to environmental cues. Here we utilize a dataset of blood samples from tree swallows that were collected prior to and during a prolonged cold snap in the 2025 breeding season in Ithaca, NY to test whether glucocorticoid regulation predicts the likelihood of nest abandonment. Analyses suggest that baseline glucocorticoids during the cold snap did not predict the likelihood that incubating birds would abandon their nests, but female tree swallows with elevated acute stress responses to capture and handling were more likely to abandon their nests. This study demonstrates how phenotypic variation can be an important predictor of resilience to challenging and changing environmental conditions.

Intraspecific variation in anuran skin texture across climate

Chesney Melissinos, Molly Womack

Anuran skin acts as a barrier between the body and the outside world. Anurans face a constant challenge of keeping the skin surface moist while also preventing evaporative water loss, which can be fatal. However, frogs and toads are found in a wide range of environments, including environments where the risk of drying out is very high. To manage this risk, we hypothesize that anurans have skin texture adaptations to deal with the pressures of dry climates. At the macroevolutionary scale, little relationship has been shown between skin texture and climate factors such as aridity, but few studies have examined skin adaptation to climates within species. An intraspecific perspective controls for differences in texture due to species differences, and allows for stronger comparison between individuals across climate. Using gel profilometry imaging from 129 preserved museum specimens across 7 species, skin texture was quantified as Root Mean Square Roughness and tested against aridity and evapotranspiration values accessed from the Global Aridity and PET Database. Interestingly, different species showed different relationships between skin texture and climate factors and no overarching patterns were found between roughness and aridity or evapotranspiration. This shows that messy relationships between skin texture and climate seen at the macroevolutionary scale are mirrored when you examine intraspecific patterns within a more limited number of species.

Experimental simulation of wildfire ash deposition reduces seed set and pollinator visitation

Grace Melone, James Crall, Amy Trowbridge

The occurrence of large wildfires are projected to increase in severity and frequency throughout the 21st century. In addition to habitat destruction, these fires generate smoke and ash plumes which can travel miles outside of fire boundaries, falling on soil, water bodies, and vegetation. Yet the impacts of ash deposition on plants and plant-insect interactions are critically understudied. Ash could affect flower reproduction through several potential mechanisms. Ash could reduce pollinator visitation due to changes in floral attractiveness, or reduce successful pollination by physically blocking pollen from adhering to stigmas. In this study, we 1) quantified the effect of ash deposition on pollination and seedset and 2) identified mechanisms underlying these effects in two California wildflower species (Trichostema laxum and Helianthus exilis). Using experimentally simulated ash deposition onto flowers under both lab and field conditions we found that ash exposure decreased visitation to both wildflower species and reduced seedset in T. laxum. ash-exposed flowers of both species received fewer visits. Together my data show that environmentally realistic levels of ash disrupt plant reproductive success and plant-pollinator interactions. Our results suggest that this is by both reducing pollinator visitation and pollen adhesion to stigmas. Understanding the effects of wildfire ash deposition on plant-insect interactions is imperative to create management and conservation decisions during and after mega-fires.

Elucidating the genetic regulators of chemical defense in the diablito poison frog *Oophaga sylvatica*

Cesar Mena, Lauren O'Connell, Stephanie Caty, David Ramirez

Chemical defenses have independently evolved across various branches of life. From the use of batrachotoxin in the feathers of the songbird Pitohui dichrous to the accumulation of tetrodotoxin in the glands of the blue ringed octopus Hapalochlaena lunulata, these defenses vary drastically in both their deployment and potency. While much is known about the chemistry and physical deployment of these toxins, the molecular mechanisms working to maintain and protect these organisms from their chemical defense is poorly understood. Poison frogs, with their ability to sequester alkaloid toxins, are a unique model to study the molecular mechanisms of chemical defense. Building on the recent discovery of alkaloid binding globulin (ABG), a protein which binds to various toxic alkaloids in frog blood, we aim to uncover the molecular pathway of toxin sequestration. To identify differentially expressed genes (DEGs) associated with alkaloid sequestration, we performed a 10-day toxin feeding experiment with the diablito poison frog Oophaga sylvatica using decahydroquinoline, a toxin sequestered by poison frogs. We then harvested tissues known to be involved in the chemical defense pathway and conducted RNA-seq analysis. With this analysis, we will identify DEGs linked to molecular machinery acting alongside or independently of ABG to maintain chemical defenses of poison frogs. By identifying these mechanisms, we can draw comparisons across species and piece together the evolution of toxin defenses from a molecular perspective.

Evolutionary history of repeated extreme elevation colonization in Phyllotis leaf eared mice

Ezra Mendales, Jay Storz, Jeffrey Good, Zachary Cheviron

Phyllotis (Order: Rodentia) is represented by 23 species that diversified primarily during the Pliocene (2-5 Mya). The genus occupies a diverse geographic range, and spans nearly the entirety of the Andes mountain range. Though there are three low-elevation specialist taxa, ~60% of Phyllotis species occupy ranges above 3,000 m in elevation. Eight of those are some of the highest living mammals in the world, with upper elevational range limits exceeding 4,000 m. One species, P. vaccarum, was discovered in 2020 at the top of Llullaillaco Volcano at 6,739 m, setting a world record as the highest continuously dwelling mammal. Although morphological variation has been thoroughly investigated within this clade, a genus-wide, genome-based phylogeny has not been published. Without genome-wide data diversification patterns are biased within this system because of the different coalescent histories genetic loci often hold. Here we present a new phylogeny for Phyllotis based on moderate coverage whole-genome sequences, and use it to examine the evolutionary history of colonization of high-elevation habitats. Our new phylogeny includes 22 of the 23 described species sampled from 49 specimens that span across the elevational and latitudinal ranges of widespread Phyllotis species. This research investigates the number of independent colonizations into high elevation, historic and contemporary hybridization, and reconstructs the elevational distribution in the most recent common ancestor, giving insight into the patterns of extreme habitat occupancy.

Gregarious and solitary larval settlement in the reef-forming annelid *Ficopomatus enigmaticus*

Alex Mendelson, Keomonyroth Nuon, Bruno Pernet

Gregarious larval settlement – where cues associated with adult conspecifics induce larval settlement – plays a role in enlarging existing aggregations of many aggregation-forming marine invertebrates. To establish new aggregations, however, some larvae must settle in the absence of conspecifics. What controls this variation in larval settlement behavior is unknown for most gregariously settling species. An exception is the serpulid annelid Hydroides dianthus, whose larvae are either “aggregators” (settling only gregariously, in response to conspecific cues) or “founders” (settling only alone, in response to non-conspecific cues); this dimorphism is genetically determined and fixed through larval life. We tested the hypothesis that larvae of another aggregation-forming serpulid, Ficopomatus enigmaticus, display a similar fixed dimorphism in settlement behavior. If true, the sum of the percentages of aggregators and founders in any given sample of larvae should not exceed 100% (since each larva can accept only one of the two cues throughout its competent period). Our data on F. enigmaticus are not consistent with this prediction, suggesting that each larva does not have a fixed behavior and can respond to several types of settlement cue. This difference between larvae of H. dianthus and F. enigmaticus, both of which are invaders in many coastal marine habitats, has important implications for how frequently they can form new aggregations and thus spread in novel regions.

How context-dependent signaling affects temporal dynamics in calling bouts

Julianna Mendez, Mariana Rodriguez Santiago, Erik Zornik, Paula Pouso, Kim Hoke

In chorusing animals, individuals must produce conspicuous signals while navigating the physical and social context of their signaling environment. Emergent patterns in signal timing and signal type are likely to arise as a strategy to avoid signal interference. Furthermore, these signaling patterns may influence individual recognition and mate choice. While receiver preferences for signal timing patterns in animal communication have been studied across many taxa, we know less about the interactions of communication network dynamics over time and what social contexts bias animals’ temporal patterns. In the acoustic signals produced by a chorusing South American treefrog, Boana pulchella, temporal patterning within a call series is relatively constant, however, over longer bouts, spacing of calls becomes irregular within an individual. Here, we report on the variation in the temporal properties of B. pulchella over natural calling bouts, as well as how acoustic context shapes call timing using playback experiments. These findings provide fundamental insight into the social interactions that drive temporal dynamics within communication networks.

Eastern Bluebird vs. Tree Swallow: Nest takeoff and landing kinematics of two different foragers

Laura Mendez, Natalie Wright, William Harrigan, Erasmia Yager

Eastern Bluebirds (Sialia sialis) and Tree Swallows (Tachycineta bicolor) are small songbirds that use nest boxes or natural cavities to build their nests. Both species share a similar nesting behavior where females mostly build the nest, females and males care for the offspring, and males are highly territorial. However, the two species present morphological and foraging flight differences that might translate into flight performance variations when arriving and leaving the nest. Bluebirds are larger, heavier, and have shorter wings than swallows, and present a sit-and-wait foraging behavior, while swallows hunt by performing low and fast flights. Given these differences, we were interested in characterizing the flight performance of these two species to study the influence of morphology in the takeoff and landing when the birds arrive and leave the nest. We recorded the free-flight takeoff and landing of males and females of both species using a set of cameras placed facing the entrance of nest boxes located in fields in Central Ohio. Videos were used for three-dimensional (3D) reconstruction and kinematic analysis of the flights to compared the performance between the two species.

Influence of facial ruff reflector feathers on the hearing of the Barred Owl

Madeline Mendez, Chris Clark

This research examines the impact of the reflector feathers on the sound perception of the Barred Owl (Strix varia), a large North American owl species. As in most owl species, the Barred Owl has a facial disk, a circular arrangement of auricular feathers forming a concave disk-like shape, surrounded by a dense facial ruff. The facial ruff is composed of thin, stiff, and dark feathers called reflector feathers. The ruff extends behind the owl’s ears and preaural flap, a movable skin flap in front of the ear canal. To research this, ten Barred owl heads will be tested with different conditions, manipulating head elevation, ear flap position, and the removal of different feather tracts. A speaker playing white noise will be placed in front of the owl and small microphones placed in the ear canal will record what is heard. Previous research on a distantly related species of owl, Barn Owl (Tyto alba), has shown that facial ruffs composed of reflector feathers acted as a “sound collector”, significantly amplifying sounds directly in front of the owl, especially those of higher frequencies. We expect our findings on the Barred Owl to align with the results found in the Barn Owl and find that the owl heads with reflector feathers would perceive sounds at higher frequencies at louder amplitude than owl heads tested without their reflector feathers intact.

Spike-based classification of tactile features with an insect-inspired antenna neuromechanical model

Lingsheng Meng, Kaushik Jayaram, Jean-Michel Mongeau

A hallmark of insect intelligence is in its efficiency and economy of behaviors in complex environments. For instance, many insects rely on touch information from antennae to guide rapid decision-making. To study how touch information is represented at the neural level for efficient feature classification, we developed a neuro-mechanical computational model of the cockroach antenna P. americana that simulates antenna mechanics and neural encoding of mechanosensory information. The mechanics of the antenna were modeled within a physics-based simulation environment (MuJoCo), which revealed spatiotemporal strain patterns (tactile tensors) arising from antennal deflections during contact with features. These tactile tensors were then used as input to a phenomenological model of campaniform and hair sensilla, where individual mechanosensory units encoded local mechanical inputs into spike rate responses. We validated the predicted firing activity against extracellular recordings from the antennal nerve and determined a strong correlation between simulated and experimental neural activity. To determine how spikes could be used for efficient feature classification, we trained spiking neural networks (SNNs) on the model-generated spike trains to classify tactile stimuli. The SNN classifiers achieved robust predictions, demonstrating the potential of sparse, spike-based codes for efficient tactile feature discrimination. Together, our results highlight how the coupling of mechanics and neural computation supports energy-efficient sensing in insects and provide a pathway for developing efficient tactile sensors.

Trade-offs between two mating-related traits in *Speyeria mormonia*

Madison Mengel, Daniel Speiser, Carol Boggs

During the pupal stage, holometabolous insects allocate resources acquired in the larval stage to various pathways that form their adult morphology and thus impact fitness. Allocation pathways that influence wing loading and wing color are vital to reproduction in many Lepidoptera. Wing loading is an indicator of flight efficiency, which is important in Mormon fritillary butterflies (Speyeria mormonia) because males fly to search for mates and females fly to locate oviposition sites. Wing color is important to mating because it is a signal between males and females, with males preferring more orange females. Limited resource availability during the larval stage creates tradeoffs between allocation pathways, suggesting that an increase in allocation to wing pigment could be connected to a decrease in allocation to flight. Using this framework, we aimed to better understand whether wing loading and color differ between the sexes and within a sex in individuals eclosing across the flight season. Then we sought to determine whether there are tradeoffs between these two

traits within each sex in a S. mormonia field population. We used calibrated and standardized images to extract metrics of color and measurements of wing loading. Through these comparisons we hope to better understand mating-related tradeoffs, in which we expect to see males prioritize flight efficiency and females prioritize wing color due to differences in courtship behavior.

Modeling attention for magnetic, olfactory, and visual navigation

Nathaniel Mengers, Brian Taylor

Many migratory animals sense Earth's magnetic field and use it for navigation. Prior computational research has shown that combinations of magnetic field parameters may be used in a manner similar to map coordinates. In some regions, magnetic cues provide only coarse guidance, so animals must rely on other senses for precise navigation. However, it is unknown how magnetic information is integrated with stimuli from other modalities. In this work, we present a simulation wherein an agent navigates to waypoints in a configurable environment with a magnetic field, odor sources, and visual landmarks. Attention and decision-making models govern which stimuli the agent uses for navigation and which waypoints the agent visits, respectively. The attention model incorporates bottom-up mechanisms that direct attention towards salient (suddenly changing) stimuli, as well as top-down mechanisms that prioritize stimuli related to the agent's chosen waypoint. We assess whether bottom-up, top-down, or a combination of mechanisms produces the greatest success rate and path efficiency when the agent experiences sensory noise. Our work demonstrates that bottom-up mechanisms may explain the proposed attentional shifts from magnetic to olfactory or visual cues for precise homing, while top-down mechanisms may improve speed and path directedness. Our simulation further confirms that magnetic parameter combinations can support navigation in conjunction with cues from other modalities.

Testing hypotheses of constraint and release in the body evolution of snakes

Magdalen Mercado

Snakes (Squamata: Serpentes) are an extremely speciose and ecomorphologically disparate vertebrate clade, despite their apparently simplified body plan (head, elongated trunk, and tail). Though simple, the snake body plan is used variously for functions including 'gaits,' (e.g. sidewinding, rectilinear) and the capture of diverse prey using a variety of strategies (e.g. constriction, striking); facility at a given function has been associated with the number of vertebrae in the trunk and tail regions and the relative proportions of each. While the developmental mechanisms underpinning the requisite acceleration of somitogenesis are reasonably well understood, the elongate body plan is also apparently coupled with reduced canalization, meaning that vertebral numbers are extremely variable both within and between species of snakes. Here I document the distribution of intraspecific variation in vertebral number in several clades of snake, highlighting lineage-specific trends in developmental variation and constraint. I also quantitatively test the relationships between meristic variation and phylogenetic, ecological, locomotory, and physiological traits. Preliminary findings emphasize the potential roles of disparate selective pressures on the evolution of developmental mechanisms. Further, these results contribute to a growing understanding of the importance of intraspecific variation to the assembly of macroevolutionary patterns.

Visual learning abilities (or lack thereof) in Guatemalan beaded lizards (*Heloderma charlesbogerti*)

Lillian Mertig, Joseph Mendelson

The sensory biology and cognitive abilities of Beaded Lizards (Helodermatidae) is poorly studied. This study investigates Guatemalan Beaded Lizard's ability to make simple visual associations, testing their reliance on visual sensory stimuli — particularly considering their anecdotally poor eyesight and their largely static prey of eggs and small newborn mammals — as well as establishing a baseline of their cognitive abilities. We ran modified Y-maze visual association training on five lizards over the course of twenty weeks, with right-left randomization of an unnatural stimulus and a food-reward. We expected the lizards to show preference for the presented stimulus indicating association with the food reward; however, we found that in the modified Y-maze conditions the Guatemalan Beaded Lizards did not attend to the stimulus more than chance. This implies an inability to make visual associations under these conditions.

Whole genomes and community science images reveal the genetics of visual mimicry in toucans

Jon Merwin, Kamila Kuabara, Matthew Soesanto, Abigail Jordan, Lukas Musher, Jason Weckstein

Mimicry is a classic example of convergent evolution. While the selective advantage of mimicry is invoked to explain phenotypic convergence in birds, few studies aim to uncover causal loci that generate mimetic phenotypes and fewer still have assessed support for alternative adaptive and neutral hypotheses which may drive the evolution of convergent phenotypes in sympatry. Toucan species Ramphastos vitellinus and Ramphastos tucanus are phenotypically convergent in the western amazon rainforest, and were proposed by previous work to be a product of interspecific social dominance mimicry. We use whole genome sequencing and photospectrometry of Ramphastos vitellinus museum specimens to show selective introgression of putative mimicry loci across headwaters of major amazonian river tributaries. We also use a dataset collected from community science images to assess the turnover of mimicry-associated soft-part and plumage colors across the landscape and to test whether phenotypic variation in these species may be adaptive. Our results show that hybrid birds with intermediate plumage and soft part characters are not intermediate genetically, and therefore that phenotypic convergence in toucans is driven by a small proportion of the genome. Using our community science image dataset we also demonstrate asymmetric clinal variation in bill color, plumage color, and facial skin color across the landscape, suggesting a divergent genomic basis for these traits as well as variation in the strength of selection between alternative traits.

The initiation and maintenance of snapping shrimp-goby mutualisms

Tanner Mierow, Myrosya Zelenchuk, Alexandra Kingston

The tiger snapping shrimp, Alpheus bellulus, engages in mutualistic partnerships with the yellow watchman goby, Cryptocentrus cinctus. In these partnerships, A. bellulus maintains a burrow that provides both partners with shelter, while C. cinctus warns of nearby predators. For a partnership to be established, one animal must first initiate the partnership. Following initiation, the partnership must be maintained by one or both partners to avoid losing the acquired mutualistic benefits. We investigated the behavioral dynamics of initiation and the subsequent maintenance of partnerships between A. bellulus and C. cinctus to ask if either partner assumes a predominant role in the initiation or maintenance of these mutualisms. To test this, we analyzed the behavioral interactions of naive A. bellulus and C. cinctus prior to bonding. After bonding, we conducted a partner seeking test to identify if one partner sought out the other more often when separated. Lastly, we conducted a partner choice test to determine if A. bellulus can identify their partner goby when given access to a partner and a "stranger" goby. We found that C. cinctus initiates partnerships significantly more than A. bellulus. We also found that A. bellulus seek out their goby partner when separated and can distinguish between their partner goby and a stranger goby. Here, we find that C. cinctus initiates and A. bellulus maintains their mutualistic partnership.

Assessing human pressure on golden-mantled ground squirrel and chipmunk flight initiation distances

Sydney Mikaru, Caitlin Wells, Travis Rainey

Species who commonly occupy territories within human settlements are exposed to frequent human disturbance, which has been linked to significant shifts in wildlife behavior in past studies. As urbanization and rural development continue to increase, we can anticipate cohabitation between humans and wildlife to also increase, creating a growing need to understand the effects of repeated human disturbance on wildlife behavior across a variety of taxa. Flight initiation distance (FID) is a common metric used to quantify antipredator

behavior and boldness in wildlife populations and is used to assess perceived risk of a pursuer from the perspective of a fleerer. We conducted FID trials on golden-mantled ground squirrels (Callospermophilus lateralis; GMGS) and least chipmunks (Tamias minimus; CPMK) across 11 sites of varying levels of human disturbance to determine the effect of human disturbance on FIDs through a generalized linear mixed effects model. We found a statistically significant positive relationship between proportion of impervious surfaces within a buffer range of the animal and FID for CPMK, as well as a reliably positive effect of distance to road on FID for CPMK. GMGS had reliably positive effects of distance to road and distance to trails on FID. Starting distance was significant for both CPMK and GMGS, reinforcing past literature examining its relationship with FID.

Macroevolutionary drivers of traits associated with rarity in *Silene*

Jenna Miladin, Jeremy Beaulieu, Maribeth Latvis

Species exhibit significant variation in their abundance within natural habitats, influenced by geographic range, local population size, and habitat specialization. These factors represent the three distinct dimensions of rarity that a species may exhibit. Since species can demonstrate multiple forms of rarity simultaneously, the underlying factors driving each dimension are likely to differ. In this study, we employed phylogenetic comparative methods to explore the macroevolutionary drivers of traits associated with rarity and assess the phylogenetic signal of rarity within Silene (Caryophyllaceae). Utilizing Silene as a model system, our research aims to establish an innovative framework for predicting rarity in a conservation context.

nkx3.2 phenotype in the Weberian apparatus of zebrafish (*Danio rerio*).

Bren Miles, Jennifer Hoeflich, Tetsuto Miyashita, Juan Liu

Zebrafish carrying a null nkx3.2 allele exhibit remarkable phenotype in their fused jaw joints, and metamorphose into functionally jawless adults with highly modified skull structures. Although the feeding mechanism is clearly affected in the mutants, it remains unclear whether auditory function is similarly impacted. We investigated the hearing ossicles and peripheral structures (Weberian apparatus) in nkx3.2-/- zebrafish and facilitated a comparison with wildtype. To visualize the Weberian apparatus and vertebral column, we used X-ray-based microcomputed tomography and clearing-and-staining methods. The Weberian ossicles of nkx3.2-/- zebrafish show reduced ossification compared to those of the wildtype. The anterior process of the tripus is fused to the centrum 3 (C3) in nkx3.2-/- zebrafish, whereas in wildtype the tripus articulates with C3 via the ascending process instead. The tripus is also more slender in the mutant than in the wildtype, especially in the anterior process. The intercalarium is hyperossified, fused to C2, and shorter in the mutant than in the wildtype. The peripheral Weberian bones, including neural complex and os suspensorium, are relatively larger and more robust in the mutant. In conclusion, a null allele of nkx3.2 not only causes fusion of the jaw joints but also leads to a host of abnormalities in the hearing apparatus, implying a pleiotropic effect in the Weberian apparatus.

Color morphs, mode of reproduction, and diversification in the lizard family Phrynosomatidae

Donald Miles, Fausto Mendez de la Cruz, Saul Dominguez-Guerrero

Many taxa exhibit substantial within-species variation in a variety of traits, e.g., size classes, discrete color morphs. Theory suggests that the evolution of a polymorphism may accelerate speciation rates. Morphs within a species may be adapted to different ecological niches, which favors range expansion. Morphic speciation occurs with the expansion of a population into a new habitat leading to the loss of a morph with subsequent reproductive isolation. To date there have been few tests of whether the appearance of a color polymorphism promotes diversification in lizards. In this study we evaluated the evolutionary patterns of morphic diversity in the lizard family Phrynosomatidae. We also test whether the evolution of color morphs spurs diversification. We obtained color-morph data on 148 species, which included monomorphic, dimorphic, and trimorphic populations. We predicted that monomorphic color was the ancestral character state with a sequential evolution of additional morphs. Color morphs exhibited significant phylogenetic signal. However, ancestral reconstruction revealed that dimorphism is the best supported ancestral state. An analysis of tip diversification rates revealed higher diversification rates in polymorphic species, but was contingent on reproductive mode and substrate preference. Polymorphic, viviparous species had higher tip diversification rates. A morph-dependent diversification analysis supported prediction that polymorphic species had higher speciation rates. Our results support the hypothesis that ecological and reproductive traits interact with color morphs to promote diversification.

Quantifying the effects of salinization on trophic interactions in a freshwater system

Cole Miller, Maya Mylott, Allison Welch, Alex Barron

Freshwater ecosystems are facing a prominent, global threat: salinization. The process of freshwater salinization is multifaceted, caused by a myriad of natural and anthropogenic processes. However, the effects of elevated salinity on ecologically important taxa and their trophic interactions remain understudied. In an attempt to address these research gaps, we employed a mesocosm experiment to test the impacts of elevated salinity on a simplified freshwater community. Over a period of five months, we collected various biomass metrics from multiple trophic levels, including algae, grazing Hyla cinerea tadpoles and zooplankton, and predatory Erythemis simplicicollis dragonfly naiads, to assess trophic transfer in fresh and weakly brackish treatments. We constructed a series of linear models using a Bayesian framework to quantify the interactions within this food web. Additional tests on time-to-metamorphosis of anurans and odonates were also performed. Preliminary results suggest, paradoxically, that higher salinities promoted more biomass production and higher rates of metamorphosis, spurred by large differences in algal availability. This result suggests that resource availability may be a key variable in salinized systems, supporting higher trophic levels even in the face of suboptimal osmoregulatory conditions. The results of this study can be used to inform conservation efforts of various taxa and to better understand how communities will shift in the face of increased salinization.

Social paper wasps as a new model for sterility via non-nutrient based stimuli

Laura Miller, Sean O'Donnell, Kari Lenhart

25% of infertile women globally have a pre-ovulatory condition such as PCOS. The molecular mechanisms responsible for pre-ovulatory conditions are unknown. This makes it difficult for health care professionals to treat patients with these conditions. The fruit fly, Drosophila melanogaster, has been used as a model to explore the mechanisms impacting egg development (oogenesis). Female fruit fly reproduction is regulated by nutrient levels. However, human infertility is not exclusively triggered by nutrient deprivation. Therefore, studying fruit flies cannot answer how female reproductive cells respond to non-nutrient-based stimuli. Eusocial insects (ants and some wasps and bees) have colonies with reproductive castes (reproductive queens and sterile female workers). The primitively eusocial paper wasp Polistes has a dynamic caste system compared to ants and honeybees. In temperate Polistes, workers are kept sterile via social interactions, while future queens are via seasonal variation. These factors make Polistes an optimal model to explore the influence of non-nutrient-based stimuli on oogenesis. I utilized immunofluorescence to visualize cell death and egg localization in the ovaries of workers, queens and future queens of Polistes exclamans. My results suggest that cell death in early oogenesis (occurring in starved fruit flies) is prevalent in workers. However, in future queens the egg becomes mis-localized, unlike in starved fruit flies. This research demonstrates how in response to different stimuli, different cellular pathways are prompted in reproductive cells.

Genomics and geochemistry suggest an archosaurian origin of avian endothermy

Megan Miller, Jasmina Wiemann

Birds and mammals independently evolved fast metabolisms that define their ecological niches. However, the drivers, timing, and origins of such metabolic endothermy is obscured in deep time: here we interrogate metabolic evolution by integrating genomic inferences for extant amniotes with geochemical observations for their stem group representatives. We surveyed 22 amniote genomes for evidence of selection across 7 orthologous protein-coding genes involved in mitochondrial aerobic metabolism. Explorative analyses revealed correlation of increased substitutions with metabolic shifts from ecto- to endothermy in the archosaurian, varanid, and mammalian stem. Probing the fossil record, we mapped metabolic capacities using a time-integrated biosignature developed from 80 Paleozoic-to-Recent fossil amniote femora via Raman-spectral fingerprinting (NIR). Fossil observations match genomic inferences of stem mammalian and varanid origins of metabolic upregulation and refine the timing of the onset of avian endothermy: fossils reveal an unexpectedly early, archosaurian origin of avian-style endothermy during the aftermath of the Permo-Triassic extinction. A trained machine-learning model (Support Vector Machine) robustly ($p < 0.05$) distinguishes convergent versus homologous biochemical approaches to amniote endothermy based on protein oxidation markers and supports homology of the biochemical underpinnings behind extinct archosaurian and avian endothermy. Tracing changes of time-integrative molecular metabolic signals across an amniote phylogeny reveals a shared metabolic legacy for secondarily ectothermic modern crocodiles and endothermic birds.

Effects of a simulated heat wave on hypothalamic-pituitary HPG axis signaling in a desert pupfish

Victoria Miller, Olivia Martin, Nola Weston, Isabel Villafuerte, Sean Lema

Temperature is one of the main environmental factors regulating reproduction in fishes. While gradually increasing temperatures can induce reproduction in temperate fishes, atypically high temperatures have been shown to impair reproduction. With the increasing frequency and severity of extreme heat wave events in aquatic habitats, understanding the impacts of those events on fish reproduction becomes crucial. In this study, we examined how a simulated heatwave impacted the reproductive endocrinology of the pupfish Cyprinodon nevadensis amargosae, a eurythermal fish endemic to the arid Death Valley region of California and Nevada, USA. Adult pupfish were maintained in mixed-sex groups under fluctuating temperatures that cycled from a morning low of 20-21°C to 31-32°C in late afternoon. After 54 d, some of the fish were exposed to a simulated heatwave for 6 d by elevating maximum and minimum fluctuating temperatures by 6°C. Examination of HPG axis signaling components in the hypothalamus revealed a reduced relative abundance of mRNAs encoding gonadotropin-releasing hormone 3 (gnrh3) in male, but not female, pupfish exposed to heat wave conditions. In the pituitary gland, males exposed to the simulated heat wave showed reduced mRNA levels of follicle-stimulating hormone subunit-β (fshβ), while females had reduced fshβ and luteinizing hormone subunit-β (lhβ) mRNAs. Taken together, these observations suggest that short-term elevations of temperature during heat wave events can alter hypothalamic-pituitary components of the HPG axis.

Social challenges shape coordinated gene expression patterns within and among brain regions

Isaac Miller-Crews, Kim Rosvall

Dynamic social environments have profound impacts on animals, from immediate changes to later carry-over effects on physiology and behavior. Here, we test the hypothesis that this socially-mediated feedback stems from differential gene expression coordination among brain regions. We manipulated social instability in free-living male juncos and measured transcriptomic responses across seven brain areas. Brain regions vary in their transcriptomic response to acute and chronic social challenges. Yet, these brain regions do not function in isolation, and we present data on gene co-expression patterns across these neural networks. Additionally, taking inspiration from landscape ecology, we developed a new approach for assessing brain networks in neuroanatomical space that is both scalable and comparable across non-model systems. Taken together, we find that social challenges lead to both rapid and lasting changes across the brain, and we underscore how systems biological approaches can advance our mechanistic understanding of behavior. Taken together, we demonstrate that social priming occurs via coordinated expression patterns both within and between brain regions, and we underscore how systems biological approaches can advance our mechanistic understanding of behavior.

Morphological development of embryonic bat nasal turbinates revealed through 3D volume visualization

Rishi Misra, Ian Jones, Alexa Kane, Alisa Hutagalung, Laurel Yohe, Bhart-Anjan Bhullar, Matteo Fabbri, Scott Yohe

Dietary specialization has played a central role in shaping morphological and sensory diversity in bats. Nasal turbinates—complex bony structures that support olfactory epithelium—are critical to chemosensory function and vary between insectivorous and plant-visiting species. Previous studies have focused on adult morphology, leaving embryonic development unexplored. Understanding developmental processes of turbinal shape provides a comparative framework for uncovering how phenotypic diversity arises. This project identifies structural differences in turbinate morphogenesis during prenatal ontogeny, offering insight into the mechanisms that may be related to dietary adaptation.

We collected high-resolution diceCT scans showing soft tissue of 146 embryo museum specimens representing 27 diverse species of neotropical bats. Turbinates were segmented in VGStudio MAX, which quantified turbinate number, length, surface area, volume, and shape to test for quantitative differences among plant- and animal-feeding bats.

Across 5 turbinates, we predict a greater turbinate density and surface area in plant-visiting bats, as it is known they rely on olfaction to a greater extent compared to insectivorous bats. We have found that some turbinates in plant-visiting species develop quicker initially, and that some species have evolved an extra turbinate that may not necessarily be homologous, both of which may increase olfaction.

Future endeavors will look at olfactory gene expression that may connect certain species' turbinates to plant-visiting cues.

2D linear metrics on first lower molar of bats reveals strong differentiation between dietary guilds

Elise Mitchell, Matthew Ebner, Sharlene Santana, David Grossnickle

In mammals, molar shapes can be strong predictors of diet. While feeding habits can be observed in extant taxa, dietary information for extinct mammals can be difficult to extrapolate. We aim to identify links between molar shape and diet, with the hope that these relationships can inform our understanding of fossil mammal diets. Using the first lower molars of bats comprising almost all families in Chiroptera, we examine the relationship between 2D dental measurements and diet in species of bats to examine whether simple measurements can strongly distinguish dietary guilds. We use bats as our model system due to their diverse diets and molar morphology. We collected 15 linear measurements on specimens and used phylogenetic comparative methods to examine relationships between molar morphology and diet. Our results suggest that there is a strong, distinguishing relationship between the first lower molars of herbivores and faunivores, and there are weaker, yet statistically significant differences among more specific diet groups such as vertivores, nectarivores, and sanguivores. These results suggest that 2D linear metrics can be strong predictors of diet and can be used as tools for inferring diet in mammals of unknown diets, including fossils. Future avenues for this project include applying 2D metrics to other mammalian groups and fossil samples to study mammalian paleoecological diversity.

Nose that's fit to print: 3D-printed nasal cartilages model bending in elephant shrew probosces

Juri Miyamae, Jongha Kim, Talia Moore

Snouts elongated into a mobile nasal proboscis have evolved multiple times in several extant mammal lineages. These appendages have superficial similarities, but a deeper examination of their anatomy reveal substantial differences, particularly in muscular and cartilaginous soft tissue morphology, which seemingly correlate with observed functional and behavioral differences. Our study investigates how the nasal cartilages that shape and support the probosces of sengis (aka, "elephant shrews") may also influence aspects of their movement. We previously reported that sengis in the subfamily Rhynchocyoninae possess tube-like nasal cartilages with a corrugated surface whereas subfamily Macroscelidinae possess nasal cartilages with fenestrations localized on the dorsal surface near the base of the proboscis. We also proposed a hypothesis that these differences in nasal cartilage morphology have a functional association with the dramatically different movement of the proboscis during the facial muscle contraction phase of yawning: a downward arch in Rhynchocyoninae versus a nearly perpendicular, upward point in Macroscelidinae. Here we introduce 3D-printed models of the nasal cartilages and characterize their movement under different loading conditions to identify key anatomical structural features that determine preferential bending direction of sengi probosces and their potential functional constraints. Our results demonstrate probable mechanisms for generating both the distinctive movements observed in biological soft tissue appendages as well as designing bioinspired soft robots with specific target curvatures.

Collective behavior shapes aggregate fluid dynamics in brine shrimp (*Artemia salina*) migration

Nina Mohebbi, John Dabiri

Various animal species exhibit collective motion, a prominent example being diel vertical migration (DVM), wherein zooplankton migrate vertically over approximately a kilometer daily. Despite field, laboratory, and theoretical estimates of mixing from collective swimming, the scale of fluid mixing induced by DVMs remains unresolved. A key challenge is linking the behavior and flow of individuals to collective-scale fluid dynamics.

We investigated the interplay of environmental factors, fluid flow, and collective vertical migration in brine shrimp (Artemia salina) by inducing upward movement via positive phototaxis in a 300-liter tank. Using a combination of Particle Tracking Velocimetry (PTV) and Particle Image Velocimetry (PIV), we simultaneously measured three-dimensional swimmer trajectories and the surrounding fluid flow within a 20x20x11 cm observation volume.

Swimmers maintained stable relative vertical velocities despite variable local flow conditions, suggesting largely passive flow interactions rather than active compensation. Horizontally, the group maintained a Gaussian-like spatial distribution, balancing attraction to light with dispersive inter-individual interactions.

Simultaneous flow measurements revealed that the induced jet mirrored the Gaussian swimmer distribution, suggesting a potential role of swimmer behavior in shaping collective flow structure. These results demonstrate how environmental cues and individual-level decisions may scale up to aggregation-scale hydrodynamics.

Using systems and systems thinking to unify biology education

Jennifer Momsen

Contemporary biology is rapidly generating new knowledge and novel approaches to address increasingly complex and integrative questions; meanwhile, biology educators face the challenge of teaching future biologists and citizens the skills and knowledge to enable them to keep pace with a dynamic field. Thinking in terms of systems is a foundational practice throughout biology but is rarely taught as an explicit objective. Although systems feature prominently in national reports informing life sciences education, there is minimal guidance about specific objectives for systems thinking, relevant strategies for assessing evidence of systems thinking, or instructional approaches that foster the competencies and conceptual knowledge necessary for reasoning about systems. Following a review of interdisciplinary literature on systems and systems thinking, we developed the Biology Systems Thinking (BST) framework, which identifies and describes the requisite skills for thinking about biological systems. In this talk, I will introduce the BST framework and share how this framework can be used to design an integrated introductory biology curriculum and what it reveals about students' reasoning about biological phenomena.

Social play in *Peromyscus*

Patrick Monari

Play is a foundational but strikingly understudied behavior found across the animal kingdom. Despite its prevalence, we lack experimental systems of closely related species to address questions about its evolution and genetic inheritance. Here, I introduce a comparative model of juvenile social play using 11 species of deer mice (Peromyscus). The New World rodents occupy diverse ecological niches and exhibit robust behavioral variation, making them an ideal model for cross-species comparisons. Using an isolation-reunion paradigm with same-sex juvenile pairs, I identify both conserved and divergent patterns in the amount and structure of social play. Importantly, when statistically controlling for species, litter size emerges as a significant predictor of play but not of non-play affiliation, suggesting distinct developmental pathways for these behavioral suites. Additionally, across species, bouts of play are consistently time-locked with periods of heightened vocal rhythmicity, pointing to a possible communicative mechanism coordinating play. Together, these findings reveal both variation and consistency in the expression of play across species and highlight questions of its heritability and ontogeny. Ongoing work aims to disentangle the genetic basis of play and uncover the neurobiological substrates that drive it.

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Effects of kinematics and muscle activation on muscle power and body stiffness in largemouth bass

Mallory Mongeon, Ryan Keleher, Eric Tytell, Yordano Jimenez

Fish swim using deceptively simple undulations that emerge from complex interactions between internal body forces and external fluid forces. The same muscles that bend the body for locomotion simultaneously tune body stiffness, influencing fluid-body interactions that could impact the acceleration, speed, stability, and efficiency of swimming. Therefore, in order to understand swimming performance, it is critical to quantify the ability of muscle to simultaneously bend and stiffen the body. In this study, we euthanized and mounted largemouth bass (Micropterus nigricans) in an oscillatory bending apparatus, where tail flexion was controlled by a servomotor at one end and bending torques were measured using a six-axis force transducer at the other end. We stimulated red muscle and bent the body using a range of published

and hypothetical kinematic and muscle activation patterns. Our data reveal a complex mechanical landscape with non-linear tradeoffs between muscle output (i.e., power and work) and active body stiffness.

Sex-differences in hibernation phenology of Wyoming ground squirrels

Nikolas Monte, Cory Williams, Austin Allison, Cole Deal, Sarah Kerr, Lise Aubry

Males and females often exhibit differential sensitivity to environmental cues, such that climate change can alter interactions between sexes of the same species. However, most phenological studies in hibernators rely on capture data and assume animals emerge immediately after terminating torpor. Using temperature and light-sensitive collars, we examined whether the timing and duration of hibernation differed between sexes in free-living Wyoming ground squirrels at a high elevation site in northern Colorado. Females entered heterothermy, on average, 9.5 days earlier than males and terminated heterothermy 16.7 days later, such that the hibernation duration was 30.0 days longer in females. Males remained in their hibernacula for 9.7 ± 6.7 days after heterothermy. Whereas females remained in hibernacula for only 1.7 ± 1.1 days after hibernation. This extended euthermic interval spent in the hibernaculum before emergence is likely used for seasonal testicular growth and maturation and may indicate that males utilize a food cache to facilitate sexual maturation prior to female emergence. Ultimately, males emerged to the surface on April 9th (range: April 6th – April 10th), prior to female emergence on April 15th (range: April 10th – April 24th). Our study demonstrates sex-differences in hibernation patterns that likely allow males to become sexually mature prior to female emergence. Further research is needed to validate whether the extended below-ground euthermic interval in males indicates the consumption of food caches.

Pokes and prods affect an aquatic frog's locomotor behavior during an escape response

Javier Montero, Chase Kinsey

The use of touch to elicit an escape response in the aquatic frog, Xenopus laevis, is a primary mode of stimulus in previous studies. However, touch may not be the best method for eliciting escape response across developmental stages as morphology changes drastically. Here we assess locomotor behavior and performance with the use of varying stimuli across developmental stage (NF52, NF60, NF66) and lateral line ablation in wildtype and albino frogs. We hypothesized that escape response would vary across development stage, and lateral line ablation will change in escape behavior. Frogs randomly received a prod and water pulse stimulus from a pipette to both their rostral and caudal side. The lateral line from a subset of frogs was then ablated using CoCl2 and frogs were randomly tested again. Escape responses were filmed with high-speed video and digitized in MATLAB. There was no significant effect of ablation or stimulus type on velocity between wild and albino frogs, though older frogs in both groups were faster than their younger conspecifics. However, escape latency and fleeing time did differ significantly across stage, ablation, and type of frog. Our data suggests that while maximal performance does not change across treatment groups, escape behavior does. Future studies on frog locomotion should consider the stage and type of stimulus used when interested in specific locomotor behaviors.

Food texture modification alters swallowing behaviors and kinematics in juvenile Pigs

Stephane Montuelle, Hannah Baker, Donna Scarborough, Susan Williams

In infants, incremental food texture modifications (e.g., liquidized to pureed diet) are regularly utilized to facilitate the successful transition from suckling to chewing. However, delayed exposure to solid foods may impact the physiology and skills associated with oral behaviors, like feeding and drinking, and swallowing. Swallowing is a critical feeding skill where oropharyngeal biomechanics and function must mature to be able to respond to changes in bolus physical properties (liquid versus solid), while maintaining coordination with respiration to avoid aspiration of food into the airway. We investigated maturation of swallowing in pigs exposed to a liquid diet of chow mixed with milk replacer and water through 12 weeks. One group was then directly switched to pellet chow, while the other was gradually transitioned to chow using weekly increases in thickness following parameters established by the International Dysphagia Diet Standardization Initiative. At 16 weeks, feeding and drinking sequences were recorded with biplanar fluoroscopy enabling X-ray Reconstruction Of Moving Morphology of the jaw, tongue base, hyoid, and epiglottis during swallowing of liquid and solid foods. We found that transition strategy resulted in differences in behavior (e.g., latency between swallows) and in key parameters of swallowing movements (e.g., airway closure duration). This preliminary analysis emphasizes how food texture modification in early life can have direct effects on the maturation of feeding, drinking, and swallowing movements.

Urbanization effects on soil microbiome, plant diversity, and deer mouse population density

Joel Moore, Tiffany Altermatt, Abbigail Amend, Elizabeth Addis, Laurie Dizney, Ashley Beck

The soil microbiome is the foundation for terrestrial plant and animal life. Urbanization causes changes in the soil microbiome as humans put additives, such as chemical fertilizers, pesticides, and herbicides, into the ground. Research shows that the soil microbiome can serve as an indicator of ecosystem and wildlife health, but much remains unknown regarding how disturbances shape microbial communities. Here, we expand our current understanding of soil microbiome influences on plant and animal diversity by examining soil microbial diversity, plant diversity, and deer mouse population density across a variety of urban and rural field sites in Spokane, Washington. Western deer mice (Peromyscus sonoriensis) were live-trapped and released in seven main field sites in May 2025, estimating population size via the mark-recapture method; plant coverage and diversity were also recorded at each mouse capture site. Soil samples were collected from each field site in triplicate, and 16S Nanopore sequencing was employed to estimate taxonomic diversity. A linear mixed model was used to assess correlation among soil diversity, plant diversity, and mouse population size. The results from this project help elucidate the complex relationships among microbial diversity, plant diversity, and ability of animal populations to thrive in urban and rural habitats. Future research should focus on effective land management to mitigate and potentially reverse detrimental urbanization effects.

Bobcats navigate environmental risk through flexible behavior and movement

Katrina Moore, Monica Daley, Primrose Thavornthon, Megan Steen, Brinda Garikapati

Wildlife navigate environments shaped by overlapping pressures, yet much of our understanding comes from studies isolating single variables such as predator presence or human impact, leaving the synergistic effects of these pressures on behavior poorly understood. Here, we aim to quantify overall risk across a landscape by evaluating spatial and temporal variation in multiple environmental risk factors, including predation, climate, landscape, and human impact. We examine how a composite risk metric shapes wildlife behavior and locomotion, followed by analyses to identify which pressures contribute most to behavioral variation. Bobcats (Lynx rufus), which act as both predator and prey, offer a valuable model due to their behavioral flexibility. We hypothesized that as environmental risk increases, bobcats prioritize vigilance and adopt locomotor strategies that maximize speed while minimizing injury. We deployed wildlife cameras across diverse habitats in Southern California to analyze behavioral and movement responses to environmental risk. Using model selection, we found that stride frequency was predicted by time of day, stationary behavior by mountain lion activity, and intermittent locomotion by shade. Bobcats increased stride frequency during the day, spent more time stationary when mountain lion activity was higher, and showed more intermittent movement at night or in shaded daytime areas. These patterns suggest flexible strategies that may help bobcats reduce human encounters, enhance vigilance against predators, or regulate temperature depending on context. NSF DBI 2319710.

Breeding & the physiological limits of species on a changing planet

Michael Moore

One of biology's oldest problems is understanding why species can inhabit some environments but not others. Uncovering the factors that structure species' ecological limits is key to characterizing the historical formation of biodiversity and to predicting future responses to global change. Much research has assessed how species' limits are shaped by their needs for growth and survival, yet species also need to be able to mate and reproduce. In this lecture, I will illustrate how species' requirements for breeding can dictate their environmental limits and responses to global change. Specifically, I will discuss two areas of my lab's research on dragonflies. First, I will show how thermal costs of reproductive characteristics have influenced where species have been able to establish and where they might be able to persist in the future. Second, I will show how aerobic challenges restrict mating behavior in the mountains and how such issues could limit elevational range shifts in the coming decades.

Hypoxia increases mortality rates among adult dragonflies and shapes species' elevational limits

Michael Moore

For >200 years, understanding the physiological barriers to high-elevation life has been a major topic in biology. Although low oxygen is one of the most pronounced environmental problems at high elevations, we know surprisingly little about whether or not sensitivity to low oxygen dictates species' upper elevational limits for most animal groups. Using dragonfly species in the Rocky Mountains, we explored how the low-oxygen conditions of high elevations influenced adult mortality rates under ecologically relevant temperatures and whether a species' sensitivity to low oxygen predicts its current elevational limits. Here, we collected adult dragonflies from a single field site in Denver, CO and conducted a 2 x 2 factorial experiment where we measured their survival under 1) a typical field body temperature vs a warm field body temperature; and 2) a normoxic condition vs a low-oxygen condition like that found at high elevations. Across >150 field-collected adults in 6 species, we found that low oxygen increased mortality rates in both temperature treatments. Interestingly, this effect was not more pronounced at higher temperatures or in larger individuals. A comparative analysis further revealed that the species that were more vulnerable to low oxygen also had lower elevational limits. Thus, low-oxygen conditions pose a substantial threat to adult dragonflies, but a species' tolerance of hypoxia may dictate how far upslope it can live.

The evolution of intramandibular flexion in reef fishes

Ruby Moore, Katherine Corn

The intramandibular joint, or IMJ, is a major evolutionary novelty among reef fishes used to access substrate-attached prey items like algae, coral, and sponges. The IMJ aids the removal of such prey items by permitting flexion between the two largest bones of the oral jaws, allowing for increased jaw gape while mitigating the trade-off between force and gape. Yet the evolution of a novel jaw joint in an already working functional system poses a challenge for any animal, suggesting that the evolution of IMJs should be rare. We explored the history of IMJ evolution and how IMJ presence affects the accumulation of body shape diversity in reef fishes. A literature review was conducted in tandem with measuring cleared and stained specimens to identify IMJ presence and flexion. We analyzed this data by simulating trait histories of IMJ presence, using joint discrete character mapping to compare transitions between feeding modes and IMJ presence, and using multivariate disparity to compare the relative body shape diversity among IMJ-bearers and non-IMJ-bearers. We found that IMJ evolution is not unidirectional, more fishes than previously thought have intramandibular flexion, and that an IMJ is associated with constrained body morphology compared to both suction-feeding and biting reef fish without IMJs. Our results suggest that while the evolution of a key innovation can be labile, it may be ecologically and phenotypically constraining.

Bite-Bot: A robotic platform for studying envenomation

Talia Moore

Venom injection is a complex process involving multi-physics interactions between the fang, the liquid venom, and the tissue of the target. The fang:target tissue interaction has been studied with pendulum-based experiments. However, there are fewer studies on the interaction between the venom and its delivering fang. Direct measurements of how fang shape modulates in-wound venom transport are scarce, as most studies isolate puncture performance or conduit hydrodynamics. It is widely assumed that tubular anterior fangs enable the most rapid, high-pressure delivery, but rigorous cross-type, standardized comparisons of delivery efficiency are limited. Here, I present Bite-Bot, a robotic platform designed to facilitate highly controlled experiments that reveal the constituent and combined effects of evolutionary variation in the envenomer and the target tissue. First, we obtained uCT scans of snake fangs that varied in overall shape and venom delivery mechanism and 3D printed them in titanium. Our rig controls the angle of attack, speed, and force of the bite. The rig also injects our bespoke venom phantom, which matches the rheological properties of specific snake species, at a given pressure. By leveraging robotics, we can now more holistically and empirically study the complex physical interactions and the coevolution between the envenomer and the target tissue.

Associations between ectoparasite load and host health in wild songbird nestlings.

Allison Morales, Victoria Coutts, Morgan Lafont, Raquel Velez, Marquise Henry, Kathryn Stewart, Christine Lattin

Northern fowl mites (Ornithonyssus sylviarum) are blood-feeding ectoparasites that live in songbird nests and can negatively affect nestling health. Altricial nestlings such as European starlings (Sturnus vulgaris) are particularly susceptible, as they hatch relatively underdeveloped and remain confined to the nest environment. However, the effects of different levels of natural mite infestation during early development remains relatively understudied. In this study, we investigated the impacts of mite infestation on hemoglobin, hematocrit, and morphometric traits in a free-living population of European starling nestlings raised in nest boxes in southern Louisiana. We predicted that naturally-occurring higher levels of mite infestation would be associated with lower hemoglobin, reduced hematocrit, shorter tarsus length, and reduced body mass in nestlings. To test this, we collected and analyzed morphometric data (tarsus length, wing chord, and body mass) and blood samples from starling nestlings at multiple developmental stages during the 2025 breeding season. Preliminary results indicate that parasite load was negatively associated with hemoglobin, but not with body mass or hematocrit. These results suggest that mite infestation has negative impacts on starling growth and the oxygen carrying capacity of blood; however, an experimental approach is needed to determine whether this link is causal.

Eluding winter through physiology or behavior? The mystery of diapause in burying beetles

Hermione Morales , Ahvi Potticary

Organisms are generally studied during breeding or active seasons, but taxa in northern climates may spend most of their lives overwintering. Yet, little is known about overwintering strategies, particularly in insects. To address this gap, we investigated overwintering behavior in burying beetles of the genus Nicrophorus. First, how do Nicrophorus mitigate winter temperatures? We hypothesized that individuals will either be freeze-avoidant, meaning they bury in the soil to avoid freezing temperatures, or they will be freeze-tolerant, indicating they have physiological mechanisms to protect against freezing. To test these hypotheses, we conducted experimental trials in the field using larvae of N. tomentosus and adults of N. sayi. We monitored diapause behavior in the field by placing pipes in the ground that allowed for natural burial up to a depth of 1.25 meters. We tracked the movement and survival of Nicrophorus in the field every month throughout the winter. We found that larval N. tomentosus were found below the frost line, buried up to 114 cm below the surface, suggesting freeze-avoidance, while adults of N. sayi survived at the soil surface, indicating freeze tolerance. Future work will

involve sequencing the genome of Nicrophorus sayi to identify possible antifreeze genes. These results suggest that even closely related organisms living in the same environment mitigate temperatures using different mechanisms, which may affect their responses to climate change.

Sensory drive selects for increased salience of courtship coloration in Habronattus jumping spiders

Nathan Morehouse, David Morris, Sebastian Echeverri, David Outomuro, Imogen Watts, Wayne Maddison, Daniel Zurek

Sensory drive theory posits that sensory systems and associated signaling traits should co-evolve under selection for increased efficacy, with the resulting evolutionary trajectories reflecting adaptation to signaling environments. As such, habitat divergence between populations should lead to predictable divergence in signaling systems. Evidence for this process is well established in aquatic systems, but its relevance to terrestrial animals remains unclear. Paradise spiders (genus Habronattus) are a rapidly diversifying terrestrial taxon well-positioned for investigating sensory drive of visual signaling traits because they inhabit diverse visual microhabitats, have excellent vision, and male visual ornamentation varies noticeably across the genus. Using 21 species of Habronattus spiders, we tested the sensory-drive-based prediction that male ornaments have evolved to be most salient in their own environments by comparing color contrasts of focal species within their home environments to those across environments of all other species in our study. To do so, we estimated chromatic salience of spider coloration in their native environments versus heterospecific environments by combining species-specific color spectra, habitat specific illuminance, and Habronattus visual system sensitivities in a receptor noise limited modeling framework to calculate chromatic contrasts between spider coloration and their habitat backgrounds. We find a consistent pattern of higher salience in home environments compared to heterospecific microhabitats, revealing a key role for sensory drive in the evolution of sexually selected ornaments within this terrestrial animal group.

Microplastics in wild songbird feces differ across species and foraging behaviors

Victoria Moreira, Jennifer Uehling, Alison Fetterman, Lisa Kiziuk, Michelle Eshleman, Megan Fork

Environmental microplastics (MPs) are increasingly recognized as an abundant and concerning pollutant around the globe. Studies in marine ecosystems have long documented the prevalence and negative effects of plastic pollution, including MPs. However, free-living terrestrial animals' exposure to MPs is still poorly understood, including behaviors that might increase exposure. Here, we asked whether terrestrial songbirds' exposure to MPs differs based on their foraging behavior. We focused on five songbird species in southeastern Pennsylvania, USA, with foraging strategies varying across species. To determine MP exposure, we collected feces from songbirds and extracted, characterized, and quantified MPs from these samples. MPs were discovered in the feces of all five species. Songbirds that foraged on the ground had more MPs in their feces by both count and density. Though fibers were the most common MP shape across all species, insectivorous birds had more MP fragments compared to species with mixed diets. Our results indicate that species may be exposed to different levels and types of MPs based on their foraging behavior. Growing evidence suggests that MPs pose harm to animal health, and management efforts should consider how foraging behavior may affect wildlife risk for MP exposure. Future work will explore whether individual diet variation predicts individual variation in MP exposure and quantify the impact of MP exposure on components of fitness in wild songbirds.

Convergent evolution in endocranial morphology of pterosaurs and birds: how the brain shapes flight

Donald Morgan, Amy Balanoff, James Clark, Samuel Broadbent, Emma Puetz, Brain Andres

Only three vertebrate groups have evolved the suite of anatomical characters necessary for powered flight—bats, birds, and the extinct pterosaurs. Navigation and movement through aerial environments are no small feat and requires a complex integration of sensory information. We collected a large comparative dataset of pterosaur endocasts to understand how their neuroanatomy compares to that of other archosaurs. We found that endocasts of pterosaurs, like birds, faithfully reflect the morphology of the brain. The pallial cerebrum and the cerebellum are of particular interest because of their role in processing visual, somatosensory, auditory, and vestibular information during flight. In addition to detailing their structure, we tested if and how the size of these regions coevolved with traits that are functional correlates for afferent sensory information (e.g., wing length as a proxy for incoming somatosensory information, orbit size for visual input). Both our qualitative and quantitative results suggest that, although the avian and pterosaur lineages evolved powered flight independently and using drastically divergent wing morphologies, their neuroanatomy converged extensively. It is likely that this convergence is a product of both the cognitive demands of using similar sensory information to navigate three-dimensional environments as well as constraints imposed by the architecture of the archosaur brain.

Feeling the heat: comparative thermal responses of early life stages in native and introduced crabs

Keria Moritsugu-Vandehey, Paola López-Duarte

Rising ocean temperatures can precipitate shifts in estuarine crustacean reproductive cycles. While temperature effects on adult crabs are relatively well studied, less is known about how increased temperatures influence embryo and larval stages, and importantly, how responses differ between native and introduced species. This study examines three co-occurring species along the Oregon coast: the introduced green crab (*Carcinus maenas*), and two native species, the purple shore crab (*Hemigrapsus nudus*), and the striped shore crab (*Pachygrapsus crassipes*). These species differ in their thermal tolerance ranges: broad (0–33°C), moderate (9–30°C), and narrow (12–18°C), respectively. With its wider tolerance, *C. maenas* is expected to remain reproductively resilient, potentially gaining a competitive advantage over native species. *P. crassipes* may retain reproductive capacity under warming conditions, while *H. nudus* appears more vulnerable to thermal disruption. Gravid crabs were collected and held under controlled laboratory temperature treatments, where we monitored embryo development, incubation duration, and larval release timing to assess thermal responses. Ongoing data collection will refine findings, but early patterns suggest that warming accelerates embryonic development and shifts larval release timing, potentially disrupting synchrony with key environmental cues critical for reproductive success. Comparative analyses of native and introduced species highlight how climate-driven warming may alter reproductive resilience and interactions in coastal ecosystems.

Fungal-bacterial interactions link the diet and gut microbiota of endangered red squirrels

Natalie Morris, Allyson Placko, Gabriele Schiro, August Walser, Bret Pasch, Lauren Petrullo

Small mammals are important consumers and dispersers of fungi, but debate persists about whether fungi detected in feces reflect resident, dietary, or environmental sources, obscuring the relative importance of consumption to host nutrition and ecosystem processes. Here, we tested the hypothesis that fecal fungi are primarily dietary, with seasonality in gut microbiota reflecting seasonal fungal consumption. We used ITS1 and 16S amplicon sequencing to characterize fungal and bacterial communities in fecal samples from Mount Graham red squirrels (Tamiasciurus fremonti grahamensis), a federally endangered subspecies of red squirrel that consumes conifer seeds and seasonally available fungi. We observed strong seasonal trends in both fecal fungal and bacterial composition, with false truffles (Rhizopogonaceae) and bacterial secondary fermenters (Prevotellaceae) dominating summer samples. Patterns of fungal diversity largely recapitulated patterns of bacterial diversity across the year, reaching their lowest point during the summer monsoon. Network analyses showed that Rhizopogonaceae and Prevotellaceae were well-connected hubs central to the fungal-bacterial network and positively associated with one another, suggesting a microbial response of Prevotellaceae to Rhizopogonaceae consumption. Given that Rhizopogonaceae form mutualistic symbioses with conifer tree roots, our

results suggest that beyond providing nutritional value, fungal consumption may contribute to forest health in a highly vulnerable habitat. Ultimately, understanding host-microbe-fungi interactions in small mammals may shed light on their potential role as ecosystem engineers.

Cadaveric bone strain patterns in sloths and primates during suspensory postures

Angela Mossor, Lorna Benden, Edwin Dickinson, Michael Granatosky, Jesse Young

Tree sloths and some primates, such as gibbons, rely heavily on suspension as part of their arboreal lifestyle. Because suspensory locomotion subjects limb bones to high tensile loads, these taxa are expected to exhibit structural adaptations to maintain adequate safety factors (i.e., decrease risk of tensile fracture). Subsequently, it may be expected that highly suspensory primates and sloths should exhibit lower bone strains in their limb bones during suspension than non-suspensory animals, reflecting these adaptations. To evaluate this prediction, direct bone strain from whole, cadaveric specimens was measured during postural suspension in sloths, gibbons, and quadrupedal cercopithecine and platyrrhine primates. Principal strains were assessed during hanging on a single forelimb, using two rosette strain gages affixed to the midshaft of the humerus, radius, and ulna, after teasing muscle bellies apart (between fascial compartments where possible) and elevating the periosteum. Initial results indicate that maximum principal forelimb strains are lower in sloths and gibbons compared to quadrupedal primates. Overall, sloth and gibbon forelimb strain registered only 18% of the average strain in quadrupedal primates. Our preliminary results support the hypothesis that adaptations towards habitual suspensory locomotion lead to overall lower bone strains in suspensory postures. These findings expand our understanding of long bone modifications that are a functional consequence of suspensory locomotion and tensile limb loading.

How competition and floral abundance drive resource partitioning in prairie bumble bee communities

Tabitha Moul, Kendra Edge, Jenny Burrow, Anthony Moth Castagna, Success Ekemezie, Afagwu Rita Nkem, Leo Carpenter, James Bynum, Ashley White, Charlotte Davis, Kierstin Howard

Diverse species often coexist in sympatry by engaging in resource partitioning, which occurs when different species that would otherwise share the same resources instead each specialize on non-overlapping subsets. Resource availability and competition are thought to be major drivers of resource partitioning among generalist animals. Yet whether these drivers influence resource partitioning in generalist pollinators such as bumble bees is unknown. In this study we assessed resource partitioning of pollen host plants by bumble bee species across 12 remnant tallgrass prairies in southwest Missouri using Roughgarden's WIC/TNW index. To assess competition and resource availability, we characterized bumble bee and flower abundance and plant richness at each prairie. Preliminary analyses indicate that all six of our bumble bee species engaged in resource partitioning. Across bee species, resource partitioning increased as overall flower abundance and intraspecific competition increased. However, competition had a much stronger effect than resource availability, which might suggest that overall flower abundance does not strongly correspond to the abundance of floral host taxa. Conversely, interspecific competition did not influence resource partitioning, possibly because our prairies had few bumble bee species and thus interspecific interactions may have been uncommon. Our work provides rare empirical evidence of resource partitioning by pollinators and suggests that intraspecific competition may be the key driver of resource partitioning.

Size polymorphism in the desert leafcutter ant *Acromyrmex versicolor*

Aicha Mounsif, Meaghan Hall, Rebecca Clark

Leafcutter ant colonies function as complex adaptive systems, where individual ants cooperate to ensure survival and growth of the whole colony. The ants have a coevolved, symbiotic relationship with a mutualistic fungus, where the ants collect leaves to provision the fungus, facilitating its growth. In turn, the fungus serves as the sole food source for growing ants (brood) in the colony. While adult workers in leafcutter colonies can range dramatically in overall body size, there is much that we still do not know about patterns of body size variation and why size variation exists. We hypothesized that the nutrients fed to the fungus garden ultimately affect worker ant body size. We gave colonies of the desert leafcutter ant Acromyrmex versicolor one of four diets with different amounts of protein, carbohydrate, and phosphorus, and allowed the ants to forage and provision their fungus gardens for 14 weeks (n=20 colonies per diet). We then froze, dried, and weighed up to 96 workers from each colony, and measured their head widths. We plan to evaluate mean adult worker body size (head width) and body condition (head width relative to dry weight). Our findings will help us understand the extent to which adult worker body size can be influenced by their diet, to better understand the implications of body size variation in leafcutter ants more broadly.

Sea urchin tube foot attachment performance exhibits rate dependence on rough surfaces

Andrew Moura, Austin Garner

Sea urchins are dominant herbivores in coastal marine habitats; the results of their grazing and associated movements have profound effects on community organization and structure. Intertidal habitats occupied by sea urchins are subjected to loading from hydrodynamic forces produced by waves and currents. Sea urchins use tube feet to generate strong, reversible adhesion to natural surfaces. The connection between tube foot performance and surface characteristics, such as surface roughness, is not well understood. Previous tests of tube foot attachment performance on rough surfaces are limited by the inability to separate the influence of surface chemistry and single comparisons between "smooth" and "rough" surfaces. Additionally, little is known about the range of surface roughness found in intertidal habitats, obscuring the connection between natural and laboratory surfaces. Here we assess the effect of surface roughness, attachment orientation (perpendicular or parallel to applied loads), and dislodgement rate (0.03 - 1 cm s-1) on sea urchin tube foot attachment performance. We also present the surface profiles of intertidal surfaces commonly encountered by sea urchins. Under perpendicular loads, increased roughness resulted in greater attachment performance. Independent of loading orientation, attachment performance showed a positive relationship with rate for surfaces with greater roughness. This suggests tube foot performance on sufficiently rough surfaces is dictated by a combination of increased surface area and viscoelastic energy dissipation by the adhesive pad.

Shifting surfaces to sand: muscle recruitment during walking

Fotini Mourelatos, Kateri Trujillo, Niclas Ulrich, Jacinto Howes, Matthew Morelos, Jenna Monroy, A Ahn

Walking on a solid running track differs from walking on dissipative sand. On solid surfaces, previous studies have shown that about half of study participants activate their medial and lateral gastrocnemii equally ("unbiased") and half do not activate their LG as much as their MG ("MG-biased"). We hypothesized that walking on sand would require increased joint stability with an increase in the recruitment of the tibialis anterior (TA), medial gastrocnemius (MG), and lateral gastrocnemius (LG) muscles. We measured electromyographical (EMG) patterns while walking (95 steps per minute) on three conditions: on track, on sand, and on track-to-sand. Unbiased subjects did not change any recruitment patterns of their three lower leg muscles when walking on sand and track, including in the LG muscle (N=3; -2%), which rejects our hypothesis. MG-biased subjects increased their LG muscle activity by 35% when walking on sand compared to track (N=3), which also rejects our hypothesis. These results were observed on all three conditions: track, sand, and track-to-sand. Some people walk without changing their muscle recruitment patterns on surfaces with divergent mechanical properties, while others modulate their LG muscle when shifting surfaces.

Impacts of developmental and acute temperature on thermoregulatory behavior

Xingjian (Henry) Mu, Rikki Laser, Linnea Niemack, Alexander Ophir

Behavioral thermoregulation is the first line of defense against changes in core body temperature for both ectotherms and endotherms. Developmental temperature has been shown to affect behavioral thermoregulation in many ectothermic species, but the role of developmental temperature on mammals has been relatively less studied. Furthermore, previous work has been largely limited to investigating the impacts on thermal preference. Importantly, posture plays a significant role in mammalian behavioral thermoregulation. Here, we use prairie voles, which are a small rodent whose natural range exhibits considerable thermal variation across and within seasons. We first established a prairie vole ethogram for behavioral thermoregulation through posture and motor activity. Then, we used our ethogram to evaluate how developmental temperature affects thermoregulatory behavior during a thermal challenge. Prairie voles exposed to the thermal challenge showed more postural extension (i.e. laying down and stretching out) and less curling (i.e. tucking head and paws into body) than voles behaving at room temperature. However, other preliminary results show no differences between behavior of animals raised at room temperature compared to those raised under heated conditions. These preliminary results contrast with studies investigating the impacts of developmental temperature on mammalian thermal preference. While our results demonstrate postural adjustments play a role in behavioral thermoregulation, they might also suggest postural adjustments are less responsive to developmental temperature than are other forms of behavioral thermoregulation.

Reproductive ecology and developmental plasticity of four tropical Anolis lizard

Morgan Muell, Kendall Jackson, Daniel Warner

Tropical environments contain the majority of global species diversity and are among the most vulnerable ecosystems to climate change. Therefore, an understanding of how tropical organisms respond to increasing fluctuations in climatic conditions is essential for predicting how populations will react to ongoing climate change. Ectotherms are especially vulnerable to changes in the abiotic environment because they rely heavily on temperature for homeostasis. Yet, the effects of developmental temperature and moisture on tropical ectotherms are largely understudied. We examined how temperature and moisture during egg incubation influenced offspring phenotypes in four species of Anolis lizards at La Selva Biological Station, a lowland tropical forest in Costa Rica. We incubated eggs in a 2x2 factorial design with two constant temperature treatments (22°C and 26°C) and two moisture treatments (-450 kPa and -150 kPa in vermiculite). We measured egg mass, egg survival, incubation period, offspring body size, and hatchling desiccation rate. We also recorded frequency of maternal egg-laying. Only incubation period changed in response to offspring developmental temperature, whereas developmental moisture conditions dramatically altered embryonic traits and body size, but not hatchling performance. Additionally, adult females altered their nesting activity in response to fluctuations in rainfall, preferring to nest in the days after major rainfall events. Our multispecies comparison provides evidence that environmental heterogeneity can influence nesting behavior and developmental plasticity in tropical reptiles.

Tracking the gossip: towards the neural basis of shoaling behavior in a highly social cichlid fish

Sarah Muh, Lanzo Pasierb-Case, Clarissa Guzman, Hans Hofmann

Many animal species live in groups, but the neural basis of collective behavior is barely known. Here we use Burton's Mouthbrooder cichlid fish, Astatotilapia burtoni, to reveal the neuromolecular mechanisms of shoaling behavior. Previous work in shoaling has mostly used zebrafish or guppies as model systems and often compares fish in group vs. solitary contexts. However, this makes it difficult to disentangle shoaling behavior (a collective behavior) from sociability (preferring conspecifics over isolation). A. burtoni forms complex communities composed of a shoal of subordinate males and non-brooding females, and a few non-shoaling dominant males and brooding females. Therefore, both sexes naturally exhibit shoaling and non-shoaling phenotypes within the community, allowing us to compare these behaviors in a naturalistic social context while accounting for sex. We first used machine learning techniques to track individual behavior in a community and found that kinematic signatures and social network metrics differed based on sex and social status. We then found that social preference differs based on social status. Ongoing work combines spatial transcriptomics and imaging mass spectrometry to uncover the neural basis of shoaling behavior in A. burtoni. Taken together, these data 1) describe the dynamics of the A. burtoni shoal and community, 2) provide more detailed insight into how shoaling and non-shoaling behaviors differ, and 3) reveals the neuromolecular basis of shoaling behavior.

On the tip of their tongues: An exploration of taste organ ontogeny in plethodontid salamanders

Baaqeyah Muhammad, Kurt Schwenk, Elizabeth Jockusch

Metamorphosis is an ancestral vertebrate trait that has been repeatedly modified or lost, enabling lineages to exploit diverse terrestrial habitats. One such modification is direct development, in which organisms hatch with an adult-like phenotype and bypass a free-living larval stage. Plethodontidae, the most species-rich salamander family, includes both biphasic and direct-developing species, making it an ideal system for examining how developmental processes shift with changes in life history strategy.Taste organs offer a valuable lens through which to examine these transitions. In biphasic salamanders, larvae possess a primary tongue bearing taste buds, which is replaced at metamorphosis by a secondary tongue bearing taste discs. To date, only one study has examined tongue development in a plethodontid: the direct-developing Plethodon cinereus, which forms taste discs embryonically without an apparent bud stage. It remains unclear whether this pattern is characteristic of direct-developing plethodontids more broadly or reflects lineage-specific variation, particularly given uncertainty surrounding the number of independent origins of direct development within the family.To address this gap, I compare taste organ development across species representing the two major clades, each of which includes both biphasic and direct-developing taxa. Using scanning electron microscopy, I document patterns of tongue and taste organ morphology across developmental stages. By mapping these patterns onto a phylogeny, this study aims to clarify the evolutionary origins of transitions to direct development within Plethodontidae.

An erratic aerial approach enables mating survival In the cannibalistic killer fly

David Munkvold, Paloma Gonzalez-Bellido, Trevor Wardill, Yiyang Wang

Mating encounters often have fatal consequences in cannibalistic species. In terrestrial ambush predators such as mantids and jumping spiders, the associated fitness-maximizing precopulatory behaviors have been studied intensely. In comparison, we have limited insight into the mating behavioral strategies of sexually cannibalistic and fast-moving aerial predators. Here we report the approach behavior of the male killer fly, Coenosia attenuata, a highly predacious, cannibalistic species of Muscidae. We show that males of this species employ a chaotic approach trajectory to search for and approach potential mates, while likely utilizing wing interference patterns (WIPs) to identify potential females. Male killer flies were observed producing erratic flight trajectories over stationary females. Approach trajectories are highly variable and consist of repeated passes over the stationary female, with each pass generally drawing closer to the female and exhibiting increasingly chaotic heading angle changes. The rates of this behavior were significantly higher for satiated males over stimuli with intact WIPs. Indeed, analysis of WIPs demonstrated significant sexual dimorphism in this species, with female wings reflecting significantly more purple and blue light (400-500 nm) than males. Together, our results show that the reported behavior reduces the risk of cannibalism while enabling the male to identity and approach the female. This study illustrates how extreme sexual conflict can drive the evolution of complex behaviors in aerial animals.

The Bogert effect helps us understand organismal response to a changing world.

Martha Muñoz, Brooke Bodensteiner, Saul Dominguez-Guerrero

Homeostatic behaviors like thermoregulation and hydroregulation 'set the pace' for physiological evolution. When buffering behaviors are accessible, organisms can shield themselves from selection; across environmental gradients, such behaviors have the capacity to limit local adaptation and slow evolution (a phenomenon termed the Bogert effect). Can the principles of the Bogert effect help us anticipate how organisms will respond to global change? We address this question by focusing on Caribbean anoles, a lineage for which much historical data on thermal behavior and thermal physiology is available. We revisited sites where data were collected on Puerto Rico, Hispaniola, and Jamaica. We found that thermoregulatory behavior predicted physiological responses to rising temperatures. Using a common garden approach, were interrogated whether physiological shifts are heritable. Our results indicate that thermoregulatory behavior is a major predictor of ecological and evolutionary responses to rising temperatures.

The importance of the Bogert effect in a changing world

Martha Muñoz, Saul Dominguez-Guerrero

Homeostatic behaviors like thermoregulation and hydroregulation 'set the pace' for physiological evolution. When buffering behaviors are accessible, organisms can shield themselves from selection; across environmental gradients, such behaviors have the capacity to limit local adaptation and slow evolution (a phenomenon termed the Bogert effect). Can the principles of the Bogert effect help us anticipate how organisms will respond to global change? We address this question by focusing on Caribbean anoles, a lineage for which much historical data on thermal behavior and thermal physiology is available. We revisited sites where data were collected on Puerto Rico, Hispaniola, and Jamaica. We found that thermoregulatory behavior predicted physiological responses to rising temperatures. Using a common garden approach, were interrogated whether physiological shifts are heritable. Our results indicate that thermoregulatory behavior is a major predictor of ecological and evolutionary responses to rising temperatures.

Kinematic evaluation of falling behavior in lizards

Victor Munteanu, Sydney DiPietro, Eleanor Prosser, Richard Blob

Arboreal lizards often navigate unstable environments and face the risk of falling from heights, yet many still manage to land upright after falls. To explore whether body shape alone enables these successful landings, we compared the falling performance of three arboreal lizard species to life sized 3D-printed models. We constructed an apparatus to simulate natural aerial drops by releasing animals onto a cushioned pad 1.5 m below. We compared trials for three species that varied in body height and tail proportions: Chamaeleo calyptratus (tall-bodied, intermediate tail), Gastropholis prasina (low-bodied, long tail), and Anolis equestris (low-bodied, shorter tail). Using high speed video, we measured fall duration and limb kinematics, as well as tracked pitch, roll, and yaw throughout trials. There was no significant difference in fall duration between live animals and models, suggesting that live animal behavior during free fall does not significantly slow falling speed. Despite their different body configurations, limb kinematics across species were similar. Lastly, live lizards consistently landed ventral (belly) side down, while models showed less rotational stability. These differences indicate that passive body shape alone is not sufficient for a live lizard to maintain a stable, ventral-side-down orientation, and that there is a preferred body orientation for falling, with undesirable rotation may be mitigated or translated to a different axis.

The effect of sweep angle on flow over seal whisker geometry

Christin Murphy, Trevor Dunt, Ondřej Ferčák, Raúl Raúl Bayoán, Seri Aldana, Colleen Reichmuth, Jennifer Franck

Harbor seals utilize their whiskers for exceptional underwater navigation and prey tracking through hydrodynamic sensing. The unique undulated geometry of their whiskers produces flow effects that disrupt coherent vortex shedding and reduce fluid forces on the structure. While this effect has been thoroughly documented with flow perpendicular to the whisker span, the influence of other flow orientations has yet to be systematically investigated. Here we utilize computational fluid dynamics to study the influence of sweep angle, defined as the angle with which whiskers are swept back relative to the freestream flow, on fluid forces, shedding frequency, and wake flow structures. This study performs direct numerical simulation of flow over a smooth ellipse and seal whisker-inspired undulated cylinder at sweep angles from 0° to 60° and at Reynolds numbers 250 and 500. The flow effects of whisker geometry were greatest at 0° sweep angle (i.e., perpendicular to the flow) and persisted from 0° to 45°, beyond which the whisker performed similarly to our elliptical control. As seals exert active musculature control over their whiskers, we paired our findings with observations of sweep angle in live seals in order to underscore the relevancy of this parameter within both a biological and engineering context.

Changes in evaporative water loss through songbird ontogeny

Jillian Murphy, Maurina Street, Andrea Liebl

Because nestling songbirds are unable to alter their surrounding microclimates, they must regulate water balance physiologically. This mainly occurs by evaporation, specifically cutaneous water loss (CWL). However, different nests provide different temperatures and relative humidity for developing chicks; further, different regions of nestlings' bodies are exposed to different rates of airflow in the nest. Yet, CWL has never been compared across nest types or body regions. Because cavity nests are generally more humid that open cup nests, we hypothesized that cavity nesting chicks would have greater rates of CWL. We collected CWL data from wild nestling songbirds in Northwestern Iowa and Southeast South Dakota using a portable evaporimeter and compared dorsal and ventral CWL rates using linear mixed models. Nest type and species were not significant predictors of CWL. However, ventral CWL increased significantly with age, whereas dorsal CWL remained static. The elevated ventral CWL of older nestlings likely represents a shift toward the physiological capacity to survive post-fledging, when the nest no longer provides protection. This ontogenetic shift in CWL might be a way that chicks cope with variable environmental conditions. How these changes may help nest-bound chicks survive in the face of climate change is unknown and merits an investigation of nest microclimates as they relate to CWL.

Sensory organs of the esophagus of *Metacarcinus magister*. How do crabs detect toxic prey?

James Murray, Lee Morris

Decapods, like many animals, ingest foods based on signals from the mouthparts, but unlike most animals, they reject distasteful foods based on esophageal receptors post-ingestion. The Dungeness crab is a predator and scavenger that co-exists with toxic prey such as soft corals and sea slugs, but how they reject toxic prey is unknown. We will show patches of putative contact chemoreceptor pores in the distal esophagus (each 1-3 micron in diameter, similar to Robertson & Laverack 1979), near the paired 'quills' (feather-shaped structures in the ventral foregut). Their placement is very near paired channel openings in the floor of the foregut that direct minute particles of food from the cardiac sac chamber, around the cardiac valve to the pyloric chamber. The function of quills is still unknown; setae covering the structure look similar to known chemosensory setae. Endoscopic and mechanical manipulation shows that the quills are in direct line from the distal esophageal valve to the gastric mill and cardiopyloric valve, suggesting any food entering the foregut would likely deform/move the quills suggesting a possible mechanosensory function as well as a chemosensory function.

Assessing immunity in wild Peromyscus sonoriensis using flow cytometry and ELISA

Susan Murray, Laurie Dizney

Deer mouse species (Peromyscus spp.) have been used as ecological indicator species because they are common, widespread across diverse habitats

and disturbance levels, and easy to capture. Thus, the physiology of certain Peromyscus species, such as P. leucopus and P. maniculatus, have been well-studied. However, few such studies have been reported on P. sonoriensis, the predominant Peromyscus species west of the Mississippi River, likely due to its recent recognition as a distinct species. In particular, studies are lacking on the ability of commercial reagents, especially antibodies, to cross-react with P. sonoriensis antigens. We tested 50 antibodies for cross-reactivity with P. sonoriensis and validated five that cross-reacted with P. sonoriensis antigens, allowing identification of CD4 helper T cells, B cells, and granulocytes. We used these antibodies to measure proportions of circulating immune cells in small volume P. sonoriensis blood samples via multi-parameter flow cytometry. In addition, we developed an ELISA for detecting levels of total circulating IgG (the most common antibody in mammals) in P. sonoriensis plasma. Such immune parameters can be assessed from a small volume (< 1 00 ul) of blood and serve as key indicators of individual, population, and ecosystem-level health. Thus, the tools we describe herein will be useful both in field and lab settings across a broad scope of disciplines and studies.

Effects of freshwater salinization and resource availability on green tree frog tadpoles

Maya Mylott, Allison Welch, Cole Miller, Alex Barron

The intrusion of saltwater into freshwater habitats has become a rising concern due to increased storm surges, sea level rise, and other anthropogenic practices. Amphibians, which are ecologically important organisms due to their ability to facilitate biomass transfer, can be greatly affected by salinization, which causes an increased demand for osmoregulation and maintaining homeostasis. Salinity may affect not only amphibians, but also their interactions with other freshwater organisms. Over the past two years, our lab has investigated the effects of freshwater salinization on trophic interactions, primarily studying green tree frog tadpoles (primary consumer) and freshwater algae (primary producer), with surprising results. In a mesocosm study, we found that both tadpole and algal biomass were higher in a treatment with mildly elevated salinity. A follow-up experiment demonstrated that salinity did not directly affect algae cultivated from the mesocosms until much higher salinities. To test whether resource availability can offset the stress of increased salinity, we compared the salinity tolerance of green treefrog tadpoles at three food levels in a laboratory experiment. Preliminary data are consistent with the prediction of reduced salinity tolerance when food is limited. This work contributes to a better understanding of the effects of salinization on trophic interactions and ecosystem function in freshwater habitats and may provide information for conservation efforts to mitigate salinity stress.

Patterns of morphological and behavioral variation depend on migratory status

Nadje Najar

Latitudinal gradients in biology abound, documented in the distribution of taxa and various ecogeographic rules that all roughly correspond to spatial variation in climate regimes. Such biogeographical patterns were discerned in largely non-migratory species. Migratory behavior, however, allows animals to escape those conditions. Migrants therefore potentially experience very different selection regimes compared with residents, and any patterns of latitudinal trait variation should thus depend on migratory status. We compared morphological traits, genetic population structure, and song repertoire size in both migratory and sedentary populations of rock wrens (Salpinctes obsoletus) distributed along a latitudinal transect to test the prediction that latitudinal trait variation would differ in migratory and sedentary populations. Rock wrens with longer migrations, measured by proxy as breeding latitude, had shorter tails and smaller bodies than short-distance migrants or residents. Song repertoire size was also correlated with migratory distance, but residents had the largest overall repertoire sizes. Overall, our results were mixed; latitudinal variation in some but not all traits followed previously predicted patterns. Population genetic structure was not correlated with latitude, morphology, or song, which suggests reproductive isolation is not required for the maintenance of differences between migrants and residents. The processes maintaining these differences are likely a complex combination of cultural, environmental and genetic effects.

Functional shift of the ribs in aquatic adaptation of mammals: from locomotor to respiratory roles

Kosuke Nakayama, Shin-Ichi Fujiwara

Organisms have adaptively radiated into drastically different environments by modifying ancestral structures. In terrestrial mammals, ribs bear gravitational loads and require high rigidity for trunk stabilization. Conversely, aquatic cetaceans, released from gravity, require rapid surface ventilation, necessitating high ribcage mobility. We hypothesized that rib function shifted from locomotor support to respiratory efficiency. To test this, we conducted an analysis of terrestrial and aquatic cetartiodactyl species, evaluating rib strength and costovertebral joint range of motion (ROM).

Our results revealed that terrestrial species possess high-strength ribs with restricted mobility, whereas aquatic species exhibit relatively lower strength but extensive mobility. This strongly suggests that aquatic adaptation prioritized ventilation efficiency over structural robustness. Furthermore, we discovered that deep-diving species, such as the sperm whale, possess thick ribs. This appears to be an adaptation to prevent thoracic collapse under high hydrostatic pressure. However, the high frequency of healed fractures in these ribs indicates a critical functional trade-off: the rigidity acquired for deep-sea survival physically conflicts with the flexibility required for breathing and lung collapse. This suggests deep divers have reached a structural adaptation limit.

In this presentation, we discuss the dynamic evolution of rib function under diverse environmental pressures—from terrestrial gravity to deep-sea hydrostatics. This study provides quantitative insight into the functional shifts accompanying major ecological transitions.

Post-fire landscapes reshape the mating behaviors of dragonflies

Sarah Nalley, Michael Moore

Wildfires are reshaping the American West, destroying vegetation and leaving behind warmer, drier habitats. Although the aftermath of wildfires has an increasingly well-documented effect on the survival of animals, their impact on mating remains poorly understood. Dragonflies offer an ideal model for such research given their 1) energetically demanding territorial mating behaviors and 2) melanin wing ornaments that improve reproductive success but can also cause overheating. We began by testing if the environmental changes after wildfire impede the territorial behavior of dragonflies, particularly in ornamented species. Our behavioral observations indeed showed that ornamented dragonflies could not fight rivals as vigorously for breeding territories in burned habitats. We next explored what environmental changes might be responsible for these effects on reproductive behavior. Field measurements confirmed that burned habitats were hotter than unburned habitats, and thermal imagery revealed that non-ornamented dragonflies had higher body temperatures in burned sites. However, body temperatures did not differ between site types for ornamented species, suggesting that ornamented species prioritize thermoregulation over territorial defense. Neither body condition nor satellite-measured aquatic vegetation cover differ between site types, suggesting that territorial behaviors are not constrained by deficient nutrition or reduced territorial habitat. Overall, this work demonstrates that wildfire-driven habitat warming can disrupt essential mating behaviors, especially for species with mating traits that amplify thermal stress.

Relationships between avian malaria and body size in a novel host, the Hawaii Amakihi

Gabrielle Names, Frédéric Angelier, Cécile Ribout

Spreading infectious diseases are impacting wildlife and domestic animals worldwide. Infections can reduce the growth and body size of their hosts directly by using host resources or indirectly by stimulating costly immune responses. Since the introduction of avian malaria to Hawaii in the early 1900s, the disease has contributed to declines of many native Hawaiian honeycreeper species. One exception is the Hawaii Amakihi (Chlorodrepanis virens), a species that has maintained stable populations at both high elevations (where avian malaria is very rare) and low elevations (where it is prevalent) on Hawaii Island. Evidence suggests Amakihi have evolved increased resilience to avian malaria, but the consequences of infections on body size remain unexplored.

To investigate the effects of avian malaria on Amakihi body size, we compared the body size of infected and uninfected free-living birds captured from 2016 to 2018. We found infected birds had significantly greater mass (P < 0 .001) and significantly smaller wings (P < 0 .001) compared to uninfected birds, while tarsus length did not vary with infection status (P=0.680). These findings suggest that infections influence some aspects of Amakihi morphology but not all in the same way. To explore how low elevation Amakihi body size has changed since the introduction of avian malaria, these present-day results will be complemented by analyses of measurements collected from museum specimens spanning pre- and post-malaria introduction (1887-1994).

Relationship between body posture and force generation in slithering snakes

Zoha Naqawe, Jacob Sherman, Christine Vega, Henry Astley

Snake locomotion is characterized by the organism's use of its long, curving body moving through complex terrain. Slithering, the most common mode of limbless locomotion, works by generating body bends which push on contact points to generate reaction forces. As a snake moves forward in its path, contact points are continuously generated and lost leading to a constantly changing system of forces which can vary in magnitude and direction. This movement is dominated by kinetic frictional forces and for a snake to move forward it requires complex coordination of these dynamic contact points to ensure net forward reaction force. However, it remains unknown whether individual contact forces are determined by the total balance of forces along the body only by local body geometry and friction. We test for governing parameters of contact force generation in slithering by measuring the forces exerted on a single contact point among the many along the body. We captured the kinematics of snakes via a motion capture system while slithering in a rigid, flat substrate with equally spaced pegs, one of which recorded forces. Preliminary results suggest snakes have a consistent relationship between body posture and contact force orientation. We will investigate how this relationship affects predictive calculation of force magnitudes, and the implications for control across complex body configurations.

Dissecting the adductor mandibulae complex: novel insights into S. acanthias muscle-tendon architecture

Jillian Nash, Jason Ramsay

Visualization of Squalus acanthias (spiny dogfish) musculoskeletal anatomy has remained consistent over the last century, with the notable exception being the adductor mandibulae complex (AMC). Despite the widespread use of S. acanthias in comparative anatomy contexts, the architecture, divisions, and insertions of the AMC remain inconsistently documented in scientific visualizations. Our investigation identifies novel muscle-tendon architectures within the quadratomandibularis divisions of S. acanthias, suggesting greater structural and functional variation than previously recognized. In comparison, dissections of Mustelus canis, which is often mistaken for S. acanthias but differs greatly in taxonomic placing and feeding style, reveal a less subdivided AMC more like the AMC depictions used in comparative anatomy texts. Mechanically, the architecture of the AMC divisions in S. acanthias results in a mosaic of mechanical outputs from force amplifying to velocity amplifying. These features may have evolved in conjunction with the disparate feeding strategies used by S. acanthias, as increased jaw closing velocity is typically observed in suction feeding species and increased muscle leverage and force output to prey is typical of bite feeding species. In M. canis, which is a crab-eating specialist, the AMC divisions are more geared for force transfer to prey for a stronger bite. These findings emphasize the diversity of AMC structure across sharks and how they may facilitate differences in feeding strategy and biomechanical performance.

The blind leading the blind: effects of visual deprivation on color-change behavior of a reef fish

Lydia Naughton, Vanessa Moreno, Lorian Schweikert

Dynamic color change is a behavior that relies on environmental perception to achieve outcomes such as adaptive camouflage and social signaling. While it is assumed that vision is required for most color changes, there is a lack of recent studies that behaviorally test this assumption in an animal that 1) is capable of rapid, physiological color change and 2) is known to have some capacity for dermal photoreception. We examined the effects of visual deprivation on color change of the Caribbean hogfish (Lachnolaimus maximus), a species known to express phototransduction genes in its skin. Using a repeated-measures design, each fish experienced blindfolded and sham conditions while exposed to an overhead looming stimulus meant to induce color change. Color-calibrated videos of the body were analyzed to measure contrast of stripe pattern, average skin reflectance, and frequency distribution of RGB pixel values before and after the stimulus. We found that blindfolded animals showed smaller changes in body coloration and patterning in response to the stimulus compared to non-blindfolded animals. Color change without blindfolds varied by individual, where some fish displayed a striped pattern in response to the stimulus, and others exhibited background-matching. These results support the conventional idea that vision is the primary driver of dynamic color change, which aligns with the hypothesis that dermal photoreception plays a secondary self-monitoring role, if any, in coordinating color-change behavior.

Octopus arm stiffening through active exploitation of passive fibrous tissue response

Noel Naughton, Bokun Zheng

The octopus arm is a flexible muscular hydrostat that lacks a rigid skeleton, instead relying on localized stiffening behavior to provide a dynamic skeleton that facilitates behaviors such as reaching towards and retrieving food. Previous studies have suggested this stiffening arises from antagonistic co-contraction of the arm's longitudinal muscle (LM) and transverse muscle (TM) groups, with LM driving shortening and TM driving elongation. Such a mechanism would then require careful coordination of the LM and TM to stiffen the arm. To investigate arm stiffening strategy, we develop a finite element model of an octopus arm with oriented fibrous elements and active muscle contraction. We find that LM-TM co-contraction does not produce stiffening of the arm as their relative contraction forces are cancelled. Instead, we find arm stiffening can be explained by geometric effects and the anisotropic, non-linear properties of the arm's muscle groups. These effects allow the arm to stiffen via only TM-actuated arm elongation, as LM fibers generate higher passive stress when stretched than when compressed. Extending the arm via TM contraction increases the total portion of the LM fibers that are in stretch, thus increasing the arm's bending-resistive moment. This stiffening mechanism simplifies the motor control necessary to produce stiffening behavior and is consistent with observations of arm elongation during reaching behaviors.

Mitochondria, microbes and the aging mind

Noshin Nawar, Emily Beck

Mitochondria evolved from alphaproteobacteria during the early evolution of eukaryotic life. As such, mitochondria (mito) and microbes (micro) maintain shared characteristics including morphological features like a double membrane structure. Due to these shared features, therapeutics (like antibiotics) intending to target bacteria can also impact mitochondrial function. We know mitochondrial dysfunction can impact cellular physiology in many ways. The broad reach of mitochondrial dysfunction stems from the multifaceted role mitochondria play in regulation of cellular processes including energy production, lipid biosynthesis, calcium homeostasis, apoptosis, and various aspects of the immune response. Mitochondrial dysfunction is therefore a core feature of many diseases including neurodegenerative diseases like Alzheimer's Disease (AD). One antibiotic of interest to the AD-community is chloramphenicol which has been shown to impair mitochondrial protein synthesis in zebrafish and elevates AD genetic markers in neuronal culture. Currently, the effects of chloramphenicol on AD genetic markers in vivo remain unexplored and the extent to which elevated AD genetic markers impacts AD pathologies warrants further investigation. To fill these gaps, we are using threespine stickleback fish (Gasterosteus aculeatus) to examine how chloramphenicol exposure alters AD-associated genetic markers via qPCR and how use of chloramphenicol perturbs mito-micro homeostasis, brain-gut

health, and AD pathology. Here I present our experimental design and first steps toward developing threespine stickleback as a model for testing the effects of antibiotics on AD.

Evaluating substrate and environmental influences on sea turtle nest incubation conditions

Thomas Naylor, Jake Lasala

Sea turtle hatchling development is heavily dependent on the varying environmental factors that a nest will encounter during incubation. These factors can influence the sex ratio of nests, hatchling body condition, and the overall emergence success of a nest. Due to female nest site choice, each nest experiences unique conditions. Sarasota County, Florida has the highest nesting populations of loggerhead (Caretta caretta) sea turtle nesting in the Gulf and the green sea turtle (Chelonia mydas) population is rapidly growing. This study aims to identify how abiotic factors (sand grain size, sand color, sand water permeability, sand temperature reactivity, and weather events) impact nest incubation temperature and subsequent emergence success of hatchlings from nests across multiple beaches in the region. Grain size composition, sand color, and resulting sand temperature reactivity differed across nesting beaches. Sand water permeability was significantly different between loggerheads and green sea turtles. Nest temperatures will be compared to these factors. Collectively, these findings suggest that hurricanes and re-nourishment projects can have adverse effects on the development of hatchlings, nest success, and likely the sex of hatchlings entering the population. Continued analyses of substrate, temperature, weather, and hatchling data is needed to determine the impacts of environmental factors on sea turtle hatchlings to better conserve these threatened turtles.

Enhancing embodied intelligence in robots: The role of additional appendages inspired by nature

Azhang Nazaripouya, Nnamdi Chikere, Yasemin Ozkan-Aydin

Animals across various species have evolved specialized body parts to simplify complex tasks related to mobility, stability, sensing, and manipulation. For example, a lizard's tail acts as a dynamic stabilizer during leaps, a rodent's whiskers provide essential feedback for navigating in the dark, and a sea star's tube feet allow it to move across uneven surfaces. These specialized structures, often called appendages, including tails, whiskers, antennae, fins, and trunks, allow an organism's physical form to handle complex control strategies, thereby improving its overall functionality. This close relationship between an organism's physical structure and its function is a key aspect of embodied intelligence, demonstrating how an organism's body can simplify interactions with its environment and reduce the cognitive and control demands placed on its brain. Robotic systems have incorporated biomimetic features to simplify complex tasks, with robotic tails enhancing dynamic stability and turning agility, whisker/antenna-like sensors facilitating navigation in cluttered or dark spaces, and trunk- or tentacle-inspired manipulators providing extended reach and compliant grasping. The use of appendages enhances a robot's overall balance, maneuverability, perception, and environmental interaction; however, it introduces trade-offs in mass, energy use, and control complexity, paralleling biological compromises. This study synthesizes findings across biology and robotics to identify key design trade-offs and emerging challenges, while outlining future directions in morphology-control co-design, adaptive materials, and learning-based adaptation for resilient, multifunctional robotic systems.

Morphological brain variation within the order of Cyprinodontiformes

John Neal, Dominik Valdez, John Phillips, Leigha Lynch

Understanding interspecific variation in brain morphology is essential for linking phenotype to environmental changes. Our model, Cyprinodontiform fishes, are found in variable environments, which may impact their brain morphologies. Here, we describe anatomical variation in the brain of six Cyprinodontiforms: Gambusia holbrooki, Jordanella floridae, Fundulus heteroclitus, Oxyzygonectes dovii, Characodon lateralis and Aplocheilus panchax. The brains and ventricles were segmented using MicroCT scans obtained from MorphoSource. We found variation in brain and ventricle size and shapes among species in several aspects. Specifically: 1) O. dovii, C. lateralis and F. heteroclitus all exhibit space anteriorly-to-posteriorly between the telencephalon and optic tectum. 2) Jordanella floridae (widest) and A. panchax (narrowest) represent the extremes of the 4th ventricle. 3) Gambusia holbrooki and A. panchax have broad, dorsoventrally flattened brains, while J. floridae has a narrow laterally-to-medially compressed brain. Similarities in brain morphology among O. dovii, C. lateralis, and F. hetereoclitus may be associated with their adaptation to freshwater niches, while those in A. panchax and J. floridae may be correlated with their brackish environment. This variation in brain morphology among Cyprinodontiformes may correlate with environmental variation, but future research will test if specific variables of aquatic environments are influencing the brain morphology of these species.

From structure to flow: microanatomy of the Megamouth shark's filter

Jordyn Neal, Karly Cohen, EW Misty Paig-Tran

The megamouth shark remains one of the ocean's most elusive filter feeders, relying on branchial filters to capture and consume plankton. These filters are composed of hundreds of gill rakers, each densely covered with hardened structures that appear to be analogous to dermal denticles. While dermal structures have well-documented functions, including protection and influencing flow, the functional role of these branchial denticles remains unknown. We µCT scanned gill rakers from seven individuals and measured the morphological parameters (crown length, width, angle, central cusp length and width, number of riblets, and imbrication) from six representative denticles per raker (n = 42). These measurements provided a framework for understanding structural variation and informed the construction of physical models. We visualized flow patterns by filming dye streams as they passed in and around a scaled physical model of a gill raker. We observed that flow dips beneath the base of the crown of the denticles, forming unstable, shedding vortices before re-entering the freestream flow near the posteriorly located apex. These flow patterns suggest a potential functional role of denticles beyond the role found along the axial skeleton. These findings offer new insight into how these microstructures may contribute to flow and feeding.

The effects of low pH on the bioluminescent Euprymna–Vibrio association

Emily Neff, Michele Nishiguchi

Euprymna, a genus of the bobtail squid known for its beneficial association with Vibrio fischeri, has been a prominent model for studying environmentally transmitted symbioses. This project is focusing on the Southern dumpling squid, Euprymna tasmanica, a sepiolid species found circumcontinentally along the coasts of Australia. Given the abiotic changes that occur with climate change (pH, temperature) we will determine whether lower pH (higher acidity) affects the symbiosis between E. tasmanica and their bioluminescent symbiont V. fischeri by analyzing gene and protein expression from the light organs of juvenile squids raised under various pH scenarios. We aim to characterize which genes are up or down regulated, which will help us understand key pathways that are involved in controlling changes while identifying specific transcription factors that regulate symbiosis in response to lower pH. We will also identify proteins and protein families that have low pH stability to understand how this symbiosis changes at the molecular scale in response to higher acidity. Our experimental design includes decreasing the pH in the water to 8.0 (control), 7.6, and 7.2 and using experimentally evolved V. fischeri strains that were cultured in low pH for 600 generations. By doing so, this will help us better understand the immediate impact of ocean acidification due to the changing pressures that occur with climate crises through the lens of animal-microbe associations.

Phylogenetics and geometric morphometrics of butterflyfishes, family Chaetodontidae

Gabriel Nelson, Mark Westneat, Linnea Lungstrom

Coral reef fishes are an ideal group of organisms to explore ecomorphological questions as they are diverse in body shape, fin shape, and ecology. Here, we explore shape diversity in an exceptionally diverse group, the butterflyfishes (Chaetodontidae), to investigate questions of structural and functional relationships as well as patterns of shape evolution. We use geometric morphometrics to quantify the diversity of head, body, and fin shapes across this reef fish family by placing landmarks and semilandmark curves on 2D lateral images. Using our newly revised butterflyfish phylogenetic tree combined with these morphometric analyses, we explore instances of novel convergence and rapid divergence in butterflyfishes. We placed 34 fixed landmarks and 15 semilandmark curves on the spines, fins, and body of 290 images across the revised phylogeny (118 species, 12 genera) to perform phylogenetic geometric morphometric analysis. We found that most genera grouped together in morphospace, with trends of circular vs more elongate body shapes contributing to main axes of diversification. Other important functional trends were variability in tail shape, pectoral fin aspect ratio, and the slope of the forehead, with these traits showing association with diet. Finally, although butterflyfishes are notable for their broad, round and laterally flattened profile, we found significant signals of evolutionary convergence among taxa, suggesting that similar dietary patterns influence convergence in body and fin shapes.

Hormonal regulation in the diploid-tetraploid gray treefrog complex

Elizabeth Neslund, Christopher Leary

Circulating levels of adrenal glucocorticoids (GCs) and gonadal steroids, and interactions between these hormones, are highly variable across vertebrates. Although the environmental and ecological correlates of this diversity are well studied, the potential genetic underpinnings giving rise to this diversity are poorly understood. We are studying endocrine regulation in polyploids to understand how associated changes in gene copy number (i.e., gene dosage) contribute to this diversity. Polyploidization may modify endocrine regulation by introducing nonlinearities in gene expression patterns and/or promoting mutations that alter the expression of gene products (i.e., receptors and binding proteins) governing the hormonal phenotype. Examination of endocrine regulation in extant polyploids is broadly relevant to understanding diverse hormonal phenotypes given that polyploidization is a historical feature of vertebrate evolution and a major source of variation in gene copy number in extant diploid species. Our work examines regulation of GCs and gonadal steroids in diploid and tetraploid gray treefrogs to understand how polyploidization impacts endocrine control. We will present results describing how circulating hormone levels and crosstalk between the hypothalamic-pituitary-adrenal/interrenal (HPA/I) and -gonadal (HPG) axes are modified in polyploids relative to diploids and the approaches we are currently taking to understand how polyploidization impacts the various endocrine elements governing the hormonal phenotype.

Identifying hermaphroditism in the Gobiosomatini tribe (Teleostei, Gobiidae)

Elliot Nettlebeck, Luke Tornabene, Jeffrey Yeabsley

Sequential hermaphroditism, or the changing of sex during the lifetime of an individual, increases the reproductive success of a species. Many individuals within the family Gobiidae possess and utilize this trait to compensate for an inability locating mates. This is attributed to other traits like reduced size and microhabitat occupation. The Gobiosomatini tribe is a group with many small hermaphroditic species that often associate tightly with unique microhabitats (e.g. sponges, corals, urchins). Hermaphroditism is described in these fish by the presence of pAGS (precursive accessory gonadal structures), structures on the gonad that allow sexual transition, as well as the simultaneous presence of spermatozoa and oocytes in the same gonad. This group is unique among many gobies with many not having obligate associations to corals, unlike many other hermaphroditic species. High rates of diverse specializations may be explained by increased reproductive rates in a population due to hermaphroditism. Using histology, gonad structure of Gobiosomatini specimens will be analyzed for evidence of hermaphroditism by taking a transverse section of the fish and looking for the presence of either pAGS or spermatozoa and oocytes in the same gonad. Cross sections of entire fish will also be taken to note any differences in internal morphology of specimens across genera. Describing hermaphroditism and delineating internal morphological differences helps bolster the existing phylogenetic connections between taxa.

An island divided: current state of the red urchin population around San Juan Island, Washington

Jasper Nevis, Willem Weertman, Jason Hodin, Bob Oxborrow, Dalton Blackwell, Taylor Frierson, Henry Carson, Kenneth Sebens

Since 2013, sea-star wasting disease (SSWD) has resulted in the loss of >97% of sunflower stars (Pycnopodia helianthoides) across their range. Prior to SSWD in the Salish Sea, sunflower stars were one of the only predators of kelp-eating sea urchins. We report progress on a modern synthesis of historic red urchin (Mesocentrotus franciscanus) population records around San Juan Island in the Salish Sea, in comparison with our recent population surveys. We conducted SCUBA surveys at 14 sites around San Juan and nearby islands, measuring urchin density, test size, and kelp quality at each site. We then combined our survey data with historic density and test diameter data from available sources. We found that the red urchin population exhibited an east-west divide in both population and test diameter with more and younger red urchins on the west side of the island. Additionally, we found that urchin density negatively correlated with our kelp quality index. Our results suggest that the loss of sunflower stars may have impacted urchin recruitment or post-recruitment survival patterns around San Juan Island, which in turn may have contributed to recent kelp forest declines. We and colleagues are currently testing these hypotheses directly through targeted releases of lab reared sunflower stars at one of our 14 sites.

The population consequences of physiological responses to stressors

Leslie New, Josh Reed, Jen Jelincic, Enrico Pirotta, Kathleen Hunt

Environmental change causes physiological impacts that can last years in long-lived species, yet there is a dearth of methods for quantifying such impacts and their population effects across the necessary decadal timescales. One of the few available is the Population Consequences of Multiple Stressors (PCoMS) framework, which is intended to link short-term responses to stressors to health, then to vital rates and from there to population-level effects. To date, work within the PCoMS framework has primarily focused on marine mammals' behavioral responses to stressors, enabled by data available from biologging devices. However, recent technological advances have facilitated the collection of physiological data, particularly hormones, through techniques such as blow and fecal sampling, as well as hormone extraction from baleen. Using baleen specimens from bowhead whales (Balena mysticetus) that were sampled for stable isotopes and adrenal, thyroid and reproductive hormones, we demonstrate how these individual histories can be used within the PCoMS framework to begin modelling the linkages between ecological change, anthropogenic actions, individual physiology, and potential population impacts.

Within- and transgenerational plasticity affect thermal tolerance across populations of a copepod

Isabelle Neylan, Rujuta Vaidya, Brant Faircloth, Morgan Kelly

Understanding how organisms respond to variable environments is becoming increasingly important in our rapidly changing world. Beyond genetic adaptation, plastic responses to the environment can alter phenotypes and fitness, but the interaction between plasticity and adaptation during environmental change is complex and there are multiple forms of plasticity (e.g., developmental, transgenerational) and their interactions to consider. We used two populations of Tigriopus californicus copepods, a thermally tolerant southern population and a thermally sensitive northern population, to conduct a fully factorial split brood experiment where we exposed adult parents to either a

sublethal heat shock or control (no heat treatment) and then exposed their progeny to control or heat shock at both the larval and adult phase in a fully factorial design. We measured heat tolerance and gene expression patterns of the adult offspring to explore how within- and transgenerational plasticity may be impacting fitness and potential mechanisms underlying these effects. Heat shock in adult offspring increased tolerance across both populations regardless of prior exposures. In animals lacking adult exposure, parental and early-life experience had an interactive effect across both populations, but this interaction did not necessarily confer higher tolerance. Our transcriptomic analyses revealed that transcriptional front-loading is a likely mechanism for parental priming while greater transcriptional plasticity was associated with developmental and adult priming perhaps explaining the saturation of benefit with repeated exposures.

Unseen yet seen: Unraveling the ecology and evolution of caecilian coloration

John Nguyen, Adam Stuckert, Rayna Bell

Coloration is employed as a mechanism for predator avoidance across diverse taxa, most commonly in the forms of crypsis, disruptive coloration, and aposematism. However, our mechanistic understanding of the function of coloration is still largely based on only a subset of the tree of life and environmental contexts. Caecilians are limbless amphibians typically characterized by a nocturnal, subterranean lifestyle. Remarkably, seemingly conspicuous coloration has evolved in three lineages exhibiting increased surface activity but whether this coloration serves an adaptive role remains unclear. Leveraging the bright yellow São Tomé caecilians (Schistometopum thomense; yellow, S. ephele; yellow with brown speckling) as a study system, we hypothesized that bright yellow coloration has evolved in caecilians as an aposematic signal. To investigate the visual aspect of this hypothesis, we conducted visual modeling to investigate whether caecilian coloration is cryptic or conspicuous to potential predators, determined whether divergence in coloration between the two species is associated with microhabitat selection, and generated an annotated genome assembly for both species. We found preliminary evidence of differences in the color space of yellow coloration between species, particularly in lightness and relative luminance. In addition, we show that the two species are partitioned ecologically by significant differences in canopy openness and compressive strength of soil microhabits. Lastly, we report ongoing research to identify the genetic basis of caecilian coloration and potential chemical defenses.

Molecular and physiological sensitivity of crabs and urchins to acidification and hypoxia

Tina Nguyen, Nina Bednaršek, Greg Pelletier, Andrew Gracey

Ocean acidification and hypoxia (OAH) frequently co-occur in productive coastal regions such as the California Current System (CCS), where anthropogenically driven intensification of upwelling, warming, and eutrophication has exacerbated these stressors. While the individual effects of acidification and hypoxia have been investigated, their synergistic impacts, particularly in early developmental stages, remain poorly understood despite their critical role in fishery recruitment. This work integrates the physiological and transcriptomic responses of two commercially and economically relevant invertebrates, the Dungeness crab (Metacarcinus magister) and red sea urchin (Mesocentrotus franciscanus), to a range of OAH conditions reflecting ecologically relevant current and projected conditions along the CCS. Sea urchin larvae exhibited skeletal dissolution, with dramatic shifts in larval morphology and gene expression detected at the pH/DO transition of 7.71/3.71 mg/L to 7.27/2.72 mg/L. In crabs, we observed carapace dissolution, increased mortality, and the upregulation of calcification and glycolytic genes, suggesting a compensatory response under metabolic stress. Together, our results identify species-specific molecular markers and physiological thresholds of OAH stress, providing further insight into potential recruitment bottlenecks under future multistressor conditions. These findings offer comparative, mechanistic indicators of early-life stage vulnerability, with implications for understanding species resilience and informing fishery management.

Comparative morphology of shark species derived from digital 3D models

William Nguyen, Isabel French-Luce, Joshua Medina, Joel Gayford, Jodie Rummer, George Lauder, Duncan Irschick

Morphological scaling in sharks provides insights into locomotion, ecology, behavior, and evolutionary adaptation. While prior studies have quantified allometric relationships among shark species primarily using either live animals or museum specimens, there remains a need for novel and non-invasive approaches that can expand species coverage and reduce the logistical and financial challenges of fieldwork. Here, we apply 3D scanning and digital reconstruction methods to quantify body form in 16 shark species spanning diverse families, ecologies, and life histories. Using Blender-based digital models, we extracted a dataset of 19 morphological variables - including areas of various fins, body volume, and other linear measures, such as pre-caudal length, body spans, circumference, and fin dimensions—comparable to those used in live morphometric studies. Across species, we found strong correlations between pre-caudal length and all morphological variables, with several variables scaling close to isometry. We also found striking differences among shark species in key aspects of body morphology, such as head and fin morphology. By integrating digital models with established morphometric frameworks, our results demonstrate the utility of 3D reconstruction for comparative morphology and functional ecology of sharks. This approach not only provides high-resolution morphological datasets across species, but also offers an ethical and scalable method for investigating biomechanical, behavioral, and ecological patterns in threatened marine predators.

Bio-inspired robotic swarm for understanding fish schooling dynamics

Di Ni

Fish exhibit remarkable collective behaviors: they school together, evade predators, and form dynamic structures such as bait balls. These complex patterns are believed to emerge from local interactions and decentralized rules.

In this talk, I will present our efforts to build a fish-inspired robotic platform to study schooling formations. I will introduce a leader–follower strategy that enables the first demonstrations of complex three-dimensional (3D) underwater formations using visual information alone. The results include leader–follower pairs executing various 3D following configurations—inline, staggered, and side-by-side—as well as a multi-robot diamond formation. I will discuss both the technical challenges we faced and the potential of this platform as a tool for advancing our understanding of fish schooling.

Spawning and development of *Mopalia muscosa* from fertilization through metamorphosis

Khrista Nicholas, Rebecca Varney

Exploring unique physiological processes across animal taxa inspires ideas and innovations. Chitons are marine mollusks that biomineralize teeth with magnetite, an iron oxide mineral. Iron is toxic to animals in high concentrations, so past research focused on how adult chitons use iron in the teeth on their radula. The radula is a rasping organ that chitons use to scrape algae off of rocks. In situ spawning and fertilization of chitons have historically been unreliable, so larval and juvenile specimens have been difficult to obtain to study radula development. Here we describe methods that induced spawning in Mopalia muscosa and Katarina tunicata, as well as several methods that failed. We maintained cultures of M. muscosa through metamorphosis. Our experimental spawning trials and photographic documentation of M. muscosa build on past literature to further understand the embryology, development, and metamorphosis of chitons. In the future, the samples we collected across developmental stages will be used to reveal the timeline of morphological and transcriptomic changes of early stages of M. muscosa, especially as it relates to radula growth and the start of iron biomineralization.

From placode to eruption: live imaging denticle formation in small-spotted catshark embryos

Ella Nicklin, Alison Fitzpatrick, Eduardo Vigil De Anda, Madison Barry, Jadzia Milian, Gareth Fraser

Sharks, skates, and rays (elasmobranchs) possess tooth-like placoid scales (denticles) embedded in their skin. These “skin teeth” serve as dermal armor and as drag-reducing structures. Previous research has primarily focused on the genetic regulation of denticle development (e.g., patterning pathways) and morphology of denticles post-eruption. Yet, most studies have been restricted to discrete embryonic stages, overlooking the continuous nature of development and the multiple subprocesses denticle formation entails, including placode initiation, morphogenesis, mineralization, and eruption.

Our study investigates the gradual progression of denticle formation in the small-spotted catshark (Scyliorhinus canicula). Through live imaging at seven-day intervals over several months, we tracked denticle development from placode initiation to eruption, identifying shared characteristics among individuals reared at a constant temperature of 10 °C. Our analysis characterizes the sequential progression of denticle formation in Scyliorhinus canicula, detailing the developmental timing and spatial distribution of distinct denticle morphotypes.

We further compared these developmental patterns with two additional chondrichthyan species, the chain catshark (Scyliorhinus retifer) and little skate (Leucoraja erinacea), to assess similarities and differences in patterning and timing.

From these data, we have an optimized staging series for Scyliorhinus canicula denticle development, providing standardized, homologous timepoints for experimental work. This framework is crucial for ensuring replicability and for recognizing the wildtype condition prior to experimental manipulation, thereby enabling more robust investigations into the origins of denticle diversity.

Notch-mediated override of spatial identity in the developing *Drosophila* visual system

Sophia Nielsen, Yen-Chung Chen, Claude Desplan

In Drosophila, visual information flows from the compound eyes to the optic lobes for processing. Optic lobe neurons develop from a neuroepithelium organized into several spatial domains; each domain expresses specific transcription factors and generates distinct cell types. For example, the Vsx domain generates Pm4 neurons, while the Optix domain generates Mi4 neurons. However, some cell types are not domain-restricted: Mi1 and Dm2 neurons are generated by both the Vsx and Optix domains, ignoring their differences. We asked what mechanism allows neurons from different domains to converge on the same fate, and found that all domain-ignoring neurons have domain-restricted “siblings” – born from the same intermediate progenitor – with differential Notch signaling. For example, domain-ignoring Mi1 neurons are Notch-On and arise from the same progenitor as domain-restricted, Notch-Off Pm3 neurons. We therefore hypothesize that Notch signaling determines whether neurons abide by or ignore progenitor domain differences. We are directly testing the interaction between Notch signaling and spatial regulators by knocking out Su(H) and overexpressing the Notch intracellular domain in neural progenitors. Our preliminary results suggest that Notch signaling is required to repress Vsx1/2 expression in neurons and thereby confer the domain-ignoring Mi1 fate. These findings reveal unexpected flexibility in spatial patterning mechanisms, potentially supporting the generation of the many neurons required for the ~800 neural circuits that process visual input from each ommatidium.

Arginine vasotocin influences responses to visual signals by perceived rivals in foot-flagging frog

Akshita Nistala, Doris Preininger, Lisa Mangiamele

The neurohormone arginine vasotocin (AVT) modulates social behavior in anurans by increasing calling and territorial behavior; however, its effect on visual signaling is unknown. We investigated this in Staurois parvus, a frog that uses primarily visual signaling for intrasexual communication. Males were treated with AVT or saline and shown a video of another male foot flagging or an unmoving frog. We used K-means clustering to group male responses using four behavioral variables: freeze, attack, foot signal and open mouth. Males were categorized into 4 clusters along 2 primary dimensions that described 57.3% of the variation within the dataset. Males in cluster 1 had high open mouth and attack frequency, whereas cluster 2 had only high attack frequency. Cluster 3 had low behavioral activity overall and cluster 4 showed the highest foot signaling frequency. We then tested whether hormone treatment or video playback affected cluster distribution. We found that C1 and C4 contained only AVT-treated males. C1 males chose to primarily open mouth, whereas C4 males chose to foot flag, suggesting AVT promotes a preference for visual signaling. Males viewing the two video stimuli were distributed evenly across the four clusters, however males shown the foot flagging video open mouthed significantly more. Our results show that AVT influences how males respond to rivals with visual signals, although individual males differ in their choice of display.

Wind gusts impact the phase selectivity of insect wing mechanosensory neurons

Madeline Nobert, Tabia Tahsin, Sinthia Ahammed, Alison Weber

Flight requires rapid and precise sensory feedback in order to maintain balance and control. Prior work has shown that proprioceptive signals originating in insect wings modulate flight behaviors. These signals are believed to be mediated by mechanoreceptors called campaniform sensilla (CS), which detect strain in the cuticle as the wing deforms. It is not well understood how these wing CS respond during flight or how responses are impacted by in-flight disturbances, such as collisions or wind gusts. To examine these questions, we recorded neural responses from wing CS in the hawkmoth Manduca sexta during periodic wing motion. We compared responses during periods of movement with and without an airflow stimulus that mimics wind gusts directed at the wing. Wind gusts were delivered at a fixed phase relative to movement. During movement without a wind gust, CS spikes are phase selective, with different CS exhibiting different preferred phases. During movement with wind gusts, CS spikes are generally less strongly phase selective rather than showing consistent advances or delays in spike timing. This work contributes to the broader goal of understanding how a relatively small number of sensory receptors can provide sufficient information to guide stable, controlled flight.

Morphology of the spotted ratfish olfactory system through ontogeny

Maylia Nong, Aubree Jones, Lauren Simonitis

Holocephalans, also known as chimaeras, are an interesting Chondrichthyan with an even more interesting olfactory system. Unlike sharks, skates, and rays, chimaeras have paired forward facing nares which each lead to an olfactory chamber connecting to the buccal cavity. While current studies have described the general anatomy of the chimaera olfactory system, ontogenetic changes have yet to be investigated. Here we quantify the nasal morphology of the Spotted Ratfish (Hydrolagus colliei) from the juvenile to adult phase. We used contrast-enhanced micro- CT to investigate morphometric parameters such as nostril size and relative areas of the buccal and olfactory cavities throughout ontogeny. These data will give us a closer window into the development of the chimaera olfactory system allowing us to relate differences in size and complexity to the changing needs of ratfish as they progress through their life stages.

Tail of turmoil: Incidental observations of lost rectrices associated with freezing rain events

Olivia Noonan, Dorothy Zahor, Ben Sonnenberg, Douglas Warrick, Thomas Hahn, Jamie Cornelius

Freezing rain poses serious challenges to free-living animals, including thermal stress, physical encumbrance, and restricted access to resources. Despite birds’ well-described thermoregulatory abilities, the impact of extreme freezing rain events, particularly regarding physical condition, remains poorly understood. Following a severe freezing rain event in Oregon in January 2024, anecdotal reports surfaced of birds missing some or all tail feathers.

We hypothesized rectrices were lost or damaged due to ice accumulation on the tail. Here we employed a citizen science approach to gather observational data on the prevalence of tail damage/loss in the region before and after the storm. We also captured wild birds shortly after the storm and again one year later to assess physiological metrics. Our results showed an increase in reported rectrix loss post-storm, with two ground-dwelling species, Golden-crowned Sparrows and Dark-eyed Juncos, exhibiting higher rates of tail abnormalities than other species. however, tail loss or damage was reported in at least 24 different species. Additionally, we found juncos captured one week after the storm had lower pectoral muscle scores but higher body mass due to increased fat deposits, compared to those caught at the same time the following year. These findings highlight the potential negative impacts of extreme freezing rain events on avian plumage and condition and underscore the need for further research to comprehend and mitigate their consequences on bird populations.

Factors influencing adoption of multiple pups in northern elephant seals

Lucy Nosbisch, Mackenzie Davidson, Olivia Springer, Molly Murphy, Heather Liwanag

Capital breeding is a reproductive strategy in which foraging and reproduction are temporally and spatially separated. For capital breeding marine mammals, that means the mother is fasting during the lactation period. Northern elephant seals (Mirounga angustirostris, NES) are capital breeding seals with a 4-week nursing period. Although NES mothers only have enough stored energy to successfully wean a single pup, there are cases in which a mother will “adopt” a pup that is not her own, nursing it in addition to the one she birthed. This behavior should be maladaptive, as the mother is splitting resources only meant for one pup among two or more, and this is unlikely to result in survival for any of the pups. However, this behavior is observed in multiple NES mothers each breeding season. To better understand what factors contribute to this phenomenon, we used drone-captured aerial images to examine the incidence of this behavior at the Piedras Blancas breeding site. Using these images, we examined whether the frequency of pup adoption differs among seven breeding beaches at this colony. Preliminary results indicate that frequency of adoption may be influenced by seal density and level of protection from high surf. Given the negative consequences of this behavior, understanding the factors driving it can provide insight into the effects of climate change and habitat loss for this ecologically important species.

Diversity of true crab (Infraorder: Brachyura) inhabitants across macroalgal hosts

Diana Noto, Robert Lasley

Guam, a US territory located in the tropical West Pacific, hosts the most biodiverse marine system in the United States. Although past work has documented much of Guam’s marine biodiversity, taxa living in cryptic habitats or in symbiotic relationships remain understudied. Macroalgae is an important component of marine ecosystems worldwide, yet there have been few studies on invertebrate macroalgal communities in tropical systems with most studies focusing on temperate habitats. To fill this gap, macroalgae belonging to three main macroalgal classes, Ulvophyceae (green algae), Phaeophyceae (brown algae), and Florideophyceae (red algae), were collected from sites around Guam to document the diversity of associated brachyurans. Samples were collected by hand in the shallows, on snorkel, and SCUBA. This study aims to: 1) document brachyuran species across diverse macroalgal hosts and annotate their associations (incidental, facultative, or obligate); 2) report and describe new records and species in a taxonomic monograph; and 3) compare macroalgal-associated crab communities across host species and habitats. Initial collections and preliminary morphological examinations have revealed 49 species of crabs inhabiting macroalgae in Guam, including two presumptive new species and ten new records. These preliminary findings indicate that Guam’s macroalgae is a source of undocumented biodiversity in need of further study.

Exploring microbiome-parasite interactions in North American bighorn sheep populations

Sakshi Nulkar, Holly Arnold, Robert Spaan, Claire Couch, Clint Epps, Justin Sanders, Johannie Spaan, Marci Witczak, Anna Jolles, Brianna Beechler

How gut microbiomes affect host physiology is relatively understudied in fragmented wildlife populations that are imminently threatened by infectious diseases. We explore 16s gut microbiomes of North American bighorn sheep (Ovis canadensis) in southeastern Oregon. This region historically experienced complete extirpation of bighorn sheep, and current populations are established from translocations and natural dispersals since 1954, forming a naturally fragmented metapopulation. Currently they are threatened by Mycoplasma ovipneumoniae, an infectious pathogen that severely affects their survival. Studying host-microbiome dynamics can uncover population-level patterns, especially since ruminant gut microbiomes play an important role in immune function and physiological resilience.

We collected 372 fresh fecal samples from eight sheep populations over five months in 2018 (April-August). These were used for 16s, 18s and ITS2 sequencing, and paired with simultaneously collected sheep-specific data for mortality and genetic diversity. We also calculated NDVI as a measure of forage availability.

Using microbiome community analyses, we describe how gut microbial diversity reflects host genetic and environmental heterogeneity. Preliminary results show microbial diversity and richness differ significantly between populations, and associate with NDVI and ewe population sizes. We will also use internal parasite data with 16s data to explore if microbial composition links with parasite groups and reflects differences in parasite pressure. These findings will inform future research into how gut microbiome communities may change when parasite pressure is experimentally removed.

Exploring an antennal premotor circuit for active sensor control in Drosophila

Olivia Nunn, Marie Suver

An animal’s nervous system enables it to detect and respond to stimuli to navigate its environment. To enhance sensory acquisition, animals can actively position sensors, altering how they extract information from the world. However, active sensing, and movement in general, produces stimuli that feeds back onto these same sensory systems – requiring mechanisms for integrating predictive motor signals with externally-generated sensations. Despite the importance of these mechanisms for guiding coordinated behavior, the cellular and circuit basis of sensation and motor control during active movements are not fully understood.

The Drosophila antennae are actuated by a set of four muscles at their base and house the largest mechanosensory organ in the animal, which enables active sensing. Previous work identified a class of antennal mechanosensory interneurons that contribute to an afferent sensory pathway responsible for the linear encoding of wind direction, but connectomic data suggest they are part of a larger antennal premotor circuit, suggesting a dual role in sensory and motor processing.

To measure the influence of mechanosensory input during active movements, I combine whole-cell patch clamp electrophysiology and machine-learning assisted antennal tracking to record changes in neural activity in the presence and absence of mechanosensory input in behaving flies. Together, this work aims to uncover the functional logic of a cell type encoding sensory and motor information, and how it contributes to active sensor control.

Nest site choice and nestling size in a long-term tree swallow dataset

Kanene Nwokeji, Patricia Jones, Liam Taylor

Tree swallows, Tachycineta bicolor, are opportunistic feather foragers who construct nests using the molted plumulaceous feathers of other birds. Feather lining in nests retains heat at higher rates and creates a thermodynamically stable environment inside the nest. Previous studies have shown that hatchlings raised in well-lined nests have higher masses and wing chord measurements pre-fledging. Studies have also shown that nests closer to

shores have higher feather counts. On Kent Island, New Brunswick, we used a long-term tree swallow dataset that monitored nests, adults, and chicks over the span of 29 years to evaluate patterns in nest site choice and nest success. We tested whether adults nest closer to shore for access to the molted feathers of a breeding gull colony. We found that nest site choice was not related to nest distance from shore; additionally, nestling wing chord and mass at 12 days was not related to distance from shore. Using nest feather counts from 2025, we found a nonsignificant negative trend between feather count and nest distance to shore. Measurements at 12 days were not related to number of feathers. Kent Island's widest point is a quarter mile, and we consider that tree swallows nesting on narrow offshore islands among breeding gull colonies encounter unique feather availability compared to mainland nesting sites.

Zebrafish neuroanatomy: a methodological comparison of sectioning techniques in adult brains

Sara O'Brien, Brooklynn Mulholland, Dayna Hayes, Hannah Stewart

Zebrafish (Danio rerio) are a well-studied vertebrate model of development, behavior, and disease. The genome has been fully sequenced, making them a useful model for targeted gene manipulation to assist our understanding of a variety of human diseases & cancers. They produce a large number of translucent embryos & undergo rapid development between fertilization & adulthood, allowing for easy investigation of both structure & function across development. Adults have well-defined behavioral characteristics and are utilized as behavioral models in evaluating aggression, anxiety, learning, & motivation. Morphologically, adult zebrafish offer distinct neuroanatomical features & region differentiation (Kenney et al, 2021). Though brain sectioning protocols have been well articulated in embryo & larval stages using embedded techniques (exploiting the benefits of more malleable bone structures), the adult techniques have traditionally relied heavily on non-fixed tissue approaches such as mRNA and ELISA to avoid tissue loss. Our current project develops a sectioning method in adults utilizing fixed tissue; specifically comparing whole-head vs. brain-excision soft tissue sectioning. We reveal that leaving the brain in situ in the skull during sectioning protected against distortion, tearing, and tissue loss, which was more common in excision techniques. Additionally, the whole-head method allows for faster processing & easier neuroanatomical tissue identification with samples that can readily be stained to explore target proteins in specific neuroanatomical regions.

Exploring microplastics in a flock of migrating songbirds: cedar waxwings (Bombycilla cedrorum)

Sara O'Brien, Katie Wheeler, Brian Walker, Andrew White, Brianna DiMaggio, Karen Powers, Matthew Close, Jamie Lau

Microplastics (MPs) are a worldwide pollutant that has been studied extensively in marine and aquatic environments. However, our group had the unique opportunity to explore microplastic pollution in a terrestrial context via opportunistic sampling of Cedar Waxwings (Bombycilla cedrorum) after a mass mortality event. Working in biosafety cabinets to decrease the risk of MPs cross-contamination, we dissected the upper and lower gastrointestinal (GI) tract of 22 individuals and flushed the lower GI tract (post-gizzard to cloaca) with triply-filtered physiological saline to collect contents. Gut flush samples were then taken through steps to digest biological materials, float MP fragments and fibers, and filter the samples to collect possible MPs. Visualizing MPs on filters allowed us to categorize fibers and fragments by shape, size, number, and color to explore the possibility of microplastics. This work will allow us to better understand the presence of MPs pollution in a sample of migratory songbirds, adding to a greater understanding of MPs presence in terrestrial environments.

Responses to shifting seasonal variation in tropical poison frogs

Lauren O'Connell, Shirley Serrano Rojas

Climate change is expected to alter rainfall patterns and the timing of seasonal events in tropical rainforests, potentially disrupting reproduction, resource availability, and species interactions. Yet, we know little about how tropical ectotherms adjust their behavior and physiology to cope with seasonal variation. We investigated these seasonal adaptations in four poison frog species with contrasting reproductive patterns: year-round breeders (Ameerega macero, Ameerega shihuemoy) and seasonal breeders (Allobates femoralis, Ameerega trivittata). Male space use varied seasonally for the seasonal breeders, with larger space use during the wet reproductive season reflecting the multiple demands placed on males during the reproductive period, including parental care, attracting mates, and territorial defense. We also found species- and sex-specific hormonal responses to seasonal variation, with testosterone and corticosterone changes in females associated with reproduction. Ongoing work includes identifying warm-sensitive neurons in anurans and investigating how these orchestrate behavioral changes across seasons and in concern with hormonal fluctuations. These preliminary findings suggest that tropical poison frogs exhibit nuanced, species- and sex-specific behavioral and physiological adaptations to seasonal variation. Although patterns are not uniform across species, they highlight the importance of reproductive strategy and ecological context in shaping adaptive responses. Understanding these adaptations is critical for predicting how tropical ectotherms may cope with climate change, particularly shifts in rainfall and resource availability that could alter reproductive timing and success.

Comparison of aquatic and terrestrial locomotion in salt marsh harvest mice and co-occurring rodents

Sharon O'Connor, Dulce Robles Martinez, Arianna Ramirez, Diego Sustaita

Salt marsh harvest mice are endemic to the San Francisco Estuary and presumably adapted for scansorial and aquatic locomotion to traverse their regularly inundated marsh habitat, which they share with congeneric western harvest mice and invasive house mice. Here we compare hindlimb kinematics of aquatic and terrestrial locomotion to determine if salt marsh harvest mice are more tailored to wetland environments in comparison to other species. We expect that salt marsh harvest mice will show greater behavioral flexibility between aquatic and terrestrial environments than the other two species, given their comparatively longer history in the San Francisco Estuary. We used high-speed footage of both species to calculate velocity, stride/stroke variables (frequency, length, phase durations) and hindfoot angular velocities for the same individuals performing both terrestrial and aquatic locomotion. Preliminary data has shown that the salt marsh harvest mouse has a higher swimming velocity with a lower power phase duration, compared to a lower terrestrial velocity with a higher stance phase duration, which is also characteristic of other semi-aquatic species. We also found stride/stroke variables and angular velocities were uncorrelated between environments, suggesting the behaviors are independent. Here we explore these patterns in co-occurring species to determine their ranges of locomotor flexibility. Our goal is to understand the ability of the salt marsh harvest mouse to persist in its changing wetland environment through its locomotor adaptability.

The skin of manta rays: three-dimensional analysis of denticle morphology

Jack O'Donnell, Meaghan Sorce, George Lauder, Julia Chaumel Cerda

Elasmobranchs (sharks and rays) possess dermal denticles embedded in the skin, thought to provide both hydrodynamic and defensive benefits. While shark denticles have been studied extensively, data on ray denticles (particularly in large pelagic species like the giant manta) remain scarce. Challenges in studying manta skin include limited sample availability and the protected status of these animals. Using preserved specimens, we characterized the 3D morphology, volume, and density of denticles in the head region of Mobula birostris (giant manta) and across the body of Mobula hypostoma (lesser devil ray). Denticle features varied significantly both within and between species. In M. hypostoma, denticles were small, sparsely distributed, had a spiky morphology, and are often embedded beneath the skin surface which results in a smooth skin texture. In contrast, M. birostris exhibited large, stellate denticles covering the head and tail. Denticle morphology also varied regionally: they were smaller and denser in the frontal lobes of the head, and larger and more stellate in the tail. These findings highlight the diversity of dermal denticle structures among pelagic rays and suggest species- and

region-specific functional roles. Additionally, denticle morphology may serve as a useful diagnostic feature for identifying tissue samples in both scientific and conservation contexts.

Frequency of wing vein defects in two species of periodical cicadas

Charles O'Keefe, Jake Socha, Frank O'Keefe

Periodical cicadas (genus: Magicicada) are remarkable for their ability to emerge in great numbers after long residence underground, with emergence events showing prime number periods of 13 or 17 years. The adult stage is relatively short (~6-8 weeks). It is unclear if these factors constrain wing venation patterns, which are important both for the mechanical design of the wing and for circulatory patterns of flow within the veins. Here, we report on the incidence of defects in the wing veins of two species of periodical cicadas, M. septidecula from Brood XIV in West Virginia, and M. septidecim from Brood XIII in Illinois. This study utilized the transient superabundance of each brood to collect large numbers of adult wings from both species. Image analysis reveals that defects are common, with 9% (M. decula; n=190) and 26% (M. decim n=180) of wings showing at least one vein defect. The difference between the species is highly signifcant ($p < 0.0001$), although the cause of this difference is unknown. The high level of vein variability in both species is surprising given that the stereotypical cicada vein pattern arose in the Jurassic and appears highly conserved in extant clades. One potential explanation for the high observed error rate may be a release of selective pressure on wing shape resulting from Magicicada's unique reproductive strategy.

Methods for measuring dimensionality compression and eigenvalue decay in phenotypic matrices

Frank O'Keefe

In 1974 Van Valen introduced his concept of phenotypic 'tightness', a concept with two components. Presented here are methods for characterizing both aspects of Van Valen's tightness: the strength of phenotypic covariance, and the amount of dimensionality reduction. These metrics are the slope ratio for measuring the steepness of the eigenvalue decay of a phenotypic covariance matrix, and the compression ratio for measuring dimensionality reduction in a phenotypic covariance matrix. These methods allow clear characterization of both aspects of phenotypic integration, namely the steepness of the eigenvalue decay and amount of dimensionality reduction. They are also dimensionless, a required property for any metric that proports to be comparable among disparate matrices. These methods are demonstrated on three very similar sets of phenotypic landmark data from the jaws of the dire wolf, the sabretooth cat, and coyotes from West Virginia. Methods for combining covariance and dimensionality in a single metric are explored, but are shown to be undesirable because they confound the two aspects of integration. The sample of modern coyotes is found to be much more integrated than the other two, both in dimensionality and in covariance. These analyses illustrated that the compression ratio is a sensitive measure of dimensional integration. The slope ratio also clearly differs between taxa, but it's partial dependence on the compression ratio leaves its interpretation as an avenue for further study.

Investigating the role of antennae in orientation and magnetic sensing in spiny lobsters

Elizabeth O'Melia, Hazel Havens, Kenneth Lohmann

Animals from diverse phyla can detect and use the Earth's magnetic field to guide themselves through their environment. Caribbean spiny lobsters, Panulirus argus, are one such species that is sensitive to the Earth's magnetic field. Spiny lobsters undergo seasonal mass migrations to offshore, temperature-stable waters and exhibit homing after displacement. Little is known, however, about how lobsters sense magnetic fields and whether antennae might play a role in orientation behavior. Here, we investigated a possible relationship between antennae, orientation, and magnetoreception. We analyzed videos of a previous orientation assay during two different field seasons in which lobsters either received or did not receive a strong magnetic pulse known to disrupt magnetic orientation behavior. During two identified locomotory behavioral states, directed and undirected movement, we calculated the antennal posture by measuring the angle from the body axis to each antenna. We performed statistical analyses to correlate antennal posture with treatment group and behavioral state, with a view toward determining whether antennae play a role in spiny lobster orientation and magnetoreception.

Every color, everywhere, all at once: Opsin genotype–phenotype maps and evolutionary repeatability

Todd Oakley, Seth Frazer

Predicting evolutionary outcomes is a central challenge in biology, with implications for vaccine design, bioengineering, and responses to anthropogenic change. A powerful framework for studying evolutionary repeatability is provided by opsins, light-sensitive proteins underlying vision. Opsins' sensitivity to different colors evolved repeatedly across animal lineages, and numerous published studies have identified mechanistic links between color shifts and amino acid changes. Yet these findings were scattered across a fragmented literature, preventing systematic evaluation of evolutionary repeatability. By synthesizing decades of functional studies into predictive machine learning models for evolutionary simulations, we show that opsin spectral tuning is both constrained and repeatable. While sequence context sometimes imposes path dependence, mutations of large effect also often recur predictably across simulated lineages. These results highlight how path dependence and determinism interact to shape evolutionary outcomes. By mapping the opsin multiverse of "every color, everywhere, all at once," we improve understanding of how chance and necessity intertwine to shape the repeatability of evolutionary pathways.

Hurry up and fail: kinematic determinants of prey capture success in salamander tongue projection

Jeffrey Olberding, Jahnita DeMoranville

Many predators rely on fast movement to capture prey before an escape can be initiated. Plethodontid salamanders use high-speed tongue projection to catch prey using one of the fastest movements of any vertebrate. Despite this impressive performance, salamander often fail to capture their prey even under highly favorable conditions. We hypothesized that prey capture success was dependent on the kinematic performance of tongue projection. We predicted that successful prey capture would result from tongue projections with high tongue projection velocity and shorter tongue projection distance, compared with unsuccessful prey capture attempts. We also predicted that prey capture in thermally robust, elastically powered tongue projection would show a large kinematic difference between successful and unsuccessful attempts, and that these patterns would be unaffected by changing temperature. We recorded the feeding behavior of Plethodon mississippi and Eurycea longicauda using high-speed video and extracted kinematics from digitized video. Salamanders were filmed on a temperature-controlled plate from 5 to 25 C at 3000 fps while attempting to feed on flightless fruit flies.

Distinct heat induced gene expression profiles in related coral species

Daniel Olivares-Cordero, Carly Kenkel, Line Bay

Coral reefs are under threat due to increased ocean temperature. Coral form symbiotic relationships with dinoflagelletes from the family Symbiodiniaceae and the breakdown of this symbiosis leads to coral bleaching. In this study, we utilize legacy samples from a time-course thermal stress experiment on three pairs of sister taxa: Acropora milepora-Montipora aequintuberculata, Galaxea acrelia-Galaxea astreata, and Porites lobata-Gonipora columna. Replicates of each species were exposed to the same ambient temperature (28°C) and heat stress temperature (32°C) for 17 days, with three sampling timepoints at Day-1, Day-3 and Day-17 post heat stress. We used Tag-based RNAseq to assess expression responses while ITS2 amplicon sequencing was used to assess symbiont community differences. First we found that each species gene expression response to heat stress was distinct with little overlap in gene level response. This is contrary to the expectation that there would be a general response to gene expression due to heat stress in all six species. Second, we

expected symbiont community assemblage to differ across species and time-points as shuffling of symbiotic partners may occur as a result of heatstress. Lastly, verified symbiont community identities, will allow us to look at their gene expression patterns as well. Overall, this project benefits from understanding the shared transcriptomic responses of evolutionarily related coral-symbiont species pairs, and will increase our understanding of their shared response to heat stress.

Vitamin D deficiency and recovery in a songbird

Christopher Olson, Jonathan Lo, Maile McSwain, Kingston Chartier

Nine months following establishment of an indoor population of zebra finches, birds developed symptoms characteristic of vitamin D deficiency (VDD), including feather loss and thin-shelled eggs. To test the deficiency hypothesis, we measured the major circulating form of vitamin D, 25-hydroxyvitamin D3 (25(OH)D), in adult finches (n= 6 females, 7 males) prior to initiating light therapy. We then placed Acadia BIRD HO T5 full spectrum UV-B fixtures at a distance of 0.5-1.5m and provided light therapy 2 hr/day. Serum 25(OH)D was measured on days 7 and 21 following the start of light therapy. Serum samples collected from the ulnar vein were used in vitamin D ELISA and magnesium and calcium assays. After 3 weeks 25(OH)D increased 24% from 12.6 ng/dL to 16.6 ng/dL. Interestingly males had higher serum 25(OH)D levels compared to females. All the birds had missing feathers and exposed skin at day 0, but by day 21 all had markedly improved feather plumage. Serum calcium and magnesium levels remained unchanged over the 3 weeks, suggesting the VDD was not severe enough to produce hypocalcemia. Artificial UV-B exposure is currently not recommended in guidelines of housing laboratory birds, but future standards should consider artificial light therapy if natural light exposure is unavailable. Further work to establish baseline vitamin D and mineral levels in healthy songbirds is needed.

Environmental influences on nuptial tubercles and body morphology of male cyprinids (Cyprinidae)

Emily Olson, Kassandra Ford

Nuptial tubercles are keratinized structures that develop on the heads and bodies of male minnows (Cyprinidae) during breeding season. While their functional role is not fully understood, tubercles are often associated with conspecific interactions, spawning behaviors, and mate recognition. Environmental conditions often drive phenotypic variation, and we hypothesize that nuptial tubercle dispersal and allometry may differ across habitat types. In this study, we will examine whether tubercle dispersal patterns and body morphometrics vary between high-flow, low-turbidity lotic habitats and low-flow, high-turbidity lentic habitats. We will measure standard length, body depth, head width, and record the number and spatial distribution of tubercles across the head and body. We predict that males from high-flow, low-turbidity habitats will exhibit larger and more widely distributed tubercles, where visual signaling and physical interactions may be more important. In contrast, males from low-flow, high-turbidity habitats are expected to show reduced tubercle expression and a more restricted distribution, with potentially deeper bodies adapted to slower-flow conditions. By testing these hypotheses, we aim to explore how environmental variation shapes the development, dispersal, and maintenance of secondary sexual characteristics in freshwater fishes.

Specialized skull shape evolution based on burrowing mode in worm lizards (Amphisbaenia)

Maxwell Olson, Philip Bergmann

The shape of the skull characterizes many vertebrate clades, often reflecting specializations in functions like feeding or sensory systems. The amphisbaenians (worm lizards) are a clade of highly derived burrowing lizards with a diverse array of skull shapes specialized for head-first burrowing. Amphisbaenians have four burrowing phenotypes, each associated with an external head shape and burrowing behavior. The ancestral phenotype is the most generalized, with a rounded head driven forward to extend and expand the burrow. The other three phenotypes are further specialized relative to the ancestral type, using dorsoventral, lateral, or twisting motions during burrowing and with head shapes specialized for each behavior. Two of these phenotypes have evolved convergently within amphisbaenians: three times for the “shovel-headed” form and seven for the “keel-headed”. However, despite similar external head shapes, there is variation in the underlying skull morphologies of convergent forms. We used a high-density 3D landmark-based geometric morphometric approach to robustly quantify skull shape and reconstruct cranial evolution across the Amphisbaenia, sampling 126/202 described species including all genera and six additional fossil species. Here, we test the hypothesis that skull shape has evolved according to burrowing behavior in amphisbaenians. We predict that species will group by burrowing behavior rather than family on major principal component axes. We also predict Ornstein-Uhlenbeck models with groupings by burrowing behavior to best fit skull shape evolution in amphisbaenians.

Endogenous and exogenous metabolites in dolphin semen

Dara Orbach, Jacquline Rich, Gisele Montano

Endogenous compounds (e.g., hormones) and exogenous compounds (e.g., contaminants) can act independently or together to modulate semen quality and affect reproductive health. No studies have explored the presence of hormones or contaminants in cetacean (whale, dolphin, and porpoise) semen, although endogenous and exogenous compounds have been assessed in blubber, blood, and urine. To establish baseline data on metabolites in common bottlenose dolphin (Tursiops truncatus) semen, samples were voluntarily provided by four sexually mature males in managed care. Sperm concentration, viability, motility, and kinematics were assessed. Endogenous and exogenous metabolites were identified in semen and sperm-free seminal plasma using ultra-high performance liquid chromatography coupled with Orbitrap Fusion Tribrid mass spectrometry. We detected 1,124 metabolites in dolphin semen and seminal plasma. Metabolite variability was primarily attributable to differences in matrices and individuals but not collection date. A targeted analysis confirmed the detection but not quantification of 6 hormones and 8 contaminants. Metabolites were assessed for correlations with semen quality to understand mechanisms of changes in fertilization potential. The detection of contaminants in bottlenose dolphin semen is congruent with other tissue matrices and increases species-specific knowledge of reproductive health. We recommend assessing semen metabolites in many animal species to determine the pathways and scale of environmental contaminant effects on fertility.

Fifty shades of blue: convergent evolution of color patches in coral reef fishes

Rosamari Orduna, Lauren Sallan, Michael Alfaro

Coral reef fish display some of the most eye-catching colors and color patterns amongst all vertebrates in the world. One of the most striking features of reef fishes is the widespread convergence of color patches across major families, yet surprisingly little is understood about the mechanistic and functional basis of this convergence. Blue color patches provide a rich system for investigating questions about these colors. Blue patches are present in most of the iconic families of reef fish including labrids, surgeonfishes, damselfishes, and mandarinfishes. Blue coloration often arises structurally via iridophores containing guanine crystals which scatter short wavelength light. In contrast, “true blue” pigments (via cyanophores) are known only from a small number of callionymids. To better understand the relationship between the arrangement of structural and pigmented elements in the skin and the colors they produce, we examined the microstructural arrangement of iridophores and pigmented cells in blue patches from six families of reef fishes. We also measured the reflectance of these patches using an imaging hyperspectrophotometer. Our results provide a foundation for understanding the nature of repeated convergence of color in reef fishes.

Algal genera are not driving differences in Exaiptasia Diaphana’s thermal resistance

Jasmine Orea, Sophia MacVittie, David Smythe, Kaden Muffett, Emilia Sogin

Climate change, including increases in ocean temperatures, is causing harm to countless marine species. Cnidarians, including corals and sea anemones,

rely on dinoflagellate algal symbionts that live within their tissue. They produce energy and carbon that is transferred to its cnidarian host to meet its own nutrition needs. However, when cnidarians experience temperature stress, they expel their algae, which results in bleaching. Here, we use the model sea anemone Exaiptasia diaphana (Aiptasia) to investigate how different genotypes respond to temperature stress. We hypothesized that some aiptasia with previous exposure to high temperatures are better adapted to resist bleaching in thermal stress. We collected aiptasia from multiple sites along a thermal gradient in the Florida Keys. Individuals were exposed to either 29°C or 34°C for six weeks to simulate a thermal stress event. Not all aiptasia bleached at the same time point, with some even initially bleached but later returning to normal. To test if this adaptation is the result of aiptasia associating with different algal genera, we performed a DNA extraction followed by a qPCR to reveal the algal type and amount present. In all samples we observed dominant levels of Symbiodinium and low levels of Durusdinium, indicating that algal type is not the driving factor for the different temperature resistance. Future steps include using extracted RNA for transcriptomics to investigate host-gene expression.

A tight spot: Roosting in recesses physically restricts bat evolution.

Andrew Orkney, Jeanne Augustin, Beyonca Akers, David Boerma, Brandon Hedrick

The sternum plays a focal role in bat flight, as the origin of powerful pectoral muscles responsible for down-stroke. Yet, while sternal evolution and its relationship to locomotion has been explored extensively in birds and their maniraptoran antecedents, these questions remain under-explored in bats. Here, we present a quantitative dataset of 3D sternal shapes of 70 bat species representing 60% of bat familial diversity and a wide repertoire of ecological niches. We explore the relationship between sternal evolution and a detailed suite of ecological descriptions. Our analyses show that bat sternal shapes differ strongly between families, but that there are some conspicuous outliers. Further investigation reveals that while many bats nestle in tight refuges, such as rocky crevices, these outliers roost in open environments such as among tree branches or suspended from capacious cave ceilings. We conduct a Brown-Forsythe test and compare Early Burst and multiple rate Brownian motion models, demonstrating that sternal evolution is more variable in free-roosting bats and has evolved at a more rapid pace. We suggest that roosting in confined spaces represents a literal physical constraint on thoracic skeletal evolution in bats, and explore the significance that the relaxation of this restriction may have had upon body size evolution.

Linking external traits to internal anuran skin features

Leah Ormaechea, Molly Womack, Marisol Hamada

Anuran skin is very diverse and has a variety of roles, ranging from protection, to camouflage, to respiration. In order for cutaneous respiration to occur, the skin must be moist. However, frogs thrive in many ecologies, including arid desert environments. This research focuses on how histological features of anuran skin such as glands, layer thickness, and the EK layer are associated with ecology, body size, and skin texture. Skin samples were collected from numerous species, embedded in resin, and stained before being photographed. Layer thickness as well as skin and gland area were measured using Fiji. Skin texture was quantified using gel profilometry. Our results indicate that skin thickness had a positive correlation with body size. Additionally, aquatic species had a thicker epidermis than most other ecologies. However, internal skin features had little to no correlation with external skin texture measures, such as roughness. While some internal skin features predictably vary with body size and ecology, skin texture on its own is not a significant predictor of internal skin features.

Muscles, mitochondria, and bioenergetics of division of labor in bumblebees

Quinton Orr, Amy Toth, Ryan Weaver

The non-reproductive activities within social bee colonies are divided among groups of workers and are broadly classified as working within the nest or foraging outside the nest. From a bioenergetics perspective, foraging is a comparatively more demanding activity which requires prolonged and frequent use of thoracic muscles during flight. However, detailed examinations are lacking in bumblebee bioenergetics across worker classes. Here, we use high-resolution respirometry to generate bioenergetic profiles of Bombus impatiens flight muscles across ontogeny and across worker types (foragers versus non-foragers). Comparing foragers to non-foragers, we found that flight muscles of age-matched bees that spent any time foraging had higher metabolic rates than bees that remained in the nest. We also quantified whole-body reactive oxygen species (ROS) production – a potentially damaging byproduct of mitochondrial respiration. Interestingly, the average ROS production rate across worker types was similar, but variation within groups covaried with proline metabolism in non-foragers, but not foragers. In ontogeny comparisons, newly-emerged bees (day 0) showed primarily carbohydrate-driven respiration, whereas adults (day 16) relied primarily on amino acid-based metabolism, showing an age-related shift in substrate use of flight muscle mitochondria. These results open up new opportunities for understanding how bioenergetic demands and constraints may shape behavior, social roles, and the structure of animal groups.

Early life parasitism and developmental trade-offs in European Starlings

Peyton Ort, Joseph Casto

Parasitism can force developing animals to trade off short-term survival against long-term health or reproduction. In birds, chronic immune activation against parasites—such as the produce of reactive oxygen species—can impair growth. We investigated how the blood-feeding Northern fowl mite (Ornithonyssus sylviarum) influences the growth and immune-system development in nestling European starlings (Sturnus vulgaris). During the breeding season, nests were randomly assigned to either a control group or a miticide treatment group to reduce mite loads. We monitored nestling growth, collected blood samples at defined time intervals and quantified mite abundance before hatching, during rearing, and after fledging. Preliminary results show significant differences in mite-load between treatments and indicate that both mite load and nestling age predict hematocrit levels. Ongoing immunological assays will test whether nestlings facing high parasitic stress prioritize immune investment over growth, or if these nestlings compensate for lost resources by maintaining growth rates. These findings will improve our understanding of how early-life parasitism shapes developmental trade-offs in wild birds.

Vortex shedding enables tiny water skaters navigate strong currents

Victor Ortega-Jimenez, Andrew Ayala-Bernal

Water skaters (Microvelia spp.) are millimeter-sized insects known for their ability to speed-skate across the water's surface in short, rapid bursts. Despite their limited leg-based propulsion, these bugs can be found in environments dominated by fast-moving currents, where flow speeds far exceed their own sprinting capabilities. Moreover, natural streams are inherently unsteady: objects such as rocks, branches or other semi-submerged bluff bodies frequently disrupt the interfacial flow, generating wakes of counter-rotating vortices known as von Kármán vortex streets. Given that Microvelia bugs are frequently challenged to navigate through these eddies, we examine how vortex shedding produced by an artificial cylinder affects their locomotory performance. We discovered that individuals skating along Kármán vortex streets are able to overcome the current and rapidly reach the cylinder. In contrast, they are unable to do so in unperturbed flow conditions. Even individuals that suddenly stop stroking can be able to move passively towards the cylinder if they reach the recirculating zone. Our results suggest that vortex shedding enables these tiny water skaters to move rapidly across fast-flowing streams with reduced locomotory effort.

Drivers wanted: what controls evolution?

Guillermo Orti

Comparative and evolutionary biologists interested in explaining certain patterns observed in nature frequently ask, “what is driving the evolution of these traits?” For groups with many species they ask, “what is the driver of speciation?” When trying to understand amazing levels of phenotypic diversity they ask, “what are the drivers of diversification?” In most cases, the studies are based on a time-calibrated phylogeny for the group of interest and additional data on the organisms themselves, their habitat, paleo-climatic conditions, or other organisms that interact with the focal group. But the increasingly used word “driver” in the scientific literature to explain cause-effect scenarios of evolutionary diversification patterns is at best misleading and generally incorrect. Such metaphors can be deeply misleading by suggesting that certain factors (extrinsic and intrinsic) do become “”agents”” that promote or obstruct speciation or diversification. This teleological narrative is not consistent with our knowledge of natural processes. The effect of temperature or inter-specific competition, for example, may affect long-term evolutionary trends that could be detectable as identifiable patterns in phylogenetic analyses. They may have had an impact at some point in time on the process of diversification that results in the pattern we see today. But they are never “drivers.” Correlation cannot be equated with causation. Phylogenetic comparative methods may identify models or correlations that best explain the data, but never drivers.

Anthropogenic and natural noise on the Preserve at Vassar College

Susanna Osborne, Megan Gall, Zahara Goldkin

Modern soundscapes are composed of anthropogenic and natural (biophonic) sounds. In temperate forests, we often find cyclical variation in the biological sources of sound across the day and across seasons. Human activity, and thus anthropogenic noise, also varies temporally, although daily and seasonal patterns may differ from those of biological sound sources. Anthropogenic noise can impact animal communication through several mechanisms, including masking, cognitive processing deficits, and stress responses. The timing and amplitude of anthropogenic noise relative to communication signals likely impacts which, if any, of these mechanisms negatively affect communication. Here, we used time-synced audio recordings and sound level measurements to investigate the relative contribution of anthropogenic and biological sources to the overall sound level at a mixed hardwood forest located within a suburban ecological preserve. Additionally, we investigated the relative change in anthropogenic and biological sound sources during fall and summer to determine how the contribution of anthropogenic noises vary seasonally. We found that across seasons, individual anthropogenic noise events had significantly higher average sound pressure levels compared to natural noise events. We also found that the overall sound pressure level was significantly higher in fall than in summer. While season and sound type were both significant predictors of overall sound level, the interaction between season and noise type was not.

Molluscs as the star in education and outreach across various communities and ages

Teresa Rose Osborne, Jingchun Li, Jann Vendetti, Elizabeth Davis-Berg

As malacologists, we know that molluscs can be the star of educational and outreach work, though they are sometimes overlooked. We have also discovered that many educators have few resources to create mollusk-themed activities for formal and informal education. Herein we present themes and activities based on a symposium at the 2024 American Malacological Society (AMS) Annual Meeting, titled “Molluscs in Education and Outreach to Underserved and Indigenous Communities”. The immense biodiversity and breadth of habitat of the Mollusca allow for myriad taxa to be used to teach adaptation, variation, the need for conservation, and other topics relevant to biodiversity science, such as scientific nomenclature. We highlight examples of activities that can do this as well as others that can be language and cultural bridges to Spanish- and Chinese-speaking communities. We discuss how to approach activities in different communities (e.g. rural, urban, majority Indigenous) and with different age groups through community-centered programs, multilingual educational tools, and accessible, culturally relevant outreach strategies. Our examples will include activities for children through adults at various price points starting at free.

Ocean acidification affects red abalone shell biomechanics in seaweed co-culture

Geoffrey Osgood, Chase Ebner, Roberto Cotlear, Scott Hamilton, Luke Gardner, Michael Graham, Maya deVries

Ocean acidification (OA) resulting from climate change has been shown to have negative effects on calcifying organisms, such as molluscs, by decreasing the availability of carbonate ions, making it more difficult to properly form shells. Conversely, algae can remove carbon dioxide from seawater through photosynthesis, increasing the local seawater pH, which possibly ameliorates the negative impacts of OA on molluscs. Animals raised in aquaculture systems may benefit from this buffering, as they experience increased stress from respiration that reduces pH compounded by increased population densities. In this study, we examined how the seawater buffering effect of algae in the context of current and 100-year projected ocean pH may impact red abalone growth, shell development, and muscle strength. We examined these questions using a co-culture system with red abalone (Haliotis rufescens) and red seaweed dulse (Devaleraea mollis). Specifically, we examined abalone in three treatments: ambient pH 7.9, pH 7.5 and pH 7.2 for 6 months, with 5 tanks per treatment (250 abalone per tank) and found that abalone in the pH 7.2 treatment were 33% smaller in terms of shell area and had 20% shorter shells that were approximately 33% weaker than abalone grown in ambient seawater. This study demonstrates that co-culture systems can provide a convenient and simplified model for larger ecological questions and are a potential solution to water quality problems facing the aquaculture industry.

A double triple threat: molluscan insulin evolution by gene duplication in nudibranchs

Kate Otter, Laurenzcia Cairo, Paul Katz

Insulin-like peptides (ILPs) in invertebrates have diverse roles, functioning as hormones, growth factors, and neurotransmitters. ILPs have undergone gene duplication events, allowing for subfunctionalization and entirely new functions. ILPs can be subdivided into distinct types based on the cysteine residues, and therefore disulfide bonds, in their A- and B-chains. In molluscs, three types of ILPs have been identified according to the cysteine motifs in their A-chains: 1) the ancestral type, which matches vertebrate ILPs; 2) ILP7, which is conserved across protostomes; and 3) molluscan ILPs (MILPs). Using BLAST searches across more than 60 gastropod and cephalopod genomes, shotgun sequences and transcriptomes and custom scripts to identify cysteine motifs in putative amino acid sequences, we found that gastropods have at least one duplication of the MILP gene, with an additional duplication present in nudibranchs. The nudibranch Berghia stephanieae has five ILP genes: an ancestral ILP, an ILP7, and three MILP subtypes. In situ hybridization chain reaction revealed that these ILPs are expressed in distinct, non-overlapping populations of neurons in the brain, indicating functional segregation. Thus, we identified new cell types in the brain of Berghia. These findings highlight the evolutionary diversification of ILPs within gastropods and lay the groundwork for studying the relationship between gene duplication and functional specialization.

Learning activities to queer biology

Kate Otter

Have you ever wanted to move beyond an “add queers and stir” approach (as coined by Rands, 2009) to diversifying biology? “Queering” a discipline means questioning assumptions, imagining new possibilities, challenging concepts of “normal” and “natural,” and resisting binary ways of understanding the world. Over the past five years, I have applied queer theory to biology instruction and invited students to use a queer theoretical lens in a variety of classes. This includes a first-year seminar called Biology but Make it Gay (offered in Fall 2022 and 2023), which challenged undergraduates to think critically about biology, especially animal behavior, from feminist and queer perspectives. The seminar was part of a scholarship of teaching and learning project that

examined how different activities centering feminist and queer perspectives shaped students' engagement with and sense of belonging in biology. I have also taught courses such as Biology of Social Issues and Introductory Biology, where I designed activities that queer core topics. In this presentation, I will share strategies and learning activities that have helped students deepen their understanding of the biodiversity of sex, explore multiple frameworks for thinking about sex, and engage with topics in cell biology and genetics that are often less straightforward to queer.

Light pollution, social context, and circadian disruption

Jenny Ouyang

Artificial light at night (ALAN), a growing pervasive pollutant, disrupts physiological and behavioural rhythms across organisms. Social interactions play a significant role in shaping individual and group biological rhythms, but they are often overlooked in the context of environmental stressors, such as ALAN. We explore how dim ALAN affects zebra finches (Taeniopygia guttata) in social and isolated environments, examining behavioural, physiological and molecular rhythms. We found that social birds under ALAN had an earlier activity onset and greater disruption in hypothalamic and liver circadian gene expression than control or isolated counterparts under ALAN. Additionally, we found that activity onset correlated negatively with hypothalamic bmal1 and cry1 expression in birds exposed to ALAN. Within ALAN-exposed birds, there was a larger disassociation between central and peripheral clock gene expression for social birds than in isolated birds. However, rhythmic melatonin concentrations did not differ among treatment groups. We show that social interactions may exacerbate the effects of ALAN, which highlights the impact of social interactions on circadian regulation at a molecular level and a critical need to consider social contexts in biological studies.

Divergent predatory kinematics promote ecological divergence in sympatric Malagasy pelican spiders?

Mariela Oviedo-Diego, Hannah Wood

Pelican spiders are a Madagascan paleoendemic group characterized by elongated chelicerae that enable long-distance attacks. In some montane regions, multiple populations of Eriauchenus workmani coexist in sympatry despite limited gene flow, raising questions about trophic niche differentiation. These populations differ in size and potentially in head and cheliceral shape. We conducted a comparative study to assess whether muscle anatomy and strike performance differ across three sympatric populations. We analyzed cheliceral strike kinematics during prey capture using high-speed videography of n≈15 adults per population. We quantify linear and angular velocity and acceleration, as well as opening and closure times tracking cheliceral movements. To relate anatomy to function, we used micro-CT techniques of cephalic musculature (n=1 per population). Muscle architecture was modeled and size-corrected to estimate physiological cross-sectional area, proxy of isometric force. Videos revealed that pop1, with larger body size, exhibited slower chelicerae closing and lower linear acceleration than pop2 and 3. Similar patterns emerged for angular velocity and acceleration. Relative muscle volume (anterior medial inner, anterior medial, lateral anterior) and PCSA seem larger in pop3. The posterior medial muscle showed a similar volume across populations, but a greater PCSA in pop3. Our findings suggest a trade-off between body size and strike velocity, with a possible coupling of velocity and force. Such differences may influence trophic niche differentiation, thereby contributing to coexistence of these sympatric populations.

Moths forgo food in favor of flight-to-light

Avalon Owens

Artificial light at night can profoundly alter the behavior of nocturnal species, yet the fitness costs of these alterations remain mostly unknown. To understand whether the flight-to-light impulse diverts individuals away from fitness-related behaviors such as foraging, we developed a scalable monitoring system capable of simultaneously recording the feeding and flight-to-light behavior of Plutella xylostella moths over several days. We found that moths overwhelmingly preferred a UV light source to a sugar source at night and subsequently fed significantly more during the day than moths in control conditions. In documenting sublethal effects of artificial light on fitness, we add to the body of evidence demonstrating that light pollution poses a threat to the conservation of populations and species.

Locomotor compensation and performance enhancement after limb loss in sea stars

Yasemin Ozkan-Aydin, Olaf Ellers, Matthew McHenry, Amy Johnson

Locomotor robustness, the ability to maintain effective movement after injury or in challenging environments, can be a critical factor for animal survival. Sea stars are a compelling model for robustness, as they can move effectively despite losing limbs. To quantify the effect of limb loss on sea star Asterias forbesi locomotion, we compared the movement of intact (five-limbed) and four-limbed individuals, measuring their velocity over at least four trials by digitally tracking each animal's center of mass. Our analysis revealed that, despite a reduction in appendages, the four-limbed sea stars demonstrated a higher average speed (1.12±0.56 mm/s) than the intact group (0.87±0.44 mm/s). The density increased from 1307.4±238.4 kg/m3 in intact individuals to 1890±1124 kg/m3 in four-limbed individuals, a change possibly attributable to a redistribution of fluids that makes the remaining body more compact. This finding, combined with the negligible difference in submerged weight between the four-limbed (11.0±7.1 g) and intact (11.6±7.63 g) groups, suggests that the observed increase in average velocity is a result of locomotor adaptation rather than a simple reduction in body mass. This phenomenon illustrates a compensatory mechanism within the sea star's decentralized nervous system, where structural damage can trigger an effective reorganization of motor control, leading to enhanced performance. These findings offer valuable insights for the design of more robust, decentralized robotic systems.

The impact of passive anisotropic friction on the locomotion of modular, sea star-inspired robot

Yasemin Ozkan-Aydin, Martín Castillo Gonzalez, Abu Nayem Md. Asraf Siddiquee, Yuhan Zhu, Murvet Seyma Ertas

Sea stars (\textit{Asteroidea}) exhibit exceptional locomotive robustness, maintaining effective mobility even following severe peripheral injury or limb autotomy. However, the precise interplay between morphological parameters and the control system that produces this robust locomotion remains an open question. To investigate this relationship, we have built a robotic platform that embodies the modularity observed in sea stars. The platform consists of five compliant, cable-driven limbs that attach magnetically to the central body. This modularity permits easy limb reconfiguration to test different morphological arrangements. To increase propulsion, the limbs are covered with an artificial skin featuring molded silicone bristles. These bristles produce passive anisotropic friction, which is analogous to the adhesive and locomotive action of a sea star's tube feet. Empirical testing of various bristle arrangements revealed that bristle distribution is a critical parameter influencing locomotive efficacy. A single-limb module equipped with bristles along its entire length demonstrated a maximum forward velocity of ~5 mm/s. In contrast, a configuration with bristles concentrated solely at the distal tip was substantially less effective, inducing retrograde motion at ~2.6 mm/s. Multi-limb configurations produced intermediate velocities, with a four-arm arrangement achieving a maximum forward speed of 1.8 mm/s. This platform provides a physical model to systematically study the complex relationship between morphology and control in organisms with non-centralized nervous systems.

How heritable is food-conditioned plasticity in ciliated band length in sand dollar larvae?

Douglas Pace, Bruno Pernet, Darren Johnson

Most feeding larvae of echinoderms develop long ciliated bands (which serve as food-capturing structures) when reared in low-food environments, and short ciliated bands when reared in high-food environments. This phenotypic plasticity has been studied for ~40 years, but because of limits to replication imposed by traditional culture methods, the shape of this reaction norm and its sensitivity to additive genetic variance and maternal effects are poorly understood. We used a paternal half-sib mating design and a novel method of

rearing larvae in individual containers to describe the shape and inheritance of the reaction norm in larvae of the sand dollar Dendraster excentricus. Each of 20 males was mated to two females, and offspring from all crosses were exposed to the alga Rhodomonas sp. at concentrations ranging from 1000-10,000 cells/mL for four days. We used an animal model analysis to estimate genetic and maternal components of variation in body size and ciliated band length. Plasticity was strong, with a ~17% decline in ciliated band length with increasing food concentrations. Additive genetic variation (slope and shape of reaction norm) explained ~18% of variation in ciliated band length, while 13% was attributable to maternal effects. The reaction norm for larval phenotypic plasticity in D. excentricus thus seems likely to be moderately responsive to natural selection.

The relationship between mercury in soil and wing size of Pieris rapae museum specimens

Saanvi Padaki, Chloe Christen, Carly Jordan

The rise of large-scale manufacturing has increased soil mercury concentration. Given the non-degradable nature of mercury, its presence accumulates in soil and crops. Many insects, like Pieris rapae, a butterfly that feeds on crops in the Brassicaceae family, depend on nutrients absorbed by their food for proper development. We hypothesized that P. rapae from areas with higher soil mercury concentrations would exhibit smaller wing sizes due to developmental stress from heavy metal exposure. Using iDigBio, we obtained 66 digitized natural history museum specimen images from across the United States, collected between the years of 1970 to 2020. We then measured their average wing size using the digital tool, ImageJ. Afterwards, we used the United States Geological Survey (USGS) database to collect soil chemistry data. Utilizing Quantum Geographic Information System (QGIS), we plotted the butterfly specimens and extrapolated their corresponding mercury concentration percentile. Using a two-sample T-test, we found that the average wing size of the top 10 percent was smaller than that of the lowest 10 percent (p-value = 0.001). This supports our hypothesis, suggesting a relationship between the levels of mercury in soil across the United States and the wing size of P. rapae butterflies. Future studies exploring levels of mercury in crops of the Brassicaceae family and larval and adult stages of P. rapae could provide additional evidence to support this relationship.

Beauty turned hazard: the invasive rise of three ornamentals in North America via museum specimens

Sofia Pagan, Sierra Nunnery, Matt Johnson

Several characteristics of plant species influence whether they become invasive, including abundant seed production, extensive root systems, allelopathic chemicals, and self-fertilization. Many of these characteristics are shared by three invasive plants in North America: Ailanthus altissima, (Tree of Heaven), Linaria vulgaris, (Yellow Toadflax), and Lepidium draba (Whitetop). Among these three plants, A. altissima appears to have a smaller distribution than L. vulgaris though it has more invasive characteristics. We tested whether the Tree of Heaven is spreading more slowly in North America using herbarium and observational data of all three species from iDigBio and GBIF. We cleaned the raw data to retain specimens with verified dates and location information, creating a comprehensive dataset for each species.To estimate species ranges over time, we used Google Maps to plot a range distribution at 20-year intervals beginning with the initial specimen of each species. We used linear regression to estimate the rate of change for each species over the past 120 years. We found that the rate of change in the range of A. altissima was significantly lower compared to L. vulgaris, but not L. draba. These results provide insights into invasive species' spatial distribution, potentially guiding future control efforts by incorporating factors beyond invasive traits, such as regional climate conditions, habitat disturbance and human-mediated dispersal.

Antifouling and hydrodynamic properties of different surface topographies found in PNW fishes

Ellen Pak, Megan Vandenberg, Karly Cohen, Cassandra Donatelli

The diverse surface topologies of marine fishes serve many functions, including camouflage, intraspecific signaling, protection, and hydrodynamic advantage by drag reduction. Fish scales contribute to antifouling and hydrodynamic performance via micro- and nano-scale surface structures, augmented by a mucus layer with species-specific thickness. While these features co-occur in nature, the distinct contributions of surface topology to antifouling and hydrodynamics remain unclear. Insight into these interactions could guide designs of more efficient, bioinspired maritime technologies. Prior research suggests rougher structures and mucus independently improve antifouling, but decrease hydrodynamics. We used μCT and microscopy to characterize surface topologies of fishes collected in the Salish Sea, creating idealized 3D models spanning scale diversity. This included cycloid scales in surfperch (Embiotocidae), ctenoid scales in flatfish (Pleuronectoidei), and bony plates of poachers (Agonidae). In a hydrodynamic flume, models with and without an artificial mucus layer were tested to quantify effects of mucus and scale morphotypes. Models were submerged across two sites in the Salish Sea, Tacoma and Friday Harbor, with differing wave action to evaluate fouling. Images of surfperch and flatfish scales show prominent ring-like structures, but morphotypes vary by family. Flatfish exhibit both cycloid and ctenoid scales across the body, while surfperch are primarily cycloid. These microtextural differences may reflect family specific trade offs between antifouling and hydrodynamics.

Genomic selection patterns underlying bat craniofacial diversity using targeted sequence capture

Melina Palakal, Daniel Moats, Laurel Yohe, Liliana Dávalos

Diversification of craniofacial features facilitate the evolution of novel food-eating niches. Phyllostomidae is known for its diversity in craniofacial structures, mainly attributed to the different structural demands of consuming varying food sources, such as fruit or insects. A small number of genetic factors that influence structural features have been previously studied, such as the RUNX2 gene, but the major genetic correlates of these changes are not fully known. The purpose of this study was to investigate the genetic basis of bat craniofacial diversity through bioinformatic analysis of bait-capture Illumina sequencing data. We identified 67 craniofacial genes from a dataset containing 93 species of bats. Within Phyllostomidae, clades that evolved to fit different food-eating niches are expected to have experienced positive selection in certain craniofacial genes. By comparing the genes with the greatest recovery rates, five preliminary genes (FBN1, DCHS2, GLI3, RUNX2, BMP3) were selected for exploratory analyses. Combining assembly data across all genes revealed that an average of 69% of genes exhibited assembly. By aligning these genes across species, we can identify potential molecular changes that correlate with morphological adaptations in bat skulls and nasal cavities. In future work, we will apply dN/dS analyses to identify genes under positive selection and gain insight into the evolutionary signatures that are associated with structural changes.

A comparison among automated and manual morphometric methods for within-species shape discrimination

Alexandra Pamfilie, Natasha Vitek

The availability and variety of high-density, partially or fully automated morphometric methods have recently grown. These methods potentially have high discriminatory power, allowing for the detection and description of subtle variations in morphology. However, this power may not function as expected if it is applied to noisy data. Last year, we reported on mink (Neogale vison) mandibular shape variation in North America using one of these methods. We were able to describe some variation in shape within our sample, but found no biogeographic explanation for that variation, despite evidence in the literature for spatial structure. It is possible this null result is explained by many-to-one mapping of jaw shapes to the generalist diet. However, this result also provides an opportunity to compare the efficacy of different high-density morphometric methods in their application to a real, complex dataset.

Here, we analyze shape variation in a continental sample of American mink mandibles and compare the results among multiple methodologies. These include auto3DGM, a landmark-free approach, and DeCA, a landmark-guided approach. By performing these analyses on the same dataset, we are able to more clearly infer potential noise introduced in fully automated methods and assess the potential benefits of some landmark guidance. The comparison of these methodologies also clarifies the root cause of the lack of continental patterns of mandibular shape variation in mink.

Impact of oxygen availability on physiology and interactions of extremophile fish

Vishwa Pandya, Nicholas Barts

Along environmental graidents, interactions of populations of the same species may differ as a function of environmental parameters. Particularly in extreme environments, these populations can exhibit unique adaptations that allow them to survive harsh conditions that would be fatal to other organisms. Populations of Poecila mexicana, the Atlantic molly, live along a gradient of sulfur and non-sulfur waters, and fish in sulfidic conditions display distinct differences in their physiology and morphology compared to their non-sulfidic counterparts. Hydrogen sulfide (H2S) is toxic to most organisms and is known to interfere with respiratory function. Previous work in this system has focused on identifying the molecular and physiological mechanisms that underlie adaptation to sulfide-rich environments, however, low oxygen concentrations are also an added stressor in these types of environments. To determine the impacts of hypoxia on P. mexicana behavior and morphology, fish were placed under hypoxic conditions for one month, and changes in gill morphology, physiology, behavior, and the overall organism were measured. We expect to see plasticity in morphology and physiology with sulfidics and non-sulfidics, with changes to a larger extent in sulfidics. Future trials will include observing interactions of populations under hypoxia and normoxia. The goal of this study is to identify how physiological variation along environmental gradients alters intraspecies interactions, and analyzing said interactions may allow us to understand potential responses to changing environmental pressures.

Fish robotics Part 2: visual and pressure feedback for efficient station holding in non-uniform flow

Kundan Panta, Divya Ramesh, Yangfan Zhang, George Lauder, Bo Cheng

Fish use visual and pressure feedback to navigate complex flows and exploit wakes for energy-efficient station holding. To study these behaviors using a robophysical model, we developed the μBot (MUBot): a 20 cm-long, modular, four-segmented robotic fish with a flexible tail. Unlike most robotic fish, the μBot carries an array of pressure sensors, an inertial measurement unit, and proprioceptive sensing, enabling it to detect flow features and body motion in real time. Without actuation, the μBot could remain stationary in the low-pressure zones of some wakes, though less robustly than biological fish. We then tested two feedback control strategies to guide the μBot into and within these wakes. First, an overhead camera provided positional feedback to a proportional-integral-derivative (PID) controller that modulated undulation frequency for speed and body bending for steering. This allowed the μBot to consistently reach the wake's low-pressure zone, where little actuation was needed to hold station. Second, we tested whether navigation could be performed without vision, guided instead by onboard pressure sensing. To achieve this, we trained the μBot to incorporate pressure feedback through imitation learning (where motor control is learned from examples of successful behavior), enabling it to enter the wake and passively hold station with minimal actuation. Although less consistent than vision-based control, this result highlights the potential and biological relevance of flow sensing to achieve energy-efficient station holding.

Molecular cloning of putative Na+-K+-2Cl- cotransporter cDNAs in the copepod Eurytemora carolleeae

Yeaeun Park, Teresa Popp, Carol Lee, Catherine Lorin-Nebel, Peter Piermarini

The estuarine copepod, Eurytemora affinis species complex has shown rapid osmoregulatory adaptation to freshwater habitats around the northern hemisphere. Previous studies have found that genes encoding putative Na+-K+-2Cl- cotransporters (NKCCs) are some of the most differentially expressed ion transporter genes associated with invasion of freshwater habitats by E. affinis complex, but specific physiological functions and localization of NKCCs within the osmoregulatory organs are not known. The goal of the present study was to clone cDNAs of NKCC paralogs in E. carolleeae, the Atlantic clade of this species complex. Here we focus on NKCC paralog 2 (NKCC-2), which is known to be upregulated in response to freshwater adaptation. Using the rapid amplification of cDNA ends (RACE) on cDNA derived from a saline population of E. carolleeae we cloned two splice variants of NKCC-2 (NKCC-2a, NKCC-2b). The two variants were identical except for the alternative use of an exon composing the 5'-untranslated region, which extended the up-stream coding sequence of NKCC-2a, resulted in a predicted extension of the cytosolic NH2-terminal domain. The impacts of the alternative splicing on the functional and/or localization of NKCC-2 isoforms in the copepod remain to be determined.

Digestion and demography of introduced wall lizards from human-built and natural habitats

Brittney Parks, Lan Do, Devon Haley, Hayden Kelner, Meg McCarthy, Maya Mohanty, Gabrielle Plunkett, Dellen Roush, Tyler Williard, Lindsay Wolverton, Jasmyn Zimmerman, Bryan Juarez, Allison Litmer, Andrea Suria, Eric Gangloff

Introduced species pose serious threats to native biodiversity, but this risk is not uniform across habitats. Therefore, it is essential to quantify the ability of introduced species to persist in different habitats. The common wall lizard (Podarcis muralis), introduced from Europe in 1951, now thrives in urban areas around Cincinnati, Ohio, USA, but is also found in natural forested areas. To understand how wall lizards can persist in these different habitat types, we used capture-mark-recapture techniques over two years to estimate population size and demography between replicate human-built wall habitats and natural forested sites and found that lizards were dramatically less abundant in the forests. To link physiological processes to variation in reproductive rates and population size, we studied two aspects of digestion which we predicted would vary between habitats. Gut microbiome diversity, measured using 16S rRNA gene sequencing, did not differ between forest (N=22) and wall (N=89) lizards. In a lab experiment, lizards at cooler forest temperatures (N=13) ate less and digested slower, thereby assimilating less energy, compared to lizards at warmer wall temperatures (N=10) over a two-week feeding trial. By linking the population density and physiological ecology of common wall lizards among habitats, we show how integrative approaches can reveal the potential future establishment and spread of introduced species.

Hydra and seek: tracing opsin evolution and diversification

Rachel Parsons, Aide Macias-Muñoz

Opsins are G-protein coupled receptors that are central to photoreception across metazoans. Although their evolutionary origins predate the cnidarian-bilatarian split, opsins exhibit striking variation in number, structure, and expression across lineages. Cnidarians, and particularly Hydra, present an intriguing case study in opsin diversification due to extensive lineage-specific expansions, as shown here and absence of image forming eyes. Using newly available genomic resources, we revisited the opsins of three Hydra strains: Hydra vulgaris 105, Hydra vulgaris AEP, and Hydra oligactis. We hypothesized that all strains should have the same number of opsins and that they present with some introns, but found there was a slight difference in number of opsins between the three and that none of the opsins identified had introns. Opsins cluster primarily on the subset of chromosomes with conserved synteny disrupted by strain-specific duplications and rearrangements. Following the identification of molecular evolution, we looked at the expression of these

genes at the single-cell level. Using a publicly available cell atlas, we found 34 AEP opsins expressed in distinct cell types, including nematoblasts, neurons, and stem cells. Expression of selected genes was validated using hybridization chain reaction (HCR), which confirmed cell-type-specific localization. Together, these findings reveal rapid opsin evolution in Hydra driven by tandem duplication and retrotransposition, resulting in the potential for functional diversification.

"Choose Your Own Adventure" lectures as a teaching approach in a biology classroom

Gregory Pask

Telling the amazing stories in the sciences, from surprising discoveries to major technological breakthroughs, is one of the most effective ways to engage both students and the general public with the scientific process. In the classroom, a lecturer is often recounting these stories from the front of the class, which results in a less active, one-way bestowal of knowledge. Here I will share an approach I developed for my Entomology class, modeled after the popular "Choose Your Own Adventure" books from the 80's and 90's, where slides are written in the second person point-of-view and the class decides the next steps to take along the way. This talk will share examples in new species discovery and sterile insect technique, and also share how to format these slides in PowerPoint for a seamless and immersive experience. By gamifying traditional lecture content, students report a deeper understanding of the scientific journey, specifically the researcher's decisions along the way.

Cascading thermal resilience in the latch-mediated, spring-propelled snaps of snapping shrimp

Sheila Patek, Melody Young, Shengwei Lei, Tarik Burlingham, Sophie Hanson, Christopher Ouifiero, Sarah Longo

Springs are far less sensitive to temperature changes than muscle. While springs are often heralded for producing ultrafast movements, they are also important for ensuring consistent movements in ectotherms, especially in variable thermal environments. Alpheus heterochaelis snapping shrimp use latch-mediated spring actuation to propel ultrafast snaps which shoot cavitation bubbles. This species experiences annual temperatures ranging from 3-33°C in their temperate coastal habitats. Even so, they produce extremely fast snaps and cavitation bubbles throughout the year. To test whether dramatic changes in temperature impact their spring-actuated snaps, we collected a large dataset of snaps across five temperature treatments (12, 15, 20, 25, and 30°C). We measured the duration of spring-loading (a muscle-driven process), the duration of unlatching and spring propulsion, and peak snap velocity. We discovered a cascade of thermal resilience: temperature dramatically affected spring-loading duration (especially at colder temperatures), modestly affected the combined duration of unlatching and spring propulsion, and had no effect on peak snap velocity. This cascading reduction of thermal impacts means that A. heterochaelis can produce snap velocities sufficient to generate cavitation regardless of ambient temperatures throughout the year. These findings highlight how the multi-dynamic process of latch-mediated spring actuation not only serves as a remarkable pathway for energy control of ultrafast movements, but is also a key pathway for the evolution of thermal resilience.

Investigating fatal injuries in San Clemente Loggerhead Shrike prey through microCT

Abby Patterson, Diego Sustaita, R. Brandon Pratt

San Clemente Loggerhead Shrikes are predatory songbirds that uses unique tactics to subdue their prey, with their sharply pointed beaks and strong bite forces. Furthermore, they swiftly shake their vertebrate prey after biting down on their prey's neck, which may also cause a significant amount of damage to the cervical spine. To fully understand the damage that the Loggerhead Shrike imparts on its prey, micro-CT scans were performed on mice and lizards that have been killed by shrikes. The types of damage (fracture or disarticulation) and locations of damage along the vertebral column were then observed and scored. Following this, 3D models of the CT scans were generated, allowing for further visualization and downstream analyses. Many of the prey specimens analyzed were found with damages to the first three cervical vertebrae (atlas, axis, and C3), with few specimens showing damages further down the vertebral column. According to the AO spine reference classifications, the damages observed could be classified as "Type A" resulting from compression, or as "Type C" translational injuries resulting in separation of vertebrae, typical of motor vehicle accidents. We hypothesize that the strong bite forces of shrikes might account for the "Type A" injuries observed, while "Type C" injuries might be explained by prey-shaking behavior, and describe plans to test this using kinematic data from those predator sequences.

The development of light detection: Opsin gene expression in green anole lizard embryos

Florissa Patterson, Michele Johnson

All animals use proteins called opsins to detect light in their environment. Opsins are concentrated in ocular (eye) tissue, but also occur in tissues across the body (including brain, skin, gonads, and liver). The development and function of extraocular opsins remains largely unknown. In this study, we measured opsin expression in green anole (Anolis carolinensis) lizard embryos at two developmental stages. Lizard eggs were collected in a captive colony, and the embryos were dissected at 14 (n = 8) or 24 (n = 8) days post-oviposition. We extracted RNA from head and body tissues, synthesized cDNA, and used qPCR to quantify and compare expression of 9 opsin genes at the two developmental stages. Preliminary results have confirmed expression of vertebrate ancient opsin (OPN 1) in embryos of both stages. This research will contribute to our understanding of vertebrate development, offering insight to the mechanisms by which egg hatching occurs.

Linking precursor carotenoids to metabolized carotenoids used to color feathers in the House Finch

Sara Patton, Yufeng Zhang, Rebecca Koch, Matthew Toomey, Geoffrey Hill

Most species of birds that use red ketocarotenoids to color feathers use dietary carotenoids like lutein and zeaxanthin as primary precursors. The enzymes that enable this conversion are BDH1L and CYP2J19. While many of these species' ketocarotenoids have been shown to be products of the CYP2J19/BDH1L pathway, House Finches (Haemorous mexicanus) and a handful of others instead deposit a ketocarotenoid with one unmodified end ring, 3-hydroxy-echinenone. It has been proposed that β-cryptoxanthin, with one unmodified end ring, is the primary precursor molecule, but the CYP2J19/BDH1L pathway does not catalyze this reaction. Recent study has also demonstrated that House Finches do not use CYP2J19 to produce their red feather pigments. Despite some evidence indicating that House Finches need β-cryptoxanthin as a precursor to produce red pigments, the necessity of β-cryptoxanthin versus lutein/zeaxanthin to produce 3-hydroxy-echinenone is based primarily on conjecture built around poorly controlled feeding experiments. In this study, juvenile and adult male House Finches were captured before molt, brought into captivity, held on a carotenoid-free diet, and then supplemented with lutein, zeaxanthin, β-cryptoxanthin, papaya, or rosehip powder until molt was completed. During molt, plasma and feather follicle samples were taken for carotenoid analysis. After molt fully-grown feathers were collected for color analysis. This data will reveal how House Finches use this novel pathway to red ornamentation.

The cucumber tree: highlights of sea cucumber evolution based on broad phylogenetic sampling

Gustav Paulay, Abigail Uehling, Jessica Whelpley, Francois Michonneau, Joseph Ryan

Holothuroids are the second largest class of echinoderms and have the most divergent body plan, with a soft-bodied, bilaterally symmetrical mode of life. The >1800 recognized species inhabit all marine regions from the intertidal to the hadal zone and are dominant in many habitats, especially the deep sea. We examine evolution across the class with a target capture phylogeny of >300 terminals and additional Sanger data covering half the known species diversity. Results confirm the deep evolutionary history of the class but also show rampant polyphyly at the family and generic levels. Polyphyly

is the result of conflict among morphological characters, commonly caused by reliance on skeletal characters prone to convergence. We present novel hypotheses about the morphological evolution of several clades, highlighting dendrochirotids. We examine character conflict and explore potential causes. Phylogenomics confirm evidence from mitochondrial data that rapid speciation is widespread in holothuroids as in other echinoderms; we hypothesize this may be driven by rapid divergence of gamete recognition proteins. We show strong biogeographical signal in several lineages obscured by past classification of polyphyletic genera and families. Cryptic species diversity is rampant, reflecting morphological simplicity.

A method to analyze mammalian steroid hormones preserved in teeth and bone using LC-MS/MS

Anna Pearson, Luis Huckstadt, Dan Costa, Jaume Forcada, Michael Tift

Historical samples from museums or federal organizations serve as biological archives, with inert tissues recording physiological and ecological information throughout their growth or turnover. Unlocking this information from samples of extant species allows us to reconstruct how animals interacted with their environments and life history events in the past, improving predictions of their future responses. Inert tissues such as bone, teeth, baleen, and hair accumulate lipophilic steroid hormones, including stress and reproductive hormones, that can provide insight into the allostatic load of a population or individual, and reproductive hormones that can inform information such as birth rates. The irreplaceable nature of historical samples creates a demand for methods that maximize data while minimizing destructive sampling. Here, we present a novel method of detecting up to 10 steroid hormones (estradiol, estriol, cortisol, corticosterone, aldosterone, androsterone, testosterone, dihydrotestosterone, progesterone, 17-α-hydroxyprogesterone) simultaneously from 300 mg of teeth (n=30) or 300 mg of bone (n=45) using liquid chromatography-tandem mass spectrometry (LC-MS/MS). Samples used in this analysis were collected from crabeater seals (Lobodon carcinophaga) along the western Antarctic peninsula between the 1930s-1980s. These historical samples offer a unique opportunity to investigate how crabeater seals responded to late 20th century warming along this region and help predict future changes as warming continues to increase.

Competing with your doppelganger: morphological similarity in sympatric poisonous newts (Taricha)

Kannon Pearson, Emmanuelle Teng, Michael Westphal, Rebecca Tarvin

While competitive interactions promote phenotypic divergence in sympatric species (competitive character displacement), interactions with predators promote phenotypic convergence in poisonous species (Müllerian mimicry). Thus, poisonous sympatric species may experience complex, opposing selective pressures on their phenotypes. We seek to investigate this dynamic in the sympatric zone between Rough skinned newts, Taricha granulosa, and California newts, T. torosa. These species are distinguished by color patterning and eyeball size, however, diagnostic characters are highly intermediate in sympatric animals. T. torosa and T. granulosa are poisonous, raising the possibility that phenotypic convergence is the result of Müllerian mimicry. Furthermore, they coexist in ponds and streams during the breeding season and return to those breeding sites every year, which may place them in consistent competition for dietary and habitat resources. Work in nonpoisonous Plethodon salamanders shows that cranial morphology exhibits competitive character displacement in sympatry. We are employing a 2D geometric morphometrics approach to evaluate Taricha torosa and Taricha granulosa head and jaw shape divergence in sympatric and allopatric populations. Additionally, we are quantitatively characterizing color patterning convergence in these populations. Our results will establish whether sympatric Taricha phenotypes follow expectations of competitive character displacement, mimicry, or both, giving insight into the relative forces that competition and predation place on Taricha morphology. Future studies will also address whether gene flow contributes to such convergence.

Sympathetic activation causes rapid decreases in beak temperature during stress-induced flights

Bradley Pedro, L. Michael Romero

The acute stress response is adaptive and crucial for surviving unpredictable environmental threats. For wild animals, the ability to escape a threat increases survival rates, thereby increasing fitness. Yet, measures of stress, especially in laboratory studies, are not often connected to behaviors that promote survival. Using wild-caught house sparrows (Passer domesticus) we address this gap in a laboratory setting by eliciting a behavior that promotes survival, startle-induced escape flights. We connect this behavior to a marker of stress-induced sympathetic activation by non-invasively measuring body surface temperature changes via infrared thermal imaging. Subjects were housed in a large aviary. When birds approached a specified area of the aviary, a randomized playback cue was remotely played, inducing flight towards a perch on the opposite end. Within seconds of a startle-induced flight, beak surface temperatures decrease dramatically (~3-6 ºC). The timing of this response varied between individual birds, reflecting individual differences in ability to respond to a threat. However, the magnitude of temperature decrease and slope of recovery is consistent within individuals, suggesting birds do not appear to habituate to the startles, and that reducing beak temperature is a robust physiological response. This study links a behavior necessary for survival to a marker of sympathetic activation in the lab. Further, it provides an experimental template for investigating how regulators of the stress response alter vital behaviors.

Big Dewlap Energy: Are Male Displays an Honest Signal of Sperm Quality in the Green Anole Lizard

Britta Pellegrin, Shannan Yates, Wayne Wang, Alex Gunderson

Sexual signals play a critical role in mate choice, as females assess males to maximize their reproductive success. Because reproduction is costly, it is hypothesized that females benefit from choosing mates whose signals reliably indicate fitness. Classic examples include antler size in red deer or plumage coloration in birds, but reptiles remain comparatively understudied. In the green anole (Anolis carolinensis), males use their dewlaps, which are extendable throat fans of brightly colored skin—to court females. I tested whether dewlap color and size correlate with semen quality in A. carolinensis. I took photographs of dewlaps and collected semen samples from males during the breeding season. From the photos, I determine the color size of the dewlap as well as the color and intensity. From the sperm samples I determine the individual's sperm count, motility, velocity and concentration. If dewlaps are an honest signal of sperm characteristics, I predict that males with brighter and larger dewlaps with have higher quality sperm. This data will provide insight into whether male dewlap traits function as honest signals of reproductive traits in Green Anoles.

Reconstructing the prehistoric shark community across the Early Eocene Climate Optimum

Elizabeth Pellegrini, Leah Rubin, Immanuel Bissell, Elizabeth Sibert

The deep-sea microfossil record allows us to explore how ecosystems respond to environmental change. The Early Eocene Climate Optimum (EECO, 53-49 million years ago) is the hottest interval in the last 100 million years, with average global surface temperatures of 27 °C. Future atmospheric CO2 predictions indicate the possibility of a future Eocene-like climate. We use fossil shark dermal denticles and fish teeth (ichthyoliths) to expand our understanding of how marine vertebrates responded to past global warmth. We compare Paleocene-Eocene denticle records from two sediment cores: IODP Site U1553 (south of New Zealand) and DSDP Site 596 (center of the Pacific gyre). Located near the Antarctic Circumpolar Current, we hypothesize these conditions would expose IODP Site U1553 to cooler temperatures compared to DSDP Site 596, located in the subtropical gyre. From analysis of IODP Site U1553, we find that denticle and tooth accumulation both have a positive correlation with global ocean temperatures through the Eocene. Both IODP Site U1553 and DSDP Site 596 denticle assemblages were significantly different from modern, with >70% of fossil denticles exhibiting geometric morphology at U1553 and >30% at DSDP Site 596, compared to < 1 % today,

suggesting that the EECO pelagic shark community was dominated by very different sharks than those today. Ecosystems across geologic time allow us to better understand how our own ocean ecosystems may respond to our future climate.

The role of aggressive vibrations in male combat of red milkweed beetles

Autumn Pembelton, Lauren Cirino, Lillian Burbulis

Herbivorous insects commonly produce substrate-borne vibrations across plants to communicate information. These vibrations may be produced in a variety of social, ecological, and sexual contexts. However, little is known about the role that these substrate-borne vibrations play during male fights. We hypothesize that the function of these substrate-borne vibrations communicates the fighting propensity of the male. Thus, male responses to a playback of these signals would have negative effects on vibrotaxis, fighting, and their own vibration production. To test this hypothesis, we used red milkweed beetles, which can produce substrate-borne vibrations during high intensity male fights. We staged male fights on a milkweed plant and played back one of three substrate-borne vibrations: a fighting vibration, a white noise vibration, or no vibrational signal (i.e., control). We recorded when males fought, initiated vibrations themselves, and retreated from the plant entirely (i.e., dropped or flew off the plant). Preliminary results showed that playback signal type did not have a significant effect on vibrotaxis, engagement in fights, or vibration production. We did however find a trend that fighting vibrations reduce the likelihood of vibrations produced, suggesting that this substrate-borne vibration is a signal of aggression or dominance. It is possible the information being communicated influences male-male competition, however more fighting trials need to be carried out to understand the function of substrate-borne vibrations in male fights.

Center of mass and postural mechanics in hopping vs bounding

Mary Pena, Craig McGowan

Desert kangaroo rats (Dipodomys deserti) are renowned for their high-powered jumps in predatory escape, but little is known about their horizontal accelerative capacity in terrestrial locomotion. Although known for their bipedal hopping gait, these animals provide as an interesting model to compare mechanics of hopping and quadrupedal locomotion as they also often use a bounding gait. In this study, we examine how posture and mechanics of the whole-body center of mass (CoM) during quadrupedal and bipedal locomotion influence horizontal accelerative capacity. Animals were startled in order to encourage accelerative bounding and hopping across a trackway instrumented with two force plates while recording high-speed videography. Sagittal-plane whole-body CoM position was calculated based on kinematics and anthropometric measurements of each individual. Preliminary analysis showed that during bipedal hopping, moments about the CoM during stance are regulated through postural changes that minimize the moment arms between the CoM and the ground reaction force vector relative to that seen in bounding. Although we preliminarily find that a greater range of accelerations is achieved with bipedal hopping, further analysis is needed to determine if an upper limit to acceleration during bounding exists independent of that measured during hopping. Outcomes of this analysis can provide evidence that horizontal accelerative capacity functions as an ecologically relevant pressure on the evolution of bipedal hopping.

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Not one way: flexibility in digestive enzyme levels is not universal in prickleback fishes

Valentina I. Peña Gonzalez, Joseph Heras, Donovan German, Michelle Herrera

Short-term dietary changes can alter the activity of digestive enzymes in an animal's gut, influencing nutrient assimilation. Dietary specialization shapes enzyme activity patterns, with many species adapting to efficiently process their typical diets. Fishes in the family Stichaeidae provide a powerful model for testing flexibility of digestive enzyme activities in response to dietary shifts. Here, we examined whether dietary shifts lead to modulation of enzyme activity and whether natural diet impacts enzymatic plasticity. We measured the activities of seven digestive enzymes along the gastrointestinal tract in four stichaeid species: Xiphister mucosus (herbivore), X. atropurpureus (omnivore), Phytichthys chirus (omnivore), and Anoplarchus purpurescens (carnivore), both from the wild, and following a four-week laboratory feeding trial on carnivore and omnivore diets. Enzyme activity correlated with phylogeny and natural diet, as sister-taxa X. mucosus and X. atropurpureus showed elevated amylase and reduced protease activities, consistent with their algivorous lineage. In contrast, A. purpurescens and P. chirus exhibited higher protease activities and greater plasticity in maltase, aminopeptidase, and N-acetyl-β-D-glucosaminidase activities. These results support the adaptive modulation hypothesis, with digestive enzyme activities matching dietary substrate concentrations. Multivariate analyses show less plasticity in the Xiphister taxa. Overall, dietary specialization and evolutionary history constrain plasticity in the Xiphister taxa, while broader diets extend plasticity for enzymatic activity levels in the others, showing that different strategies are adopted in the same family.

Using behavioral assessments to test spatial vision in an eye-regenerating snail (Pomacea diffusa)

Quaid Pendleberry, Brandon Jolley, Madison Janakis, Daniel Chappell, Daniel Speiser

Regeneration of appendages is widespread among animals, but the complete regeneration of eyes is rare. Pomacea is a genus of freshwater gastropod capable of fully regenerating their camera-type eyes. They are an emerging model for eye regeneration studies because they can be bred in captivity and are amenable to genetic manipulation. A common challenge in eye regeneration studies is that although eyes appear fully regenerated, they may not be functional. To demonstrate the functional significance of eye regeneration, reliable tests of visual performance are required. Our goal is to establish these tests in Pomacea diffusa using behavioral assessments. In a bright, exposed environment, P. diffusa will instinctively seek shelter. Using this behavior, visual spatial resolution can be estimated from how large a stimulus needs to be for snails to perceive and move towards it. In a 360° arena, we tested the responses of P. diffusa to static, isoluminant, visual stimuli within their lateral field of view. P. diffusa showed directed movement with a unimodal distribution to a stimulus with an angular width of 10° and showed undirected movement with a uniform distribution when presented with a 20° or 40° stimulus. These behavioral assessments indicate that P. diffusa have coarse-grained vision with an angular resolution of around 10°. This methodology can be applied to future studies to test the functional significance of eye regeneration in Pomacea.

Characterizing the foraging flights of Leach's storm petrels

Henry Penfold, Patricia Jones, Robert Mauck, Liam Taylor

Leach's storm petrels (Hydrobates leucorhous) are small procellariiform seabirds which lay a single-egg clutch and exhibit obligate biparental care during incubation and chick-brooding periods (Mauck et al., 2022). During these periods, adult storm petrels take turns embarking on multi-day foraging trips with average cumulative distances of over 1000 km (Hedd et al., 2018). During the summer of 2025, I sought to characterize the foraging flights of Leach's storm petrels nesting on Kent Island, NB. Using a combination of GPS tracking, radio frequency identification, and newly-developed burrow scale monitoring technology, I examined the foraging flights and yields of 19 individuals during the incubation period. I analyzed the foraging yields of these individuals in relation to a variety of variables including flight distance, duration, target foraging area, individual sex, and exit mass. Individuals that exited their burrows at lower masses returned with larger foraging yields. No significant differences were found between the yields of individuals foraging in the Gulf of Maine as compared to individuals foraging in beyond the continental shelf, between the yields of male and female individuals, or between individuals differing in foraging trip duration. Future work should focus on tracking individuals across multiple foraging flights, defining foraging areas more precisely, and characterizing foraging behavior outside of the incubation period.

The stability of evolvability over 63 million years of primate evolution

Anna Penna, Fabio Machado

Evolvability—the capacity of populations to respond to selection—is shaped by the structure and amount of phenotypic variation transmitted from generation to generation, as summarized by the additive genetic variance-covariance matrix (G-matrix). Whether G itself remains stable or evolves rapidly over macroevolutionary timescales is a central, yet unresolved, question in evolutionary quantitative genetics. Here, we address the long-term stability of evolvability in primates by applying a comparative evolutionary quantitative genetics framework to phenotypic covariance matrices (P-matrices) on a broad phylogenetic scale. Using 37 Euclidean distances derived from 20 homologous 3D landmarks captured on the skulls of 309 primate species (N = 10406 specimens), we estimated and compared P-matrices across 57 genera within a Bayesian framework. Our results show that P-matrix structure and the inferred capacity for evolutionary response remain strikingly conserved across the primate clade, despite over 60 million years of morphological diversification. We propose that this pervasive stability can be explained by shared developmental constraints and unbiased, fluctuating selection, which have together preserved a conserved framework for morphological evolution. Our findings bridge the gap between micro- and macroevolutionary processes, providing empirical support for the hypothesis that evolvability itself can remain stable over deep evolutionary time, with implications for understanding the role of constraint versus flexibility in shaping macroevolutionary trajectories.

Habitat-specific temporal variation in the pace of fish diversification

Nicholas Peoples, Michalis Mihalitsis, Peter Wainwright

Speciation and extinction events are concentrated unevenly through space and time1–4. While slowing diversification characterizes many groups5–8, accelerated diversification usually requires innovative traits, ecological stimulation or major environmental change to occur5,9,10. Likewise, habitats vary in their ecological properties, physical characteristics, and stability, asymmetries that can shape speciation over short timescales11–14. However, how temporal trends in diversification vary between habitats over longer timescales has been overlooked. Here, we show that the pace of ray-finned fish diversification through time is habitat-specific. Tree-wide net diversification rates have accelerated 1.5-1.7x in reef-associated, freshwater benthopelagic and freshwater demersal lineages, which inhabit complex benthic environments, while remaining constant through time in other marine and pelagic habitats. Combined evidence across multiple diversification models implicates the rise of benthic-feeding fishes, which capitalized on functional feeding innovations and the reorganization of benthic resources following the Paleocene-Eocene Thermal Maximum, in giving rise to this pattern particularly on coral reefs. Our results show that the global biodiversity of ray-finned fishes is shaped by a combination of clade-specific pulses and tree-wide rate shifts, an outcome of the dynamic interplay between the traits of species and the features of the habitats they occupy.

Extinction risks in deep-sea populations revealed by genomic data and ecological niche modeling

Pedro Peres, Keith Sellers, Tracey Sutton, Heather Bracken-Grissom

Despite being the largest environment on Earth, the current biodiversity crisis is poorly documented in deep-sea ecosystems. The mesopelagic zone (200–1000 m), in particular, is a habitat whose conservation status remains poorly understood. Here, we integrate genomic data with ecological niche modeling to assess and forecast the conservation status of populations of five mesopelagic species in the Gulf of Mexico. Samples were collected from 2011-2023, representing one of the longest time-series datasets of mesopelagic fauna collection in oceanographic history. All species analyzed exhibit effective population sizes (NE) below the minimum thresholds for long-term viability (NE > 500). Genomic erosion ranged from ~2-8% in a decade, representing elevated rates compared to other habitats. Furthermore, ecological niche models predict the Gulf will be unsuitable for most of the species under future climate change scenarios. Therefore, our work reports potential unnoticed extinction risks in mesopelagic species from the Gulf and underscores the possibility of a more widespread and unnoticed crisis. These findings challenge traditional assumptions of stability and resilience in mesopelagic species and underscore the urgent need to change paradigms considering the conservation of deep-sea taxa.

Influence of symbiont density on coral antibacterial defense across regions in Astrangia poculata

Amelia Rae Perez, Chloe Poenisch, Isabella Changsut, Sydney Dutton, Koty Sharp, Lauren Fuess

Reef-building corals are a cornerstone for marine ecosystems, and rapidly changing environmental conditions linked to global climate change has resulted in mass coral morality as a result of increased bleaching, disease, and other stressors. There is wide variation in coral response to climate-induced stressors; yet the drivers of this variation are unknown. Using the facultatively symbiotic coral Astrangia poculata, we investigated the impacts of two potential drivers of variation in coral immunity: regional population structure and symbiont density, Astrangia poculata colonies with varying algal symbiont densities were collected from three geographically distinct locations along the eastern and gulf coasts of the U.S. (Texas, Virgina, and Rhode Island). Protein extracts from A. poculata were then used to quantify antibacterial activity against Vibrio coralliilyticus, a known coral pathogen. While there was no significant difference between antibacterial activities across sampling sites, there was a positive trend when comparing symbiont density to antibacterial activity, particularly in Rhode Island. The findings from this research can help disentangle the complex relationship between symbiont density and immunity in corals and improve our understanding of the relationships between symbiont density and relative disease or bleaching risk.

Tissue density estimates of humpback whales in the Gulf of Maine over two decades

Valeria Perez, Susan Parks, Kenneth Shorter, David Wiley, Jooke Robbins, Ari Friedlaender, Jennifer Tackaberry, Mason Weinrich

Energy is the fundamental currency of life, shaping survival, reproduction, and population dynamics. Capital breeders rely on energy stores accumulated during limited foraging periods to sustain migration, reproduction, and other costly activities. Body condition, often reflected in lipid reserves, is closely linked to fitness. Warming events have altered food availability and nutrient content in many ecosystems, with consequences for energy transfer. Humpback whales are generalist feeders but show a strong preference for lipid-rich forage fish, whose abundance has fluctuated over the past two decades. Whether humpback whales are successfully adapting to these changes remains unknown. We estimated tissue density for 47 humpback whales from 2004 to 2025 using biologging tag data and hydrodynamic models. Because fat is less dense than water, higher tissue density reflects reduced lipid reserves and poorer body condition. Mean tissue density increased during 2011–2017 and declined during 2018–2025, indicating temporal fluctuations in lipid reserves. These patterns overlap with unusual warming events since 2010, which alter forage fish abundance, suggesting that physiological condition is sensitive to ecosystem variability. This population has also experienced an Unusual Mortality Event since 2016, raising concerns about health and resilience. By expanding the dataset on humpback whale tissue density, this study contributes to defining thresholds for “good” body condition. Establishing such benchmarks is critical for linking physiology, behavior, and demography in marine mammals.

Temperature-dependent variation in the LuxR protein from symbiotic *Vibrio* in bobtail squids

Pedro Antonio Pérez Ferrer, Michael Thompson, Michele Nishiguchi

The sepiolid squid-Vibrio symbiosis provides a powerful model for understanding host-microbe interactions. This association gives us the capability to examine the one-to-one dialog between Vibrio bacteria and its squid partner. Our research focuses on sepiolid squids from the Mediterranean-Atlantic (MA): Sepiola affinis from the Mediterranean Sea and S. atlantica

from the Atlantic Ocean, and their Vibrio symbionts: the psychrophilic Vibrio logei and V. wodanis, and the mesophilic V. fischeri. We are interested in observing temperature ranges that shape the molecular machinery which controls bioluminescence, particularly the quorum-sensing protein LuxR. This project examines whether the LuxR protein from Atlantic and Mediterranean strains differ in how they function or fold at various temperatures—differences that might reflect adaptation to their environments. To achieve this, we are expressing the LuxR protein in Escherichia coli BL21 transformed with a plasmid where LuxR is encoded along with a His-tag. After confirmation by Liquid-Chromatography/Mass-Spectrometry, we will proceed with the crystallization of the LuxR protein from four symbiotic strains, V. fischeri, V. logei, and V. wodanis from the Atlantic Ocean and V. fischeri from the Mediterranean Sea. By characterizing temperature-dependent conformational and functional variation in the LuxR protein, this study seeks to reveal how environmental pressures shape the structural evolution of quorum-sensing regulators in the squid-Vibrio symbiosis, and whether cooperation exists among different species of bioluminescent vibrios in the same host squid.

Transcriptomics reveals novel Gα signaling and CR-like receptors in molluscan chemosensation

Jorge Perez-Moreno, Tess Thattacherry, Emma Johnson, Paul Katz

Vertebrate and insect chemoreception rely on distinct molecules: G protein-coupled receptors (GPCRs) and ionotropic receptors, respectively. The mechanisms in molluscs, however, are not well-established. This investigation centered on the nudibranch mollusc, Berghia stephanieae, using transcriptomic analyses to study genes involved in chemoreception, focusing on G proteins and chemotactile receptors (CRs). Our analysis of Berghia's nervous system and sensory organs identified multiple Gα subunit paralogs. A phylogenetic analysis revealed one Berghia Gα gene, related to Drosophila Gαs, that also showed significantly higher expression in the rhinophores and oral tentacles, the main chemosensory organs. This suggests that Gαs may play a primary role in chemosensory transduction, representing a potential divergence from the canonical Gαolf-dependent signaling in vertebrate olfaction. Secondly, we discovered multiple candidate CR-like genes. These ligand-gated ion channels were previously thought to be unique to cephalopods. Phylogenetic analysis positioned these as a gastropod-specific sister group to known cephalopod CRs, indicating that CR-like receptors likely diversified before the evolutionary split between gastropods and cephalopods. This discovery broadens the functional and evolutionary landscape of these receptors within Mollusca. Collectively, these findings underscore Berghia's utility for identifying novel chemosensory mechanisms and reveal greater evolutionary diversity than previously recognized.

The role of sensing in the social networks of schooling fish

Ashley Peterson, Nathan Swanson, Christopher Martinez, Matthew McHenry

Sensing governs the interactions within animal groups, yet how different sensory modalities contribute to social networks remains unclear. We investigated the influence of vision and flow sensing in schools of neotropical tetras by manipulating school size and the functioning of the lateral-line system. By quantifying swimming kinematics and the flow of information between individuals, measured as mutual information (MI), we evaluated how local sensing shapes network structure. Removal of flow sensing caused relatively small changes (< 1 5%) in nearest-neighbor distance, polarization, and rotation, but networks exhibited half the algebraic connectivity and twice the heterogeneity of control schools at the largest school size. These effects suggest that flow sensing plays a major role in maintaining school cohesion. Compared to vision, which operates with at least tenfold greater latency, flow sensing enables rapid responses to neighbor movements. These findings highlight a mechanistic link between rapid sensory feedback and the stability of collective networks. Extending this framework across five tetra species revealed striking diversity in school network structures. Species with greater MI swam faster, maintained highly polarized schools, and formed cohesive, homogeneous networks. Species with minimal MI exhibited shoaling behavior with weaker connectivity. Such interspecific differences suggest that evolutionary and physiological factors regulate how species use sensory information to maintain social networks.

Dynamics of a long-term aspen leaf miner outbreak in boreal Alaska

Christopher Peterson, Patricia Doak, Diane Wagner, Jill Johnstone

Outbreaks of insect herbivores are a major source of disturbance to forest ecosystems worldwide. In boreal forests, insect outbreaks can interact with increased temperatures, drought, wildfire, and consequences of climate change to generate to drive large-scale ecosystem changes. Trembling aspen (Populus tremuloides) has been experiencing an aspen leaf miner (Phyllocnistis populiella; ALM) outbreak since 2000 in Interior Alaska and Yukon. We surveyed ALM herbivory over 18 years at four sites near Fairbanks, AK and used hierarchical Bayesian models to understand the direct and indirect factors driving leaf mining damage. We found that mining damage was primarily driven by intrinsic population dynamics operating at the population level and local demographics within individual leaves. Natural enemies and leaf defenses had indirect negative effects on mining damage when present, but neither were not capable of ending the outbreak. Environmental factors had limited impact, with reduced damage after colder winters and when more time elapsed between snowmelt and greenup. Overall, our analyses highlight the primary importance of biotic factors and emphasize the need for species-specific life history information to effectively explaining patterns of forest pest damage. These findings can help contribute to a broader understanding of interacting and indirect effects that are reshaping boreal forests.

Fool me once: successful mimicry in a cryptically dioecious plant species despite bee learning

Oscar Peterson, Leo Carpenter, Marco Russo, Chris Martine, Avery Russell

Flowering plant species often manipulate pollinators via deception. About 5% of plant species are dioecious, with pollination requiring animals such as bees to visit separate male and female plants. Although male and female flowers often look alike (cryptic), quality of male vs female food rewards can differ substantially. We thus expect bees to learn to discriminate flower sex to avoid exploitation. We evaluated how a nectarless dieocious plant species (Solanum ossicruentum) with female flowers resembling males (but offering inferior, relatively deceptive rewards) manipulates bumble bees (Bombus impatiens) and the role of bee experience in avoiding exploitation. Although male flowers offered 4.4x as much pollen as females, bees initially did not discriminate male and female flowers but rejected females more with experience. Removing access to pollen in female flowers enabled bees to learn to discriminate male and female flowers more quickly. However, bees that learned to avoid the less rewarding female flowers often did so at the cost of avoiding male flowers as well. Our results indicate that male parts on female flowers are responsible for initial exploitation of the pollinator, while pollen in female flowers maintains exploitation as bees gain experience.

Effects of formalin preservation on gecko toe pads

Kane Petty, Travis Hagey

Formalin is used to preserve specimens by creating cross-links that prevent bacterial decay and effectively preserve them. However, there is evidence of shrinkage occurring during preservation by a small amount (~ 1-3%). This shrinkage could affect our ability to accurately measure preserved specimens. We quantified the change in shape in gecko and anole lizard specimens before and after preservation. 23 anoles (16 Anolis carolinesis and 7 Anolis sagrei) and 9 Phelsuma laticauda were collected in Hawaii in the summer of 2018. We photographed their toe pads, collected morphological measurements, and then euthanized them. After euthanasia, they were preserved in formalin for 12-24 hours and then kept in 75% ethanol until March 2023 (~ 5 years later). They were then rephotographed and remeasured. Measurements were taken externally using calipers. Toe pad shape and area were measured using three programs: TPSDig, ImageJ, and R. TPSDig was used to record landmark coordinates on our toe pad photographs. ImageJ was used to record area of the lizard toepads. Lastly, R was used to compare toe shape and area of

the pre and post preservation toepads, and generate plots to visualize our results. Results will be used to investigate if a change in preserved specimens is significant enough to impact future studies using preserved specimens.

Sex-based differences in the habitat use and movement of *Aspidoscelis inornatus*

Alicia Pham, Sarah Heckmann, Maria Eifler, Jasmyn Zimmerman, Kaera Utsumi, Samantha Molino, Robyn Altham, Dahtiya Stanley, Michelle Fan, Douglas Eifler

Within a species, sex can underlie variations in habitat use because of constraints from differing energetic needs, particularly in sexually size-dimorphic species. In monomorphic species, the ecological implications of sex can be cryptic. Aspidoscelis inornatus, the little striped whiptail, exhibits size monomorphism and color dimorphism. We assessed the habitat use of A. inornatus at varying wind speeds and temperatures, characterizing vegetation occupied during observations. Our study was in the northern Chihuahuan Desert in west Texas, consisting of open sand substrate with interspersed shrubs and grasses. We observed 55 individuals during June 2025, measuring the movement path of each individual for 30-min and recording their spatial location, movement, and habitat every 30-s. Our analysis included a measure of the entropy (i.e., randomness) of movement and the foraging space. Males had a higher proportion of 30-s intervals with movement and traveled more during the observation. In addition, during intervals with movement, males had longer step lengths. Both females and males displayed higher movement entropy at higher wind speeds while spending more time in vegetation when temperatures were lower. Despite the relatively open habitat, lizards spent more time in vegetation. Males occupied larger foraging spaces. We will be applying step selection analysis to raster data of the land cover on our study site obtained by a drone to assess habitat preferences.

Polysectoid, a hyperredundant Nereid-annelid-inspired soft-bodied robot

Huy Pham

Biological inspiration offers new and innovative solutions to exploration of challenging terrains, as well as insights to their model organisms. In particular, annelids (segmented worms) such as Nereis sp. (ragworms), prove to be a useful subject for their multimodal locomotion as an evolutionary adaption to their active lifestyles. This research aims to mimic many aspects of their anatomy in order to develop a new bio-inspired soft robot, named “”Polysectoid””. This robot is constructed from a combination of elastic material strips, 3D-printed rigid components, and longitudinal-muscle-like motor-driven tendon cables as well as parapodia and chaetae to replicate the musculoskeletal structure of these annelids. These innovations compared to previous worm robots allow the Polysectoid to make large bends at each body segment and thus, perform both undulatory and peristaltic locomotion. We tested its performance on different flat substrates with different textures and under various vertical compression conditions with different parapodium designs. As a result, the Polysectoid is able to perform an undulatory gait in addition to peristalsis without sacrificing much of its deformation rate at full contraction during peristaltic locomotion. The motion of parapodia and chaetae are shown to be important factors, with different effects on different gaits and substrates. The robot can navigates through tight gaps, which can have application in confined space inspections, and provides a platform to further examine the biomechanics and neural control of Annelid-inspired locomotion.

Zebra finches maintain endocrine rhythms in response to simulated night shift work

Kevin Pham, Victoria Coutts, Alex Hoffman, Haruka Wada

Human night shift work (e.g., working hours outside common day shift hours) disrupts circadian rhythms, and is strongly associated with the development of pathological diseases. However, most mechanistic evidence is derived from nocturnal rodents, limiting insight into how organisms with different phase relationships respond to chronic light disruption. To this end, we exposed two groups of zebra finches (Taeniopygia guttata castanotis), a diurnal songbird, to a consistent 12L:12D cycle or alternating light cycles (12L:12D followed by 12D:12L) every three days for 66 days, simulating rotating night shift work conditions. We found that birds under alternating lighting cycles exhibited an inversion of corticosterone rhythms, with peak levels detected at night rather than during the day, while melatonin rhythms remained robust, with partial evidence suggesting a phase reversal. Additionally, we found that treatment birds had a reduction in superoxide dismutase 1 protein expression in the brain. Yet, there was no increase in lipid peroxidation markers in the brain. These results indicate that diurnal zebra finches are able to adjust endocrine rhythms in response to alternating patterns of light that mimic night shift work conditions through plastic mechanisms, with limited physiological costs. Given the widespread, and permanent, alteration to the nighttime environment, identifying how organisms circumvent variation in lighting intensities, wavelengths, and temporal patterns will be critical to identify both ecological consequences and human health impacts.

Evolving against the currents: how ecology and evolutionary history shape tadpole skin morphology

Quang Pham, Molly Womack

Most anurans have a complex life cycle that contains a free-living larval phase (tadpoles) with extraordinary morphological diversity across taxa. Many species show specialized morphological adaptations to distinct freshwater habitats, such as lentic (still water) and lotic (flowing water) environments. Tadpole skin, as the body’s outermost barrier and a key physiological interface, may facilitate adaptation to diverse niches; thicker and more durable skin structure could protect species from excessive abrasion and mechanical stress exerted by fast flowing currents. However, the diversity of tadpole skin form and function that arises within different ecological contexts remains little explored. Here, we use histology to investigate tadpole skin morphological evolution in relation to different habitats within a phylogenetic framework. We also present a review of existing literature on tadpole skin morphology. Our results address gaps in tadpole biology and provide important baseline information about the evolution and diversification of the largest organ in anuran larvae.

Two-faced frogs: comparative macroevolution of tadpole and adult skulls using 3D morphometrics

Jackson Phillips, Molly Womack, Daniel Paluh

Metamorphosis is a process that allows morphologically distinct larvae and adults to occupy different ecological niches, raising the possibility that they evolve semi-independently. However, this idea has rarely been tested at macroevolutionary scales. Frogs are ideal for such a test: their tadpoles have complex cartilaginous skulls that transform dramatically into a bony adult skull. Using contrast-enhanced microCT scans, we assembled 3D larval skull data for 100 frog species matched to adult skulls. We combined geometric morphometrics with comparative methods to ask how larval skull shape reflects ecology, body size, phylogeny, and adult morphology. Our results reveal striking diversity in larval skull form and clarify the degree to which it is coupled—or decoupled—from adult shape across the frog tree of life.

MorphoDepot: A decentralized collaboration platform to create and share 3D collections

Steve Pieper, Cassandra Donatelli, Paul Gignac, Matthew Kolmann, Christopher Noto, Adam Summers, Natalia Taft, Murat Maga

We report on an application of a software development paradigm to the difficult problem of maintaining, modifying, and updating 3D morphological data. Open-source computing flourishes under a “fork and contribute” collaboration model. Repository owners share their products publicly under a permissive open-source license. An interested party can “fork” this repository under their own account, make changes and contribute back to the original project. This

empowers anyone to contribute to projects they are interested in; allowing them to be part of that community. It benefits the repository owners, who might otherwise not be able to commit resources.

We adapted this paradigm to 3D digital morphology, specifically segmentation of 3D scans. MorphoDepot allows anyone to create public repositories of 3D scans, along with segmentation, and the specific anatomical terminology that needs to be used for the project. Users can download these data, make changes (e.g., segment new structures, or revise details) and, if they choose, contribute back to the original repository. MorphoDepot, which uses the distributed version tracking software 'git' under the hood, has been implemented as an extension for the open-source 3D Slicer application. The same module is used for creating, updating, searching and editing the repositories. In addition to facilitating remote collaborations and enhancing 3D rendering documentation, MorphoDepot fosters group comparative projects and promotes incorporating digital morphology into classroom settings in a structured manner.

Undulatory locomotion in random obstacle arrays

Christopher Pierce, Dmitri Kalinin, Tianyu Wang, Yesol Moon, Hang Lu, Daniel Goldman

Animals locomote by deforming their bodies, propelled by reaction forces from the surrounding medium. In homogeneous environments, these self-deformations and the corresponding reaction forces are often periodic. However, animals frequently encounter unpredictable heterogeneities in naturalistic landscapes, making purely periodic motion unfeasible. To understand the effects of environmental disorder on locomotion, we studied the undulatory gaits of starved nematodes (Caenorhabditis elegans, ~1mm in length) roaming in a set of obstacle landscapes (2-dimensional arrays of pillars in a microfluidic device). We systematically tuned the level of randomness by varying the width of the distribution of distances between neighboring obstacles. When the obstacles were arranged periodically in space (forming a hexagonal lattice), worms typically moved in straight-line trajectories along the lattice vectors, interrupted by intermittent turning and reversal events. As randomness increased, turning became more frequent, and the persistence length of trajectories associated with forward locomotion decreased. Correspondingly, the mean-squared displacement of the trajectories and the angle correlation function showed a transition from ballistic to Brownian motion at a shorter time scale (~3-5 seconds) in random lattices relative to trajectories observed in ordered obstacle arrays and on homogeneous agar plates (~7-10s). These results show that the presence of disorder in the terrain affects the statistics of search behaviors in C. elegans, suggesting that mechanical and structural properties of the environment play a significant role in nematode behavior and ecology.

Neural control of substrate grip in Drosophila

Sara Pierce-Lundgren, John Tuthill, Anthony Azevedo

Terrestrial insects have evolved specialized structures, such as claws and adhesive pads, that allow them to dynamically attach and release their feet from the ground. These attachment systems must function across diverse substrate textures and during rapid movements. Using a custom-built centrifuge, we measured adhesive forces of Drosophila melanogaster on substrates of varying roughness by accelerating the fly until it could no longer hold on. By measuring the acceleration of the fly at the moment of detachment, we calculated the corresponding adhesive forces. Flies showed the strongest adhesion on smooth plexiglass and at roughness values 1 µm, 3 µm and 30 µm, with weaker performance on surfaces of 0.3, 9, and 12 µm roughness. These results suggest that effective attachment depends on how tarsal structures mechanically engage with surface features, likely reflecting a shift in the relative use of claws and adhesive pads depending on the substrate roughness. We hypothesize that as roughness increases, flies shift from relying on the passive mechanical forces of the adhesive pads to active neural control of the claw. In ongoing work, we are using optogenetics to test the role of specific leg muscles in actively controlling surface attachment. In summary, our work establishes a framework for investigating the relative contributions of neural control and passive biomechanics to substrate grip under changing conditions.

Comparative cognition in queen and worker bumblebees.

Smruti Pimplikar, Felicity Muth, Jessica Buelow

Cognitive traits such as specific learning abilities are generally assumed to be adaptive, but significant variation can exist within a single species living in the same environment, raising the question of why this variation exists. One possibility is that cognitive traits trade-off with other traits, including other cognitive abilities. Bumblebees (Bombus spp.) are a useful system to study trade-offs in cognition since closely related individuals have distinct behavioral phenotypes with associated cognitive abilities. Foraging queens are better at learning than foraging workers, but it is unclear if this comes at the cost of cognitive flexibility. We hypothesized that queens are better at both learning and reversing associations. Alternatively, superior learning in queens might trade-off against reversal learning, making them worse at reversing than workers. We compared the cognitive flexibility of queen and worker bumblebees of two species (B. vancouverensis and B. flavifrons) by testing individuals on a reversal learning test. While we did not find differences in learning performance between queens and workers, queens reversed learned associations better than workers. We also found species differences, where B. flavifrons workers were particularly good at reversal learning. In conclusion, our findings indicate that queens perform better than workers at reversal learning ability, highlighting that both caste and species identity of bees contribute to our understanding of cognitive flexibility across bumblebees.

Effects of rearing temperatures on lipids in aging starvation-selected *Drosophila melanogaster*

Katrina Pinili, Elena DeLaTorre, Allen Gibbs

An organism's ability to withstand stressful temperatures may be affected by their energy reserves. Lipids are known to be metabolized during thermal stress, especially at warmer temperatures. Similarly, during starvation, lipids are mobilized in order to offset nutrient depletion. This is particularly displayed by flies selected for starvation resistance. Starvation-selected (SS) flies survive for weeks with no food as opposed to 2-3 days in fed control (FC) flies. In contrast to FC flies, SS flies have an additional 24 hours of development during the 3rd larval instar, using this time to consume food. Upon eclosion, SS flies have increased lipid storage by 2-3-fold. Because lipids are the primary fuel source for flies during heat stress and starvation resistance, we want to know how SS flies tolerate extreme temperatures. To assess metabolite content, we reared FC and SS populations at cold (18°C), control (25°C), and warm (29°C) temperatures during development and the first 3 weeks of adulthood. During adulthood, lipids were depleted much faster in SS flies housed at 29°C than at 18°C and 25°C. We also measured protein content which was not adversely affected by rearing temperature. When adult flies were starved at 25°C, flies reared at 29°C were less starvation resistant than those reared at 18°C or 25°C.

The effect of heat stress on larval survival in the porcelain crab *Petrolisthes cinctipes*

Kevina Pinto, Brian Tsukimura

Global warming has resulted in an increased incidence of atmospheric and marine heat waves. The intertidal zone is unique in that its temperatures naturally vary with tidal immersion and emersion throughout the day, and its organisms experience both heat waves due to this. Such thermal stress can impact early development. However, it is not easy to predict these effects in invertebrates. A potential response mechanism for this is transgenerational plasticity (TGP). To study this further, I have worked with the porcelain crab, Petrolisthes cinctipes, that lives in the upper intertidal zone. These organisms can tolerate higher temperatures but are limited in their ability to respond to increased heat stress as they live near their upper thermal limit. I have focused on growing the larvae to juveniles. Raising the zoea to megalopa is important to get to the next generation and to study TGP. By keeping the zoeae isolated in a floating tank and feeding them freshly hatched Artemia spp. nauplii, they lived, on average, for seventeen days and have progressed to the second larval stage. These results show that it's possible to raise these larvae. I also heat stressed female crabs to determine whether their F1 can better mitigate heat stress, and eventually if they themselves pass that down to their offspring.

Aerodynamic consequences of prey reorientation by ospreys (*Pandion haliaetus*)

Ava Pistacchio, Audrey Kellogg, Tyler Gillette, Catherine Eno, George Loubimoc, Aren Hellum

Ospreys (Pandion haliaetus) are known to reorient captured fish into a streamlined, head-first position during flight. This behavior is hypothesized to reduce aerodynamic drag, thereby improving flight efficiency and reducing the energetic cost of transport. To quantify the aerodynamic consequences of prey orientation, we created a physical model for wind tunnel testing. A composite 3D model was developed by integrating a photogrammetry-based mesh of a menhaden fish with a publicly available osprey talon model. We measured aerodynamic forces on the 3D-printed model across a 360° range of yaw angles at flight speeds of 13.4, 17.9, and 22.4 m/s (30, 40, and 50 mph). Results confirm that the drag coefficient was minimized when the fish was aligned with the flow (0° and 180° yaw) and maximized when presented broadside to the flow (90° and 270° yaw). Interestingly, we observed asymmetrical drag forces between the 90° and 270° orientations, suggesting complex flow interactions with the fish's body curvature. We found no significant difference in drag between the head-first and tail-first orientations. Our findings provide empirical support for the drag-reduction hypothesis and highlight the utility of physical modeling in studying the biomechanics of animal flight, with implications for bio-inspired aerial payload systems.

Linking the gut microbiome to immunity and body condition in two sympatric species of wild mice

Allyson Placko, McKenzie Matlock, Gabriele Schiro, Lauren Petrullo

Both phylogeny and ecology influence the structure of the mammalian gut microbiota, which regulates host investment in major physiological processes like metabolism and immune modulation. In this study, we examined relative contributions of phylogeny versus ecology on gut microbiota composition and investigated potential gut microbiota mediated trade-offs between immunity and body condition in two closely related species of wild mice (Peromyscus maniculatus and P. leucopus). We obtained fecal samples from 409 individuals spanning 2019-2023 from the NEON Biorepository, across three distinct sites where both species co-occurred and one single-species site each. We calculated body condition as a scaled mass index using mass and hind foot length. We used 16S amplicon sequencing to determine gut microbiota composition and developed an assay for quantifying secretory immunoglobulin A in feces as a proxy for mucosal immunity. We found site-level differentiation and weaker species-level differences in gut microbiota, suggesting ecological versus phylogenetic effects. Gut microbial diversity predicted body condition in both species, but the direction of this relationship was context-dependent. Generally, P. leucopus exhibited consistently higher body condition and microbial diversity compared to P. maniculatus, with less variability in both measures. We then assessed whether investment by P. leucopus into more stable body condition came at a cost to immune function. Our results suggest that these species employ different strategies, potentially influenced by the microbiome, to meet environmental demands.

Influence of variation in individual capacity on balance performance in walking

Ilana Plager, Skylar Taylor, Marcus Garcia, Bryan Alvarez, Monica Daley, Alexandra Voloshina

Maintaining upright balance in human walking is challenging as minor deviations from the center of mass generate gravitational accelerations that must be counteracted to prevent falling. Here we investigate the mechanisms of dynamic balance and the predictors of individual variation in performance to provide insight into sensorimotor control mechanisms and inform clinical interventions. Prior research has focused on group-level averages in balance control, offering limited insight into how individual differences in capacity shape balance strategies.

We quantified individual capacity through measures of morphometrics, joint flexibility, proprioceptive function, and psychological profiles. We assessed dynamic balance performance by tracking deviations in medial–lateral center of pressure (CoP) during a treadmill tandem-walking task at five speeds, beginning with a self-selected pace. Data from 22 participants were analyzed using linear mixed effects models. Results indicated that balance performance was higher with increased hip and ankle flexibility, reduced personality scores of extraversion, and reduced treadmill speed.

Given variation in CoP deviations across participants, we also examined variation in torso sway as a compensatory strategy. In this study, greater CoP deviation, interpreted as poorer balance, was associated with greater torso sway, most influenced by reduced proprioception and limited joint flexibility. The findings suggest that individual capacity and cognitive measures can predict variation in balance performance, which may be important for personalizing fall risk prediction and physical therapy programs.

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Morphological changes from nauplius to cyprid provide hydrodynamic benefits to barnacle settlement

Cailey Plainte, Kyla Polack, William Ballentine, Mimi Koehl, Kit Yu Karen Chan

Barnacle larvae undergo significant morphological changes as they transition from the free-swimming nauplius stage, which has limbs and body extensions, to the fusiform cyprid stage for settlement. However, the hydrodynamic consequence of such a shift has not been fully characterized. Using dynamically-scaled models of Tetraclita japonica nauplius and cyprid, we tested whether these developmental shifts result in hydrodynamic differences during settlement in different marine environments. Each model was attached to a force transducer and towed through a large tank beside a glass plate, simulating a landing surface. Forces and torques were recorded at three different Reynolds numbers, ranging from a lower turbulence environment, settling on a hermit crab, to a higher turbulence environment, a rocky intertidal zone. Our preliminary analysis demonstrates that, when at a "head-to-flow" orientation, the cyprid experienced significantly less drag and lift forces than the nauplius model, along with reduced pitch. This contrast applied across all flow regimes tested. Such observations support our hypothesis that the drastic change in body form from nauplius to cyprid confers a biomechanical advantage and reduces the risk of dislodgement. Our work highlights the importance of considering changes in hydrodynamic forces as a selective pressure during benthic-pelagic transitions.

From water to land: multi-modal locomotion of an amphibious fish

Theodora Po, Fidji Berio, Neelima Sharma, Emily Hillan, Fumiya Iida, Neil Shubin, Valentina Di Santo

The evolutionary transition from water to land is among the most transformative events in vertebrate history, yet the mechanisms by which ancestrally aquatic morphologies supported terrestrial performance have not been fully resolved. Experimental studies of Polypterus senegalus have shown that rearing on land can alter body form and locomotor mechanics, highlighting developmental plasticity as a key factor in bridging aquatic and terrestrial modes. However, the physiological consequences of such rearing, and their integration with biomechanical and skeletal adjustments, remain poorly understood. Here, we investigated walking and swimming in P. senegalus raised under exclusively aquatic or terrestrial conditions, with a subset subjected to uphill training. We measured oxygen consumption, body kinematics, and fin morphology to assess how environment and functional loading shape performance. Terrestrially reared fish consumed less oxygen during walking than aquatic-reared individuals, while swimming costs remained similar between groups. During walking, terrestrially reared fish exhibited greater body curvature and reduced fin-angle range, producing higher stride speeds and overall locomotor speed. Morphologically, their pectoral fins showed increased bone density, particularly in ramp-trained individuals, consistent with tissue-level reinforcement under terrestrial loading. Preliminary evidence indicates that benefits to terrestrial performance may arise as much from repeated use and environmental history as from subtle morphological shifts. This study therefore highlights multiple, interacting pathways by which an ancestrally aquatic body architecture could be co-opted for terrestrial capability.

The curious case of the kept capsule

Robert Podolsky

Most gastropods, the largest class of non-arthropod animals, reproduce by enclosing embryos in capsules that are deposited on substrates. Eggs are fertilized using stored sperm typically just before encapsulation and deposition. In the Eastern mud snail Ilyanassa obsoleta, snails in captivity produce dozens to hundreds of capsules in a reproductive bout, nearly always with a single odd capsule that is physically distinct and contains embryos at an advanced stage of development. This unique capsule shows that snails are fertilizing and encapsulating these eggs well before deposition. I examined the length of time these capsules are retained as well as whether they differ from more typical capsules in size, embryo density, or hatchling size. Backdating of encapsulation based on hatching time shows that embryos are retained on average for more than half of their development. Number of embryos per capsule and size of hatchlings did not differ significantly between retained and typical capsules, suggesting that retained capsules are produced in typical fashion and that their purpose is to prepare or block the oviduct. In other species where a similar process is observed, however, deposition is preceded by formation of a mucus plug or similar secretion. The benefit of oviduct blockage is not well understood but may involve control of copulation or parasitism. This mechanism of embryo retention indicates a possible pathway toward a transition to ovoviviparity.

A new method to assess host-pathogen dynamics in *Astrangia poculata*

Chloe Poenisch, Amelia Rae Perez, Sydney Dutton, Isabella Changsut, Koty Sharp, Lauren Fuess

Corals are foundational to marine ecosystems, providing habitat for immense biodiversity across tropical oceans. However, coral health is increasingly threatened by environmental factors such as heat stress and associated rises in coral disease. Previous research has suggested that susceptibility to disease in particular may be linked to variation in coral-algal symbioses. In this study, we used the non-reef building coral, Astrangia poculata, as an experimental system for studying the impacts of symbiont density on host-pathogen dynamics. Astrangia is an abundant facultatively symbiotic coral, naturally existing with both high and low algal symbiont densities. To investigate the impacts of variability in symbiont density on host immune response, and to develop a protocol for successful infection of the Astrangia, coral colonies were experimentally challenged with two bacteria: Leisingera spp. and Vibrio coralliilyticus (strain: Oft6-21). In this study, we developed methods for exposing A. poculata via pathogen injection directly into coral tissue and identified evidence of infection to the pathogens. Our findings demonstrate that A. poculata exhibits phenotypic responses to pathogen exposure. These insights will guide optimization of pathogen challenge methods for reproducible assessments of coral-pathogen response. Ultimately, we intend to establish A. poculata as a system for studying symbiosis-immune interplay and testing/development of future coral disease intervention techniques.

Hydrodynamic effects of barnacle nauplii spines: Dislodgement from benthic predators and substrata

Kyla Polack, William Ballentine, Kit Yu Karen Chan, Cailey Plainte, Mimi Koehl

Zooplankton play a vital role in marine food webs, so their ability to capture food and avoid predation influences energy transfer through ecosystems. Planktonic animals exhibit a wide range of body shapes, and many possess long, slender body extensions, such as spines and horns. that may affect their hydrodynamics. We used nauplius larvae of barnacles to investigate how body shape and spine-like extensions affect the hydrodynamic forces and torques they experience on surfaces (e.g., capture surfaces of predators, habitat substrata). We focused on the nauplii of species with different morphologies: Lepas anserifera (slender body, long horns, and tail spines), Polyascus plana (thick, rounded body; short horns and tail), and Tetraclita japonica (intermediate body shape and horn/tail lengths). Dynamically-scaled physical models of these nauplii and a substratum were towed together at a range of speeds mimicking the Reynolds numbers (ratio of inertial to viscous forces that determine flow patterns and forces on a body) of larvae exposed to ambient currents in different habitats. We measured the forces and torques on models and found that slender body extensions increase the drag, pushing the larvae downstream. Thus, larvae with long extensions are more likely to be dislodged by ambient currents from capture surfaces of predators and from benthic substrata. There is a trade-off for settling larvae between enhancing escape from predators versus avoiding dislodgement from substrata.

How do variations in cellular models' materials influence the formation and functionality of cellular 3D printed constructs?

Finnigan Poling, Sundar Madihally

Introduction: Cellular 3D printing is very important to the medical industry but thus far the equipment required is expensive and not widely available.

Objectives: The primary objective of this study was to optimize the process of cellular 3D printing on an inexpensive, generic 3D printer.

Methods: Using a modified 3D printer that was originally designed for plastic materials, this project printed cellular materials for medical applications. The typical print head was replaced with one designed to hold a syringe that was used to hold phosphate-buffered saline (PBS) or cellular materials. The needle used for printing was a crafted coaxial needle which creates a gelatin tube with PBS inside. The desired configuration was printed into a calcium chloride solution bath at varying concentrations. The various gelatin solutions were made with different concentrations of sodium alginate and gelatin from porcine skin. The resulting constructs were viewed under a microscope, and the images analyzed in order to obtain its fiber size.

Results: Trials with 1, 2, and 3 percent sodium alginate and 6 percent gelatin from porcine skin in a 4 percent calcium chloride bath had an average fiber size 438 µm, 489 µm, and 498 µm, respectively. Trials in 0.1, 1, 2, and 4 percent calcium chloride baths with 3 percent sodium alginate and 6 percent from porcine skin had an average fiber size 795 µm, 483 µm, 460 µm, and 434 µm, respectively.

Conclusion: Previous results indicate that the increased sodium alginate concentration increases fiber size, the cells survive the printing process, and the fiber structure was not well maintained. Upon further experimentation, the results will include the findings of varying configurations, the effect on the hydrogel from incubation, measuring cellular growth, and the average fiber size of trials using different hydrogels.

Evolution of physiological mechanisms: rapid adaptation of ion transporters during salinity decline

Teresa Popp, Peter Piermarini, Carol Lee, Catherine Lorin-Nebel

Rapid salinity change poses a severe challenge for aquatic species, often requiring physiological adaptation to ensure survival. The estuarine copepod Eurytemora affinis has repeatedly colonized freshwater from saline habitats across the northern hemisphere, providing a valuable model for studying mechanisms of rapid adaptation.

Ion transporter genes are prime candidates for facilitating these habitat transitions, as they consistently exhibit differential expression between saline and freshwater populations. Using targeted qPCR, we compared ion transporter gene expression in saline and freshwater populations reared under both common garden and laboratory natural selection conditions. In response to salinity change, we observed evolutionary shifts in gene expression, with NKA-α1, NKCC-3, and NHA-5 showing strong divergence between the invasive freshwater population and the native saline population. We also identified acclimatory responses, with NHA-7 and NKCC-2 having elevated expression at low salinity relative to high salinity. Together, these findings demonstrated rapid evolutionary shifts, acclimatory responses, and the evolution of plasticity in ion transporter gene expression.

To bridge gene expression patterns with functional insight, we also characterized full-length NHA-5 and NHA-7 transcripts, implicated in adaptation

(above). We discovered multiple splice variants for both paralogs, which will be expressed in Xenopus oocytes to assess NHA's ion transport function and its role in freshwater adaptation.

By integrating the fields of physiology and evolutionary, this study identifies specific ion transporters as rapid-response targets during salinity decline and offers a framework for predicting species resilience under accelerating climate-driven change.

Evolution of Hawaiian cave-adapted arthropod communities along the space-time continuum

Megan Porter, Mireille Steck, Jordan Gossett, Rebecca Chong

Islands have long been recognized as natural history laboratories for studies of the processes that generate biodiversity, although these processes have not generally been studied in island subterranean habitats. On volcanic islands, like the island of Hawai'i, lava tubes in flows of different ages additionally provide fine-scale time constraints on evolutionary process, allowing for estimates of the timing of speciation, cave adaptation, and community assemblage processes. Using bioinventories of understudied lava tube systems and comparative genomic approaches, we are investigating the patterns of dispersal and speciation for the 44 documented troglobiont taxa found in lava tube habitats across three volcanoes on Hawai'i Island. Our recent work documented significant range expansions for described species and revealed many new cave-adapted species, three of which have been described (Paratachys aaa, Spelaeorchestia pahoehoe, Iolania frakenstonei). Comparison of phylogeographic patterns across multiple arthropod lineages (planthoppers, assassin bugs, cave treaders) suggests similar routes of evolution across the landscape, with a secondary contact zone on the southern region of the island. Broader studies within the cixiid planthoppers identified at least four independent invasions of lava tube habitats from surface species, with diversification in to at least ten cave adapted species, only four of which have been described. Collectively, this research contributes to understanding the diverse yet understudied arthropod species that live in Hawaiian lava tube caves.

Scaling up 3D morphometrics for macroevolutionary research

Arthur Porto

Macroevolutionary research often requires dense, comparable measurements across thousands of specimens, but data collection is often a major bottleneck. Manual landmarking is slow and biased (observer). Moreover, existing automated methods often fail when applied across diverse taxonomic groups. With the rapid digitization of natural history collections, our ability to assemble large-scale datasets has become the rate-limiting step for comparative biology. To address this bottleneck, I will here introduce ATLAS, a 3D Slicer module that automates the generation of dense, anatomically informed correspondences from 3D models coming from heterogeneous sources (e.g., microCT, photogrammetry) with minimal human input. By standardizing pose and transferring landmarks, ATLAS produces high-quality statistical shape models suitable for downstream analyses of disparity, modularity, integration, and evolutionary rates. Designed with a simple interface for museum workflows and a batch mode for large-scale research, ATLAS significantly reduces processing time and interobserver bias, greatly facilitating 3D morphometrics.

Social dynamics and energetics of flocking in birds

Steven Portugal

When birds flock, they typically form two distinct flock shapes: clusters or V-formations. The positional spacing for an individual within each flock type has implications for their energy expenditure, vulnerability to being predated upon, and their potential for leadership. Using a combination of biologging and 3D camera arrays, this talk will focus on several model systems, including Homing Pigeons (Columba livia), Western Jackdaws (Corvus monedula), Pink-footed Geese (Anser brachyrhynchus) and Ring-necked Parakeets (Psittacula krameri), to explore what intrinsic traits determine individual positioning – both behavioural and physical – within a flock, and subsequent energy expenditure. Phenotypic traits measured include boldness, neophobia, dominance, feather reflectance and basal metabolic rate, in turn linked to flocking parameters such as density, spread and inter-individual distances. Ground- and flight-based social networks are also explored. It is likely that variations in morphological and life-history traits—such as body mass and pair-bond monogamy—shape the social dynamics of flocking, each with distinct implications for energy expenditure.

Offspring overcome the effects of poor parenting by being better parents

Ahvi Potticary, Allen Moore, Christopher Cunningham

The evolutionary repercussions of parental effects—the impact of the developmental environment provided by parents on offspring—are often discussed as static effects that can have negative influences on offspring fitness that may even persist across generations. However, individuals are not passive recipients and may mitigate the persistence of parental effects through their behavior. Here, we tested how the burying beetle, Nicrophorus orbicollis, a species with complex parental care and size-based competition for ephemeral resources, responded to poor parenting. We cross-fostered young and manipulated the duration of parental care received and measured the impact on traits of both F1 and F2 offspring to experimentally extricate the effect of poor parenting from other parental effects. As expected, reducing parental care negatively affected traits that are ecologically important for burying beetles, including F1 offspring development time and body size. However, F1 parents that received reduced care as larvae spent more time feeding F2 offspring than parents that received full care as larvae. As a result, both the number and mass of F2 offspring were unaffected by the developmental experience of their parents. Our results show that flexible parental care may be able to limit negative parental effects to a single generation. These data also support the predicted role of parental care in buffering offspring development from environmental perturbations, even when poor environments are produced by the behavior of past generations.

Constraint and ray-diation: pectoral fin diversification across batoid fishes

Emily Poulin, Christopher Martinez

The balance between lift and maneuverability represents a general performance trade-off for locomotor systems, like wings and fins, that is expected to influence the design and diversity of these structures at macroevolutionary scales. Batoid fishes (stingrays, skates, and their allies) are united by the presence of enlarged pectoral fins that are fused to their head and trunk, but this group also shows wide variation in morphology and swimming mode. Previous work has shown that pectoral diversity and swimming kinematics in batoids are strongly correlated with variation in fin aspect ratio (AR), making it an ideal trait for exploring functional diversification. We examined the tempo and mode of pectoral fin evolution in 246 species of batoids, studying how AR has diversified across four orders with marked differences in lifestyle. Evolutionary model selection revealed that pectoral fin AR has evolved toward different optima and at different rates across batoid orders. Stingrays (Myliobatiformes) had the most complex trait distribution with two peaks corresponding to distinct benthic and pelagic ecomorphs. Skates, interestingly, occupied an intermediate position relative to these peaks. Electric rays and guitarfishes evolved low AR fins, potentially associated with increased reliance on powerful tail-derived thrust in these groups. Our study highlights the role that anatomical novelty may play in promoting divergent evolutionary outcomes with respect to morphological, functional, and ecological diversity.

From clock genes to behavior: Molecular and behavioral rhythms across a light pollution gradient

Elisset Poveda, DiDiAlice Coker, Jenny Ouyang

Rapid urbanization around the globe has introduced novel stressors, such as artificial light at night (ALAN) to wildlife, perturbing critical time-keeping mechanisms. To gain a holistic understanding of the mechanisms and consequences of light pollution, we continuously monitored free-living breeding

house sparrows (Passer domesticus) to assess their locomotor activity and circadian gene expression. We integrate genome to phenome analyses of birds exposed to three levels of ALAN (5, 10, 25 lux). We found that urban individuals elongated their window of daily activity and were more restless at night: activity onset advanced with increasing ALAN intensity, activity offset was delayed under >5 lux ALAN, and nocturnal activity increased with increasing ALAN. Although there were no significant differences in hypothalamic Cryptochrome 1 (Cry1), Period 2 (Per2), or Period 3 (Per3) expression among individuals exposed to different light pollution levels, Brain and muscle Arnt-like protein-1 (Bmal1) showed a significant earlier phase shift in individuals exposed to 10 and 25 lux compared to 5 lux of ALAN. Furthermore, Bmal1 expression strongly predicts average activity onset, demonstrating a link between circadian gene expression and behavioral rhythms. We report clear associations between circadian gene expression and daily behavioral patterns in free-living, urban-adapted individuals. The dose-dependent nature of the observed behavioral and genetic changes supports urban planning measures, such as the reduction of ALAN intensities to a level that preserves wildlife health.

Prolonged exposure of ALAN on songbird neurocognitive development

Elisset Poveda

Light pollution from artificial light at night (ALAN) disrupts natural environmental cues, profoundly impacting health and behavior. ALAN's interference with circadian rhythms has been associated with sleep disturbances, cognitive decline, and metabolic disorders. Beyond circadian disruption, recent studies highlight the negative effects ALAN-exposure can have on cognitive development and function. To gain a better understanding of the mechanisms and consequences of light pollution on brain health, we exposed zebra finches (Taeniopygia guttata), a diurnal model organism, to dim levels of nighttime light throughout development. I hypothesize that prolonged exposure to ALAN induces long-lasting changes in brain function, leading to deficits in cognitive processes, particularly in tasks requiring learning and memory. I predict birds exposed to ALAN will have reduced gene expression in brain areas related to learning and memory and therefore will perform worse on cognitive tasks compared to their control counterpart. By exploring how ALAN impacts brain function and cognitive outcomes, this research aims to elucidate key mechanisms driving environmental neurobiological changes. These findings have the potential to inform strategies for mitigating the neurological impacts of light pollution in an increasingly illuminated world.

Investigating sustained force production in amphibian muscles

Anthony Powell, Stephen Deban

Sustained force production by muscles is a phenomenon in which skeletal muscles produce force between tetanic contractions when no electrical stimulus is applied. This muscle function appears to be associated with the maintenance of force over an extended period, such as during prey- or mate-gripping. Sustained force production has been found within several species of frogs, but its prevalence across different taxa and muscle groups is not well documented. We investigated physiological properties, including sustained force production, of different muscles in several species of amphibians via muscle stimulation performed in situ or in vitro using a force transducer or muscle lever to record isometric force over time. The muscles include the adductor mandibulae, flexor carpi radialis, and gastrocnemius muscles, because they represent key contributors to the ecologically important behaviors of biting, amplexus, and locomotion, respectively. Preliminary results show differences in presence and magnitude between species (11% and 3% of maximum tetanic force in the adductor mandibulae for Osteopilus septentrionalis and Lithobates pipiens, respectively) and muscle group (3% and 7% for adductor mandibulae and flexor carpi radialis, respectively, with no evidence for the gastrocnemius in Lithobates). This analysis will aid in developing an ancestral reconstruction of the evolutionary history of this phenomenon in amphibians, which can help provide further understanding of the selective pressures that may lead to the development of sustained force-producing muscles.

Mechanisms of ion regulation and ammonia excretion by novel salt-secreting glands of marine larvae

Shrinidhi Prabhakaran, Elissa Khodikian, Andrea Durant

Less than five percent of mosquito species have aquatic larvae that can develop in seawater, and these salt-tolerant larvae have evolved a unique anatomical adaptation: their rectum is divided into functionally distinct anterior and posterior segments. The posterior rectum actively secretes salts from the hemolymph and into the urine, eliminating excess salts while conserving water. Other flies, notably midges, have members with saline-tolerant larvae of which we know nothing of their osmoregulatory strategies. The main goal of this research is to characterize the ion, water, and ammonia transporting properties across the different rectal morphologies of the larvae of two marine mosquito and one midge species. Using immunohistochemistry, real-time ion flux measurements, and RNA-sequencing[EK1] , we confirm that the rectum serves as one of the primary organs for salt excretion and shows an enriched expression of both ion and ammonia transporters compared to whole animal transcript levels. This increased expression supports the secretion of hyperosmotic urine, a critical adaptation for survival in seawater.[EK2] Using 3-dimensional renderings of larval rectal tissues, we show morphological adjustments between larvae reared in either freshwater or seawater to attenuate the salt and water challenges of each condition. Overall, this research describes mechanistically the critical role of the rectum in enabling salt-tolerant larvae to thrive in saline environments through its ability to actively secrete ions with the use of ion pumps. [EK1]Ideally you want to define the acryonyms - though here I think saltwater and freshwater is good enough! [EK2]Just keep it consistent with either salt-water or saltwater :)

The impact of nipple size and ontogeny on suckling mechanics and coordination in preterm infant pigs

Cate Pradhan, Elska Kaczmarek, Ani Smith, Maressa Kennedy, Harlow Smith, Helaina Callis, Dylan Anderson, Hannah Shideler, Thomas Stroud, Christopher Mayerl

Suckling in infant mammals involves latching onto a nipple and using wave-like movement of the tongue to acquire milk. Premature infants often struggle to successfully feed compared to term infants, yet we have a poor understanding of why. Potential explanations include that the small size of premature infants' oral cavity limits their ability to successfully latch on a nipple, and that preterms may not be able to coordinate the structures involved in suckling because of their limited neurological development. Decreasing nipple size to better fit premature infants' mouths may contribute to better seal quality and subsequent suction generation. We assessed how differences in nipple size affect suction generation and suckling biomechanics throughout ontogeny in premature infant pigs. Infants were raised on either standard or small nipples (scaled to preterm body size), and at 13 days of age, were fed on the nipple they were raised on, while measuring tongue kinematics and suck rate using high-speed biplanar videofluoroscopy synchronized with intraoral suction generation. We found that suction generation increased with age for infants fed on the small nipple, likely due to changes in tongue kinematics and coordination. In contrast, infants fed on the standard nipple generated minimal suction throughout ontogeny. These data demonstrate that nipple size can have profound impacts on feeding biomechanics, ultimately improving suction generation and performance in a pathological population.

Distribution changes of *Mytilus* species around Hokkaido, Japan

Olivia Prelog , Emma Carmichael, Fernando Lima, Pamela Brannock

Mytilus (blue mussels) are considered ecosystem engineers in the rocky intertidal ecosystem. Changes to their distribution patterns can have grave ecological and economic impacts. This study explores potential changes to M. galloprovincialis, M. trossulus, and their hybrids distribution around the coast of Hokkaido, Japan after a 17-year period. In May and June 2025, Mytilus species were sampled along the Hokkaido coast. DNA extractions and genotyping at three nuclear molecular markers are being conducted to be directly compared to the previously collected 2008 distribution data. Preliminary remote sensing data suggests sea surface temperatures around portions of

Hokkaido have increased at unprecedented levels since 2006, especially along the southern Hokkaido coast. Since M. galloprovincialis has a higher temperature tolerance than M. trossulus, it is predicted that the presence of M. trossulus parental species will be greatly reduced along the southern coast of Hokkaido and individuals in this geographic region will have a higher M. galloprovincialis signature. Along the northern Hokkaido coast, it is predicted changes in species distributions will occur, but levels will not be as drastic or uniform towards one species due to the lower amount of warming occurring. Future work includes incorporation of newer molecular tools (ddRAD, SNP array, etc) to examine distribution patterns to increase the number of loci examined.

Olivia G. Prelog and Emma E. Carmichael contributed equally and will co-present this poster.

How a self-fertilizing fish copes with fluctuating tidal conditions

John Preston, Garcie Askew, Mark Garcia

Conditions within coastal waters such as temperature and salinity shift with the tides and inhabitants of these waters must cope with these fluctuating conditions. The Mangrove Rivulus (Kryptolebias mamoratus) fish, is a self-fertilizing, simultaneous hermaphrodite residing in coastal, red mangrove forests. Adults are amphibious, capable of traversing land to find and take refuge in water-filled, carb burrows or galleried logs during low tide. However, rivulus eggs are immobile and at the mercy of the elements during low tide. Our study seeks to quantify the effects tidal fluctuations have on egg survivorship and development, juvenile growth, and adult behavior to elucidate how rivulus cope with persisting in such a dynamic environment. We are collecting eggs within 24hr post laying and either constantly submerging them in 12ppt salt water (control) at constant air temp or placing them into a simulated tidal environment (treatment) for 21 days. Treated eggs are then placed under control conditions until hatching. We then monitor egg survivorship, latency to hatch, growth rates in juveniles, sex ratios, fecundity, and boldness/risk-taking behaviors in adults. Initial findings indicate higher egg survivorship but not latency to hatch or mass at two months of age in the tidal treatment relative to control. Results from this work will potentially expand our understanding about the evolution of how a coastal resident copes with dynamic environmental conditions.

Can externally fertilizing anurans temporally adjust gamete release to ensure reproductive success?

Alex Price, Molly Albecker

In external fertilization, gametes are directly exposed to the environment, rendering fertilization success in this mode of reproduction particularly vulnerable to environmental stressors. However, in environments that vary temporally, external fertilizers could adjust the timing of gamete release to cooccur with conditions that are conducive to fertilization. Coastal populations of anurans amphibians are an apt model to investigate this hypothesis. These external fertilizer relies on hypoosmotic cues to activate sperm motility. However, some coastal populations of anurans inhabit brackish wetlands that vary considerably in salinity (and thus osmolality) and reach salinities that could be detrimental to fertilization. Thus, anurans could adjust their reproductive timing to occur during low salinities to ensure successful fertilization. We deployed autonomous audio recorders in conjunction with conductivity loggers at 10 sites on Sapelo Island, Georgia, to passively monitor at which salinities male anurans of six species tend to call to females within sites. Additionally, we visited the 10 sites opportunistically after rainfall to actively search for amplectic pairs (breeding male and female pairs). This combination of passive and active surveys allowed us to estimate the probability that each species attempts reproduction during a bout of calling at different salinities. This study demonstrates how external fertilizers respond to stressors that influence reproduction, and sheds light on how anurans could respond to freshwater salinization from sea level rise.

Linking morphology, jaw biomechanics, and ecological data in Mormyridae

Kassi Price, Kassandra Ford, Richard Hoover, Christine Mantegna

Mormyridae, a family of weakly electric fishes native to African lakes and rivers, display remarkable diversity in their craniofacial morphologies from brachycephalic to dolichocephalic. However, ecomorphology in these fishes remains largely understudied. The goal of this study is to investigate the functional implications of face elongation on the mechanical advantage of the lower jaw, an important proxy of force transmission in the jaws of teleost fishes, and to place these biomechanical data into a broader ecological context. We hypothesized that mormyrids with longer shouts (i.e., orbit-rostrum distance) would have lower mechanical advantages due to assumed jaw elongation. We assessed mechanical advantage using simple lever mechanics measured from high resolution microCT scans of multiple mormyrid species. Preliminary results show that generally, species with extreme craniofacial phenotypes exhibit different mechanical advantages, with longer jaws producing less force. After a sampling trip to the Lake Victoria region, we obtained water quality measurements that may correlate directly with species caught in various habitats. For example, longer snouted species (e.g., Mormyrus kannume) were primarily caught in lakes (both large and small) with low turbidity, while the short-snouted species (e.g., Pollimyrus nigricans, Marcusenius victoriae) were caught in fast-flowing rivers with higher turbidity. While we need additional analyses to determine the complex effects of abiotic factors on mormyrid biodiversity, initial trends show a relationship between water quality parameters and morphological diversity.

Evolution, optics, and development of color-enhancing microstructures in tanager feathers

Rosalyn Price-Waldman, Allison Shultz, Gustavo Bravo, Ping Wu, Cheng-Ming Chuong, Mary Caswell Stoddard

Morphological modifications in the microscale branches of feathers are well-studied in feathers that are specialized for flight, insulation, and other nonsignaling functions. However, the microstructural morphology of colorful feathers is vastly understudied, and the optical functions, evolution, and development of modified microstructures in colorful plumage remain enigmatic. Using vibrantly colorful Tangara tanagers as a model system, we first characterized the microstructural diversity present in structurally colored and carotenoid-pigmented feathers. We discovered that fundamental modifications to the branching structure of feathers modulate the appearance of both structurally colored and carotenoid-pigmented feathers. One particularly striking modification associated with enhanced coloration is the reduction or absence of barbules, the smallest branch of the feather. Remarkably, barbules are hidden on the ventral surface of blue and violet structurally colored feathers but completely absent in some red and yellow carotenoid-pigmented feathers, suggesting that these feathers have convergently evolved a similar modification to enhance coloration through alternative developmental mechanisms. To test this hypothesis, we sampled developing feathers from wild, molting tanagers. We identified two distinct development pathways that control color-enhancing microstructural modifications in structurally colored versus carotenoid-pigmented feathers. In green feathers containing both nanostructures and pigments, the two pathways interact to produce an extraordinary diversity of yellow-green to blue-green colors, highlighting how novel phenotypes can arise through the modification of existing developmental pathways.

Calibration of Motus-compatible radio telemetry receiver network for tracking fine-scale movements

Mackenzie Prichard, Levin Brandt, Morgan Pfeiffer, Susan Ellis-Felege

The ability to estimate the location of animals is an essential element for wildlife research and conservation. Among the technology available to gather spatial data, the Motus network (motus.org) is an attractive choice due to its emphasis on collaboration and the number of species that can be fitted with miniature radio transmitters. However, Motus receiver stations vary widely in terms of set up, and the detection data typically only indicates presence within a wide area, limiting fine-scale location tracking. We aimed to establish an analytical approach to precisely estimate locations using data collected by a network of

Motus receiver stations. To do this, we first calibrated our receiver network to create an accurate model of how signal strength varies with position relative to directional antennas. We combined the exponential decay of signal strength with distance and the Gaussian-like relationship between signal strength and angle to create a two-dimensional model that could be used to estimate the position of a tag using trilateration. Additionally, even within our own network in which all receiver stations were assembled the same way, we found that there was considerable variance between stations in the quality of the detection data. This research provides valuable insight into the data collected by Motus receiver stations and may broaden the horizon of things we can infer as part of this research community.

Gene flow and the evolution of insecticide resistance alter the evolution of plasticity across multiple stressors

Eric Prileson, Seth Rudman, Bianca Campagnari, Brynne Ruotsalainen, Cristian Zetina

Adaptive phenotypic plasticity can limit negative effects to fitness and potentially rescue populations from extinction. Processes that alter underlying genetic variation are expected to lead to the evolution of plasticity, but how this occurs under multi-stressor conditions faced by natural populations is unknown. Here, we address this knowledge gap by examining how selection and gene flow, two evolutionary processes that can change genetic diversity, affect the evolution of plasticity in multiple environments. To do so, we use field-derived populations of Drosophila melanogaster in a laboratory common garden design across temperature and insecticide treatments to test the following questions: 1. Have populations that have recently evolved insecticide resistance exhibit evolved shifts in plasticity relative to naïve populations? 2. Does gene flow from high diversity populations lead to the evolution of plasticity relative to the absence of gene flow? We find that both gene flow and prior evolution of resistance shift plastic responses of multiple traits including body size, fecundity, cold tolerance, and starvation tolerance. Further, the shifts in plasticity for resistant and gene flow-restricted populations for certain traits are consistent with maladaptation, suggesting that the overall maintenance of genetic variation is critical for the evolution of adaptive plasticity. Our study illustrates how evolutionary forces can lead to shifts in labile traits that, if adaptive, might contribute to persistence with implications for conservation of threatened populations.

Season and social cues influence patterns of circadian gene expression in green treefrogs

Nichole Procter, Dario Rimicci, Ashley Lucas, Daniel Hummer, Walter Wilczynski, Deborah Lutterschmidt

Transitions to seasonal reproductive behaviors are associated with changes in environmental light cues, with photoperiod capable of influencing patterns of circadian gene expression. However, the influence of social cues on the circadian clock is unclear. We asked whether social experience influences the expression of clock genes in reproductively active green treefrogs (Hyla cinerea). We field-collected reproductively active frogs and acclimated them to the lab for 14 days. Frogs were then transferred to individual chambers and exposed to a recording of a conspecific population, silence, or tones. Within each acoustic treatment, these nocturnal animals experienced acoustic cues either in phase (during scotophase) or out of phase (during photophase) with their natural activity pattern. Quantitative PCR on whole brain demonstrates that the reception of reproductive calls significantly influences the 24-hour expression of clock and period 2. Next, we compared the expression pattern of clock genes in breeding versus nonbreeding frogs. Our results show that the 24-hour expression of clock, cryptochrome, and period 2 in the brain varies between reproductive and non-reproductive animals. Collectively, these data reveal that reproductive social cues modulate the expression of select clock genes. Our results further suggest that social cues can act as potent zeitgebers, aligning internal molecular rhythms with reproductive opportunities. Seasonal differences in 24-hour expression patterns suggest that environmental and social signals interact to regulate both circadian and circannual clocks.

Biomechanics of active anti-predator defense in kinetic-shelled turtles

Eleanor Prosser, Sydney DiPietro, Robert Greco, Victor Munteanu, Richard Blob

Several types of turtles have evolved hinged shells that help protect them from harm. This active shell closing not only defends the body of the turtle against predators, but also can close quickly and forcefully enough to potentially hurt any predators caught between the portions of the shell as it closes, providing a powerful repellent against future attacks. Using two species of kinetic-shelled turtle, we measured these shell-closing forces by placing a force transducer between the plastron and carapace (lower and upper parts of the shell). This action elicited a shell closing behavior, and we measured the maximum force output at several anatomical locations. Overall, there is a significant difference in absolute force produced between species, with Kinosternon leucostomum (white-lipped mud turtles) producing higher forces than Terrapene carolina (common box turtles). However, these differences are not significant after normalizing for body mass. Anatomical location had a strong effect on the forces produced, with the anterolateral and posterolateral locations showing the highest values across species. The forces observed across species, especially in lateral locations, are sufficient to injure predators, suggesting kinetic shells may have multimodal defensive properties.

Burrowing head-first: exploring the cranial morphology of Ammodytes personatus over ontogeny

Owen Proulx, Elynore In, Karly Cohen, Cassandra Donatelli

The Pacific sand lance (Ammodytes personatus) is a key forage fish in the Salish Sea, linking lower and upper trophic levels as a food source for birds, mammals, and fishes. Adults avoid predation by burrowing head-first into the substrate; yet unlike typical head-first burrowers, their skulls are fragile, kinetic, and triangular rather than heavily fused or robust. We hypothesize that mineralization and shape changes may be localized to elements that first meet the substrate, reflecting selective pressures for efficient burial. µCT scans of preserved specimens (20–95 mm SL, n = 23) were analyzed to estimate the bone mineral density (BMD) of eight cranial bones (premaxilla, maxilla, dentary, suspensorium, lacrimal, nasal, neurocranium, and palatine) and to assess their growth using geometric morphometrics. The most mineralized bones were those that comprised the jaw of the fish, namely the dentary, maxilla, and premaxilla. With increasing body length, mineralization rose across all skull elements, consistent with the prediction of skeletal reinforcement for burrowing in adults. Morphometric analyses showed that skulls lengthen and narrow with age, supporting wedge-driven crack propagation as the burial mechanism rather than substrate fluidization. These findings support the hypothesis that burrowing in sand lance relies on increased mineralization of the jaw bones that first penetrate the substrate and a shift toward a wedge-like skull, together forming a reinforced and streamlined tool for efficient burial.

X-ray imaging helps to elucidate severe reversible bending of cockroach antennae

Adam Puchalski, Kostya Kornev, Andriy Andreyev, Jeffery Owens

Over millions of years in development, the antennae of cockroaches (Blattodea) have come to possess unique flexibility, enabling tactile investigation of narrow crevices, pores and micro trenches. Despite lacking intrinsic muscles, their antennae are capable of precise motion and exceptional resilience. AIMS lab recently discovered that many of these antennal features are supported by circulating hemolymph [Donley et al]. However, the most intriguing ability of cockroach antennae to reversibly fold on itself when the insect investigates narrow holes has never been explained. We use the ZEISS Xradia Versa X-ray Microscope and a Deben CT5000 in-situ loadcell stage for real-time mechanical testing with high-resolution imaging. We performed compressive and bending tests on insect antennae in longitudinal and cross-sectional orientation, capturing internal structural responses using 2D radiography and 3D tomography. The experiments on Periplaneta americana revealed that the minimum radius of the antenna curvature before breakup is measured in a few flagellomere lengths. We discovered that such severe flexing is supported by the hemolymph pressure that transfers the bending

stress onto the trachea, which wrinkles and reversibly collapse, releasing the load on the flagellomeres and connecting membranes. This first in situ X-ray visualization of antennae under controlled mechanical loading points to the important role of hemolymph and trachea in developing tactile sensing in insects. These antennal features may inspire designs for lightweight, damage-resistant engineered fibers.

Macroevolutionary dynamics of the dinosaur cerebrum

Emma Puetz, Donald Morgan, Amy Balanoff

Although it is widely acknowledged that phylogenetic distributions of characters can be the result of differing evolutionary models, alternative scenarios are often ignored–leading either to the overinterpretation of every character shift as the result of selective forces, or under-interpreting meaningful evolutionary trajectories by assuming universal Brownian Motion (BM). Relative cerebral size evolution within dinosaurs is a prime example of how model fitting can provide insight into the mechanisms behind character shifts. Previous work has shown a complex pattern of cerebral size within dinosaurs, with multiple apomorphic increases, most notably within the maniraptoran and ornithopod clades. The evolutionary mechanisms that might have contributed to these shifts, however, remain unclear. Here, we reconstruct continuous character evolution under various models to decipher which best explains the distribution of cerebral size in dinosaurs. We found that cerebral evolution is not consistent with BM, but rather with an Ornstein-Uhlenbeck (OU) pattern, suggesting some changes may be the result of stabilizing selection. This result raises questions regarding what selective mechanisms might underlie these patterns, and if correlations with traits such as body size, social dynamics, or locomotory strategies might be present. Deciphering cerebral evolution in dinosaurs is crucial not only to understanding the biological, ecological, and cognitive mechanisms at play, but also provides a framework to better understand the diverse morphology of the brain within crown-group birds.

Chromatophore organization and dynamic pattern production in two color-changing fish species

Rejana Pullarkat, Mae George, Annaleise Lukens, Lorian Schweikert

Dynamic color change, or the ability to rapidly change skin coloration, is achieved via specialized skin cells known as chromatophores. Despite our understanding of how individual chromatophores change color, there is limited information on their topographical organization, especially as it relates to outcomes of color pattern production. Here, we investigated chromatophore organization in the Caribbean hogfish (Lachnolaimus maximus) and summer flounder (Paralichthys dentatus), which are two color-changing fish species with putatively fixed and fluid pattern-generating capacities, respectively. We hypothesized that hogfish chromatophores are regularly arranged and non-uniformly distributed over the body, allowing for pattern production at fixed body positions, while summer flounder chromatophores are randomly arranged and uniformly distributed over the body, allowing for pattern production in fluid body positions. We performed nearest neighbor analyses of chromatophore cell fields to calculate the degree of regularity in chromatophore arrangement. Then, we examined chromatophore abundances between pattern landmarks to determine whether chromatophores are uniformly or non-uniformly distributed over the body. Finally, we evaluated iterative pattern production to empirically test whether patterns are produced at fixed or fluid body positions. Neither hypothesis was supported, but rather, both species were found to exhibit regularity in chromatophore cell fields, uniformity in bodily chromatophore distribution, and capacities to generate patterns at fixed body positions. These findings suggest there may be shared physiological strategies of pattern production among color-changing fish species.

Bite marks and possible evidence of predation on a late Eocene giant catfish (Siluriformes)

Aidan Purcell, Jennifer Hoeflich, Juan Liu

A giant catfish, Socnopaea grandis, was recovered from the late Eocene Qasr el Sagha Formation of Egypt (~37.71 - 33.9 Ma). The formation, composed of shallow marine and estuarine deposits, has also yielded assemblages of vertebrates including sharks, crocodylians, and basilosaurid whales. We investigated bite marks observed on the left frontal of a large Socnopaea grandis specimen (UCMP 41167) to determine whether the marks represent active predation or scavenging, and to assess the identity of potential tracemakers. High-resolution x-ray-based computed tomography, three-dimensional modeling, and heatmap visualization were used to analyze the morphology of the bite marks. We compared the morphologies to diagnostic characteristics of mammalian, crocodylian, and shark induced bites, as well as the toothrows of the sympatric basilosaurids. Preliminary results show depressed fractures and fracture lines indicating significant force was used, and a lack of bite marks elsewhere on the skull lines up with interpretations of the bites as lethal predation attempts. A hooked score and a bisected puncture indicates the bone modifications were from a crocodylian. Although scavenging cannot be completely ruled out, this is possibly the first evidence of predation on the giant marine catfishes of Egypt during the Eocene. We are in the process of quantifying and further analyzing the bite marks, which may provide a basis for future investigations on predator-prey dynamics.

Osmolyte-mediated heat tolerance in *Tigriopus californicus*

Ella Purvis, Caroline Terry, Wes Dowd

An organism's ability to tolerate environmental change in more than one parameter is essential. In some cases, exposure to multiple stressors can actually improve tolerance. For example, when environmental temperature and salinity increase concurrently, certain osmolytes may enhance macromolecular stability and improve survival. The splash pool copepod Tigriopus californicus lives in an environment where temperature and salinity both fluctuate drastically. Copepods exposed to high salinity levels exhibit increased heat tolerance. This response is potentially driven by the accumulation of osmolytes such as proline, which has been shown to rise under elevated salinity in this species, or by other protective molecules. We investigated the effect of enriching several known osmolytes on heat tolerance in T. californicus by quantifying changes in median lethal temperature (LT50). To achieve this, environmental salinity was kept constant while experimentally manipulating concentrations of specific osmolytes (e.g., proline, taurine, TMAO) within copepods, after which animals were exposed to an acute heat ramp. Our results to date indicate no effect of proline enrichment on acute heat tolerance. Identifying the molecule with the strongest impact on LT50 will guide future experiments exploring how it influences thermal preference and heat tolerance in T. californicus. This study illuminates mechanisms by which simultaneous exposure to two stressors can non-additively affect physiological performance.

Visual morphology of mosquitoes from distinct diel niches

Ruchao Qian, Elina Barredo, John Currea, Jamie Theobald, Matthew DeGennaro

Vision is central to mosquito behaviors such as host-seeking and flight control, yet interspecific and sex-specific variation in compound eye structure remains poorly characterized at high structural resolution. We examined the eye morphology of two globally important species—the diurnal Aedes aegypti and nocturnal Culex quinquefasciatus—to test how diel niche influences the trade-off between light sensitivity and spatial acuity. Using an automated ommatidia detecting algorithm on microscope images, we quantified the number of ommatidia, diameter of corneal facets, eye surface area, and average interommatidial angle ($\Delta\varphi$). Both sexes of Culex had significantly larger facets and eyes than Aedes, while females of both species had more ommatidia than males. Despite these structural differences, average $\Delta\varphi$ remained similar across species, suggesting that larger eyes in Culex preserve overall sampling density. To explore regional specialization, we employed micro-computed tomography (μCT), which revealed a pronounced horizontal acute zone in Culex characterized by locally reduced $\Delta\varphi$ and flatter eye curvature, while this feature was absent in Aedes. We interpret this acute zone as an adaptation that enhances horizontal resolution under dim nocturnal conditions, likely improving host detection against cluttered backgrounds. Together, our findings support the view that diel niche modulates the trade-off between light sensitivity and spatial acuity, reflecting divergent visual strategies for nocturnal and diurnal lifestyles in mosquitoes.

A comprehensive guide to puncture characterization in biomaterials

Jennifer Quigley, Gabriela Moreira Lana, Alfred Crosby

Puncture is ubiquitous in nature, serving functions ranging from predation and protection to feeding and reproduction, and it has inspired extensive research into both the mechanics of natural puncture strategies and their application to materials testing. As a characterization method, puncture integrates principles of fracture mechanics, large-deformation elasticity, and contact phenomena, making it particularly suited to capture the complex failure modes of tissues and bioinspired materials. Over the past few decades, studies have applied puncture testing to estimate fracture toughness, quantify strain-stiffening responses, and examine the roles of structural heterogeneity, friction, and adhesion across a broad array of soft solids. These efforts span multiple length scales, from hydrogel network structures to biological tissues, and have been informed by theoretical modeling, simulations, and experimental techniques. In this presentation, we will review the current state of puncture mechanics research, highlighting how the method provides insights into biological functions and material design. We will also discuss emerging directions for the field, including opportunities to adapt puncture testing for high-throughput screening of complex biological and engineered materials. By combining biological inspiration with advances in materials mechanics, puncture testing has evolved from a specialized method into a broadly applicable, quantitative tool for understanding and engineering soft biomaterials.

Passive acoustic monitoring reveals noise avoidance by a soniferous fish in a global port

Thomas Quigley, Xylo Lazrinth, Sydney Gdanski, Rachel Rodriguez, Paul Forlano

Few studies of anthropogenic noise have examined its effect on soniferous fish in a major global port. New York City provides reproductive habitat for the oyster toadfish (Opsanus tau), a species in which females must hear the male advertisement call in order to reproduce. The goal of this study was to use bioacoustics to deeply interrogate toadfish calling behavior and its relationship to several parameters of vessel noise. Passive acoustic monitoring at four locations revealed that noise incidence varied widely and is periodic. Toadfish advertisement calls were also periodic. Toadfish called over twice as much in early-morning samples without noise than in either the quiet or noisy portions of samples with noise, demonstrating strong diurnal avoidance. In samples with noise, toadfish exhibited active avoidance by calling less when the duration of noise was longer, when the amplitude of noise was greater and when the dominant frequency of noise overlapped the fundamental frequency of their calls. Toadfish did not increase call amplitude in noise (the Lombard effect), nor did they change call frequency or duration. This study represents one of the most exhaustive uses of bioacoustics to examine the behavior of a soniferous fish in a global port, and it demonstrates how a fish that relies on sound for reproduction alters behavior to cope with noise.

Hair sensors contribute to control of flight trajectories and wing kinematics in Myotis auriculus

Brooke Quinn, Calder Montross, Sharon Swartz

Bats rely on sensory input to enact complex maneuvers during flight. Echolocation and vision are important for prey tracking and steering, and recent work has shown that sensory hairs play a role in sensing airflow along the wing. Using videos of wild-caught Myotis auriculus flying in a field arena, we compared flight trajectories and kinematics of bats before and after removal of sensory hairs from the ventral wing surface. Turning radii increased and turning rates decreased after we disrupted the wing hair sensory system. Sensory hair removal resulted in differences within the wingbeat cycle for kinematic variables such as elbow and wrist flexion. Hair condition and pursuit status (cruising vs. prey pursuit flight) also significantly affected flight speed and wingbeat frequency predictions, respectively. Together, these results inform our understanding of the functional role of sensory hairs in maintaining robust flight at broad and fine scales. Future research on this sensor network should focus on elucidating the sensory factors governing its inputs (i.e., airflow, wing membrane strain) and motor output (i.e. activation of specific muscles).

Phylogeny and ontogeny of a middle Miocene kentriodontid (Cetacea: Odontoceti) from Oregon

Andrea Quintanilla, Madeline Ball, Samantha Hopkins

Evolutionary relationships within Kentriodontidae, a diverse family of extinct odontocetes, remain poorly understood. Distinguishing genera is complicated by extensive homoplasy, and recent analyses suggest that the family may be polyphyletic. This is not unexpected, given the repeated evolution of small, narrow-snouted ecomorphs within odontocetes. Here, we describe a kentriodontid partial cranium from the University of Oregon Museum of Natural and Cultural History (UOMNH F-37129). The specimen shows close similarity to Wimahl chinookensis, expanding the known geographic range of the genus from coastal Washington to the broader Pacific Northwest. Several unfused cranial sutures, including between the intertemporal and supraoccipital suture indicates that the specimen is likely a subadult. Morphological differences between this specimen and the type specimen may reflect ontogenetic variation within the genus. Recognizing the differences between developmental and individual variation is essential for refining the taxonomy of this specimen and clarifying its phylogenetic placement within Kentriodontidae.

Corticosterone levels across years of variable drought in overwintering dunlin in central California

Ella Rader, Kenneth Glynn, Jamie Cornelius

In the Central Valley, California, wintering shorebirds rely heavily on flooded rice fields as wetland habitat alternatives in the absence of traditional wetlands in the region. These heavily modified interior wetland habitats are crucial foraging grounds for shorebirds as they prepare for spring migration and their arctic breeding season. However, the long-term sustainability of these habitats remains unknown in the face of increasing environmental instability from extreme weather events like drought. Further, recent evidence suggests that Dunlin populations in the region are declining, despite conservation efforts that promote the efficacy of their usage. To elucidate the reasons behind their declines, an assessment of physiological condition is needed. We investigate the influence of drought conditions on baseline corticosterone (CORT) levels (the primary avian stress hormone), in Dunlin (Calidris alpina) in Central Valley, California over four wintering seasons (November - April) between 2021 and 2025. CORT levels are analyzed in relation to month, year, and annual precipitation rates indicative of drought. We predict that elevated drought conditions (i.e., lower annual rainfall) will limit habitat availability, reduce foraging opportunities, and ultimately push birds into a state of allostatic overload, evidenced by higher baseline CORT. Such data are important for assessing wetland habitat management and for supporting the health of wintering shorebirds under changing climate conditions.

Thermal plasticity of transcription is largely non-conserved across Drosophila species

Greg Ragland, Jimmy deMayo

An accumulating body of literature suggests that evolution in relatively novel environments may often reflect initial suppression of maladaptive plasticity rather than enhancement of beneficial plasticity. This pattern seems to be particularly consistent for transcriptional, plastic responses that serve as a snapshot of tissue-wide or organism-wide physiological change across environments. Less is known about how transcriptional plasticity may evolve as species diversify across environmental space over macroevolutionary timescales. We performed experiments on the plasticity of transcriptional responses to acute cold stress across eight species in the Drosophila genus diversified into tropical and temperate environments to test several hypotheses about macroevolutionary trends in plasticity evolution. We find that long-term evolution in cold environments does not consistently enhance or repress transcriptional responses to cold – in other words, cold-adapted species are not necessarily more or less transcriptionally plastic than warm-adapted species. Rather, divergence in transcriptional plasticity is best predicted by the degree of evolutionary conservation of differentially expressed genes – plastic transcripts tend to map to genes that have diversified via gene gain/loss across species lineages. There are very few exceptions to this rule, and we will briefly discuss a notable example including possible links to the circadian clock.

Natural variation reveals functional and genetic integration of a polyphenism

Erik Ragsdale

Integration and modularity can have a profound impact on the function and evolution of environmentally responsive traits, especially when they result in discrete, alternative forms—that is, developmental polyphenism. An unresolved issue for understanding this impact is the degree to which the genetic architectures of the individual components of a coordinated, plastic trait permit independent versus coordinated evolution. Here, we address that issue with the nematode Pristionchus pacificus, which develops into either a bacterial-feeding (St) or a predatory (Eu) morph depending on its perception of local food-resource availability. By creating recombinant inbred lines (RILs) from natural isolates with divergent morph-induction biases, followed by quantitative trait locus analysis, we tested the extent to which component traits of this polyphenism are linked. We found that RILs with more frequent induction of the predatory morph also produced Eu individuals that were more effective predators. We also found that these two traits are associated with the same major-effect locus, suggesting their causal genes are physically linked, if not the same, and therefore likely to experience coordinated selection. In contrast, we found that morphological variation was not linked to these two traits, and this variation within each morph was even independent of variation in the other. Our findings show that the same coordinated plastic trait exhibits a blend of independence and coordination whose balance shapes the trait's evolutionary potential.

Fire ant raft kinematics under oscillatory perturbations

Aradhya Rajanala, Hosain Bagheri, Michael Goodisman, Daniel Goldman

Many animals engage in sophisticated group behaviors to survive in uncertain environments. S. invicta fire ants form living rafts when nests are flooded, improving their collective survival. However, little is known of their collective dynamics and energetics in response to mechanical perturbations. To systematically investigate ants' responses to water waves, we sinusoidally oscillated a closed container with and without water, varying peak accelerations from 0.5-9g at 20-30 Hz and measuring the raft's projected areas and CO2 concentrations. When oscillated at 0.6g and 20 Hz, few-layered rafts compacted into tight clusters within 5 minutes, accompanied by a 200% spike in CO2 respiration that returned to baseline within 15 minutes. Similarly, ants oscillated at 3g and 30Hz without water also tightly clustered and comparably increased CO2. However, respiratory rates remained elevated until perturbations ceased. To model these processes, we developed a Discrete Element Method simulation treating ants as particles colliding with walls, other ants, and an oscillating floor while cohering with neighboring particles. Particles transitioned to a passive state (less cohesion and energy use) when surrounded by a threshold (T) of 2-6 neighbors. At peak acceleration of 2g, clustering occurred with T=2 with low energy usage, while 6g required T=5 and higher energy use to maintain clustering. We hypothesize that rafting ants dynamically adjust this threshold to reinforce clusters while minimizing energy use across varying wave-like perturbations.

Appendage flexibility and aspect ratio effects in hybrid metachronal rowing

Noel Rajive, Mitchell Ford, Arvind Santhanakrishnan

Aquatic crustaceans like copepods, shrimp, krill, and mysids employ a paddling strategy known as hybrid metachronal rowing to augment their swimming performance. This strategy involves the use of an antiplectic metachronal power stroke and a nearly synchronous recovery stroke. Copepods, for example, commonly employ this technique during escape responses to generate large accelerations. Analysis of published data shows that the aspect ratio (paddle length/paddle width) of paddle-like swimming limbs in crustaceans varies between 1 to 4. The appendage flexibility likely also varies across different species and is hypothesized to affect rowing hydrodynamics and swimming performance. In this work, three-dimensional particle tracking velocimetry (shake-the-box) measurements were conducted on a dynamically scaled robotic model programmed to perform hybrid metachronal rowing with four rectangular paddles. The paddles were programmed to move with kinematics adapted from published data of copepod escapes. The aspect ratio of the paddles was varied between 1 to 4, and we comparatively tested both rigid and flexible models in the robotic platform. The results showed that as the aspect ratio increased, the strength (circulation) of the tip vortices formed during power stroke (indicative of thrust) was reduced for both rigid and flexible models. However, the peak circulation values were mostly unaffected with varying aspect ratio. Flexible paddles also showed a delay in the vortex formation as compared to rigid paddles due to spatiotemporal bending. Swimming performance of rigid and flexible paddles will be presented.

Built for brawls: competitive environment predicts weaponry in an intertidal sea anemone

Sriram Ramamurthy, Jacob Stinnett, Carter Kaulback, Armand Kuris, Todd Oakley

Variation in functional traits is expected to mediate organismal responses to their abiotic and biotic environment. Yet, empirical associations between traits and environmental conditions are often surprisingly weak or inconsistent. Acrorhagi—inducible structures produced by many actiniid sea anemones—offer an attractive system to examine this paradox because they function as weapons in territorial contests over limiting resources. Acrorhagial morphologies vary widely within and among taxa, but the extent to which this reflects investment under varying degrees of intraspecific competition is unclear. Here, we conduct extensive morphometric analyses to show that in the solitary anemone Anthopleura sola, certain acrorhagial traits exhibit differential allometry in accordance with the density of conspecifics. The number of acrorhagi per anemone positively scales with body size, yet increases disproportionately in high-density populations. Anemones in high-density populations also exhibit a greater degree of acrorhagial maturation and development relative to their body size. Meanwhile, the sizes of acrorhagial cnidocysts (stinging organelles) are relatively conserved across populations. Together, our findings are consistent with a role for competitive context influencing trait variation primarily at the organismal level via plasticity or local selection. More broadly, our comparative analyses of acrorhagial morphologies and scaling relationships will provide insight into how ecological pressures contribute to the maintenance of functional trait variation within and across species.

Fish robotics Part 1: navigating and sensing a complex flow landscape with feedback control

Divya Ramesh, Kundan Panta, Yangfan Zhang, Bo Cheng, George Lauder

Fish excel at sensing environmental pressure and maintaining position in challenging flow environments. Fish robots, however, mostly have used open-loop control which has no feedback and have difficulty navigating into and holding their position in low-pressure regions. A key issue is the ability to use sensory feedback to modulate motor output, dealing with unpredictable, unsteady flow patterns and rapidly generating appropriate motor patterns. We used μBot, a 4-segment fish robot with flexible tail, that can integrate multi-modal sensory feedback (via direct pressure sensing, IMU sensors, joint angle measurements, and external vision–based robot steering) to examine how the μBot can deal with shifting fluid dynamic conditions. We tested μBot navigation performance in different flow regimes generated using a foil at orientations from 0° to 90° in a recirculating flow tank. We tested open-loop control with steering capability and PID closed-loop control based on frequency modulation via visual feedback and steering, and imitation learning (i.e., imitating PID control) based on pressure sensing on the robot. We used PIV analysis to quantify the flow landscape encountered by the μBot. In the free stream with no obstacles, the μBot was able to hold a stable position using open-loop control. The PID controller navigated the μBot reliably into the low-pressure region behind the foil, and the imitation learning controller worked decently in station holding but not as consistently.

Variation in thermal tolerance between insect species in an obligate brood-pollination mutualism

Teri Ramey, Shayla Salzman

Physiological responses to environmental variables can be potent drivers of species distributions. In strict mutualisms, species ranges further depend on the physiological capabilities of interacting partners. Zamia integrifolia, a hardy cycad native to Florida and Southern Georgia, is a near-threatened plant that depends on two obligate pollinators for reproduction: the weevil Rhopalotria slossoni and the pleasing fungus beetle Pharaxanotha floridana. In this brood-pollination mutualism, both pollinators rely exclusively on Z. integrifolia reproductive tissue for food, shelter, and egg laying sites. Thus, reproduction of both plant and pollinators is intimately intertwined. Historically, P. floridana has been observed across the entirety of Z. integrifolia's range, whereas R. slossoni is more restricted.To assess the impacts of environmental variables on the range of Z. integrifolia and its pollinators I modeled geographic distribution using Maxent and Bioclimatic variables (bioclim) for all interacting partners and assessed physiological plasticity of pollinator populations across the host plant range using critical thermal maximum (CTmax) measurements. These approaches may help us understand how the relationship between thermal tolerance and environmental factors influences species distribution, including range shifts and expansions, and ultimately how climate change may impact tightly linked and highly specialized plant-insect systems.

Capturing the depths: A review of deep-pelagic eDNA and a case for museomics in an advancing field

Nina Ramos, Annette Govindarajan, Allen Collins, Heather Bracken-Grissom

Environmental DNA (eDNA) is rapidly gaining traction as an effective approach for biodiversity monitoring and is especially advantageous for difficult-to-characterize ecosystems like the deep-pelagic ocean. It provides a complimentary tool to capture biological communities and illuminate organisms underrepresented or missed in traditional sampling methods (e.g., nets, acoustics, ROVs/HOVs). Environmental DNA analysis possesses several constraints, creating downstream challenges for its interpretation and it is unclear how nuances in methodology translate across different ecosystems. Therefore, eDNA methods optimized in other environments (e.g., rivers and coastal ecosystems), cannot necessarily be relied on to inform deep-sea eDNA applications, highlighting the need to synthesize deep-sea specific eDNA research. We present a synthesis of eDNA research focused on the water column >200 m, highlighting knowledge gaps and directing future studies addressing uncertainties. Deep-pelagic eDNA is especially hindered by the lack of vouchered eDNA reference libraries resulting in insufficient ecological detail (i.e., community composition). Demand for eDNA results greatly exceeds the time and effort to curate comprehensive reference libraries. Therefore, we propose a framework emphasizing ""museomics"", the application of -omic approaches to generate sequence data from specimens, to accelerate the expansion of reference libraries. Leveraging museum collections for reference libraries ensures they are curated from accurately identified, archived, and traceable vouchers while museums could concurrently host standardized eDNA data repositories allowing data to be reanalyzed with improved databases.

Re-assessing pulses of algal food as triggers for echinoderm larval cloning

Coral Rankin, Jonathan Allen

Larval echinoderms have the unique capacity to clone themselves via budding or fission and then regenerate into multiple individuals. Prior research has demonstrated that increased algal food availability induces higher frequencies of cloning in sea star larvae. Seasonal algal blooms may rapidly increase algal food available to echinoderm larvae, providing a potentially acute trigger for larval cloning. While there is strong evidence that consistently abundant algal food induces cloning, we sought to re-evaluate the related hypothesis that sudden pulses of algae also induce cloning. The pulse hypothesis is best supported in sand dollars, which we investigated along with 6 additional species of echinoderms. For the seven species tested (four sea stars, two sand dollars and one sea urchin), larvae were exposed to one of three food treatments: low food, high food, or an initial low food treatment followed by a pulse of high food. Larval abundance was assessed every other day to monitor cloning frequencies. Sand dollar and sea urchin larvae entirely failed to clone under the conditions of these experiments. Sea star larvae cloned at low frequencies, but there were no significant differences among treatments. Unlike prior pulse experiments that exhibited high levels of larval mortality, we observed high survival in all species tested. We suggest that the algal pulse hypothesis should be reconsidered, especially in echinoid species where no cloning was observed.

Turning up the heat: Does urban tree heat tolerance vary across the season and within a species?

Ashley Rasmussen, Natalie Love, Miquel Gonzalez-Meler, Evan Rehm

Urban trees provide critical ecosystem services including temperature reduction, carbon sequestration and air filtration. However, urban landscapes are stressful locations for plants to grow since they are significantly hotter than rural areas. Trees rely on physiological traits to withstand these hot conditions. Given that urban trees are an essential nature-based solution to combat urban heat and ongoing climate change, understanding the relationship between heat and urban trees is crucial. We assessed whether heat tolerance varies among cultivars of Acer rubrum and Ulmus americana and whether heat tolerance changes over time. We chose 3 cultivars and 1 ""wild type"" for each species. Leaves from each individual were subject to heat treatments via a temperature controlled water bath from June until the end of the growing season. Heat tolerance was defined as the point at which photosynthetic efficiency (measured via fluorescence) declined by 50% and 95%. Results showed that for most genotypes, heat tolerance declined through the season. For a select few, their heat tolerance increased with time. Moreover, there was more variability in heat tolerance among A. rubrum genotypes and U. americana genotypes were consistently more heat tolerant. These results will help urban forestry planners understand how trees respond to heat over time, identify which species are more vulnerable and may need extra care, and determine which are likely to thrive in extremely hot urban climates.

Sound-evoked escape responses of the mosquito *Aedes aegypti*

Michael Rauscher, Gabriella Wolff

Mosquito-borne illnesses pose major global public health challenges, prompting study of all aspects of mosquito sensory biology including antennal audition. While this has been extensively studied in the context of courtship and mating behaviors, other auditory-evoked behaviors are comparatively less understood. Here, we characterize auditory-evoked escape responses to low frequency sound (100-300hz) in the dengue mosquito Aedes aegypti. We show that mosquitos in tethered flight respond to these stimuli by rapidly increasing wingstroke amplitude and frequency. These responses resemble those evoked by visual expansion, as well as those evoked by concurrent auditory and visual stimulation suggesting a "winner-takes-all" mechanism. In agreement with these data, we also show that free-flying mosquitos increase their vertical velocity and initiate a rapid ascent in response to low-frequency auditory stimuli. We hypothesize that these responses may reflect the acoustic signatures of aerial predators faced by mosquitos such as dragonflies.

Comparing the Effects of Sample Storage on Avian Gut Microbiome

Daniella Ray, Kevin Kohl, Jessica Diaz, Elizabeth Rudzki, Aaron Schrey, José Goyco-Blas

Fecal samples provide a non-invasive method for inventorying the gut microbiome through sequencing 16S rRNA gene. However, studies have shown that sample collection and storage methods may influence this composition, potentially introducing bias. While immediate freezing is often the preferred method for microbiome sample storage, it is not always feasible under field conditions. Previous studies in mammals have found 95% ethanol and FTA (Whatman) cards to induce minimal bias compared to individual-to-individual variation in microbiome signatures. However, whether the avian microbiome is

equally robust to technical variation is unclear, especially given difficulties with DNA extractions and weak correlations between the gut microbiome and host phylogeny in birds compared to mammals. Here, we compare microbial inventories of frozen fecal samples to Whatman card samples in two bird species, the Gray Catbird (Dumetella carolinensis) and the Cedar Waxwing (Bombycilla cedrorum). Our goal is to determine if these storage methods yield significant differences in recovered inventories of microbial composition. Determining a stable storage method for bird gut microbiome samples would be crucial to ecological and microbiome studies, particularly those that involve international transport.

Morphological variation in *Euphydryas gillettii* butterflies across time and space

Jenna Rechsteiner, Carol Boggs

Examining variation in dispersal capability is essential to understanding the effects of global environmental change on the ability of organisms to colonize new habitats. Dispersal capability depends on wing morphology. We examined the disparity in dispersal potential between and within two populations of differing age of Euphydryas gillettii in the Colorado Rocky Mountains. To examine morphological differences as a function of space, approximately 70 butterflies were photographed from two sites, which differ in their habitat characteristics. Wing and body size measurements were taken from the photographs, and the butterflies were weighed. These measurements were used to determine wing loading and aspect ratio. To determine how E. gillettii morphologies have changed across time, wing measurements were compared to measurements derived from photos in one of the sites in 2011, 2013, 2017, 2019, and 2024. Initial data analysis shows significant differences in wing loading as a function of sex and site, and differences in aspect ratio as a function of site, sex, and year. Our results indicate that dispersal capability is changing across both space and time.

Understanding hormones in time: Incorporating time series analysis into endocrinology research

Josh Reed, Cory Matthews, Jen Jelincic, C. Loren Buck, Kathleen Hunt, Leslie New

The study of endocrinology provides insights into the upstream drivers of behavior and physiology of wild and captive populations to both natural and anthropogenic stressors. Most studies of wildlife endocrinology rely on single samples from multiple individuals to understand differences between different demographic states or populations. However, neither stressors nor hormone secretion are static, fluctuating over time within and between individuals. The use of non-traditional sample types that accumulate hormones concentrations through time, or repeated sampling of individuals through time can elucidate natural hormone fluctuations and the influence of stressors over time. With studies containing a temporal component come numerous challenges when interpreting and analyzing the data due to the inherent correlation between data points. Time series analysis is a group of statistical methods that were developed to analyze data collected with a temporal component. Here we present a review of classic time series analysis methods, describe how they can be used with endocrinology data, when they can be used, and how to interpret the results. By integrating time series analysis into endocrinology studies, researchers can get a better understanding of the temporal and individual variation in specific hormones. Through highlighting these tools and how they can be applied, we hope that they can be more readily available to all members of the endocrinology field to further understand wildlife endocrinology.

Parental 'fin'ography: a kinematic description of parental care behaviors in *Lythrypnus dalli*

Makenzie Reed, Veronica Britton, Reagan Piel, Deeksha Seth, Devaleena Pradhan

Parental care in many fishes is a dynamic behavior involving whole body movement patterns. The bluebanded goby, Lythrypnus dalli, is a haremic marine fish in which the male performs parental care. Parental care is composed of two primary behaviors: fanning and rubbing. Fanning involves fin movement to oxygenate eggs, while rubbing involves direct abdominal contact to the substrate, releasing sperm and nourishment to developing embryos. Although these behaviors directly relate to embryo success, male L. dalli perform fanning and rubbing regardless of embryo presence. While this behavior has been described previously at an organismal level, the precise kinetics of fin movement and body orientation have not been described mechanically. Using a novel recording system, parental care bouts of wild caught male L. dalli were recorded at 800 frames per second for 30, 45, or 60 minutes. For each behavior, we quantified the overall body orientation and the relative fin kinetics (patterns, duration, velocity) of the caudal, pectoral, and dorsal fins. Preliminary data highlights that while there is a general pattern in parental care behaviors, high levels of individual variation in the number and duration of bouts, as well as differences in fin movement are present. Measures from this study will allow for the development of a mechanical description of body and fin movement during complex behaviors, as well as creating a baseline for future studies.

Novel filter feeding simulation reveals a pathway for microplastic consumption in baleen whales

Lindsey Reimels, Sarah Davis, Shirel Kahane-Rapport, Andrew Davies, Coleen Suckling

Microplastics (MPs), a ubiquitous pollutant in marine environments, have been found in the feeding grounds and in the tissues of several baleen whale species. Current research suggests that a majority of MP consumption by rorquals whales (Balaenopteridae, Mysticeti) is an indirect result of trophic transfer. However, the prevalence of MPs in rorqual foraging areas and overlapping characteristics between MPs and prey species suggests that rorquals may ingest MPs directly through their feeding behaviors. To test this hypothesis, we developed a physical model based on a humpback whale baleen rack (a member of the rorqual family) and inserted it into a flume tank. We adjusted the water velocity in the tank to mimic humpback filter feeding and released polyethylene beads (355um and 600um) and polyethylene terephthalate fragments (435um and 1mm) upstream of the model in high and low doses. After a precalculated filter time, we collected the MPs with an underwater vacuum and sieve, and quantified them using a stereomicroscope. Our results illustrate that a maximum of 16.2% of MPs are captured by the baleen rack during a single humpback feeding event. The larger particles, regardless of polymer type and dose, were retained significantly more than the smaller particles. This information is essential to understanding baleen function, improving calculations estimating rates of MP consumption, and provides context to the potential health impacts these species face.

Song syntax is conserved over great distance

Emma Reinhardt, Keith Sockman

In bird populations with limited post-natal dispersal, differentiation in song-types becomes more apparent as the distance between populations increases and often results in the formation of dialects. Dialectal differences can manifest in such ways as within-song pitch transitions or variation in placement or performance of a discrete acoustic song element, or syllable-type. However, the formation of dialects in species with high rates of post-natal dispersal, such as Lincoln's sparrows (Melospiza lincolnii), is not well understood. With the aim of characterizing population-level syllable-type repertoires and within-song syntax across the range of a highly dispersive species, I recorded songs and identified unique syllable-types from males along a transect from New Mexico, USA to the Northwest Territories, CAN, spanning the vertical range of the Lincoln's sparrow breeding habitat. I found that syllable-type repertoires displayed decreasing overlap as distance between populations increased. However, the internal acoustic structure of songs remained conserved, even in distant populations. Over 70% of songs from each population showed an increase in center frequency from the first phrase to the second, and long, high-frequency 'buzzy' syllable-types always appeared in the last third of a song. This suggests that individuals who disperse far from their natal grounds may perform syllable-types unfamiliar to locals, but their songs may still be recognizable as conspecific because of universal syntactical constraints.

The origin of location impacts viral and microbial associations in the sea anemone *Nematostella*

Adam Reitzel, Sydney Birch, Yehu Moran

Estuaries are home to a diverse array of microorganisms, enabling animal-microbe interactions that can influence the physiology of host animals. The sea anemone Nematostella vectensis ranges along the east coast of North America, from Nova Scotia to Florida. Previous research has shown that anemones from different locations possess unique microbial communities. Additionally, an initial examination of the virome has been conducted on the standard lab population; however, how viromes differ between populations remains unexplored. Here, we conducted a mesocosm experiment with six populations of anemones to investigate whether the location of origin impacts the diversity and functions of viruses and bacteria that associate with Nematostella. We collected samples before mesocosm exposure and 14 days after exposure to sequence the viromes, microbiomes, and host transcriptomes. Additionally, we sampled anemones from a natural population to compare with experimental animals. The virome and microbiome analyses revealed an increase in the number of taxa and functional terms at day-14, with a greater increase in southern locations. Additionally, we find that both the viromes and microbiomes from experimental anemones do not become more similar to the natural population, but rather, they interact with viruses and microbes differently across populations. Differential gene expression revealed a relatively low host response, while WGCNA showed a north vs south response. Altogether, this work demonstrates that Nematostella populations preferentially associate with distinct viruses and microbes.

Eggs-ceptional defense: how does lysozyme protect lizard eggs?

Allison Remick, Samantha Fontaine, Madeline Desmond, Brian Trevelline

Microbes are known to influence the growth and development of many vertebrate species. However, there is little known about how these microbes explicitly influence a host's earliest stages of life. Recent studies have demonstrated that wild vertebrate eggs contain microbial DNA, suggesting that eggs may harbor microbial communities that could have significant effects on embryo development and hatchling fitness. It is unknown whether this microbial DNA is living given high concentrations of lysozyme that protects the embryo from bacterial colonization. To address this knowledge gap, we sought to: (1) determine whether lizard eggs contain viable microbial communities and (2) test whether total bacterial abundance is affected by lysozyme concentration. We collected eggs directly from the oviduct of adult female wall lizards (Podarcis muralis) at various stages of gravidity. Egg contents were extracted after external sterilization by lysing the egg and diluting in sterile PBS. Each sample was cultured on both brain heart infusion and trypticase soy agar. We next quantified lysozyme activity and total bacterial abundance using 16S rRNA qPCR. Preliminary qPCR results revealed a consistent presence of microbes in each egg regardless of developmental stage. Bacterial abundance was not associated with lysozyme concentration, suggesting the presence of lysozyme resistant bacteria. Culture plates showed growth of morphologically similar colonies across samples. These results support the hypothesis that living microbes are present within vertebrate eggs.

Predictors of painted lady butterfly body size: Assessing range and morphology of two host plants

Claire Reynolds, Amanda Carter, Richie Hodel

Over the past century, climate change has driven shifts in biological communities — directly impacting species' ranges, phenology, and morphology. Research in our group has demonstrated that wing and thorax size have decreased in painted lady butterflies (Vanessa cardui) in western North America from 1920-2024. These morphological shifts can impact flight and, ultimately, migration. Food availability and abundance during larval stages play a large role in determining adult body size. Therefore, the productivity of V. cardui's host plants may directly shape butterfly morphology with potential influence on flight, migration, and distribution. In this study, we use two host plants, desert globemallow (Sphaeralcea ambigua) and Canada thistle (Cirsium arvense), to assess if shifts in host plant ranges coincide with changes in butterfly body size. We collected morphological and environmental data from 633 S. ambigua and 357 C. arvense georeferenced herbarium specimens from western North America encompassing two time periods: 1934-1978 and 1979-2013. To quantify temporal change in each species' environment, we used a principal components analysis of bioclimatic variables to characterize the environment each species occupied in each time period. We extracted leaf characters (lamina/petiole dimensions; leaf area and perimeter) from host plants using the machine learning program LeafMachine2. By synthesizing morphological and environmental data in a multiple regression framework, we infer how these shifts may impact the morphology of both host plants and V. cardui.

Nest site choice and brooding behavior in response to temperature in the five-lined skink

Michael Reynolds, Daniel Warner

For many ectothermic organisms, survival and development of embryos is largely dependent upon temperature. Most reptiles abandon their eggs after oviposition, which could leave the developing embryos exposed to a range of unpredictable and suboptimal thermal conditions. The Five-Lined Skink (Plestiodon fasciatus), however, remains with its eggs and broods them throughout development. Females often make fine-scale manipulations to the incubation environment, moving eggs within the nest chamber. To characterize the nest site choice of brooding five-lined skinks, we collected gravid females from areas around Auburn, Alabama. We provided lizards with a choice between nest sites at either 25 C (room temperature) or 33 C (warmed by a heating pad), which is the upper limit of embryo thermal tolerance. We monitored female behavior every two hours from 8am to 4pm before, during, and after brooding. We found that lizards preferentially laid eggs in the unheated nest box and would bask on the heating pad in the morning before returning to brood their eggs. In addition, when the nest box containing the brood was heated, females would spend more time with their eggs. These results suggest that the brooding behavior in this species is responsive to temperature. These findings provide a foundation for further research on parental care behaviors in response to a range of different environmental conditions.

Mitochondrial physiology in White-throated and Rufous-collared Sparrows in genus *Zonotrichia*

Emma Rhodes, Amanda Carpenter, Geoffrey Hill, Didier Ramírez Morales, Alfonso García Piñeres, Luis Sandoval, Wendy Hood

Until recently, the role of mitochondria in migration physiology and energetics has been mostly unstudied. The migratory phenotype consists of whole-organism to subcellular adaptations although a paucity of information exists on the role of organelles within the cells. Previous research comparing two subspecies of White-crowned Sparrow (Zonotrichia leucophrys), migratory Z. l. gambelii (Gambel's) and non-migratory Z. l. nuttalli (Nuttall's) showed that Gambel's had higher mitochondrial respiratory performance in flight muscles during active migratory periods compared to Nuttall's. In this study, we examined another migratory species within the same genus the White-throated Sparrow (Zonotrichia albicollis) to measure mitochondrial physiology for both a pre-migratory (spring) and non-migratory (winter) period with populations located in Auburn, Alabama. Additionally, we measured non-migratory Rufous-collared Sparrows (Zonotrichia capensis) for one timepoint at the University of Costa Rica. We discuss the limitations of this migrant and non-migrant comparison while elucidating underlying patterns observed which will help us to understand mitochondrial adaptation across the crowned-sparrows.

Novel wearable device captures continuous, dynamic and rapid beak cooling during acute stress

Rachel Riccio, Surya Varchasvi Devaraj, Isaac Medina, Sameer Sonkusale, L. Michael Romero

Peripheral temperature change is a strong indicator of autonomic responses to stress and sympathetic nervous system activation. In birds, stress-induced temperature changes occur in the beak, a key thermoregulatory structure, but capturing the dynamics of thermal responses in the beak is limited. We

developed a novel non-invasive wearable device for wireless, continuous monitoring of beak temperature, and tracked thermal responses in birds across repeated trials of acute stress. Stress induced a sharp drop from baseline (30° C) of approximately 2.5° C. The initial drop in temperature occurred on average 6.5 seconds post stressor onset and reached the minimum temperature on average around 90 seconds. Upon cessation of the stressor, there was a gradual recovery that tended to overshoot by approximately 2° C before returning to baseline. These results were consistent across trials, and except for the time to return to baseline, variation between birds was marginal. These changes are comparable with literature reports of repeatable beak cooling during acute stress, however, reveal additional complexity of thermal responses, which may be linked to stress-driven vasomotor activity. This approach demonstrates the power of continuous, wearable devices as effective tools for fine-scale monitoring of stress physiology in birds.

Monarchs and mating: persistence of secondary sexual ornaments within a coercive system

Eleanor Rice, Zoey DeLaney, Scott Villa

Although many sexually reproducing species have evolved mating systems of persuasion, where one or both sexes use their appearance to attract conspecifics, some vertebrate and invertebrate species have shifted from persuasive to coercive mating tactics. In these scenarios, one sex, usually the male, evolves to bypass traditional modes of female choice and instead forces copulation. However, comparatively little is known about the fate of persuasive traits when males evolve coercive mating strategies. Traditional sexual ornaments are presumably reduced or lost when males evade female choice, but this assumption is rarely tested. Here, we investigated the role of wing pattern ornamentation in monarch butterflies (Danaus plexippus), in which males forgo typical courtship strategies and instead use forced copulatory tactics. We experimentally manipulated distal white wing spotting, and used full knockout, hindwing knockout, and sham manipulated monarchs in mating trials to directly test the hypothesis that female preference for spot ornamentation is maintained in this forced copulatory system. Our findings indicate that, contrary to males' coercive mating strategies, female monarchs indeed relied on white wing spotting for mate choice, and we further hypothesize that pattern development concentrated in the hindwings may be under sexual selective pressure. This research challenges prevailing theories in sexual selection by revealing the power of female choice in a forced copulatory system where seduction is more successful than coercion.

Development of novel semen collection device with potential to improve semen quality

Jacquline Rich, Guillermo Sánchez-Contreras, Jonathan Cowart, Dara Orbach

Semen is routinely collected from livestock and animals in zoos and aquaria to support artificial insemination. Artificial vaginas (AVs) are semen collection devices that often collect higher-quality ejaculates compared to other collection techniques, such as manual stimulation or electroejaculation. Most commercially available AVs are tube-shaped and do not reflect species-specific diversity in genital morphologies. To explore the effect of vaginal morphology on semen collection, we developed a novel bioinspired artificial vagina (BAV) for bottlenose dolphins (Tursiops spp.) reflecting the unique shape of the dolphin vaginal lumen and possessing a skin-like texture. Semen was collected with the BAV and manual stimulation from five adult bottlenose dolphins in managed care that were previously trained for voluntary semen collection. Semen quality parameters were assessed, including volume, sperm concentration, plasma membrane integrity, motility, and kinematics. Sperm collected with the BAV exhibited patterns of increased progressive and rapid motility and increased linearity of movement. Sperm concentration was increased with manual stimulation while semen volume and plasma membrane integrity were not affected by collection technique. Patterns of improved sperm motility with the BAV suggest the importance of species-specific genital morphologies has been overlooked in commercially available AVs. Our BAV design may be modified to reflect vaginal morphologies of other species, presenting an innovation to existing semen collection techniques with the potential to improve collected semen quality for assisted reproductive technology applications.

Bumblebee queens differ in brain morphology but not learning performance across life stages.

Leeah Richardson, Christopher Jernigan, Shalene Jha, Felicity Muth

Animals' cognition and investment across brain regions is shaped by ecology. Social bumblebees face distinct ecological pressures over the colony lifespan. Future-queens (gynes) and workers share challenges as they both forage to provision a colony, but as gynes develop into queens, they stop foraging and remain in the underground colony to reproduce. Past work indicates gynes are better visual learners than workers, but we know little about how cognition changes as a gyne transitions to a queen. We compared bumblebee (Bombus impatiens) color learning in a FMPER (free moving proboscis extension response) assay and brain morphology with confocal imaging across workers, gynes, and queens. We hypothesized that nest-bound queens would perform worse at visual tasks and invest less in visual brain regions. However, we found gynes and queens were equally good at color learning and performed better than workers. We also identified that reproductive queens had larger olfactory regions (antennal lobes) than gynes, while visual regions (medulla and lobula) did not differ. This suggests that, unlike some social insects, queen brains do not shrink when they transition to a nest-bound reproductive stage, and may even expand – with disproportionate investment in olfactory regions. Finally, we found brain regions vary by body size differently across castes. These results highlight how shifts in ecological role across the colony lifecycle shape cognition and neural investment in distinct ways.

Heat flux drives avian performance and responses to climate

Eric Riddell, Cody Porter, Ofir Levy, David Adams, Urinovsky Nathan

Thermal performance curves (TPCs) are widely used to predict ectothermic responses to climate but fail to capture the thermal dependence of performance in endotherms, where thermoregulation often decouples body temperature from ambient conditions. We develop theory and provide empirical evidence for performance curves in endotherms based on net sensible heat flux (Q), an integrative index of thermoregulatory imbalance. Using biophysical simulations in tree swallows, we show that Q-based performance curves (QPCs) explain variation in nestling provisioning performance, reproductive fitness, and geographic limits, while also forecasting responses to climate change. We also demonstrate that heat flux helps shape breeding ranges of birds across North America. Our findings highlight Q as a broadly relevant ecophysiological dimension and introduce a new framework for predicting endotherm responses to climate.

Venom peptide diversity in cone snails and their activities on the zebrafish model system

Nadine Riddle, Joseph Schulz

Cone snails are venomous marine snails that use a harpoon-like radular tooth to sting their prey and inject a highly potent, paralytic venom. Neuroexcitatory (NEX) peptides encoded by the A-superfamily conotoxin genes are unique because they cause tetanic paralysis and have an unknown molecular target. This project focuses on identifying novel NEX peptides from museum specimens by using DNA from periostracum, the outer organic coating of shells, to amplify and sequence A-superfamily encoding peptide sequences. Periostracum is collected from museum specimens for digestion, extraction, and purification. Resulting DNA samples are then amplified using PCR and the size is estimated using gel electrophoresis. The resulting amplicons are massively parallel sequenced, and subsequent sequence analysis identifies novel venom peptide encoding genes. Selected novel peptides are synthesized and folded in vitro into active conformations to examine NEX peptide activities. Our laboratory has developed a spinal motility assay using larval zebrafish to quantify the effects of synthesized NEX peptides on spinal circuits in real time. This procedure utilizes small-volume, parallel assays in the absence of supraspinal inputs, and quantifies venom activity using motion-tracking software. These approaches contribute to a growing library of cone

snail neurotoxins, which has important implications for studying and understanding other venom-encoding genes, the broader evolution of cone snails and their venom, and the control of spinal motor circuits in vertebrates.

Hanging in the balance: how cornsnakes balance speed and force trade-offs when climbing

Calvin Riiska, Michelle Lee, Joseph Mendelson, Jennifer Rieser

Snakes in arboreal habitats face unique challenges; they must traverse branches and tree trunks with variable curvature, stiffness, and roughness, all without limbs. Several snake species can climb flat, vertical surfaces, somehow supporting their body weight with only a few small surface protrusions. To investigate how cornsnakes (Pantherophis guttatus) utilize surface features when climbing, we performed experiments that recorded kinematics and forces as snakes climbed up a single column of force-sensitive pegs on our custom-built wall. With pegs protruding 25 mm, we find that cornsnakes generally use shapes with ≥4 body waves with low amplitude and low mechanical bending energy. Cornsnakes geometrically match body bends to contact posts but may only weave between 60-80% of the posts along their path. We also find that forces nearly balance at each moment in time, indicating the dynamics are quasistatic. These observations inspired a computational model for examining trade-offs; we prescribe body deformations and find a center of mass velocity that minimizes the total force at each timestep. Modelled shapes similar to those from experiments produce lower speeds, but instead, forces in the system nearly balance. In contrast, longer wavelength shapes have fewer peg contacts, higher bending energies, and less balanced forces, which may indicate these shapes are unfavorable for climbing. Future work will explore how shapes and dynamic patterns vary among species with differing levels of arboreality.

Do species differ in their response to a heat challenge? A case study in two cavity-nesters

Atalanta Ritter, Emily Levy, Seven Wilson, Mary Woodruff, Kim Rosvall

Wild birds are encountering more intense heat waves, yet some species may be more successful under warming conditions. Thus, interspecific comparisons of traits relevant to heat tolerance can be informative in predicting resilience to global change. Here we compared two co-occurring cavity-nesting songbirds, the tree swallow (Tachycineta bicolor) and Eastern bluebird (Sialia sialis), in their responses to heat during a critical developmental window. Tree swallows are expanding their breeding range southward, contrary to many other North American species, suggesting they may be better able to cope with heat than other species. To evaluate this, we heated nest boxes of tree swallows and Eastern bluebirds for 4 hours when nestlings were 12 days old. We used air-activated heat packs to achieve sublethal temperatures within experimental nests and contrasted them with unheated controls. During the trial, we used cameras to record and quantify thermoregulatory behaviors during the first hour of the trial, including panting and movement toward cooler microclimates within the nest box. Forthcoming results will shed light on any species differences in heat responses, and the degree to which behavioral coping mechanisms may influence responses to global warming.

Resilience of the Argonauts: dynamic pressure distributions across octopus egg case ornamentation

Kathleen Ritterbush, Nicholas Hebdon, Megan Jones, Lexi Bohman

Females of the open-water octopus Argonauta produce delicate planispiral egg cases that earn the name Paper Nautilus. The egg cases differ from true mollusk shells in minerology, microstructure, and appearance. But the egg cases strongly resemble conch shapes of extinct ammonites, offering a unique morphological analogue. Generally, fine ornament occurs on compressed specimens, while coarse ornament occurs on blunter specimens. Argonauta argo produces hyper-streamlined egg cases with high-frequency, low-amplitude ribs. Argonauta hians produce squat egg cases with low-frequency, high-amplitude ribs. We 3D scan Argonauta specimens from museum collections, and create synthetic specimens via digital editing (Blender) or computer modeling (ShellGenerator2). We study the hydrodynamic consequences of these shape features with simulations in computational fluid dynamics (Ansys). Dynamic pressure is starkly divided across a smooth-flanked specimen: positive (inward) pressure in the face of flow, and negative (outward) pressure in the rear. Argonaut egg cases with ribbing show dynamic pressure distributed along peaks (inward) and troughs (outward). At millimeter scale, dynamic pressure is obliquely opposed by the localized rib flanks. We speculate that this redistribution of dynamic pressure gives the egg case its resilience in the face of rapid locomotion or harsh currents: it is lightweight but not flimsy. Drag analysis shows the ribs increase viscous drag, but we speculate the animals use intermittent jetting to foment turbulence that negates any locomotory cost of ribbing.

Many mates, one female: examining polyandry in a frog-biting mosquito

Gloria Rivas, Ximena Bernal, Richa Singh

Polyandry, a mating system where a female mates with multiple males, is observed across numerous insect taxa which influences the species' genetic diversity, offspring viability, female fecundity, and the dynamics of sexual selection. While mosquitoes are generally considered monandrous, where females mate with only one male, emerging evidence suggests that some species exhibit polyandry. However, far less is known about such mating behavior in non-vector species, those that do not transmit pathogens to humans. This study examines polyandrous behavior in Uranotaenia lowii, a mosquito species that primarily feeds on anuran hosts. We hypothesize that female Ur. lowii exhibit polyandrous mating behavior to enhance their reproductive fitness. To test this hypothesis, we carried out two controlled laboratory mating experiments which included blood feeding for egg production after each mating cycle and performing dissections to examine their spermatheca for signs of insemination. We then quantified the mating frequency and assessed the reproductive outcomes associated with polyandrous behavior. Our understanding of mating strategies in non-vector mosquito species provides a valuable comparative framework to evaluate the ecological and evolutionary significance of polyandry across the Culicidae family.

Deducing the evolution of allorecognition and primordial immunity in cnidarians

Alberto Rivera, Andy Baxevanis

The allorecognition system of the hydroid Hydractinia symbiolongicarpus plays an essential role in mediating self vs. non-self recognition in cnidarian colonies, which is analogous to the role of the major histocompatibility complex (MHC) in bilaterian immune systems. Both complexes have contiguous stretches of similar, highly duplicated genes, suggesting a homologous relationship between the ARC and MHC. Protein structural prediction methods such as AlphaFold2 also indicate structural similarity between the proteins encoded within the Hydractinia ARC and the MHC. We have deduced the structure of the ARC in the related hydrozoan Podocoryna to determine the overall conservation of the cnidarian allorecognition complex. Genome annotation and protein structural prediction methods have revealed a number of candidate Podocoryna allorecognition proteins that form a long contiguous complex. Phylogenies suggest that there is homology between cnidarian allorecognition genes, as well as syntenic conservation of this gene complex across cnidarians. We are currently applying these methods to analyze the high-quality whole-genome sequence of the basal bilaterians Branchiostoma and Ciona to identify potential ALR orthologs. We have also begun identifying homologous regions in other bilaterian species to determine likely ALR homologs. Future comparative genomics work with other basal chordates and vertebrates will be focused on determining the relationship between the ARC and the bilaterian MHC, to help elucidate the evolution of the immune system in early vertebrate history.

Hot on the trail: Temperature-driven genetic variation in invasive green crab populations

Erica Ro, Carolyn Tepolt

Invasive species often establish and spread despite losing diversity after introduction, raising key questions about how they maintain adaptive potential in novel environments. The European green crab (Carcinus maenas) exemplifies this, rapidly invading worldwide despite genetic bottlenecking. Recent studies in Europe and North America suggest a potential explanation in a supergene—a cluster of tightly linked genes inherited together, likely an inversion polymorphism—with alleles associated with environmental temperature and thermal tolerance. Here, we investigate the global distribution and evolutionary origin of this temperature–supergene relationship. Using a nuclear single-nucleotide polymorphism (SNP) diagnostic of allele type, we compared supergene allele frequencies to mean sea surface temperature (2000 - 2010) in nine populations of C. maenas and its sister species, Carcinus aestuarii, spanning five continents across their native and invasive ranges. We find both "warm" and "cold"-associated SNPs in all invasive C. maenas populations, with allele frequencies correlating significantly with temperature across this global dataset. C. aestuarii populations carried only the "cold"-associated SNP and showed no significant temperature-supergene relationship, suggesting the supergene evolved after the two species diverged. These results indicate that diversity preserved within key genomic regions—such as a supergene—may help offset overall diversity loss during invasions, enabling selection to drive rapid adaptation and range expansion. Understanding such evolutionary mechanisms of invasiveness provides a framework for predicting marine invasion risks under accelerating environmental change.

Small-scale differences in temperature affect the timing of reproduction in three-spined stickleback

Ashley Robart, Gabi Hansen, Kale Fries

Organisms utilize environmental cues to time life history events, with increasing daylength and temperature during the spring initiating reproduction for many animals. Three-spined stickleback fish (Gasterosteus aculeatus) use both these cues to regulate the timing of reproduction, with different populations experiencing a range of photoperiodic and temperature regimes during their breeding season due to their extensive distribution throughout the Northern Hemisphere. However, while populations at the same latitude experience identical photoperiods during the breeding season, temperature can vary widely even at small local geographic scales. This variation in temperature has the potential to impact both the timing and duration of the breeding season since temperature influences a suite of physiological and reproductive traits in ectotherms. We scored gonadal development to examine potential differences in the timing of breeding between two populations of three-spined sticklebacks within central Oregon that differ by as much as 12°C during the breeding season, despite being separated by less than 2 km. Early in the breeding season, we found that females from the warmer site had more advanced ovarian development and a higher gonadosomatic index compared to females from the colder site. However, except for a single individual, all males had mature testes. These findings suggest that at localized scales, differences in temperature may more strongly influence the timing of female reproduction, while male reproduction may be more regulated by photoperiod.

Off the Waals: setal field configuration in natural and urban populations of *Anolis*

Aaliyah Roberts, Austin Garner

Subdigital adhesive pads of Anolis lizards are considered a key innovation that catalyzed exploitation of novel ecological niches and subsequent diversification. Anolis subdigital pads have been a strong focus in the genus' ecomorphology, whereby distantly related and geographically isolated species develop similar morphologies depending upon habitat use. Previous studies use macroscopic features of Anolis toepads (e.g., width, area, and number of adhesive lamellae) to make connections between morphology, clinging or locomotor ability, and habitat use. However, these external features do not explain all variation in subdigital pad performance, and few studies consider the actual agents of attachment in Anolis, especially in an ecomorphological context. The subdigital pads of Anolis are adorned with adhesive microstructures (setae and spatulate) that make intimate contact with substrates and induce adhesion through van der Waals forces. With the ever-growing industrialization of landscapes worldwide, human-made structures are driving changes in morphology, performance, and behavior of multiple species of Anolis, offering a unique opportunity to explore the ecomorphology of Anolis setae. Using urban and natural populations of A. carolinensis, as well as the introduced A. sagrei, we used scanning electron microscopy to examine setal field configuration along subdigital adhesive pads to investigate whether fiber morphology is related to urbanization. Our findings allow us to understand the extent of urban evolution in the Anolis adhesive apparatus and assess the lability of setal fields.

Understanding eco-evolutionary influences on patterns of evolutionary integration

Alexus Roberts Hugghis, Edward Burress, Ole Seehausen

The complex impacts of evolutionary integration (i.e., coordinated trait evolution) on phenotypic diversification continues to be investigated across diverse biological systems. Strong integration has been linked to increased diversification due to evolution along "genetic lines of least resistance". Other studies have found that weak integration or modularity increases diversification by allowing relatively independent evolution of subunits within intricate functional systems. In addition to understanding the potential consequences of integration, it remains unclear how various ecological and evolutionary processes may influence this phenomenon. Combining functional morphology, kinematics, ecology, and phylogenetic comparative methods, we begin disentangling the effects of key innovations, feeding ecology, and hybridization on trait covariance patterns on macroevolutionary timescales. Opposing long-held predictions, our recent work reveals that specialized pharyngeal jaws are associated with greater evolutionary integration within the fish feeding system. Comparing integration patterns between Neotropical and Lake Victoria cichlids, we find few differences at the radiation level suggesting that hybridization has a minor influence on trait covariance despite its major role in adaptive lineage diversification among African cichlids. In contrast, we find that feeding ecology significantly affects covariance strength within the pharyngeal jaws and between oral and pharyngeal jaw structures. Together, these studies provide insight on the role of integration in phenotypic diversification and its interplay with critical eco-ecological factors to give rise to extraordinary biodiversity.

Patterns in *Polyphylla*: shifts in color in response to climate change.

Colton Roberts-Zaffiro, Amanda Carter, Grey Gustafson

Climate change is causing shifts towards hotter, more arid environments, generating intense selective forces on thermoregulation and water balance across taxa. In insects, many aspects of color and pattern impact thermal biology and hydroregulation. For example, melanin – a dark, hydrophobic pigment– increases heat gain and reduces water loss when deposited in the cuticle. Whereas, white structural coloration can reduce heat gain by reflecting near-infrared (NIR) radiation. We wanted to know if these aspects of color are shifting with climate change in Polyphylla rugosipennis. P. rugosipennis is a black, nocturnal beetle with white stripes composed of individual whitescales. We analyzed the proportion of white versus black coloration in 290 museum specimens of P. rugosipennis collected in northern Arizona between 1944-2024. Specifically, we measured scale area, density, and stripe area. Preliminary results suggest that stripe area is increasing, while individual scale area and density remain the same. We hypothesize that these changes increase reflected NIR, subsequently reducing heat gain during inactive periods, while maintaining the water retention benefits of melanin. We plan to assess the relationship between stripe area and NIR reflectance by altering stripe size and measuring heat gain via thermal imaging. Our results suggest that insects may be able to respond to climate change via shifts in pigmentation and patterning, which may help buffer them from a warming world.

A dynamic model of heat stress and recovery in ectothermic populations

Alison Robey, David Vasseur

Thermal stress accumulates through dynamic fluctuations between permissive temperatures, where organisms can grow, reproduce, and recover from injury, and stressful temperatures, where thermal damage imposes acute limits on growth and survival. Though experimental work indicates a vastly different scaling of vital rates between these two regimes, we lack a mechanistic understanding of how organisms accumulate and recover from thermal damage under fluctuating temperatures. This knowledge gap, in turn, hinders our ability to predict when fluctuating thermal regimes will actually result in organism death. Here, we present a unified framework for modeling the thermal dependence of population death rates based on the additive contributions of metabolism and proteome degradation in the absence and presence of a heat-shock response. We show how such frameworks can be used to generate extinction risk forecasts for transient heat events of different severities, frequencies, and durations. We then demonstrate the critical importance of explicitly modeling the temperature-dependent rate of recovery from thermal damage in order to capture the full effect of complex and realistic changes to thermal regimes, such as warmer winters or hotter summer nights.

Comparative morphology of the bivalves *Glycymeris septentrionalis* and *Leukoma staminea* using microCT

Isabella Robinson, Megan Schwartz, Rebecca Varney

Micro-CT is a commonly used tool in medicine and vertebrate morphology studies to image hard parts and has recently been used with invertebrate animals featuring hard parts. Our aim was to examine qualitatively which morphological features could be rendered in micro-CT scans of bivalves, which feature both hard parts of the valves and internal soft body morphology. We compared the morphologies of the subtidal clam Glycymeris septentrionalis and the intertidal clam Leukoma staminea, collected from San Juan Island, WA.Three specimens of each species were stained with iodine to enhance the contrast of soft body parts prior to scanning. Our results demonstrated that the hard parts of the valve like the radial ribs, hinge ligaments, hinge and lateral teeth, and only some of the soft tissue of the adductor muscle were easily distinguishable. Although there was not a significant difference in shell thickness between the species, this study reveals the effectiveness of micro-CT for studying bivalve morphology.

Dietary butyrate health effects on *Batrachochytrium dendrobatidis* infected *Lithobates sylvaticus*

Tyler M. Robinson, Alexa Dulmage, Robert Pearhill, Erica Crespi

Globally, amphibian populations are declining due in part to the deadly fungal pathogen Batrachochytrium dendrobatidis (Bd), which has been detected in ~700 amphibian species. The antifungal drug itraconazole is currently used to reduce Bd infection, but it requires multiple water baths and precise dosing as it can be toxic to smaller amphibians. A new approach is to leverage endogenous factors that strengthen the immune system to fight infections of Bd. We hypothesize that dietary butyrate, a short-chain fatty acid known to enhance adaptive immunity and skin barrier integrity in mammals, will reduce Bd zoospore load on amphibian skin and thus increase survival outcomes. To test this, we exposed recently metamorphosed wood frogs to Bd and stratified them by weight and developmental stage into three dietary groups (n=37): control (flies only), butyrate (flies dusted with sodium butyrate), and Reptivite (flies dusted with a common amphibian supplement). We were able to confirm frogs were equally consuming flies regardless of treatment group, and infected individuals exhibited increased sloughing and lethargy, indicating successful inoculation. Frogs were then monitored for 30 days post-infection for Bd-related symptoms, zoospore load, and growth. If our hypothesis is supported, dietary butyrate could offer a safer, more practical alternative to current antifungal treatments, potentially improving conservation efforts by reducing the impact of Bd and other pathogens on amphibian populations.

Hormonal control of female signaling: effects of estrogen on chemical cues and receptive behavior in eastern fence lizards

Abigail Robison, Chris Andraos, Katie O'Neill, Stephanie Campos

Chemical cues are central to mate choice in many vertebrates, yet the role of female signals and their hormonal regulation remains poorly understood. Estrogen is a key regulator of sexual receptivity across vertebrates, but its influence on female signaling in reptiles is not well known. In eastern fence lizards (Sceloporus undulatus), males rely on femoral pore secretions for chemical communication, while females lack such glands and may instead produce chemical cues via lipids on the surface of their skin. We tested whether estrogen influences female signaling and sexual receptivity by surgically manipulating estrogen levels to create low-estrogen (ovariectomized) and high-estrogen (sham surgery) females. Male odor preferences were measured in a three-zone choice arena to assess whether males respond to potential chemical cues from females and whether female estrogen levels affect such responses. Additionally, live male-female interactions were staged to quantify female receptivity and male courtship intensity. Together, these approaches evaluate how estrogen shapes both potential chemical signals and behavioral contributions to mate choice. This work provides new insight into the hormonal regulation of female signaling and its role in lizard courtship.

Fitness effects of mitonuclear incompatibilities in Swordtail (Xiphophorus) hybrids

Nemo Robles, Madison Murata, Maria Jose Rodriguez-Barrera, Molly Schumer

As populations diverge, they accumulate genetic variants which may result in negative interactions in hybrid individuals, known as hybrid incompatibilities. Hybrid incompatibilities are often studied in a laboratory environment; as a result, their impact on hybrid fitness under natural conditions is poorly understood. Swordtails (Xiphophorus) are freshwater fish endemic to México with a history of extensive hybridization between species. Previous work by our group identified a lethal mitonuclear incompatibility in F2 hybrids between X. malinche females and X. birchmanni males, involving the X. malinche mitochondria and X. birchmanni version of the gene ndufs5 which results in stalled embryonic development. We have further identified two non-lethal hybrid incompatibilities involving the X. birchmanni versions of ndufa13 and atp5mg which result in reduced body size. While ndufa13 and atp5mg incompatible individuals survive in the lab, we have not found them in the wild despite extensive sampling. This suggests that their natural environment selects strongly against these hybrid incompatibilities, possibly contributing to the speciation process in this group. We hope to identify how ndufa13 and atp5mg reduce hybrid fitness in different environmental conditions to uncover what selection pressures hybrids face in the wild.

Do seasonal increases in maternal investment increase the fitness of offspring under competition

John Rodgers, Daniel Warner, Chris Norris, Anthony Gilbert, Sydney Wayne

Competition has important effects on communities, populations and individuals. At the individual level, several factors (e.g., sex, size, age) can influence competitive outcomes, especially when members of the same species occupy similar niches. The brown anole lizard (Anolis sagrei) is invasive in the southern United states and often occurs in very high densities, often leading to intense intraspecific competition for space, food, and mates. Importantly, brown anoles have a long reproductive season (April-October) and mothers increase investment into their eggs over this time, resulting in larger eggs/offspring produced later in the year. We hypothesized that the temporal increase in investment is a response to increased competition that late-produced hatchlings would experience when interacting with early-produced individuals that had already had time to grow. To test this, we manipulated the competitive environment of late-hatched offspring to quantify the effect of within-cohort (late vs late-hatched individuals) and among cohort competition (early vs late-hatched individuals) under low and high density. We also raised included a solitary control. Preliminary results suggest that increased mortality in treatments with

older cohorts present. Older individuals also grew faster than the late cohort suggesting they are better competitors. Individuals laid later in the breeding season experience higher levels of competition which could play a role in the emergence of the pattern we observe in hatchling body size.

eDNA characterization and recruitment of microbial and metazoan communities at hydrothermal vents

Angel Rodriguez, Heather Bracken-Grissom, Danielle DeLeo

Environmental DNA (eDNA) is increasingly used to identify marine organisms for purposes ranging from biodiversity surveys to harmful algal bloom detection. Originally developed for gut microbiome studies, eDNA now enables analysis of environmental microbiomes and their role in holobiont symbiont recruitment. This is particularly relevant in hydrothermal vent ecosystems, where chemoautotrophic bacteria form a fascinating symbiotic relationship with alvinocaridid vent shrimp. These shrimps acquire epibiotic and digestive symbionts from their surroundings, yet the mechanisms and timing of recruitment remain unresolved. We implemented eDNA metabarcoding to characterize community structure at the Lucky Strike hydrothermal vent field (n = 3 edifices) and assess associations of alvinocaridid shrimp and their chemoautotrophic symbionts. Using a remotely operated vehicle (ROV Jason) and an in-situ filtration system, 50-liter water samples were collected in replicate (n = 3) across horizontal and vertical transects at 10 m and 5 m intervals, respectively. eDNA was extracted and sequenced using four metabarcoding primers targeting cytochrome oxidase-1 and 16S regions of mitochondrial and bacterial genomes. Our minimally invasive approach revealed vent community structure across macro- and micro-scales and distance (vertical and horizontal) from the active venting sites. These bacterial community patterns improve our understanding of where these vent shrimp may differentially recruit both their long-term digestive system and short-term gill chamber symbionts.

The Gulf eDNA Network: a centralized framework for regional biodiversity monitoring and collaboration

Jaelyn Rodriguez, Sheila Kitchen, Yasmina Shah Esmaeili, Nick Versfelt

Environmental DNA (eDNA) is transforming biodiversity monitoring by providing a non-invasive, accessible, and scalable tool for detecting species and tracking ecological change. Across the Gulf of Mexico, eDNA applications are rapidly expanding in research, conservation, and industry, yet the data remain fragmented across disparate repositories, limiting regional synthesis and decision-making. To address this gap, we launched the Gulf eDNA Network (GeN), a centralized initiative to unify data, connect practitioners, and build capacity for eDNA research in the Gulf. As an initial step, we compiled a foundational species list for the region by integrating records from WoRMS, GBIF, and published literature. Using a custom scripting framework, we then cross-referenced this list with NCBI to identify genomic coverage gaps. Preliminary analyses highlight a strong taxonomic bias toward well-studied groups, with many cryptic or understudied taxa absent from existing databases. As GeN grows, we aim to refine these genomic gap analyses and shift data products from a global perspective to one tailored to Gulf-specific needs. Beyond serving as a repository, GeN seeks to foster collaboration among researchers, students, and early-career scientists, linking laboratories across institutions and national borders. In doing so, GeN will strengthen the visibility and utility of eDNA as a decision-support tool for managing Gulf ecosystems.

Effects of thermal stress and caloric restriction on Petrolisthes cinctipes reproduction

Matthew Rodriguez, Brian Tsukimura

Consequences of climate change are present within marine ecosystems like the rocky intertidal zone. Rising global temperatures not only exert thermal stress upon organisms, but also have the potential to intensify the El Niño-Southern Oscillation climate patterns, reducing food availability. The porcelain crab Petrolisthes cinctipes is abundant within the rocky intertidal, prone to thermal stress and caloric restrictions, and displays predictive reproductive cycles. Because reproduction can be used to assess how well organisms cope with stressors, P. cinctipes serves as an ideal organism to study caloric restriction. Reproduction can be measured through measurements of the precursor yolk protein vitellogenin (Vg), gonadosomatic index (GSI), and hepatopancreas weight. This study investigates how thermal stress and caloric restrictions affect the reproductive activity of P. cinctipes by assessing Vg, GSI, and hepatopancreas weight. Female crabs were subjected to various treatments of temperatures (12 °C and 21 °C) and feeding levels (0°, 1°, or 2° restriction) to simulate climate stressors. Results showed a main effect of thermal stress with increased Vg levels ($p \leq 0.002$), caloric restriction showed no difference, and no interaction was found. GSI was unaffected by both stressors, and there was a main effect of thermal stress ($p \leq 0.004$) and caloric restriction ($p \leq 0.021$) on reduced hepatopancreas weight, with no interaction found. These findings suggest the possibility of oocyte resorption within P. cinctipes, and the diversion of reproductive energy towards survival to cope with stress.

Water wave reflection from obstacles during whirligig beetle (*Gyrinidae*) locomotion

Chris Roh, Yukun Sun, Cade Sbrocco, Christopher Dougherty

The water surface-dwelling whirligig beetle (Gyrinidae) has been hypothesized to use water ripples for sensing obstacles. The so-called active sonar potentially employs two wave sources: 1) a pulse of wave trains generated when the whirligig beetle accelerates (linear and rotational) 2) a stationary capillary-gravity wave field generated when the whirligig beetle swims faster than the minimum surface wave speed (~23 cm/s).

Here, we theoretically and experimentally model the wave field accompanying the whirligig beetle when moving faster than the minimum wave speed. In addition, we show the reflected wave that returns to the beetle as the whirligig beetle surrounded by the wave field moves past a stationary obstacle. The swimming speed-dependent wave signatures of the reflected wave exhibit a down-chirp sound signature (i.e., decreasing frequency over time), whose frequency depends on the swimming speed of the whirligig beetle.

Run-and-turn locomotion in tiny water striders

Pankaj Rohilla, Jace Holmes, Sarah Bender, Saad Bhamla

Microvelia, among the smallest water-walking insects, live under constant threat of predation from fish, larger water striders, and backswimmers. Despite their vulnerability, they persist by rapidly locating and feeding on prey trapped at the air-water interface. We investigated how Microvelia sp. employ run-and-turn locomotion, consisting of sequences of straight runs with brief pauses and sharp reorientations, to locate their prey. Using springtails and fruit flies as model prey, we quantified their trajectories and showed that prey activity provides directional cues that guide pursuit. Our findings reveal that Microvelia adapt their paths to run-and-stop sequences, minimizing travel distance while converging rapidly on prey. This strategy not only enhances survival in predator-rich habitats but also offers principles for microrobotic design, where run-and-turn motion could enable efficient surface exploration and target acquisition.

A T-box gene regulates regionalized cell differentiation in the ectoderm of a model sea anemone

Moey Rojas, Archawin Ice Kittirattanapaiboon, Emily Setton, Fredrik Hugosson, Marc Servetnick, Leslie Babonis

T-box genes are an evolutionarily conserved group of transcription factors found throughout metazoans. Previous work suggests the T-box gene Brachyury is involved in axial patterning and morphogenesis in both cnidarians and bilaterians, but the function of other cnidarian T-box genes remains unspecified. The T-box gene Tbx2/3 in the sea anemone Nematostella vectensis is expressed in the developing pharynx downstream of Brachyury and in an ectodermal population of cells that are Brachyury-independent. We use short hairpin RNA knockdown and subsequent RNA-sequencing to explore the function of Tbx2/3 during embryonic development in Nematostella vectensis. Examination of downstream targets of Tbx2/3 identified by RNA-Seq and verified by in situ hybridization reveals that Tbx2/3 has regionalized effects on ectodermal cell type differentiation during oral-aboral

axis patterning. Knockdown of Tbx2/3 resulted in downregulation of a Sox transcription factor in neural cell progenitors in the aboral region and upregulation of a Zic transcription factor in cnidocyte progenitors in the oral region. The rate of morphogenesis also decreases following Tbx2/3 knockdown, an observation supported by a reduced number of EdU-labeled proliferating cells in knockdown embryos relative to wild types. These results support previous observations that Tbx2/3 is involved in morphogenesis and differentiation of sensory cells in invertebrates outside of Cnidaria.

Morphological traits in the paws of high runner mice may facilitate a more efficient run stride

Reinalyn Jasmine Rondez, Marcell Cadney

Morphological traits in the paws may facilitate a more efficient run stride. Using mice that were selectively bred for high voluntary running behavior, measurements of digits were taken prior to wheel running. These were compared to a control group which are the same strain of mice but unselected for specific traits. Measurements of their digitswere measured, then compared to analyze the 2D:4D ratio. A higher 2D:4D ratio is linked to masculine behaviors (Yan et al., 2008). Our study omitted sexual dimorphism and focused on female mice. We expected to see a higher ratio of 2D:4D in the three selected lines, but found no significant difference which suggests that its role in facilitating enhanced running behavior may not be as hypothesized.

Characterizing long-wavelength opsins in Apodemia virgulti via molecular and comparative approaches

Ash Rosales, Jennifer Sanches Soriano, Adriana Briscoe

Butterfly color vision depends on opsin proteins, which are sensitive to specific wavelengths of light such as ultraviolet, blue or longwavelength. In Apodemia virgulti, the genetic basis of long-wavelength sensitive opsins (LW1 and LW2) have not been characterized. In Apodemia mormo, a closely related species, two duplicated opsins were previously identified with peak sensitivities at 505 nm and 600 nm via epimicrospectrophotometer, suggesting functional divergence. Building on this, we aim to investigate whether similar duplications exist in A. virgulti and how they might contribute to spectral tuning. To explore this in A. virgulti, we extracted genomic DNA from three individuals and confirmed species identity through PCR amplification of the mitochondrial CO1 gene. Full length LW1 gene was annonated and in the future, we will anotate the LW2 opsin gene, including exon-intron boundaries, using available genome and transcriptome data. This will guide the design of primers to amplify and sequence these genes in the collected DNA specimens. We predict that structural differences between LW1 and LW2 will reflect functional divergence in long-wavelength vision. By comparing gene sequences across species, we aim to understand how genetic changes underlie differences in color vision and contribute to visual system evolution in butterflies.

Impact of gut microbiome modulation on nestling house sparrow physiology

Kristen Rosamond, Gábor Czirják, Kevin Matson, Patricia Parker, Melissah Rowe, Lon Chubiz

Host-associated bacterial assemblages in the gut microbiome undergo fluctuations and successions in early life until becoming more stable in adulthood. Various factors such as dietary changes, environmental stressors, and pathogen exposure can impact gut microbiome colonization. Existing research indicates that such alterations can affect health outcomes including immune system function, growth rate, and disease susceptibility. However, these interactions are poorly understood in wildlife. We altered gut microbiome colonization in wild nestling house sparrows by administering either probiotics or antibiotics to birds three times throughout their first week of life. Then, we administered a noninfectious immune challenge (lipopolysaccharide, LPS) in the second week to examine if probiotic- or antibiotic-triggered gut microbiome disruptions influenced the response to LPS. We collected fecal samples from nestlings to measure gut microbiome composition, as well as plasma samples to measure physiological indices, including immunity and oxidative stress. Nestlings fed either probiotics or antibiotics lost significant mass, a key indicator of fitness in nestling birds, suggesting that treatments substantially disrupted gut microbiome colonization. However, measures of immunity and oxidative stress did not differ by treatment group, indicating that these changes in mass may be mediated via other mechanisms, such as behavior or metabolism. Further experiments are needed to unravel the processes by, and circumstances under which, disruptions to gut microbiome colonization impact wildlife health.

Parental care, sexual dimorphism, and cranial integration in *Betta* fishes

Luke Rose, Sarah Arnette, Lindsey DeHaan, Matt Friedman, Matthew Kolmann

The Betta fishes (or “bettas”) are a group of small-bodied and vibrantly-colored labyrinth fishes native to Southeast Asia. The genus Betta is the most diverse among the Anabantiformes, with 78 currently recognized species. Bettas possess a unique vascularized, bony structure in the back of the cranium known as a “labyrinth organ,” which they use for aerial respiration. Bettas show complicated behaviors relating to spawning and parental care; including the building of nests made from mucus bubbles produced by the labyrinth organ (“bubble-nests”), and mouthbrooding, where eggs/fry are brooded in the oropharyngeal cavity. These behaviors are male-specific, since males are responsible for building and protecting bubble-nests, and for mouthbrooding. We microCT scanned species from across the genus Betta, including multiple males and females from different bubble-nesting and mouthbrooding lineages, which have both evolved several times. We then used 3D geometric morphometrics to characterize skull shape in these fishes and test whether males or females, and bubble-nesters or mouthbrooders, exhibit alternate patterns of cranial integration, with attention to the suprabranchial and oropharyngeal chambers. It is expected that males will possess larger suprabranchial chambers when bubble-nesting and larger oropharyngeal chambers when mouthbrooding. Females are expected to exhibit weaker cranial integration than males, regardless of whether they belong to bubble-nesting or mouthbrooding lineages. This work was supported by the National Science Foundation awards DEB-2333683 and DEB-2333684.

A tale of two fins: examining interactions between flying fish caudal and pectoral fins in taxiing

Derrick Roseman, Valeria Saro-Cortes, Brooke Flammang, Raúl Raúl Bayoán, Aimy Wissa

Flying fishes are pelagic fish capable of aerial and aquatic locomotion. They can glide above the ocean surface using enlarged, wing-like pectoral fins. Before taking flight, flying fish often enter a distinct “”taxiing”” stage, where they build speed by rapidly beating their caudal fin against the water while the rest of their body remains above the water surface. This brief but critical phase bridges aquatic and aerial locomotion, with the caudal and pectoral fins acting as the primary propulsors under simultaneous aerodynamic and hydrodynamic loading. Previous research has explored the roles of these fins in swimming and gliding, but little attention has been given to how they function jointly during this transitional locomotion phase. Unlike swimming or gliding, taxiing involves the fish maintaining an upward body inclination at the air-water interface, where surface phenomena and aerodynamic ground effect influence overall taxiing performance. To better understand the combined roles of the fins during taxiing, a robotic model organism (RMO) of a flying fish is developed and experimentally tested in a water channel with above-surface wind speeds of 15 BL/sec. The RMO is placed in varying taxiing configurations, including different body angles and pectoral fin incidence angles. Force measurements capture thrust, lift, and pitching moments to assess taxiing performance and stability, while flow visualization techniques reveal the flow structures responsible for generating forces at the air-water interface.

Nascent urbanization effects on physiology and behaviors in Darwin's finches

Michelle Ross, Kiyoko Gotanda

Globally, urbanization is rapidly encroaching on native habitats and presents a formidable threat to the continued survival of native fauna as species are forced to adapt to urban environments or go extinct. Although we know urban and non-urban populations differ in their adaptive traits, the underlying mechanisms and processes of urban adapters are not well understood. Using the Galápagos Islands, which only recently began urban development, we can better understand how animals adapt to nascent urbanization and apply this knowledge to the future conservation of animals as urbanization increases worldwide. My research assessed the differences between urban and non-urban Darwin's finch physiology and behaviors in Santa Cruz (the most urbanized) and San Cristóbal (2nd most urbanized). We investigated corticosterone (CORT) concentrations for the physiological trait and neophobia and territoriality for the behavioral traits. For our data collection, we plucked tail feather samples to measure CORT levels, performed a behavioral assay for neophobia using an arena setup, and finally measured aggression by conducting a staged territorial intrusion and measuring in-hand aggressive behaviors. Pre-liminary findings suggest the finches might not be locally adapted to their environments due to urbanization being so recent in the Galápagos.

Testing for morphological and microbiome differences between sympatric phenotypes of Tozeuma sp.

Matthew Rossi, Jose Moscoso, Samantha Levell, Kent Hatch

Tozeuma is a genus of epibenthic caridean shrimps with unique bodies that can be found in seagrass beds along the east coast of the United States, including Sarasota Bay. There are several undescribed species in this genus, and individuals within species present various morphologies, which makes this group of shrimp an excellent genus to identify cryptic species. In Sarasota Bay, there are two main phenotypes of Tozeuma shrimp; one has a clear body, while the other shows either green or brown pigmentation. This project evaluated differences in morphology, genetic barcodes, and microbiomes of the different phenotypes of sympatric Tozeuma shrimp in Sarasota Bay. We visually evaluated morphological characteristics such as the dry weight, length and RGB coloration of the shrimp, as well as the analysis of sequenced COI marker genes of the host using Nanopores, and characterized the microbiomes by sequencing bacterial 16s rDNA using an Illumina platform.

Ichthyosaurs inform the functional interpretation of anterior supratemporal fossae in reptiles

Sofia Rossman, Lucas Florsheim, Joseph Cox, Kaia Gelatt, Lars Schmitz

The temporal region is a variable and evolving part of the vertebrate skull. Skull fenestration and associated fossae are often shaped by feeding biomechanics. In ichthyosaurs, the supratemporal opening is anteriorly flanked by a sometimes large, terrace-like fossa, interpreted as a muscle attachment area or a salt gland trough. We describe a new, well-preserved ichthyosaur specimen (Cymbospondylus sp.) from the Middle Triassic (Anisian) of Nevada that helps evaluate these hypotheses. The large skull features deep anterior supratemporal fossae, a strong sagittal crest, and a slender, elongated rostrum. Biomechanical modeling suggests the anterior terrace could be the origin of the superficial pseudotemporalis, one of four jaw adductors reaching into the supratemporal opening. A long tendinous insertion may have let the muscle wrap around the opening's edge while increasing the jaw adductors' cross-sectional area, enhancing bite force. Anterior supratemporal fossae also occur in other longirostrine marine reptiles of the Mesozoic, including mosasaurs and sauropterygians. We propose that this diversity of terraces across diapsids is best explained by biomechanics and jaw adductor attachment, especially in forms with well-developed pseudotemporalis muscles. The repeated presence of large anterior supratemporal fossae in longirostrine diapsids may indicate shared biomechanical advantages, such as reduced jaw joint forces and lower bending and torsional stresses, though further testing is needed.

Behavior as a keystone trait in adaptation to heat

Kim Rosvall, Elizabeth Derryberry

Rising global temperatures underscore the need to understand how at least some animals cope well with heat. We advocate for direct testing of a behavior-centric model to determine whether behavior is the front line of defense against heat. Though this idea is not new, existing approaches are not in step with some key features of behavioral variation in the wild, particularly in endotherms. This leaves uncertainty on the scope of individual differences, plasticity, and population variation, which should shape the pace of and potential for future adaptation. Via explicit testing of a behavior-centric framework that expands the conception of behavior as a keystone trait, we can better understand when and how species will persist or succumb to intensifying environmental challenges.

Feeding the Balance: Linking Diet, Digestive Efficiency, Gut Micro-biomes, and Ecological Flexibility in an Invasive Omnivore

Angela Roth, Charles Watson

Omnivores that consume both arthropods and plant material face a unique digestive challenge: breaking down tough compounds like chitin and cellulose. To meet this demand, many species form complex symbiotic relationships with gut microbes that support digestion and nutrient absorption. This study investigates how dietary composition—both in the short and long term—impacts digestive efficiency and gut microbial communities in Phelsuma grandis, the giant day gecko. Fifteen individuals were divided among three dietary treatments: cricket-only, banana-only, and a mixed diet reflecting the species' natural omnivory. Fecal samples were collected for bomb calorimetry and microbiome sequencing to assess physiological and microbial responses. Bomb calorimetry is currently underway, and microbiome analysis is planned in the coming months. Based on the ecological and dietary flexibility of the species, it is anticipated that the mixed diet group will exhibit higher digestive efficiency and a more stable, diverse gut microbiome, while the restrictive diets may disrupt microbial balance and reduce caloric assimilation. These processes will provide insight into how diet diversity influences gut function and microbial flexibility in omnivores. These findings may inform broader discussions on personalized nutrition, host-microbe coevolution, and how dietary adaptability can support digestive health in both reptiles and humans.

Urbanization and haemosporidian parasites in house finches

Anneliese Roth, Xue Her, Joel Slade

Urbanization can affect ecological dynamics and wildlife health, particularly in the context of parasite-host interactions. Cardueline finches, such as house finches (Haemorhous mexicanus), inhabit urban, suburban, and rural environments and are susceptible to vector-borne haemosporidian parasites (Plasmodium, Haemoproteus, and Leucocytozoon) transmitted by sanguivorous flies. Previous work looking at blood smears from our study system revealed house finches in suburban and rural habitats have higher haemosporidian prevalence and parasitemia than in urban habitats throughout the spring, but the genetic identity and diversity of these parasites remains unknown. This study aims to genetically characterize haemosporidian lineages along three levels of urbanization. We hypothesize haemosporidian diversity will differ by habitat, with distinct genetic variants emerging in urban, suburban, and rural areas. Specifically, we will amplify the haemosporidian mtDNA cyt b gene from roughly 87 positive samples using nested polymerase chain reaction (PCR). Sequencing is currently underway. Data quality analysis and phylogenetics will take place using Geneious software, followed by haplotype networks and statistical analyses in R. Ultimately, this research will offer insight into whether urbanization is shaping the distribution and diversity of avian haemosporidian parasites and to better understand how environmental change influences parasite lineage distribution. In addition to aiding conservation efforts, this research may help guide urban planning to promote biodiversity and contribute to understanding how parasite-host dynamics are altered at the human-wildlife interface.

Replicating without oxygen: genome stability in the anoxia tolerant killifish.

Riley Roth-Carter, Jason Podrabsky

Faithful replication of the genome must be completed before each mitotic cellular division, a process through which all cells must pass successfully. Obstacles to DNA replication can lead to a slowing or halting of replication forks, termed replication stress. Anoxic exposure causes a burst of reactive oxygen species (ROS) and loss of available ATP, both of which can lead to replication stress. To study replication during anoxic exposure we use a cell line derived from embryos of the killifish Austrofundulus limnaeus which can survive for months in anoxia. This tolerance is maintained in this cell line which survives for 49 days in anoxia. We hypothesize that these cells are continuing through normal cell cycle stages in the presence of increased replication stress. Using quantitative image based cytometry and γH2AX staining we have shown that for 32 hours after anoxic exposure there is no change in the distribution of cell cycle stages, though a slow decrease in S phase cells and concomitant increase in G1 cells is seen by 48 hours. γH2AX levels remain low at early points (4-12hr) but reaches levels around the same time the cells start to accumulate in G1. This information could support the bioengineering of non-tolerant cells to survive anoxic events like stroke and lead to a better understanding of how resistant cancer cells can survive within hypoxic tumor microenvironments.

Northern elephant seal weanling mass and morphometrics at Piedras Blancas

Marshall Rottier Johnson, Alie Hall, Julia Schedler, Heather Liwanag

For animals with parental care, the transition to independence is a critical life history juncture. As capital breeders that fast during the lactation period, northern elephant seal (Mirounga angustirostris) mothers abruptly wean their pup after a short, 4-week nursing period. Post-weaning survival rates to the next year are less than 50% for northern elephant seals, and mass at weaning is a significant predictor of weanling survival in this species. The objective of this study was to examine the factors affecting weanling mass and morphometrics (standard length, curvilinear length, and axillary girth) at Piedras Blancas, the largest mainland northern elephant seal colony, from 2018-2025. A multiple regression model of weanling mass revealed no significant difference in average weanling mass among different beaches at Piedras Blancas, but did indicate a positive association between weanling mass and the girth/length ratio, as well as a positive association between weanling mass and averaged values of the Southern Oscillation Index (SOI). Specifically, using changes in SOI as a proxy for El Niño/La Niña conditions, the model's estimates were consistent with an estimated increase in average weanling mass when the SOI trends towards La Niña conditions (positive values of SOI). These findings have implications for the health of the Piedras Blancas population and for the effects of climatic variation on the transition to independence in northern elephant seals.

BeakerBox: Inquiry-based curriculum and outreach supporting South Carolina middle schools

Althea Roy, Meredith Schwendemann, Summer Landreth, Ashley Hunter, Katherine Mulholland, Kara Powder

Many students gain or lose interest in science, technology, engineering, and mathematics (STEM) around middle school. To address this, the BeakerBox outreach program aims to promote excitement, belonging, and interest in STEM, all critical factors towards keeping students in science. A multidisciplinary team of 63 undergraduates and 5 graduate students support science education in 6th-8th grade by generating and distributing free class materials. We develop inquiry-based curricula aligned with national and state standards that integrate three-dimensional learning models. Low-cost activities include simulating beak adaptations with binder clips of varied sizes or generating dating profiles for organisms while learning reproductive strategies. Optional extension activities introduce socioscientific issues like climate change and food insecurity. Since August 2023, we have distributed physical boxes with reusable materials to 169 middle school teachers (~9,700 students; 47% at Title I schools). Our team has further impacted >6,300 members of the public through outreach at campus events, STEM nights at local schools, and regional STEAM festivals. This work all serves BeakerBox's mission of promoting science literacy and a love for STEM, while keeping science engaging and accessible. Supported by NSF-IOS #1942178 and the Clemson Creative Inquiry program.

The influence of UV radiation on a trait important to mating preference in Cabbage White Butterflies

Iliana Rubet, Lydian Phommachanh, Kathryn Weglarz

Cabbage white butterflies (Pieris rapae) live worldwide with populations in the United Kingdom and introduced populations in the United States. Reduced genetic diversity in introduced populations influences the adaptation and evolutionary trajectories of these butterflies. Our research focuses on melanized spots located on the dorsal forewing (Cu2) of females involved in intersexual communication. Spot size and presence change with environmental factors like Ultraviolet (UV) radiation and temperature. UV radiation affects both the physical traits and behavior of these butterflies, improving visibility of traits under sexual selection. We hypothesized the regional influence of UV radiation affects Cu2 presence and size. We used digitized natural history specimens, collected between 1821 and 2023, from iDigBio.org (nUK=486, nUS=421) and measured the Cu2 spot in ImageJ. After cleaning our data, we used QGIS and UV raster data from NASA to extract UV levels from 2007 for our sample locations. We used an ANOVA and Tukey-Kramer test to analyze the Cu2 spot size across gender, time, and location. Our results support our hypothesis that this trait, involved in sexual selection, is influenced by UV levels ($p < 0$ .05). In high UV regions like the US, Cu2 spot sizes are larger while in low UV areas, such as the UK, spot sizes remain small. These findings help us understand how the environment affects the cabbage white butterfly's intersexual communication.

Trait Relationships Across Evolutionary Levels: Testing the Influence of Within- and Among-Species Correlation and Phylogenetic Structure on Macroevolutionary Patterns

Ericka Rubio, Charles Bell, Philip Bergmann, Simon Lailvaux

While it is often assumed that trait correlation patterns observed among species reflect those within species, this assumption has rarely been explicitly tested. To test whether intraspecific correlation predicts interspecific patterns, we simulated hierarchical trait data by evolving species-level trait values along simulated phylogenetic trees using the mvMORPH package in R and then generating intraspecific variation using multivariate normal sampling. Using these simulated data, we then manipulated intraspecific and interspecific correlation structure and varied the strength of phylogenetic structure across replicate datasets. We used phylogenetically informed comparative analyses to quantify interspecific trait relationships and tested the extent to which intraspecific correlations were reflected in interspecific patterns. We found that while intraspecific correlation was mirrored interspecifically under certain conditions, broader factors like phylogenetic structure and correlation sign and magnitude influenced how trait relationships scaled. The results suggest that trait integration patterns do not scale predictably across hierarchical levels. Future research concerning trait relationships should therefore consider how intraspecific correlation is represented in comparative trait patterns across species by explicitly testing for such patterns rather than assuming them.

A Bayesian function-valued approach to the mechanistic constraints on color evolution in Thraupidae

Nicholas Ruffolo, Marc Suchard, Michael Alfaro

Traditional color studies use reflectance spectra for key spectral features, such as chroma and brightness, or use the spectra to derive various color parameters. Both approaches typically discard much of the information contained in the full reflectance spectra. To circumvent any data loss, we developed an approach to model reflectance using cubic splines. In this model, a diffusion process occurs on the spline coefficients, with each coefficient representing specific subregions of the spectra. Under a Bayesian framework, our function-valued approach can be easily extended to test various color hypotheses.

One such hypothesis is determining whether different color production mechanisms have varying rates of evolution at similar regions of the reflectance spectrum. We tested our approach on an empirical dataset of color patches in tanagers (Thraupidae), identifying three distinct color production mechanisms (pigments, structural, or both). We then used Bayes factors to compare models that either used a singular rate matrix or separate rate matrices for each color production mechanism. Our approach shows the power of using a function-valued approach for gaining insight into color and illustrates the advantages of using a Bayesian framework to test the hypotheses of color evolution. This extension has broad applications as it can be tested with any function-valued trait and its mechanisms, providing key insights into how the other traits can influence the evolution and diversification of complex biological systems.

Cellular mechanisms of symbiont sorting in the cnidarian model, Aiptasia

Maria Ruggeri, Jennifer Qian, Jacob Myers, Virginia Weis

The endosymbiotic relationship between corals and algal symbionts underlie both the historical success and contemporary vulnerability of reef ecosystems. Although functional variation among natural or artificially-evolved symbionts could increase coral resistance to climate change, specificity among partners imposes limits to potential associations. Further, it is unclear whether specificity is driven by the ability of the host to discriminate among symbiont species or the ability of the symbiont to manipulate membrane trafficking and/or evade a host immune response. In this study, we used Aiptasia larvae as a model system to test the hypothesis that symbiont sorting is driven by symbiont-derived signals which modulate host immunity. We found that incompatible symbionts were taken up into host cells (phagocytosed) but eventually lost, whereas compatible symbionts remained and proliferated. Interestingly, larvae colonized with incompatible symbionts survived better than larvae not offered any symbiont (aposymbiotic), which suggests that incompatible symbionts are unable to prevent phagolysosomal fusion and are lost through host digestion. Using immunofluorescence microscopy, we localized membrane-trafficking proteins Rab7 and LC3 around compatible and incompatible symbionts indicative of conventional or immune-modulated degradation. In addition, we heat-killed both algal species to test whether symbionts play an active role in recognition and downstream membrane trafficking cascades. Overall, this study contributes to our understanding of recognition and winnowing mechanisms during the establishment of cnidarian-algal endosymbiosis, informing coral biology, ecology, and conservation.

Coupling across stages: evolutionary consequences of life-cycle complexity in two hemimetabolous insect orders.

Peter Rühr, Alexander Blanke

Life-cycle complexity is often thought to free adults from juvenile constraints, allowing independent adaptation of different stages. Yet in hemimetabolous insects, which lack a pupal stage, the extent of such decoupling is less clear. In this study, we used high-resolution micro-CT scans and geometric morphometrics on more than 200 species of earwigs and stoneflies to test how juvenile ecology shapes adult head morphology. The results show that, rather than being decoupled, adult form is strongly predicted by nymphal ecology, suggesting that ecological demands in juveniles can constrain adult evolution. Interestingly, species with stronger niche shifts during development also show greater adult disparity. These findings highlight life-cycle complexity as a continuum: while holometabolous metamorphosis may foster strong stage decoupling, hemimetabolous insects reveal how juvenile ecology continues to influence adult design.

Bacteria associated with eelgrass (*Zostera marina*) and implications for harmful algal blooms

Madelyn Ruiz, Ashton Ellis, Kelsey Griffin, Michael Martorell, Christine Weilhoefer, Ryan Kenton, Cecilia Brothers

Harmful algal blooms (HABs) are characterized by groups of algae that grow out of control and produce harmful toxins, negatively impacting their environment. One genus of unicellular algae causing HABs is Pseudo-nitzschia, a diatom, which produces domoic acid, a toxin that accumulates in consumers during a bloom. Pseudo-nitzschia spp. may also influence the community composition of bacteria associated with eelgrass (Zostera marina) and the health of coastal eelgrass meadows. The purpose of this study is to determine the relationship between Pseudo-nitzschia spp. and the bacterial community of seawater in proximity to eelgrass meadows. To investigate this, eelgrass was grown in the laboratory for 14 days under ambient conditions and exposed to non-harmful algae (Thalassiosira pseudonana; n=2), harmful algae (Pseudo-nitzschia subcurvata; n=6), or a control with no algae (n=6). DNA was extracted from the water surrounding the eelgrass and 16S rRNA MinION sequencing was conducted to determine bacterial taxa. Bacterial community composition and diversity will be compared across non-harmful and harmful algal treatments. Bacterial co-occurrence networks will help identify significant correlations between bacterial taxa for each treatment. These experiments will help explain the interactions between HABs, bacteria, and eelgrass in coastal Pacific Northwest ecosystems.

Three-dimensional shape change during the flight stroke in diverse bat wings

Andrea Rummel, Kiara Moya de la Rosa, Brooke Quinn, Sharon Swartz, Kenneth Breuer, Brandon Hedrick, Alexandria Shockney, Kate Manges Douglas

Bats are the only mammals capable of powered flight. Their wings are composed of modified mammalian forelimbs that attach to a wing membrane stretching from greatly elongated fingers to the hindlimbs. This membrane is thus composed of numerous joints which enable modifications to wing membrane conformation and dynamic shape change during flight. Although this shape change during flight is complex and likely differs between species, the relationship between wing morphology and flight ecology has almost exclusively been investigated two-dimensionally (2D) using wing silhouettes. However, the extent to which wing conformation during flight matches wing silhouette is unknown, and a better understanding of conformational change during flight will likely yield functional and ecological insights. Here, we explore wing kinematics and 3D shape in a range of species (covering four bat families) from Orange Walk, Belize, and laboratory bats using high-speed videography. From high-speed videos of bat flying, we digitized landmarks across the wing and body, and used 3D geometric morphometric and kinematic analysis techniques to evaluate wing shape for each bat. This allowed us to compare wing shape throughout the wingbeat at 2 ms increments within and among species. We found that 3D wing shape varies substantially within the wingbeat of a single individual, and substantially between species. These data are now being used to examine how 3D wing shape relates to diet and flight style.

Latent feeding behaviors and kinematic variation support trophic flexibility in Cichlids

Khalil Russell, Peter Wainwright

The relationship between morphology and ecology is mediated by behavior. We test this idea by assessing the relationship between trophic ecology and the use of prey-specific feeding behaviors in a cichlid fish model. Cichlid diversification features repeated transitions between evasive midwater prey and attached benthic prey, requiring predators to evolve prey-specific approaches to feeding. Using 2000 Hz video, we characterized feeding behavior on an experimental attached benthic prey in seven species of Mesoamerican heroine cichlid spanning three independent transitions to specialized piscivory and two to benthic-feeding ecology. We investigated the effect of feeding ecology on the behavior and kinematics of benthic grazing, a derived, specialized mode of cichlid feeding. All species readily fed on benthic prey, regardless of feeding ecology. Nearly all non-benthic species used the same benthic-feeding behaviors as ecological benthic-feeders, but at lower frequencies. Our findings demonstrate impressive behavioral flexibility among cichlid species in exploiting functionally demanding prey outside their typical diets. We propose that this repertoire of latent feeding behaviors supports trophic flexibility and facilitates niche diversification. We also show that two benthic-feeding lineages of Neotropical cichlids evolved distinct approaches to benthic feeding, exhibiting the highest and lowest total feeding-strike kinesis,

respectively. Together, our findings highlight the importance of behavior in linking morphology and ecology and motivate further study into the diversity and evolutionary context of benthic feeding across the Cichlidae.

Having the guts to cope with global change: Exploring the role of gut plasticity in amphibian larvae

Katharina Ruthsatz, Paula Eterovick, Maline Türk, Marjoriane de Amaral

Climate change is altering both temperature regimes and resource quality, creating major energetic challenges for ectotherms. Amphibian larvae, in particular, must balance increased metabolic costs under warming with limited access to high-quality food, yet the mechanisms enabling them to sustain performance remain poorly understood.

Here, we tested whether plasticity in gut morphology and microbiota helps buffer these constraints in Rana temporaria tadpoles. We reared larvae under a fully factorial design manipulating food quality (low, intermediate, high), rearing temperature (18 °C, 24.5 °C), and exposure to a simulated heat wave (48 h: 28 °C). We then quantified gut morphology, gut microbial composition and predicted metabolic pathways, growth, and thermal tolerance (CTmin, CTmax).

Low food quality induced elongation of the gut, consistent with enhanced digestive capacity, but this response disappeared at high temperature, suggesting energetic constraints. Microbiome composition shifted both with rearing temperature and heat wave exposure, with altered bacterial communities correlating with improved growth at low food quality and increased heat tolerance. Importantly, gut bacterial diversity was jointly shaped by food, temperature, and heat wave exposure: diversity declined in larvae fed medium-quality food, but only when reared at 24.5 °C and subjected to a heat wave.

Together, these results highlight gut plasticity, both structural and microbial, as a central axis of resilience, mediating interactions between food and temperature that shape amphibian coping capacity under global change.

Salt, heat, nucleic acids: cnidarian DNA methylation response to salinity and temperature gradients

Auston Rutlekowski, Adam Reitzel

DNA methylation is an epigenetic process that potentially links environmental cues to molecular changes in an organism's cells. Previous research in cnidarians has shown that methylation can change seasonally and in response to abiotic environmental factors such as temperature or salinity. This epigenetic process is a potential mechanism for individuals to acclimate to physiologically stressful changes in their local environment. Here we subjected clonal lines of the model cnidarian Nematostella vectensis from different populations to both salinity and temperature gradients and measured changes in DNA methylation. We compared differentially methylated regions of individuals at ranges of ecologically-relevant salinity and temperature, as well as differences in response between each population. We identified differentially methylated regions between time points for clonal individuals in both salinity and temperature gradients, showing that N. vectensis does alter its methylation profiles in response to their environment as quickly as a matter of hours. We also found unique differentially methylated regions between all pairwise population comparisons, suggesting that genetically distinct populations have unique epigenetic profiles and responses. We also compare these experimental laboratory results with methylation profiles of wild N. vectensis to begin to tease out how we can use laboratory responses to inform us about natural variation in DNA methylation.

Evaluating hypotheses to explain patterns of widespread conspecific nest visitation in a wild bird

Thomas Ryan, Maren Vitousek, Conor Taff

Social interactions can alter fitness by modifying access to resources or mating opportunities, or by providing information that can help optimize current and future behavior in the context of their environment. Conspecific nest visitation behavior in birds appears to be relatively common but isn't well understood, and may require evaluation of multiple hypotheses to explain it. We investigated the adaptive function of frequent visits during the breeding season by tree swallows (Tachycineta bicolor). We recorded the occurrence of 27,097 visits to 335 nearby nests over 12 breeding seasons with an extension automated RFID monitoring system (2013-2024). We evaluated the evidence for several, non-mutually exclusive hypotheses to explain visitation patterns. Visitation patterns were inconsistent with hypotheses that receive support in other species: visits didn't result from mistakes, extra-pair mating, competition for nest sites, or prospecting for future breeding sites. Visitation patterns were instead more consistent with a less explored hypothesis: that birds gather information during extra-territorial visits that may be used to inform current reproductive decisions. Nests that successfully fledged young were visited at higher rates, and females whose nests ultimately failed increased their trips late in nestling provisioning. Our results show that tree swallows consistently invest in visits for reasons that cannot be explained by hypothesized functions of this behavior in other species. Accessing social information may be an important breeding behavior for certain species.

Resin-ating anatomy: 3D printing a magnetic dog skull for veterinary education

William Ryerson, William Hooker, Rita Liu, Alexis Slack, Emma Schachner, Brandon Hedrick

Veterinary education often relies on cadaveric specimens, but there is increasing demand for alternatives due to limited resources and ethical considerations. To address this, we developed a 3D printed 'explodable' model of a dog cranium with detachable, magnetized cranial bones for teaching anatomy to students. This model was generated from a CT scan of a juvenile dog cranium for which cranial sutures were still partially open and segmented such that major cranial bones were isolated. All bones are printed at real size and retain openings for cranial nerves and major vessels. This model enhances anatomical education by supplying a hands-on tool that can be used in the classroom setting or for independent learning and can be integrated at the high school, college, or veterinary school level. It is currently being integrated into the first-year anatomy foundation course at Cornell University's College of Veterinary Medicine. The model may be especially valuable to institutions that lack their own teaching specimens or the resources to acquire them, as it can be printed using any hobbyist or specialist 3D printer and we outline assembly instructions on how to attach magnets at prefabricated attachment points. Through the use of both digital and 3D printed resources, we hope to help to address current shortages of anatomical resources, but also to inspire future generations of practicing veterinarians by making anatomy more accessible.

Climbing the urban ladder: Locomotor performance of urban and rural geckos in Bengaluru, India.

Amith S J, Kristin Winchell, Chetan K S

Urban ecosystems exhibit distinct environmental conditions, including altered climate, simplified vegetation, which drive adaptive shifts in species and influence their survival and fitness. The contrasting selective pressures between urban and rural environments continue to drive the rapid evolution of species, offering a unique opportunity to study adaptation in real-time. The current study under the morphology–performance–fitness paradigm wanted to investigate whether nocturnal and diurnal gecko species from urban and rural Bengaluru differ in sprint performance across substrates and inclines, and if diel activity patterns influence responses. We hypothesized urban geckos to perform better on artificial substrates, with diel differences shaping responses. Sprint trials were conducted on Cnemaspis mysoriensis (diurnal) and Hemidactylus parvimaculatus (nocturnal) from urban and rural sites of Bengaluru. Individuals were tested on five substrates (concrete, painted concrete, bark, glass, metal), under two inclines (0°, 37°), and in both directions. Our Preliminary analyses indicate that urban geckos, especially Hemidactylus parvimaculatus, outperform rural counterparts, with statistically significant differences most evident on artificial substrates. Substrate was the main driver, while incline and direction had minor effects. Additional data collection is underway to evaluate the robustness of these findings and further test performance–morphology–fitness links. Our preliminary results have the

potential to contribute significantly to understanding urban animal adaptation and evolutionary responses in Bengaluru, informing conservation and urban planning strategies amidst rapid urbanization.

Unveiling the role of cloacal morphology in the diversification of frogs reproductive strategies

Julia S. Parreiras, Molly Womack

While dealing with distinct selective pressures of water availability in the terrestrial environment and egg desiccation risks, anurans evolved the greatest reproductive diversity of tetrapods. Multiple levels of independence from water for reproduction have convergently evolved across the anuran phylogeny, ranging from eggs laid fully submerged in water to completely terrestrial. Furthermore, some anuran lineages have independently evolved additional strategies to cope with egg desiccation, including foam nests built with female fluids during oviposition, in both aquatic and terrestrial sites. Although evolution of these diverse reproductive strategies is well documented, the reproductive morphology variation that facilitates these multiple successful adaptations is largely unknown. The cloaca receives waste of the digestive and urinary systems and is also the final passage of gametes and might be involved in the production of secretions that helps reduce desiccation and allow eggs to survive varying water availability. However, very few studies have investigated the anuran cloaca. To address this gap and to determine whether cloacal evolution has contributed to the diversity of successful reproductive strategies, we investigated female cloacal variation across numerous species, and sexual dimorphism in cloacal morphology within Rana clamitans. Using histology, we tested for sexual dimorphism in the cloaca, as well as, whether differences in cloacal epithelial layer thickness, gland diversity, and gland density were associated with oviposition site (aquatic or terrestrial) and foam nest presence.

Physiological plasticity as a compensatory mechanism to warming temperatures in a tropical lizard

Lila Salazar, Martha Muñoz, Saul Dominguez-Guerrero

Climate change is a growing threat to ectothermic animals, whose physiological processes depend on the thermal conditions of their environment. Whereas mobile ectotherms from heterogeneous thermal habitats (such as xeric forests) rely on thermoregulatory behavior to cope with rising temperatures, their relatives from homogenous thermal habitats (such as cloud forests) rely on physiological adjustments of their thermal capacities. For example, anole lizards from shaded forests in the Greater Antilles have increased their heat tolerance by 2°C over the last decade. Yet, it remains unclear whether such a shift in the upper thermal limits of shaded-habitat species is the product of physiological plasticity. Using the stout anole as a model system, we conducted common-garden experiments where lizards were grown to adulthood under the thermal treatment of 28°C. We estimated both thermal preference and the critical thermal maximum (upper thermal limits) of the individuals. We then transferred individuals to a treatment of 32°C and re-estimated their upper thermal limits. Our results support physiological plasticity as a mechanism of resilience to rising temperatures in a tropical lizard. These findings expand current knowledge of ectothermic physiological plasticity and advance our understanding of their resilience to climate change.

Linking weapon quality and consistent individual differences in aggression in weapon-bearing insect

Christina Salerno, Janice Yan, Noraly van Meer, Phil Hahn, Christine Miller

Physical contests occur in many animal species, and fight outcomes often dictate key processes related to overall fitness, like access to high-quality territories or mates. Many traits determine contest outcomes synergistically, including morphological traits like weapon size, or behavioral traits like consistent individual differences (CID) in aggression. However, variation in weapon quality, irrespective of size, can occur naturally within a population – a pattern frequently driven by natural variation in diet quality. Despite their likely importance for determining contest outcomes, little research has examined the relationship between diet, weapon quality, and CID in aggression. To investigate this gap, we used the weapon-bearing leaf-footed cactus bug, Narnia femorata (Hemiptera: Coreidae). In this species, seasonal differences in diet quality are directly linked to weapon quality, though CID in aggression remains unknown. We predict that low-quality diet individuals will be more aggressive, as previous work in the lab revealed increased weapon signaling within a low-quality diet in apparent dishonest signaling. Furthermore, within a diet, we predict the quality of the weapon will correlate positively with aggression: better quality weapons will be wielded by more aggressive males. To answer our questions, we manipulated diet quality and repeatedly tested males in dyads to record their aggressive behaviors. Our understanding of animal weapons is often biased towards size, and this work will help disentangle how weapon quality and aggression shape contest outcomes.

Ecomorphological changes in squirrels (Sciuridae) through time

Joshua Samuels, Jonathan Calede, Keila Bredehoeft

Squirrels (Sciuridae) are one of the most successful groups of mammals, with about 300 living species. Sciurids are distributed in terrestrial ecosystems all over the world, and displays great morphological and ecological diversity. The group also has a very good fossil record, including 126 species in North America alone. Recent ecomorphological studies have improved understanding of rodent form and function, and combined with recent phylogenetic studies and an extensive fossil record, these provide an outstanding comparative framework for understanding the evolutionary change within Sciuridae. Here we examine a broad sample of sciurids (60 extant, 20 fossil taxa) and use a wide range of cranial, dental, and postcranial measurements to estimate body mass, study dietary adaptations (incisor strength and bite force quotient, mechanical advantage of jaw muscles), and study locomotor ecology (based on limb proportions and astragalus shape). Multiproxy ecomorphological analyses of craniodental structure and the postcranial skeleton allowed inferences of diet and locomotion for fossil species. These data were used to examine the evolution of dietary and locomotor specializations through time, with functional indices mapped onto squirrel phylogeny and compared to past climate and habitat changes. Evidence indicates as climate became cooler, more arid and seasonal through time and grassland habitats expanded, marmots (Marmota and Paenemarmota) became larger and more specialized for feeding on grass and burrowing.

Creating 3D digital atlases of gavialid forelimbs for accessible anatomical comparison

Elise Samuelson, Ryan Carney

The two extant species that make up the crocodilian family Gavialidae, Gavialis gangeticus and Tomistoma schlegelii, have distinct morphological adaptations for a highly aquatic lifestyle, exhibiting some of the smallest limb-to-body size ratios of any living crocodilian. Despite this, detailed analyses of gavialid limb anatomy, particularly joint surfaces, cartilage, and muscle attachments, are limited due to the rarity of both species. This study presents the first-known 3D digital atlases of the pectoral girdle and forelimb bones and soft tissues for both G. gangeticus and T. schlegelii, and provides comparative anatomical analyses. Bone and cartilage models were generated using DICECT scans of both species from Morphosource.org and segmented using Avizo and Biomedisa. Comparative dissections of juvenile Alligator mississippiensis provided reference for segmentation accuracy and served as a means of visual comparison. Joint surfaces and orientations were analyzed using shape fitting and topological coordinate systems (TCSs), and compared across various crocodilian species. Notable morphological differences are discussed, including humeral torsion as well as the scapulocoracoid cartilage that greatly affects the attachment site of the omohyoideus muscle. These findings offer new insights into gavialid anatomy, and the resulting digital atlases provide accessible, comparative tools for future research into crocodilian musculoskeletal anatomy.

Sexual dimorphism in the cranial lateral line of the bonnethead shark (Sphyrna tiburo)

Danna Valentina Sanchez Hernandez, Lauren Simonitis, Aubree Jones

The cranial lateral line canal system in elasmobranchs consists of fluid-filled cartilaginous canals containing mechanosensory neuromasts that detect water movements and pressure changes. In hammerhead sharks (Sphyrnidae), the expanded cephalofoil alters hydrodynamic conditions across the head, potentially modulating sensory perception of the lateral line. Mature adult bonnethead sharks (Sphyrna tiburo) exhibit sexual dimorphism in cephalofoil shape and roundness, yet it is unknown whether these differences correspond to variation in lateral line morphology. We hypothesize that sexual dimorphism in cephalofoil morphology results in measurable differences in the distribution of the cranial lateral line canals and pores, with potential consequences for sensory function (e.g., detection thresholds). Using micro computed tomography, we examined adult male and female S. tiburo to document canal location , branching patterns, and complexity of the cranial lateral line. Canal morphology was compared between sexes to identify structural differences such as branching density, total canal length and total canal volume. Alterations to spatial coverage could indicate hydrodynamic adaptations linked to cephalofoil morphology, building upon studies that have suggested the evolution of head shape Sphyrnidae is driven by sensory adaptations. This study provides quantitative assessment of sexual dimorphism in the cranial lateral line of S. tiburo, offering insight into how head shape can modulate sensory performance and, ultimately, influence ecological roles and foraging strategies in bonnethead sharks.

Alternative androgen receptor pathways mediate mating behavior in a pentamorphic fish

Ben Sandkam, Nora Prior, Ehren Bentz, Matthew Taves

Sex steroids are central regulators of vertebrate morphology and behavior, and differences in their abundance are often invoked to explain both inter- and intrasexual diversity. Yet abundance alone cannot account for species in which extreme diversity arises within a single sex. An alternative is that diversity is generated by altering the regulatory targets of steroid signaling. The livebearing fish Poecilia parae provides a powerful system to test this idea: males occur as five discrete morphs that coexist in natural populations and employ strikingly different reproductive tactics, ranging from large aggressive fighters to colorful courtship specialists and diminutive sneakers. We combined behavioral assays, pharmacological manipulations, and transcriptomic profiling to investigate how androgen receptor (AR) signaling mediates these strategies. We found that the role of AR signaling differs by tissue across morphs: reproductive behavior is mediated through AR signaling in the brain of the aggressive morph, through peripheral AR signaling in the display morphs, and is independent of AR in the sneaker morph. Morphs did not differ in circulating androgen levels or AR abundance. Instead, AR signaling triggered distinct transcriptomic responses across morphs, revealing that a shared hormonal signal can be rewired to divergent genomic targets. These results show how shifts in regulatory architecture, rather than hormone abundance, can generate extreme intrasexual diversity, illustrating a general mechanism by which endocrine systems foster evolutionary innovation.

The impact of a Pacific Herring spawning event on seagrass-associated pipefish in Sitka, AK

Katie Sands, Samantha Levell

Each year, ecologically, culturally, and economically significant Pacific herring spawn en masse, with Sitka Sound in southeastern Alaska hosting some of the largest spawning events. During these events, their eggs coat kelp and seagrass over miles of shoreline, often blanketing seagrass beds. Two poorly studied fish species, the bay pipefish, Syngnathus leptorhynchus, and kelp pipefish, Syngnathus californiensis, offer unique examples of how fishes experience these spawning events. Little is known about the movement patterns of these syngnathids, but they are unlikely to leave during the spawning period. To assess the impact of herring spawns, we surveyed pipefish twice monthly using a pushnet at two sites in Sitka Sound, AK. We hypothesize that this period leaves pipefish with potentially limited food access and increased exposure to predation stress, which will be reflected in reductions in pipefish health metrics. We compared metrics for each species between the pre-spawn period, the mid-spawn period, and the post-spawn period in order to determine whether there are changes in pipefish health associated with the Pacific herring spawning event.

Microbiome dynamics in the absence of winter dormancy in the temperate coral Astrangia poculata

Mia Sarris, Anna Dormitzer, Megan Harrington, Ciaran Fitzpatrick, Alicia Schickle, Anya Brown, Sean Grace, Justin McAlister, Koty Sharp

The temperate coral Astrangia poculata undergoes quiescence (hibernation) when temperatures drop below 5°C. Previous research demonstrates the A. poculata microbiome exhibits predictable seasonal shifts around quiescence. Post-quiescence microbiome studies in A. poculata have identified taxa that may drive coral microbiome re-assembly after environmental disturbance, with implications for our understanding of tropical coral recovery from disease and bleaching. In this study, microbiome dynamics through a non-quiescent winter are compared with previously published A. poculata microbiomes.

We used high-throughput 16S rRNA gene sequencing to characterize microbiome composition across a non-quiescent winter. Species richness was significantly different across months. Microbiome composition significantly changed across sample time, driven by differential abundance of eight bacterial families: Endozoicomomadaceae, Flavobacteriaceae, Fokiniaceae, Terasakiellaceae, Rubritaleaceae, Pirellulaceae, Stappiaceae, and Bacteria (unknown). Comparative analysis with previously published quiescent microbiomes suggests substantial differences, including lack of a predictable post-quiescence microbiome re-assembly. Ongoing work includes generation of new models of host-microbial interactions in non-quiescent corals. These climate change-related shifts in microbiome dynamics may have significant implications for coral health and broader ecosystem stability. Understanding how A. poculata's microbiome responds to warming waters that didn't reach the quiescent threshold provides insight into the impact of climate change on the A. poculata microbiome, and, more broadly, on host-microbe interactions, informing future monitoring and management strategies for coastal ecosystem changes.

When ice is nice: mitochondrial protection in freeze tolerant crickets

Stefane Saruhashi, Soren Coulson, James Staples, Yanira Jimenez-Padilla, Martin Moos, Brent Sinclair

Most animals are killed by freezing. We investigated how freeze-tolerant insects protect their aerobic machinery from freeze damage using Malpighian tubules of the cricket Gryllus veletis. We tested whether freeze-tolerant insects protect mitochondria from freeze damage by assessing mitochondrial function and structure with high-resolution respirometry and transmission electron microscopy. We first compared the responses of freeze-tolerant and freeze-intolerant mitochondria to chilling and freezing. Freezing significantly damaged freeze-intolerant inner mitochondrial membrane, reducing OXPHOS control efficiency and cristae integrity, whereas the function and structure of freeze-tolerant mitochondria was maintained, supporting the protection hypothesis. Cold exposure alone altered the morphology of freeze-tolerant mitochondria, but not freeze-intolerant mitochondria, suggesting that freeze-tolerant mitochondria relax their structure at low temperatures. Thus, while freeze-intolerant mitochondria resist cold but tear apart during freezing, freeze-tolerant mitochondria remain structurally and functionally resilient to cold and freezing. We then investigated the mechanisms underlying this resilience using lipidomics and transcriptomics. Our results showed that membrane lipid composition did not change with the acquisition of freeze tolerance; however, transcript abundance of protein complexes (e.g., MICOS) important for anchoring and shaping the inner mitochondrial membrane changed. Therefore, mitochondrial structural plasticity mediated by protein remodeling appears central to supporting mitochondrial function, cellular integrity, and survival under extreme cold stress.

Preferences in enrichment of the Okapi (*Okapia johnstoni*)

Zaha Sarwar, Kelly Diamond

Found in the rainforests of the Democratic Republic of Congo, the endangered okapi (Okapia johnstoni) spends the majority of the day browsing for food. These rainforests contain a wide variety of vegetation, such as ferns and leaves, that make up the okapi's diet. Zoos play a critical role in the conservation of many endangered species, including the okapi. For captive okapi, replicating natural foraging behaviors through enrichment is a critical component of animal welfare. Enrichment for okapis typically consists of various food items, such as branches, leaves, and pellets, placed at various heights around the animal's enclosure. In this study we examined the enrichment preferences of the okapis by comparing the time spent engaging with different categories of enrichment. We predicted that the okapis would have a preference for enrichment hanging at higher heights due to its similarity to trees and ease of access. To document okapi interactions with enrichment, the two okapis at the Memphis Zoo were filmed for one hour a day for 12 days over 4 weeks. Videos were analyzed to measure the amount of time okapis spent interacting with enrichment at high and low heights and in buckets. We found no differences in enrichment preference in either okapi. Results from this study suggest that the diversity of enrichment activities provided to captive animals is important for effective animal welfare.

Predicting kinematics from visual field stimuli during collective swimming in large-bodied predators

Darien Satterfield, Stephen Kajiura, Marianne Porter, Ashkaan Fahimipour

Understanding collective motion remains a major challenge in biology. While sensory systems are thought to play a key role in regulating group coordination, the complexity of large, freely-moving groups makes linking the sensory information an individual receives to its resulting kinematics difficult. Thus, the role of individual sensitivity to sensory information in group-level coordination remains a gap in the understanding of large-bodied predator collective movement. Blacktip sharks form massive seasonal aggregations in the clear, shallow waters off eastern Florida, providing an opportunity to address this gap. We used drone videography and deep-learning based pose estimation to track individuals' kinematics in time, quantifying variables such as tail beats and swimming velocity. To test our hypothesis that visual cues trigger kinematic responses and underlie group dynamics, we leveraged a computer graphics method, typically used to render virtual scenes in video games, to reconstruct each individual's first-person perspective, and to measure motion cues like neighbor looming and translation. By combining kinematic and visual data in deep-learning models, we find that local visual cues trigger behavioral cascades within the group. The perceived movements of a shark's neighborhood were predictive of its subsequent changes in kinematic variables. This work provides evidence that coordination in wild predator groups is governed by distributed, localized visual cues and that group-level dynamics emerge from cascades of rapid, decentralized behavioral changes at the individual scale.

Ultrahigh-speed kinematics of spring actuation and latch mediation in ultrafast, cavitating snapping

Jackson Savage, Abhinav Vaduri, Melody Young, Sheila Patek

Latch-mediated spring-actuation (LaMSA) enables some of the fastest repeated-use motions in nature. Spring actuation can be deduced by measuring the deformation of elastic structures and the timing of deformation relative to spring-actuated movement. Latch mediation controls the release of this deformation and the onset of spring-actuated movement. Here we examine the kinematics of latch mediation and spring actuation in Alpheus heterochaelis snapping shrimp. We recorded high speed images of dactyl snaps (20 kfps-80 kfps) from both lateral and dorsal views of the major claw. The claw's propodus deformed prior to each snap, and rebounded to its original shape after dactyl closure initiated, undergoing a 12% length change. This rebound began once the dactyl traveled 26% of its total rotation, at which point dactyl angular velocity increased dramatically. These findings indicate that elastic potential energy is stored via propodus deformation and that the snap is propelled by spring actuation once it reaches 26% of its total rotation. Latch mediation likely occurs during the first 26% of rotation, prior to spring actuation. By imaging the timing and deformation of the propodus relative to dactyl rotation, this study reveals the timeline and mechanism of LaMSA in ultrafast snapping shrimp.

Digging deeper into the semi-fossorial predatory behavior of Borophagus

Anissa Savani, Emily Bogner

The extinct canid, Borophagus is well known for its bone-crushing capabilities, however, limited morphological data of their postcranial skeleton has restricted the understanding of their locomotor behavior. A previous study documented that Borophaus possibly had aspects of a semi-fossorial lifestyle and this research aims to test that hypothesis. We compared Borophagus to 10 of the 12 species of extant semi-fossorial carnivorans within the mephitid, mustelid, and canid families, utilizing 3D geometric morphometrics and linear measurements of the forelimb bones (humerus, ulna, radius). Morphological results of the ulna reveal Borophagus had a relatively small olecranon process and straighter diaphysis, aligning with other canids. Borophagus did, however, have the highest Ulnar Robustness Index, functionally grouping them within the semi-fossorial locomotor type. When analyzing humeral morphology, Borophagus had one of the smallest epicondylar breadths of any species tested, but one of the largest Shoulder Moment Index, indicating mechanical advantage of the pectoral muscles. Radial morphology indicates Borophagus is most akin to other canids, characterized by a larger distal epicondyle, and having one of the lowest Brachial Indices, demonstrating Borophagus was not running adapted. Overall, Borophagus is morphologically similar to other canids despite differing predatory and locomotor behaviors. Functionally, Borophagus had highly dexterous forelimbs with morphological features similar to semi-fossorial carnivora and cursorial canids. This could indicate that Borophagus utilized a digging behavior more than extant canids.

Songbirds on stress: Assessing avian physiology in post-fire habitat with stress-induced CORT series

Linnea Schaefer, Parker Guzman, Natalie Ng, Lambert-Mullen Amalina, Creagh Breuner, Zachary Cheviron

Wildfires are becoming an increasingly powerful agent of landscape disturbance across the globe. Spurred by climate change, record-breaking "megafires" are transforming montane landscapes in the Western US. The evolutionary and physiological effects of wildfire have been well-documented in plants, but similar research on vertebrates is scarce. High-severity wildfires modify habitat for decades to come, and these changes likely induce nutritional, hydric, and thermoregulatory challenges, particularly for diurnal animals, including songbirds. We predict that these physiological challenges will cause chronic stress and lower the condition of songbirds that recolonize burned habitats. Here, we integrate several metrics of general condition (e.g., hematocrit, body weight) with comparative endocrinology to explore differences in avian condition and stress response across the scar of the Dixie Fire in Northern California. We conducted stress series with a dexamethasone suppression on free-living Mountain Chickadees, Dark-eyed Juncos, and Brown Creepers. We measured circulating corticosterone (CORT) at baseline, stress-induced, and negative-feedback levels to explore differences in stress response between unburned and burned sites. We hypothesize that birds in burned sites will have weaker stress-induced responses and weaker negative feedback, compared to birds in unburned sites, since chronic stress reduces the ability to respond to future stressors. We also predict that these trends will scale with fire severity. This research integrates endocrinology best-practices with disturbance ecology to explore avian resiliency to environmental challenges.

Reduced ambient light induces gait changes in cathemeral lemurs

Nicole Schapker, Aidan Miller, Abdelrahman Boghdady

Some species of lemur are cathemeral, or active throughout the light and dark portions of a 24-hour cycle. However, not all lemur species possess a tapetum

lucidum (TL), the reflective tissue layer behind the retina that enhances vision in dim light. Low ambient light levels may make arboreal locomotion riskier, especially for lemurs lacking a TL. Here, we investigate the effects of reduced light availability on the gait of three genera of cathemeral lemur housed at the Duke Lemur Center – the larger-bodied Varecia (no TL) and smaller Eulemur (no TL) and Lemur (TL). Lemurs were recorded in bright and dim light as they moved across poles of varying diameter oriented at 25 degrees. Varecia made the most pronounced gait changes to enhance stability in dim light, which was expected because of their larger body size and absence of a TL. Varecia used shorter, less frequent strides and increased forelimb duty factors ($p \leq 0.024$). Eulemur used a narrower range of speeds in dim light (though mean speed did not decrease) and trended towards increasing hindlimb duty factors ($p=0.088$). Lemur slightly increased the mean number of limbs supporting the body through a stride ($p=0.03$) in dim light. These results suggest that light availability may induce gait changes regardless of eye anatomy.

Investigating tapeworm diversity in wild turkeys from Central Tennessee

Meghan Schauble, Grace Perrin, Freya Goetz, Rick Gerhold, Anna Phillips

Eastern Wild Turkey (Meleagris gallopavo silvestris) populations have been declining throughout Central Tennessee for the past decade, and, as a result, parasites can be a contributing factor. With the potential for disease transfer between eastern wild turkeys and domesticated poultry having implications for human health and food supply security, cestodes can provide a better understanding of host populations, complex ecosystems, and human relationships. In this study, 31 eastern wild turkeys were analyzed from turkey hunter check stations in seven counties. Parasites were collected by flushing intestinal tracts, and cestodes were preserved in 70% ethanol in the field. 42 different subsamples were examined from the turkeys, with scanning electron microscopy, light microscopy, and molecular phylogeny. Examination revealed the presence of two cestode species, Rallietina williamsi Fuhrmann, 1932, and Metroliasthes lucida Ransom, 1900. Across all samples, Raillientina williamsi was identified in 66.67% of the samples, and Metroliasthes lucida was found in 33.33%. Both species were found in counties with stable and declining wild turkey populations. These preliminary results suggest these cestode species are not a contributing factor to the eastern wild turkey decline in Tennessee. By studying cestode diversity in wild turkeys over time and space, we can better understand their impacts on host populations and within complex ecosystems.

A prickly problem: studying locomotion in the four-toed hedgehog

Charly Scherbarth, Caroline Sontra, Charlotte Easterling

Hedgehogs are nocturnal mammals, known for their startle response of rolling into a tight ball and erecting spines for protection. These shy animals have become common in the pet trade, namely the four-toed hedgehog (Atelerix albiventris), requiring a better understanding of their husbandry needs to maintain active, healthy lifestyles. This study focuses on the successful methods for measuring slow and fast paced walking of the four-toed hedgehog. While this study began with the aim of researching the locomotion and general activity of hedgehogs, challenges were quickly encountered in measuring these behaviors. Slow walking is difficult to document because the limbs are often concealed beneath the body, making lateral imaging impractical. To overcome this hurdle, we imaged the animal from below using a plexiglass floor in a darkened enclosure. Individual footsteps were illuminated using LED lights to produce frustrated total internal reflection as the foot contacted the walking surface. In faster-paced locomotion, hedgehogs extend their legs, making them visible for lateral imaging, however, it's difficult to encourage a quicker gait without triggering the animal's startle response. By placing a running wheel in the filming enclosure, timing locomotion sessions with the animal's natural sleep-wake cycle, and imaging under UV light, quicker locomotion bouts were recorded. These methods hope to provide insight into overcoming issues in observing behaviors in elusive, nocturnal animals while in a controlled, laboratory environment.

Song structure, territory quality, and body condition in the Black-capped Vireo (Vireo atricapilla)

Aurora Schermbeck, Jennifer Phillips

In territorial birds, song is thought to help females recognize high quality mates and allows males to competitively assess each other. In theory, males with complex songs or large repertoires should have better body condition and higher resource holding potential. While many studies investigate these relationships in model species, often little is known about species of conservation concern, and whether song can be used as a proxy for understanding connections between body condition and habitat. The threatened Black-capped Vireo (Vireo atricapilla, BCVI), is a migratory songbird that prefers short canopy oak scrub habitats of Texas, Oklahoma, and Mexico, and has complex song bouts but no known studies assessing repertoire, territory quality, and body condition. Here, we assess the relationship between morphometric data, song, and habitat quality from 18 male Black-capped Vireos at Government Canyon State Natural Area near San Antonio, Texas. We mapped territory size and habitat characteristics such as percentage of high and low canopy cover and used Raven Pro to determine the average song length, bandwidth, and song and note repertoires for all focal males. We predict that males with larger repertoires, longer song bouts, and wider bandwidths will have better body condition and hold higher quality territories. Results from this study may provide insight into whether acoustic recordings can be used as a conservation tool to assess BCVI population health.

Temporal dynamics of inherited microbiota in response to environmental fluctuations in a wild mammal

Gabriele Schiro, Allyson Placko, Stan Boutin, Jeffrey Lane, Andrew McAdam, Ben Dantzer, Lauren Petrullo

Animals in heterogeneous environments can face both regular and irregular changes to environmental conditions, including fluctuations in resource availability. The gut microbiome may contribute to host adaptation to this variability by conferring metabolic flexibility. Mechanistically, the transfer of microbiota from mothers to offspring (vertical transmission) can promote this flexibility by maintaining microbes that are adapted to these fluctuations. In this study, we investigated temporal gut microbiome dynamics in response to seasonal changes in food availability and irregular, inter-annual food booms in a population of wild North American red squirrels (Tamiasciurus hudsonicus) in the Yukon, Canada. We hypothesized that vertically-transmitted microbes would primarily respond to regular, seasonal change rather than to cues of irregular food booms. Using 16S-rRNA amplicon data from 771 fecal samples collected from 110 squirrels across 14 years, we detected seasonal effects on microbial diversity, with declines in alpha diversity during breeding that were steeper in food boom years. We then used a subset of 25 mother-offspring pairs to identify microbial groups with signatures of vertical transmission and tracked their dynamics across timescales. Vertically-transmitted microbes were strongly responsive to seasonal change, but also exhibited potentially anticipatory responses to inter-annual changes in food availability. These results suggest that vertical transmission may maintain a gut microbial community that helps hosts navigate both small-scale, regular changes and large-scale and irregular shifts in resource availability.

Caffeine-induced chemical stimulation impact on AMPK enzyme in murine muscle cells under environment

Amber Schlater, Sophia Ansello, Jadyn Lind, Sam Johnson

Activated Protein Kinase (AMPK) is a key enzyme that regulates cellular energy homeostasis. In this way, it is activated under metabolic stress, such as low glucose. This study aimed to explore how caffeine, a stimulant that activates muscle contraction responses, can modulate and/or regulate AMPK activity in murine skeletal muscle cells, and how glucose availability influences this effect. It was predicted that caffeine will increase AMPK activity in murine skeletal muscle cells with a greater response to low glucose conditions. To test this, C2C12 myoblasts were differentiated into mature myotubes for seven days in either high- or low-glucose media. On days 4-7 of differentiation, cells underwent a 0.05mM caffeine treatment to simulate exercise. Following protein extraction, we performed various protein assays, including an AMPK

enzyme assay. Additionally, varying assays were run to determine concentrations of key metabolic enzymes. Results from this study will provide insight into metabolic regulation relating to cellular physiology and environmental stressors like glucose availability and caffeine-influenced metabolic enzyme activity in murine skeletal muscles.

The effect of vitamin C supplementation on reactive oxygen species during exercise in murine cells

Amber Schlater, Jadyn Lind, Sam Johnson, Sophia Ansello

Aerobic exercise is defined as exercise that involves the repetitive movement of large muscle groups, increasing mammalian use of oxygen, and promoting cardiovascular health. Elevated aerobic exercise metabolism increases reactive oxygen species (ROS). It has been shown that as intracellular oxygen concentrations increase the rate of electron leakage to oxygen increases. This means that the oxygen taken in from aerobic exercise can create more superoxide radicals within cells. Ascorbic acid, also known as vitamin C, is a water-soluble antioxidant vitamin that reduces cellular oxidative stress, scavenges free radicals, and inhibits peroxidation of membrane phospholipids. Previous research has suggested that vitamin C may be a viable supplement to enhance collagen synthesis and soft tissue healing, like skeletal muscles. In this study, murine C2C12 cells were cultured to mimic human skeletal muscle development and differentiation. Two groups were analyzed: exercised subjects, each with or without ascorbic acid supplementation. A Bradford protein assay, cytochrome c-oxidase assay, and comet assay were used to determine collagen protein concentration, the catalytic rate of cytochrome c oxidation, and DNA damage. We hypothesized that the cells under aerobic exercise without ascorbic acid supplementation would show disruption in collagen synthesis and DNA damage caused by ROS.

Evaluating the impact of life history strategy on morphological evolution in lampreys

Noah Schley, Devin Bloom

The macroevolutionary drivers of morphological diversification are varied, ranging from extrinsic factors such as environmental shifts and geological activity, and intrinsic factors such as developmental processes and species ecology. Variation in life history strategy, which influences prime targets of natural selection, such as growth rate, age of sexual maturation, and fecundity, may also drive morphological evolution. Lampreys have three remarkably different life history strategies: anadromous-parasitic, freshwater-parasitic, and freshwater-nonparasitic, each evolving repeatedly across the lamprey phylogeny. We explored how life history strategy drives morphological diversification dynamics in lampreys. We analyzed 14 traits that capture phenotypic variation across 35 species using a suite of phylogenetic comparative methods. Our preliminary results reveal that body size is the primary axis of divergence and is most strongly associated with migration. We found that body size evolves faster in migratory than in nonmigratory species of lamprey. We also found that selection on traits is occurring but might not be entirely driven by life history strategy. Our study emphasizes the importance of life history strategies in driving morphological diversification and adaptation.

Ranaviruses and trypanosomes in *Culex territans* mosquitoes and their ranid hosts

Iris Schmeder, Joanna Reinhold, Ella Halbert, Isabella Roeske, David McLeod, Chloe Lahondere

Around the globe, many amphibian populations are currently threatened with extinction. Much of this threat is driven by disease-causing pathogens, including the chytrid fungus, ranaviruses and, to a lesser known extent, trypanosomes. Understanding how pathogens are being moved within and between amphibian populations is imperative to slowing amphibian population declines. Only recently have ectotherm-feeding mosquitoes, such as the northern frog biting mosquito—Culex territans, been considered possible disease vectors among amphibians. Since 2021, we have been investigating the prevalence of trypanosomes and ranaviruses in populations of Cx. territans, Rana clamitans (green frogs), and Rana catesbeiana (bullfrogs) at Mountain Lake Biological Station (Pembroke, VA, USA). Our results reveal a consistent presence of the ranavirus Frog Virus 3 (FV3) and several trypanosome species, including Trypanosoma ranarum and Trypanosoma chattatoni, in both mosquitoes and frogs. In 2025, there was an outbreak of trypanosomes among all three species and an outbreak of FV3 in Cx. territans and R. clamitans. Furthermore, instances of coinfection of FV3 and trypanosomes have been detected in both Cx. territans and R. clamitans. Understanding the role mosquitoes play in pathogen transmission to amphibians may provide novel tools aiding efforts to slow the rapid loss of global amphibian diversity.

Complex environments drive adaptive hunting strategies in mice

Aidan Schneider, Keith Hengen

Prey capture is crucial for survival and fitness in many species, shaped by the intricate interplay of genetics, adaptation, and learning. Traditional laboratory studies on prey capture using mice and insects have provided valuable insights but often rely on simplified, largely barren environments that fail to capture the complexities of natural habitats. This study aims to explore how the dynamics of prey capture change with increasing environmental complexity. We designed an experimental setup enriched with objects reminiscent of refuse commonly found in cluttered anthropogenic environments where mice and cockroaches may coexist. We compared the predatory strategies of mice in this enriched setting to those in a bare, object- free environment. This required specialized computer vision tools to track the animals despite frequent occlusions, as well as novel machine-learning models to classify both brief individual actions and extended behavioral states integral to the hunt. Our analyses revealed new hunting behaviors in the complex environment that were absent in the empty setting. These include: 1. skillful maneuvering through dense clutter, 2. persistent tracking of prey over extended periods and through uncertainty, 3. discovering and revisiting potential prey hiding locations, and 4. complex, sequential hunting and search strategies. These behaviors, while observed within an enclosure, resemble the prey capture strategies seen in wild animals, suggesting that complex behaviors often emerge in response to a complex environment.

Metabolic Response to Changes in Diet in a Common Medical Model Xenopus laevis

Luke Schneider, Dillon Monroe

African clawed frogs (Xenopus laevis) are becoming increasingly popular for studies of evolution and development because of their distinct developmental stages, biphasic life cycle, and well-characterized endocrine physiology. These features also make them a potentially useful model for metabolism research. Altering the diet of African clawed frogs is an effective way to examine how diet and nutrition influence metabolism. We employed a straightforward yet informative approach by modifying the ratios of macromolecules (sugars, fats, and proteins) in the diet of X. laevis. Using a longitudinal experimental design, we measured changes in metabolic rate indirectly through respiration gas analysis. Understanding metabolic rates is essential for comprehending the physiology of a species. As a developing model system, studying the metabolism of X. laevis will aid in understanding how environmental changes can produce lasting physiological effects on a species.

Adaptation or reversion: Mechanism and evolution of a novel feeding strategy in chameleons

Nikole Schneider, Dylan Anderson, Christopher Mayerl, Christopher Anderson

Chameleons are well known for their highly specialized feeding mechanism which allows them to ballistically project the tongue out of the mouth at high performance to catch prey up to 2.5 body-lengths away. Due to the extreme nature of this feeding system, it could be assumed that this system is not easily coopted to perform alternate behaviors, and that chameleons would be limited to feeding only via tongue projection. However, some chameleon species have been documented to feed by approaching and directly grabbing slow or nonmobile prey items using only their jaws. The underlying mechanisms of

this feeding strategy have never been examined. We compared the feeding kinematics and muscle activity patterns during tongue projection and jaw prehension in two chameleon species and a closely related agamid to determine whether jaw prehension in chameleons is a co-optation of the tongue projection feeding strategy, or whether it is an evolutionary reversion back to an ancestral mode of feeding, similar to patterns seen in other iguanian lizards. Our results suggest that the jaw prehension feeding strategy involves distinct kinematic and muscle activity patterns compared to the tongue projection feeding strategy in chameleons. Further analyses will elucidate whether the underlying mechanisms powering feeding are conserved across iguanian families, or if the extreme specialization of the chameleon feeding system has necessitated the evolution of a novel feeding mechanism.

Dual duty of AP gut patterning systems during larval metamorphosis and in adult stages of an annelid

Stephan Schneider, Wahyu Cristine Pinem, Grace Sonia

A through-gut is one of the major features of bilaterians. Comparative work among bilaterians has identified common molecular mechanisms during early gut patterning, but the primordial gut later often undergoes different degrees of reorganization in each lineage to form a fully differentiated adult gut with specializations along its anteroposterior (AP) axis. Yet, how the conserved embryonic gut AP pattern relates to the adult guts in diverse bilaterians after metamorphosis is still poorly understood. To close this gap we set out to unravel the development and AP differentiation of the digestive system in a marine worm through transcriptome analyses of the annelid Platynereis dumerilii. We generated spatially resolved bulk RNA-seq data from tissues along the AP axis of adult guts, and temporally resolved bulk RNA-seq data across metamorphosis from early larval (1dpf) to juvenile stages (8dpf) in 12h intervals, with corresponding single nucleus RNA-seq data. Intriguingly, we found AP restricted expression domains of AP patterning systems including hox, parahox and other known transcription factors, not only during the formation of the gut at larval stages, but also in fully differentiated gut tissues in adults. In summary, our study suggests that AP patterning systems are dually deployed, during gut development and in differentiated adult guts, and that this dual duty of the AP gut patterning system might be an ancestral bilaterian feature.

How skin microbiomes shape epidemic trajectories in a guppy-gyrodactylus host–parasite system

Tabea Schneider, Sadie Evanov, Noah Leith, Carolyn Tett, Rachael Kramp, Niclas Kolm, Kevin Kohl, Jessica Stephenson

Climate change is rapidly affecting the frequency and severity of epidemics. Predicting how climate change affects epidemic dynamics is vital to preserve future biodiversity and human health. Epidemic dynamics are directed by three main components: host immunity, parasite fitness, and parasite transmission. Host-associated microbial communities play a key role in modulating immune responses, and research now shows that skin microbiomes significantly influence infection intensity and host-parasite interactions. Microbiome diversity may also predict individual host activity level and social interactions. Host immune function, behavior, and associated microbial communities are all affected by thermal environment, particularly in ectotherms. Given the importance of both infection intensity and host behavior to disease transmission, we tested whether variation in skin microbiome translates to variation in parasite transmission, and how this interaction may vary across thermal environments. We conducted experimental epidemics of the socially-transmitted ectoparasitic worm Gyrodactylus turnbulli in guppies (Poecilia reticulata). We collected skin microbiome samples from each individual guppy prior to the start of the epidemic. During the subsequent 10-day experimental epidemics in groups of guppies, we recorded behavior, and parasite counts daily to test how unmanipulated host microbiomes affected the dynamics of the guppy-gyrodactylus system under three heatwave treatments. Our heatwave treatments had striking effects on epidemic dynamics, mediated through complex interactions between host immune function, behavior, and skin-associated microbial community structure.

Integrating sensors and statistics: thermal coping mechanisms in heat-stressed desert bighorn sheep

Lauren Schreck, Anna Jolles, Brianna Beechler

Biologging technologies offer insights into physiological tradeoffs between thermoregulation and energy expenditure in extreme environments. We investigated the responses of desert bighorn sheep to a naturally occurring extreme heat event (EHE) by deploying rumen implant transmitters (RITs), GPS collars, and accelerometers on 49 free-ranging individuals from ecologically and genetically distinct populations. RITs recorded heart rate and body temperature, collars measured external body temperature, and accelerometers tracked activity levels. Ambient temperature data were obtained from proximal weather stations. This multi-sensor approach captured physiological and behavioral dynamics before, during, and after the unprecedented 2021 EHE in the Pacific Northwest. We characterized individual thermal and metabolic patterns using generalized additive mixed models to identify key drivers of variation, including demographic, nutritional, genetic, and immunological traits. To further explore patterns of response, we propose an unsupervised clustering algorithm adapted for longitudinal data to generate functional profiles of individuals exhibiting similar thermal responses. These clusters will be analyzed to identify common explanatory traits across time steps. By leveraging biologging data and a natural climatic event, this study advances our understanding of physiological stress and energy allocation strategies in wild ungulates. Our findings have direct implications for conservation and management under increasing frequency and intensity of EHEs due to climate change.

An exploration of how telomere length varies across latitudes in house sparrows (Passer domesticus)

Olivia Schroeder, Jeffery Kittilson, Isaac Rush, Samuel Lane, Britt Heidinger

Many organisms exhibit latitudinal patterns in body size and other life-history traits, but the underlying mechanisms are not well understood. One factor that may be important in this context are telomeres. Telomeres are highly conserved, repetitive sections of DNA at chromosome ends that enhance genome integrity but shorten during cell division and limit cellular lifespan. Individuals with longer telomeres often live longer and evidence suggests that environmental circumstances including exposure to metabolically costly activities like growth and reproduction can increase the pace of telomere loss. Thus, telomeres may be an important mechanism and/or serve as a biomarker of latitudinal variation in life-history patterns. However, much of what we know about telomeres comes from studies across species or within a population, limiting our understanding of how telomeres vary among populations and within species. Telomeres may decrease with latitude because larger, northern birds experience rapid or extended growth that increases telomere loss. Alternatively, telomeres may increase with latitude if resource availability during development simultaneously allows for larger body size and investment in telomere maintenance. To examine these possibilities, we measured telomeres in the red blood cells of free-living adult house sparrows (Passer domesticus) from 20 populations throughout the United States. Results will be discussed within the context of life-history theory and as an extension of Bergmann's rule.

Animals for All – creating accessible bio-inspired tactile art and fidgets across length scales

Andrew Schulz, Abigale Stangl

Describe an elephant without using the verb look. How can you effectively provide alt-text for a complex microscopy image especially factoring in to the length scale? Can bio-inspired structures provide a more effective fidget for neurodivergent individuals? The world is filled with materials too small for our eyes to see: the setae on a gecko's feet, the cuticles covering a rat's whisker, or the fuzziness of a bat's wing. Furthermore these structures are non-homogenous often shifting from stiff to soft with ease. In this work we investigate working on different techniques to create bio-inspired mimics allowing tactile accessible biology and bio-inspired design. This work looks to leverage new and innovative techniques including more advanced 3D printing allowing

creation of tactile graphics and art to help create more accessible science while providing a new form of investigation of biological structures: tactile exploring materials.

Conservation tools through project based academic-zoo collaborations

Andrew Schulz

Conservation technology describes utilizing technology for wildlife conservation and is a field that has found rapid growth in the twenty-first century. A challenge in conservation technology is as the field itself is a collaboration between biologists, engineers, and computer scientists it has a high barrier-to-entry and often students do not get introduced until graduate school or later. Over the last several years we have worked to change this through creation of a project-based course on zoo-academic collaborations. This course works to create interdisciplinary undergraduate teams that can develop conservation technology with wildlife conservation partners including zoos, wildlife facilities, and more. This course's projects are made successful through a longstanding Georgia Tech – Zoo Atlanta research collaboration allowing undergraduate students to create technology that can help provide enrichment to diverse species while giving undergraduate students exposure to conservation technology. In this talk we will go over creating and implementing the course, known at GaTech4Wildlife, and showcase some of the specific technology created by students including an open-source wildlife tracker for bald eagle monitoring, a machine-learning enabled rabies vaccine distributor, and an automated feeder for western lowland gorillas.

The biomechanics and physiology of prey capture by the fish hunting cone snail *Conus catus*

Joseph Schulz, Vanessa Escobar, Nadine Riddle, Kelly Shen

Cone snails like Conus catus combine a high-speed delivery mechanism with fast-acting peptide neurotoxins to rapidly subdue their stung prey. Puncture is central to this process by both allowing for the entry of the venom into prey as well as tethering the paralyzed prey to the snail prior to engulfment. Previous work from our lab has elucidated details of the high-speed delivery mechanism involving the hydraulic propulsion of a hollow, spear-like radular tooth whose release is controlled by a soft latch within the proboscis. Recently, kinematic studies of venom ejection from the radular tooth post-strike revealed a rapid rise in venom velocity that quickly dissipates. However, questions concerning how the proboscis lumen is pressurized to propel the tooth and expel the venom remain. These details may be revealed through a combination of comparative morphological and behavioral studies. The injected venom results in a spastic paralysis that quickly incapacitates the prey. The neurotoxins responsible for this rapid paralysis belong to a novel family of peptide excitotoxins whose molecular target is currently under investigation. To study the activity of these toxins our lab has developed tools in the zebrafish model system to investigate their effects on cultured spinal neurons and in situ on intact spinal circuits in a multi-sample spinal motility assay. Combined, these approaches provide a holistic view of prey capture by these fascinating animals.

Evaluating the use of maze tasks to quantify spatial memory in a wild mammal

Rachel Schulz, Ben Dantzer, Andrew McAdam, Jeffrey Lane, Lauren Petrullo, Stan Boutin

Spatial memory enables animals to use past experiences to drive adaptive behavior, such as locating mates and caching and retrieving food. Studies of spatial memory have largely focused on scatter hoarding species, while the role of spatial memory in the caching performance of larder hoarders is less understood. In addition, while sex differences in spatial memory have been found in some polygamous species, whether this difference in spatial memory is correlated to sex differences in food caching is unknown. In this pilot study, we assessed the use of two mazes frequently used in laboratory studies to measure spatial memory (the Y-maze and radial arm maze) on a wild population of North American red squirrels in southwestern Yukon, Canada. We compared performance in these mazes measured in June and July to the number of spruce cones cached in a central larder hoard by each individual in October to determine whether differences in spatial memory performance in these mazes is related to caching success. We also assessed sex differences in maze performance. The results of this study contribute to our understanding of how individual and sex differences in spatial memory correlate with caching behavior in larder hoarding species, which may ultimately drive individual differences in fitness.

Occam's razor in dynamic camouflage research

Lorian Schweikert, Mike McKimm, Lydia Naughton, Rejana Pullarkat

The law of parsimony, or Occam's razor, is a problem-solving principle suggesting that the simplest explanation is usually the correct one. In studying dynamic color change (particularly for background-matching camouflage), this principle has been critical for inducing this behavior in the laboratory and understanding how it is achieved in the field. Here, we recount lessons provided by failed experiments and unexpected findings in the behavioral investigation of color change in hogfish (Lachnolaimus maximus) and summer flounder (Paralichthys dentatus). We explain the nuanced effects of behavioral state on color change outcomes and the importance of relevant ecological context in eliciting repeatable, reliable color change in the lab. Then, we describe unexpected insights that contribute to the idea that, although dynamic camouflage can appear infinitely adaptable to surrounding conditions, it may be governed by a set of behavioral principles that produce an illusion of flexibility. Specifically, our findings suggest that dynamic camouflage in summer flounder is achieved by color change patterns that are fixed in body position, dependent on body placement, and selected from a discrete set of color change outcomes. Taken with other studies, these ideas provide a basis for developing hypotheses and designing experiments in the study of color change, where 'keeping it simple' has helped to advance new knowledge in this field.

Investigating migration strategies, haemosporidian infection and fitness consequences in a partial migrant population

Sarah Scott, Stephanie Galla, Allison Simler-Williamson, Stephanie Hudon, Julie Heath

Migration shapes host-pathogen dynamics, which may create differential infection consequences for individuals in a partial migrant population. We aimed to test the hypothesis that migration strategy affects pathogen prevalence by comparing haemosporidian loads and diversity between migrant and resident American Kestrels (Falco sparverius) in a partial migrant population. Further, we examined associations between haemosporidian infection, sex, and individual condition (telomere length), as well as how haemosporidian infection varies across the annual cycle and between years in both migrants and residents. We analyzed historic (2009-2012, n=150) and contemporary (2023-2025, n=400) samples to examine temporal patterns of infection. Telomere length, infection status and parasite load (Plasmodium, Leucocytozoon, Haemoproteus) were determined using quantitative PCR. Migratory strategy was determined using stable isotope analysis. Preliminary results reveal high rates of infection and the presence of co-infections in breeding American Kestrels with significantly higher relative parasite loads in migrant individuals compared to resident individuals. Results support the hypothesis that migratory behavior affects risk of parasite infection. Investigation of pathogens in this population will result in a better understanding of the burden of infection on individuals, parasite prevalence across the annual cycle for migrant and resident individuals, and changes in an avian disease system across time periods.

Exploring the evolution of chordate innate immunity through the study of tunicate blood cells.

Tal Scully, Gabriela Rodriguez, Bradley Davidson, Allon Klein

The innate immune system serves as the first line of defense against pathogens in a broad range of organisms. However, our current understanding of innate immune blood cell types and the molecules they utilize is primarily from vertebrate studies. To explore the evolution of innate immunity, we utilized single-cell RNA sequencing (scRNA-seq) and morphological analysis

to characterize blood cells in Ciona robusta. Ciona is a tunicate, the closest invertebrate sister taxa to the vertebrates. Thus, studies of Ciona blood cells will reveal shared ancestral traits among chordate innate immune cells and how they have diversified. Our scRNA-seq analysis identified 33 transcriptionally distinct Ciona blood cell states. 24 cell state morphologies were annotated in fixed samples using marker gene expression. 7 states had in-vivo morphology and behavior characterized using fluorescent reporters. While Ciona blood cells express orthologs to vertebrate innate immune genes, most do not appear to be specified using conserved regulatory pathways. Recently we detected a giant multi-nucleated blood cell morphotype that was not observed in our scRNA-seq analysis or previous studies. These giant cells appear to arise in response to severe inflammation or necrosis and may result from macrophage fusion, a process observed under pathological conditions in human macrophages. Future studies on the diversification of blood cells among Cionid species will allow us to productively evaluate hypotheses of cell type and immune gene evolution.

Something to chew on: effects of food and cycle type on tongue kinematics in Macaca

Yeganeh Sekhavati, Lamine Camara, J.D. Laurence-Chasen, Nicholas Hatsopoulos, Callum Ross

Feeding requires the tongue to adapt its movements to food of different sizes, textures, and mechanical properties. Nevertheless, the mechanisms by which the tongue's kinematics change to accommodate varying foods with distinct mechanical demands remain unclear. We used X-ray Reconstruction of Moving Morphology (XROMM) to track radiopaque markers in the tongue and jaw to analyze tongue sagittal flexion and roll in a rhesus macaque across two food types: half grape and gummy bear. The marker set included anterior, posterior, midline, and lateral tongue points and mandibular markers to segment the gape cycles. We calculated the amplitudes of left and right flexion, lateral roll, and posterior roll for each cycle, and compared them using Bayesian hierarchical models. Chewing half grapes led to more tongue bending and rolling than chewing gummy bears. This is likely due to the increased demand for manipulating a larger bolus. Chewing half grapes resulted in ~5.9° more lateral roll (credible interval [CI]: +2.0–9.0°), ~4.5° more posterior roll (CI: +2.4–6.5°), ~3.9° more left flexion (CI: +1.6–6.1°), and ~3.3° more right flexion (CI: +0.7–6.3°). These findings demonstrate that tongue flexion and roll amplitudes change with bolus size. They provide biomechanical evidence for how the tongue adapts to diverse feeding demands and establish a framework for linking food properties to tongue kinematics.

Limit cycle analysis of the sled dog team

Benjamin Seleb, Saad Bhamla, Matt Bull

Gait is traditionally defined by the sequence and timing of footfalls, requiring high-speed video or force-plate data to analyze. However, in field settings—particularly with high-speed animals like sled dogs—such instrumentation is often impractical. Here, we show that animal-borne accelerometers can reveal gait transitions by treating periodic acceleration trajectories as limit cycles in phase space. Gait transitions often manifest as discrete changes in limit cycle shape, providing a data-driven method for classifying movement behavior. We extend this approach across multiple individuals to explore how transitions do—or do not—align across the sled dog team.

TinkerTrap: a customizable camera trap platform

Benjamin Seleb, Saad Bhamla

Camera traps are among the most valuable tools for wildlife researchers, enabling noninvasive, around-the-clock monitoring of elusive animals. However, most commercial camera traps are designed for recreational hunting and present significant limitations for research applications: higdh cost (>$250 USD), poor sensitivity to small or cold-blooded animals, and little to no flexibility for custom triggering or sensing. To address these challenges, we are developing TinkerTrap---an open-source, modular camera trap platform built around a $50 USD development board. TinkerTrap provides complete control over sensing, timing, and peripheral integration, enabling researchers to adapt deployments to a wide range of species and experimental goals.

Lunar cycle influence on reproductive output in the rocky intertidal crab: Petrolisthes cinctipes

Megan Selecky, Brian Tsukimura

Reproductive success is contingent on fitness and generally follows cyclic patterns. The porcelain crab, Petrolisthes cinctipes (Decapoda: Anomura), found in the mid to upper zone of the rocky intertidal, ranging along the California coast (Haig, 1960), are oviparous, and produce reproductive proteins (Vitellogenin: Vg) that vary seasonally and with lunar cycles (Tsukimura, 2001; Delmanowski et al., 2017; Salas, 2017). This study investigates the effects of lunar phases on the reproductive activity of P. cinctipes. Fine-scale reproductive patterns will establish baseline rates of increase and decline in activity, creating a framework for future studies to assess how environmental stressors alter both the timing and pace of reproduction. Gravid females were collected throughout the year and maintained under controlled conditions for a 28-day lunar cycle. An average of 3-5 individual crabs were sacrificed each day to measure gonadosomatic index (GSI) and analyze hemolymph for Vg concentrations using an enzyme-linked immunosorbent assay (ELISA). Mean Vg levels were elevated from January through March, the lowest levels occurred between May and July ($p < 0.01$). Mean Vg levels were elevated during the New Moon (69.5 ± 15.82 µg/ml), the lowest levels occurred during the Full Moon (3.29 ± 1.52 µg/ml). GSI was elevated from January through March, decreasing from April through August ($p < 0.01$). There was reduced reproductive activity during the summer months.

An investigation of spatial cognition and navigation in the sepiolid Euprymna berryi

Rebecca Senn, Kirt Onthank

Cephalopods are a unique class of molluscs with some of the highest brain-to-body size ratios among invertebrates. Their relatively large and complex brains, combined with diverse wild and captive behaviors, have fueled interest in cephalopod cognition, including learning, memory, problem solving, social behavior/communication, and navigational capabilities. However, most research in these areas has focused on octopus and cuttlefish models, leaving other cephalopod groups poorly studied. I investigated spatial cognition in bobtail squids (family Sepiolidae), a globally distributed group of small, benthic-dwelling cephalopods closely related to cuttlefishes. To examine spatial learning in sepiolids, juvenile Euprymna berryi were lab-reared and tested in a circular open-field maze designed to measure navigational strategies through escape behavior. I presented each individual with a series of trials to determine if sepiolids use path integration, piloting and/or beaconing in navigation by manipulating starting positions, in-tank landmarks or beaconing markers in the maze. Across procedures, path length and escape times were recorded and analyzed for patterns consistent with spatial learning, cue use, and cognitive mapping. My results provide new insight into spatial cognition in sepiolids and contribute to comparative perspectives on cephalopod cognition and the evolution of navigational strategies and spatial learning.

Multiple selection pressures and genetic compensation in high-elevation deer mice

Nathan Senner, Jon Velotta, Maria Stager, Zachary Cheviron

Organisms encountering novel environments can exhibit maladaptive plasticity that reduces their fitness. Ultimately, these responses should be eliminated by selection via genetic compensation. Genetic compensation, in turn, can result in a cryptic form of trait variation across environmental gradients known as countergradient variation, in which genetic changes oppose environmental effects on trait expression. Organisms novelly exposed to high-elevation environments, for instance, can exhibit a suite of hematological changes that provide short-term benefits, but result in negative consequences long-term. We used both lab and field studies to quantify potentially maladaptive hematological responses to hypoxia in deer mice (Peromyscus maniculatus) across their ~4000 m elevational range. When low-elevation mice raised in the laboratory were introduced to simulated high elevations, they increased their hemoglobin concentrations and hematocrit. High-elevation mice did not increase hematocrit and hemoglobin to the same degree, however, consistent with genetic compensation. In the field, despite predictions of trait uniformity,

high-elevation populations exhibited higher values of both traits than low-elevation populations, although less so than lowlanders in the lab. Deer mice thus appear to have attenuated their maladaptive hematological responses to high elevation via incomplete genetic compensation, leading to weak countergradient variation. This pattern is likely the result of a balance between positive selection imposed by other pressures – such as cold temperatures – for increased oxygen carrying capacity and antagonistic selection against elevated blood viscosity.

Effects of ocean acidification and freshening on the Antarctic limpet *Nacella concinna*

Hyein Seo, Jibin Im, Taewon Kim

Meltwater input into coastal areas of the Western Antarctic Peninsula is increasing due to warming, potentially leading to ocean acidification and freshening. Antarctic organisms are generally vulnerable to environmental changes driven by climate change. Nevertheless, some marine calcifiers may possess mechanisms to cope with such changes. In particular, the Antarctic limpet Nacella concinna, inhabiting the intertidal zone where environmental conditions fluctuate, is expected to exhibit unique mechanisms for responding to climate change. To assess the acclimation or adaptive potential of N. concinna to ocean acidification and freshening, limpets were exposed to combinations of two pH levels (8.0 and 7.6) and two salinity levels (34 psu and 27 psu) for 30 days. Neither pH nor salinity affected mortality, condition index, or righting behavior. However, both factors influenced shell characteristics. Low pH and low salinity increased dissolution by reducing carbon content, with interactive effects of pH and salinity. Meanwhile, an increase in M+1 layer thickness under low pH was likely to compensate for the shell damage caused by dissolution and thinning of the M+2 layer, thereby maintaining mechanical properties. Overall, these results suggest that ocean freshening negatively affects survival through shell damage, whereas N. concinna possesses a compensatory mechanism against ocean acidification. Ongoing analyses of chitin synthase and heat shock protein 70 will provide further insights into biomineralization and stress responses in N. concinna.

Falling with a spin: the dynamic flight of Entada seed capsules

Yohan Sequeira, Pranav Khandelwal, Jake Socha

Many aerially dispersed seeds experience complex aerodynamic interactions while falling. For example, maple samaras transition through multiple flight modes before reaching a stable autorotative descent, which can increase dispersion. In this study, we characterize a similar phenomenon in the seed capsules of genus Entada, a tropical climbing vine from South America. Each Entada seed is enclosed in a relatively flat, lightweight rectangular capsule that, when released, enters a forward-spinning motion and a glide-like trajectory. This phenomenon parallels well-studied instabilities in falling thin plates and paper strips, where changes in aspect ratio determine flight mode and distance traversed. To understand how shape influences the dynamics of dispersal in Entada seeds, we conducted controlled seed drop experiments and dynamical simulations. Video was recorded from a set of stereo-cameras and used to measure trajectory kinematics and dispersal range. Computational simulations of dynamics allow us to understand how aspect ratio and asymmetry may influence the aerodynamic forces that govern seed motion. Future work will explore potential factors that may influence a seed's transition to spinning, and how sensitive this transition is to initial conditions. Additionally, testing 3D-printed seed capsules may uncover additional modes of flight and allow for exploration of a larger space of seed geometries. Overall, these experiments highlight the complexities of fluid-structure interaction and extend our understanding of how natural systems harness aerodynamics for passive locomotion.

Comparing acute temporal exposure to tire particle leachate in larvae of two sea urchin species

Emma Service, Luke Cuypers, Michelle Rife, Riley Aquilino, Danielle Moloney, Justin McAlister

Tire dust particles, produced from vehicle tire wear and composed of many different chemicals, are a ubiquitous yet understudied pollutant. As tire particles weather, chemicals leach into watersheds impacting organism and ecosystem health. Exposure to tire particle leachates upon fertilization is lethal at high concentrations for sea urchin larvae. However, in nature, the timing of gamete and larval exposure to pollutants may vary and exposure may be sublethal. Arbacia punctulata and Lytechinus variegatus are common sea urchin species that inhabit nearshore marine ecosystems and differ in egg size; both species are used as model organisms for studies of larval development. In this study, we manipulated acute exposure by A. punctulata and L. variegatus larvae to tire particle leachate at different concentrations and at different larval ages to examine their impacts on growth and development. Tire dust leachates are lipophilic toxins; comparing how each species responds to toxin exposure may reveal differences in how egg size, and the differential lipid content contained therein, impacts larval development. Therefore, species with larger eggs with more lipids produce larger larvae with larger lipid storage organs (stomachs). They may thus allocate energy and resources differently when exposed to lipophilic toxins at different times during development. We will present results of our ecotoxicological experiments and discuss their relevance to larvae of marine benthic organisms.

Integrative methods to untangle olfactory preference across the Rhagoletis fruit fly genus

Anastasia Seville, Jessi Lin, Cheyenne Tait

The Rhagoletis genus of tephritid fruit flies has been crucial for studying speciation. Their olfactory preferences for host fruits, coupled with life history differences matching fruiting phenology of hosts maintain their evolutionary divergence. This group contains agricultural pests infesting apples, blueberries, cherries, junipers, and walnuts. The genus has also invaded new territory in Europe. We are therefore researching the mechanisms that give rise to their divergent olfactory preferences. Here, we describe several neural labeling techniques which enable us to compare their olfactory systems more efficiently than previously. An antibody for phosphorylated extracellular response kinase (pERK) was used to visualize odor-evoked activity in the antennal lobe after stimulating with host and non-host odors. In-situ hybridization chain reaction (HCR) was performed across species to label for expression of the tryptophan hydroxylase gene, coding for an enzyme in the serotonin pathway. Successful labeling of specific neurons illustrated that HCR probes made for highly conserved genes, like tryptophan hydroxylase, from the sequence of one species can then be used across the genus. Our experiments pave the way for in-situ hybridization to be widely used in Rhagoletis. Our focus is now on olfactory receptor genes expressed on the antennae, beginning with highly conserved olfactory co-receptors. By applying techniques from modern neurobiology to the Rhagoletis genus, we are bringing comparative mechanistic neurobiology to an important model in evolutionary biology.

Persistent urban aggression: urban male song sparrows (*Melospiza melodia*) are more aggressive

Kendra Sewall, Taylor Fossett, Samuel Lane, Isaac VanDiest, Casey McLaughlin

An animal's first line of response to any environmental change, including rapid anthropogenic environmental change such as urbanization, is behavior. For example, wild animals living in cities are reliably more aggressive than their rural counterparts. It is often assumed that the human built environment has the greatest impact on wild animals, but animals also flexibly adjust their behavior in response to human presence, as well. Understanding the relationship between urbanization, human presence, and aggression in urban animals requires comparing behaviors as human population and presence changes. The quarantine in response to the COVID-19 pandemic offered an opportunity to study the effects of human presence on animal behavior in urban areas. We investigated how urban song sparrows (Melospiza melodia) responded

to simulated territorial challenges over 10 years (2015–2024), including the years before and after the COVID-19 quarantine, and compared their behavior to that of rural birds. We found that urban birds were more aggressive than rural birds across all 10 years. Both urban and rural birds were less aggressive during the quarantine than in prior years. However, this was part of a pattern of decreasing aggression in both urban and rural birds over the 10 years. Our findings encourage long term studies of behavioral flexibility in wildlife facing ongoing changes in human presence and the built environment.

Plasticity in ventilatory kinematics across teleost fishes

Katelyn Sewcharran, Stacy Farina

Aquatic pump gill ventilation is the primary mode of gas exchange for most teleost fishes, yet the extent of kinematic variation in this process remains under-researched. Pump ventilation relies on both the buccal force pump and opercular suction pump. Still, species differ in their dependence on each mechanism, with pelagic taxa generally exhibiting force-pump dominance and benthic taxa tending toward suction-pump dominance. Such distinctions are not universal, and interspecific variation in ventilatory strategy may have important implications for coping with environmental stressors such as warming and hypoxia. This study examines whether teleost fishes exhibit far greater flexibility in their ventilatory kinematics than previously documented. High-resolution videos of respiration were recorded from 52 individuals across multiple species at the National Aquariums and analyzed using DeepLabCut for markerless tracking of the jaw for scalable kinematic analysis. We then used jaw motion to quantify the duration of inhalation and exhalation across individuals. Preliminary results show that resting fishes displayed distinct breathing patterns compared to actively swimming individuals, with species commonly reducing ventilation frequency by lengthening the jaw-opening phase. By expanding this dataset across species and individuals, this project will quantify buccal expansion and compression durations as proxies for pump dominance, identify evolutionary and ecological patterns in ventilatory mechanics, and evaluate whether kinematic flexibility serves as a functional buffer against anthropogenic reductions in oxygen availability.

Hemodynamics in large rorqual whales revisited

Robert Shadwick, Ashley Blawas, Dave Cade, Paul Ponganis, Jeremy Goldbogen

Using heart rate (HR) data collected by ECG recorders on free diving blue (B) and humpback (H) whales, and data on arterial dimensions and elasticity for fin whales (R. Shadwick, J. Gosline Am. J. Physiol. 267:R805, 1994), we estimated pressure wave velocity and vascular impedance in the aorta for the HR extremes at depth and during surface recovery. Artery biomechanics showed the enlarged aortic arch is the major vascular compliance site and may absorb >90% of the blood volume from each heart beat, while the boundary between the aortic arch and stiff descending aorta increases impedance dramatically, reflecting ~90% of the pressure wave. HR ranged from 2.6 - 36min-1 (0.04 - 0.6 Hz) for B and 3.1 - 45min-1 (0.05 - 0.75Hz) for H whales. Corresponding pressure wavelengths (l) estimated to be 108 - 8m for B and 90 - 6m for H whales. In the most extreme bradycardia for B whales l in the ascending aorta could be up to 100X longer than the aortic arch, resulting in low peripheral pulse propagation. At higher recovery HRs l could be 10X shorter and propagation effects would become important. In either case it seems that, unlike terrestrial mammals, the arterial compliance is almost exclusively in the aortic arch alone, while the remainder of the descending aorta is functionally part of the peripheral resistance.

Effects of climate warming on hosts and parasitoids: insights from aspen leaf miners and parasitoids

Alisha Shah, Emily Hamant, Juan Rubalcaba, Beau Larkin, Andrew Forbes, Art Woods

Because temperature has pervasive effects on biological rates, climate warming may alter the outcomes of interactions between insect hosts and their parasitoids, which, for many host species, constitute the single largest source of mortality. Despite growing interest in parasitoid-host responses to climate change, there are few empirical tests of thermal tolerance differences between non-model lepidopteran hosts and their parasitoids and almost none from mountain ecosystems where warming is occurring more rapidly. We examined the thermal ecology of a host– parasitoid interaction in the Rocky Mountains using wild populations of the aspen leaf miner (Phyllocnistis populiella) and a set of previously unknown eulophid parasitoids that attack them. Upper thermal limits of adult parasitoids were lower than those of host caterpillars, and in choice experiments, parasitoids reared at different temperatures showed no plasticity in preferred temperatures. However, when coupled to simulations of leaf microclimates in aspen canopies, these observations suggest, contrary to expectations, that climate warming may potentially benefit parasitoids.

Constraint and flexibility in neuromuscular circuits: Insights from larval insects

Annika Sharma, Elizabeth Heckscher

Muscle fibers—individual contractile cells that collectively generate forces for movement—are the key intermediary between the nervous system and the external environment. Despite their critical role, the evolution of muscles remains poorly understood: muscles do not fossilize, and they comprise many aligned fibers in most animals, creating redundancy that obscures evolutionary change. To overcome these challenges, we study larval insects, which are highly species diverse, and in which each muscle comprises a single fiber. We find that the number of muscle cells varies by ±25% across 15 dipteran species spanning ~250 million years. Muscle anatomy is highly conserved within species, enabling us to identify homologous muscles and reconstruct evolutionary gains and losses. Two striking patterns emerge: (i) muscles near the body surface are more evolutionarily variable than internal muscles, and (ii) muscles innervated by a single motor neuron are more variable than those innervated by multiple motor neurons. These trends also extend to other larval insects when comparing anatomical groups of muscles. We link these cell-level anatomical comparisons with developmental mechanisms and functional roles to examine developmental constraint, evolutionary potential, and trait covariation. Finally, we investigate how a conserved set of motor neurons—-derived from an independent set of progenitors—-innervates evolutionarily flexible muscles, demonstrating how neuron-muscle interactions structure neuromuscular systems as integrated evolutionary units.

The developmental genetic basis for convergent evolution of prehensile arthropod legs

Prashant Sharma

Convergent evolution of complex traits is a fascinating phenomenon that can be achieved by multiple developmental pathways. One intriguing complex trait that has not been studied is the prehensile walking leg of arthropods, such as daddy-longlegs (Opiliones) or whip spiders (Amblypygi). Prehensility of these arthropods' legs is facilitated by subdivision of their distal-most leg segment (tarsus) into articles called tarsomeres. How tarsomeres are formed is virtually unexplored outside of the fruit fly Drosophila melanogaster. Here, I show that the patterning of tarsomeres in the daddy-longlegs model Phalangium opilio draws upon markedly different sets of transcription factors by comparison to the fruit fly. I show that sequential addition of each tarsomere unit occurs at the proximal end of the tarsus, mediated by dynamic Notch-Delta signaling during tarsus elongation. Disruption of Notch-Delta signaling using small molecular inhibitors or RNA interference incurs the loss of tarsomeres as well as podomere (true joint) boundaries. Disruption of a distal EGFR signaling center via RNA interference causes tarsal shortening and the formation of only the proximal-most tarsomeres. Disruption of growth via RNA inference against the transcription factor clawless results in a shortened tarsus and few or no tarsomeres, reflecting the undivided tarsal condition found in basally branching Opiliones. These datasets provide the first insights into the mechanisms underlying sequential addition of repeated tarsal articles and the origins of prehensile arthropod legs.

A robust and low-cost force/torque transducer for hawkmoth virtual reality experiments

Varun Sharma, Simon Sponberg

Behavioral studies, ranging from work on simple reflexes to cognitive decision-making, have informed us about how neuromuscular systems work across species. While simple reflexes or individual, trained tasks can be studied in open-loop, more complex cognitive functions involving sequences of decisions may require the animal's actions to affect stimulus presentation. Therefore, the use of behavioral readouts in real-time (along with electrophysiology) is essential in understanding perception and action.

In insects such as flies, wingbeat-analyzers have been used extensively, but these are limited to averaging readouts across multiple wingbeats. Force sensors exist for larger insects, but these are often expensive and fragile. A low-cost and robust solution is needed. To address this need, we built a 6-axis force/torque transducer for hawkmoths. This transducer has 6 sensing elements composed of 1D load cells, connected by a CNC-machined aluminum body. We further developed calibration methods using commercial, single-axis transducers, and used a Python-based, open-source VR environment (Holocube) to present visual stimuli in closed-loop with sensor outputs.

This approach involves rapid prototyping using readily available sensors and 3d printing. It has similarities to frugal science, but is aimed at solving problems faced even by well-funded labs. We apply engineering approaches with an open-science mindset, so that we may take the next steps in studying behavior and ecology. This work is funded by AFOSR MURI grant FA9550-22-1-0315

Visual contributions to hawkmoth position-locking are driven by flower velocity

Varun Sharma, Yaqing Wang, Simon Sponberg

Stabilization and tracking tasks are common across the animal kingdom. These include optomotor reflexes, object-identification and target-tracking. The control of tracking tasks may or may not involve a temporary sensory reference. The identification of such a transient form of reference-point is challenging.

Hawkmoths of the species Manduca sexta perform an agile tracking behavior, wherein they hover-feed from moving flowers using their straw-like proboscis. This often involves "position-locking", with these moths maintaining a fixed positional offset relative to the moving flowers. Our previous work, using high-speed cameras and robotic flowers, showed the presence of positional reference, with persistence, re-formability and mean-reversion. We next asked whether this positional memory is the outcome of a position-snapshot, or velocity integration. To distinguish between these possibilities, we built a screen-feeding setup, with a transparent acrylic feeder (filled with sugar-water) in front of a monitor with a projected flower. The feeder provides a neutral, lateral mechanosensory cue. By presenting jumps, ramps, and sum-of-sines stimuli, we found position drift, lack of jump response, and coherent ramp response. Thus, we showed that the visual component of flower-tracking is driven by changes in flower velocity, and mechanosensory cues mediate position-locking, resulting in the observed multisensory tracking dynamics. Finally, we postulate that mechanosensory contributions are responsible for the positional component of reference-locking in hover-feeding hawkmoths. This study was funded by AFOSR MURI grant FA9550-22-1-0315

Effects of elevated temperature on male–male behavior in zebra finches

Seth Shaw, Tara Empson, Juan Zuluaga, Elizabeth Derryberry

Extreme weather events are becoming increasingly frequent, posing significant risks to small endotherms worldwide. While heat waves are well known to disrupt breeding behaviors, their effects on same-sex social interactions remain less well understood. In songbirds such as zebra finches (Taeniopygia castanotis), male–male interactions shape dominance hierarchies, access to resources, and group dynamics. Understanding how these interactions respond to thermal stress is key to predicting the broader social consequences of climate change. Here, we investigate how elevated temperatures influence social dynamics in zebra finches by exposing pairs of males to temperatures within and above their thermal neutral zone. We quantify both social behaviors (aggression, affiliation, and spatial proximity) and thermoregulatory behaviors (panting and use of microclimates). We expect heat exposure to reduce affiliative behaviors and increase aggressive interactions, as competition for cooler microsites intensifies. Alternatively, male pairs may reduce aggression and increase proximity under heat stress if cooperation improves thermoregulation. We also expect thermoregulatory behaviors to increase with temperature, potentially interacting with social behavior (e.g., dominant males monopolizing cooler perches). By linking thermal stress to social dynamics, this research advances our ability to predict how avian social behaviors could be affected by extreme weather events.

Quantifying the number of neurons in the fathead minnow (*Pimephales promelas*) brain

Darain Sheikh, Levi Storks

The isotropic fractionator is a method for quantifying total cells and neurons in brain tissue by dissociating brain regions into suspensions of cell nuclei. This study examines variation in neuron numbers across regions in the fathead minnow (Pimephales promelas). Fathead minnows are a small North American cyprinid widely used in ecotoxicology research, yet their neuroanatomy remains uncharacterized. We applied the isotropic fractionator to adult fathead minnow brains, quantifying total and neuronal nuclei in the telencephalon, cerebellum, and remainder of brain (ROB). We hypothesize that, as in other vertebrates, the cerebellum will show higher neuron densities than the telencephalon and ROB. In addition, we will compare neuron densities in fathead minnows to those of other vertebrates, including other teleost species. Charctering cellular organization in this species will inform neurobehavioral studies and comparative brain evolution, highlighting region-specific specializations and advancing efforts to link neural architecture with functional adaptations across vertebrates.

Can the behavior of tropical and temperate dung beetles douse the fires of climate warming?

Kimberly Sheldon

In insects, temperature strongly affects offspring development and survival, and the warmer and more variable temperatures associated with climate change are expected to result in insect population declines. However, during breeding, behavioral plasticity of adults could modify the temperatures offspring experience, buffering earlier life stages from climate change. Using tropical and temperate dung beetles in field and laboratory experiments, my lab is 1) testing the ability of adults to alter their breeding behavior in response to warmer and more variable temperatures, and 2) examining how behavioral responses of adults impact offspring. Our findings suggest adult behaviors can shield developing offspring from temperature changes, but the ability to do so appears to vary with the body size and evolutionary history of species.

The effects of temperature variation on plastic traits in desert- and mesic-adapted frogs

Eleanor Shell, Elisabeth Cummings, Cris Ledón-Rettig

In addition to mean temperature change, extreme temperature fluctuations are an emerging threat to biodiversity. One particularly vulnerable group is anurans (frogs), most of which exhibit an aquatic tadpole stage. To understand how increasingly variable temperatures influence anuran biodiversity, we must therefore ask how variable temperatures affect tadpole traits and how such plasticity influences anuran resilience. Additionally, how anurans respond to variable temperatures may depend on their evolutionary history with thermal environments. To address these questions, we compared tadpoles of two species of spadefoot toad (family Scaphiopodidae), the desert-adapted Spea bombifrons and mesic-adapted Scaphiopus holbrookii, across multiple ecologically relevant temperature regimes. We specifically asked whether behavioral, physiological, and morphological trait plasticity contributes to tadpole resilience — measured by growth and survival — and whether such plasticity is shaped by evolutionary history. We hypothesized that heat-reared tadpoles would be more resilient to heat shock — as assessed by

glucocorticoid responses — than those reared at cooler temperatures, but would develop faster and at smaller sizes with impaired swimming performance. Further, we hypothesized that these consequences of a warmer developmental environment would be exacerbated in a mesic-adapted species. Results from this experiment will provide insight into the degree to which temperature influences early-life phenotypes, whether these phenotypic responses contribute to resilience, and the consequences of plasticity in a rapidly changing environment.

Tracking breeding range movement of North America's smallest avian species

Kyle Shepard, Carl Rudeen, Emma Rhodes

Avian tracking technology has advanced significantly in the past several decades, though researchers have yet to track some of the smallest birds on the planet including most hummingbird species. While the ecology and migratory behaviors of several larger hummingbird species have been elucidated, smaller species that breed in North America, such as Calliope Hummingbird (Selasphorus calliope), Black-chinned Hummingbird (Archilochus alexandri), and Broad-tailed Hummingbird (Selasphorus platycercus) have yet to be tracked, thus, major knowledge gaps in their life history exist. To solve this problem, we deployed new solar transmitters developed by Cellular Tracking Technologies—the BlūMorpho transmitter. Weighing only 0.06g, the BlūMorpho makes tracking sub-five gram species possible. In this study, we present our preliminary breeding season results from tagging efforts of Calliope, Black-chinned, and Broad-tailed Hummingbirds at our study site in southeastern Idaho during the 2025 season. While hummingbird banding data in North America has provided critical baseline information, it has only provided snapshots of information regarding these species' movements. We discuss the importance of how this technology will elucidate the ecology and basic biological behaviors of species that have previously been too small to track.

Skink-inspired robotic steering while burrowing

Nimran Shergill, Hannah Stuart

Researchers continue to study the mechanisms behind controlling and maintaining depth for fossorial robotic locomotion. The sandfish skink (Scincus scincus) has been closely studied to understand its unique morphologies and specialized behaviors that enable burrowing in dry granular media. Prior work demonstrates that a fixed discrete head shape influences lift force, and, as a result, two dimensional movements of a robophysical model. However, no work thus far modulates head orientation continuously to produce varied trajectories. We study continuous snout orientation change using a fixed head shape to test whether closed loop trajectory control is achievable. We characterize the effect of head orientation on resulting lift force across four different head shapes; we confirm that the trends observed in continuously reorienting the head roughly correspond with prior art with a fixed orientation. However, substantial variation in trajectory emerges for even a single head angle and shape, depending on prior burrowing behaviors, revealing history-dependent results. Thus, we find that simple open loop control of trajectory using head angle is not adequate to perform precise movements, even in homogenous granular media. We test a closed loop controller using head angle as a means to allow a burrower to achieve objective target location with position feedback. This work provides insight on applying morphology-driven locomotive behaviors for developing steering capabilities of burrowing robots.

Muscle shortening and vertebral column curvature during propulsive vertical bending in snakes

Jacob Sherman, Kelsey Garner, Jessica Tingle, Henry Astley

Snakes' multiarticular muscles let them move through cluttered environments by generating complex bending patterns. While muscle strain directly corresponds to curvature in purely lateral bends, recent studies have shown that snakes can also generate propulsive forces through vertical bending, either in combination with lateral bending or via a single vertical bend. Given the likely importance of three-dimensional movements during snake locomotion in natural environments, the muscular basis for propulsive vertical undulation can provide a broader understanding of the mechanics of limbless locomotion. To quantify muscular strain during three-dimensional slithering, we implanted radio-opaque metal beads into three muscles in four corn snakes (Pantherophis guttatus), and then we recorded X-ray videos to measure muscle length and vertebral column curvature during vertical bending. Our analysis suggests that muscle length change and vertebral column curvature are closely related, and that this curvature is occurring simultaneously in complex ways in multiple directions. Observed muscle shortening patterns during vertical and lateral bending confirm functional predictions from muscle anatomical positions. Additionally, particular combinations of vertical and lateral bending allow certain muscles to remain isometric or near-isometric despite continuous body motion. Snakes may benefit from these lower shortening speeds due to increased muscle force output, as overcoming frictional forces is a major requirement for effective limbless locomotion.

Effects of artificial light at night and traffic noise on tadpole morphology and physiology

Jabez Shin, Stiwar Albeiro Cataño-Cardeño, Ximena Bernal, Ana Ospina-L, Caitlin Gabor, Jonathan Lopez

Urbanization transforms landscapes, exposing species to artificial light at night (ALAN) and traffic noise. These pollutants can disrupt adult morphology and physiology, yet their effects on development are less understood. Research on their combined effects remains limited, despite their frequent co-occurrence. We examined the independent effects of ALAN and the combined effects of ALAN and traffic noise on American toad (Anaxyrus americanus) tadpoles. Glucocorticoid (GC), measured as corticosterone (CORT), regulates immunity, inflammation, and stress resistance making it important to assess how GCs change. To simulate sensory pollution, we used playbacks of traffic noise and white light, creating a "phantom road". To examine the effects of two common sources of light pollution, we tested two spectra of light for ALAN: "white" and "yellow". We hypothesized that these stressors differentially disrupt development resulting in changes in tadpole morphology and physiology. Tadpoles exposed to the white light exhibited higher body weights, whereas yellow light reduced body and tail length, indicating impaired growth. Tadpoles under combined effects were comparable to those under natural conditions. Tadpoles in the control showed strong coping capacity with a stress response and recovery unlike other treatments that had reduced CORT release rates and didn't show recovery. Yellow light alone impairs tadpole growth, while white light can increase body mass without amplifying stress responses. This study provides insights for mitigation strategies in urban environments.

Using dental topographic analysis to differentiate diet in extant turtles

Brenlee Shipps, Priyank Kapur, Alexandria Lardent, Zariel Zamudio, Jenny Zhan

Dental topographic analysis has been used to correlate feeding surface complexity with diet in a wide range of vertebrate taxa, including taxa without dentition. Our prior work found that a low occlusal surface complexity, as measured by orientation patch count (OPC), correlated strongly with carnivory in extant turtles. These results were promising enough to warrant further investigation. We have set a new goal of analyzing every extant species of turtle, providing maximum living taxonomic diversity in this ancient and widespread clade. So far, data uploaded to MorphoSource, loans from herpetology collections, and a team of dedicated undergraduate researchers have allowed us to increase our total number of specimens to 112, and our number of species to over 50. In more than doubling our original sample size we find that carnivores, herbivores, and omnivores all significantly differ from each other in occlusal surface complexity, with omnivores falling in-between the low complexity of carnivores and the higher complexity of herbivores. Our results also suggest that occlusal surface complexity can help inform our understanding of turtle phylogeny, ecology, and sexual dimorphism. As our dataset continues to expand, we anticipate further insights into the important role feeding surfaces play in turtle evolution.

Genetic architecture underlying feeding kinematics of threespine stickleback

Seth Shirazi, Sara Smith, Sean Rogers, Dina Navon, Tim Higham

Numerous studies have examined the morphology and kinematics of suction feeding in fishes. However, there can be a disconnect between morphology and function. Thus, it is necessary to understand the genetic architecture underlying the movements during suction feeding. Using threespine stickleback (Gasterosteus aculeatus), we examined the morphology, kinematics, and genetics underlying feedings events in F2 hybrids resulting from crosses between marine and freshwater populations near the Bamfield Marine Sciences Centre on Vancouver Island. These populations differ significantly in their attack strategies and suction feeding kinematics, making them ideal for this study. We first quantified morphological (e.g., body length and depth, pectoral fin length and area) and kinematic (e.g., acceleration, deceleration, maximum gape, maximum cranial elevation, and predator-prey distance) traits of 60 individuals. We then sequenced each using genotype-by-sequencing (~1M reads per individual), and single-nucleotide polymorphisms (SNPs) were identified and analyzed using genome-wide-association study (GWAS). We identified SNPs associated with the number of pectoral fin rays and a series of kinematic variables, such as maximum cranial elevation and maximum deceleration. Several significant SNPs were localized near genes potentially associated with biomechanical function, such as regulators of calcium release in muscle and an enzyme necessary for creatine synthesis. These may influence locomotor performance through variation in energy availability and muscle contractility. Our results highlight the importance of genetic architecture when studying biomechanical performance in predator-prey interactions.

The effects of drought on subalpine wildflower size and seed set

Grace Shirley, Janelle Bohey, Diane Campbell

Climate change is leading to shifts in precipitation, including longer and more severe droughts, and subalpine dry meadows are affected by current and potentially by future droughts in the Rocky Mountains. Several plant species from these meadows have shown phenotypic plasticity in their reproductive traits in response to environmental factors, including soil moisture and precipitation patterns. To investigate the effect of drought on subalpine plant fitness, we compared the floral size and seed set of plants under drought conditions simulated by rainout shelters to control plants experiencing natural water availability. We hypothesized that plants under the rainout shelters would produce smaller flowers and less seeds in the focal species Delphinium nuttallianum, Eremogone (Arenaria) congesta, and Erigeron flagellaris. We found no significant difference between treatments in the flower size, nectar tube depth, or inflorescence height for any species. Seed set also did not vary significantly between rainout and control transects, and we did not find any correlation between floral size and seed set. These results do not indicate that the plants' reproduction is negatively impacted by increased drought stress beyond that already present in the year of study.

Echoes in a concrete jungle: temporospatial variation in urban bat foraging activity

Alexandria Shockney, Kenna Dixon, Caroline Pollan, Rachel Obrero, Desiree Wilson, Tyler Olivier, Andrea Rummel

While the world changes rapidly around us, animals must adapt to an increasingly urbanized habitat. Bats, the second largest order of mammals, are no exception. Previous research has explored bat activity across urban-rural gradients using acoustic monitoring, but to our knowledge, this is the first attempt at quantifying bat presence across a large urban area with an emphasis on the effect of season on activity and occupancy. This allowed us to investigate if seasonality influences the way bats utilize urban spaces. We hypothesize that the urban factors that correlate with bat activity change across seasons. In this study, we surveyed bat presence/absence in Houston by driving six mobile acoustic transects across the city. We drove routes twice within one week of each other across four seasons between June 2024-April 2025. Files were vetted, superimposed on a city map in ArcGIS, and analyzed in R with generalized linear models and occupancy models to assess if bat activity and occupancy varied by season or urban factors (population density, canopy coverage, and land-use type). We found that the urban factors that had a positive trend on occupancy varied between seasons. This shift in resource utilization highlights the resilience of urban animals to survive in a rapidly changing world. Future research will guide initiatives that support these animals in large urban centers.

Comparing limb positions and body posture in walking versus climbing for Rattus norvegicus

Cassie Shriver, Arthur Zhao, Young-Hui Chang, David Hu

Climbing is a challenging type of locomotion requiring organisms to constantly ascend against gravity. The lack of a restoring force to bring a climber back into contact with the climbing surface suggests diversification in the functional roles of limbs: in vertical ascent, the presence of compressive forces in hindlimbs needs to be balanced by tensile forces in forelimbs to mitigate pitchback. How do limb positions and body posture change between horizontal and vertical locomotion, particularly in the context of maximizing the effective mechanical advantage (EMA) of the limb muscles? We present experimental work with Rattus norvegicus (Long-Evans strain) performing both horizontal and vertical locomotion. We compare center of mass (COM) positioning from the locomotor surface, joint angles, and other gait parameters. We hypothesize the different locomotor constraints in walking versus climbing yield differences in COM positioning that advantage the EMA of muscles, and predict that the COM will be closer to the locomotor surface in climbing to help mitigate pitching torque. Furthermore, we hypothesize that joint angles will differ between horizontal and vertical locomotion, particularly during paw-on and paw-off. We predict that joint angle differences in climbing will be driven by COM position relative to limb posture and improving EMA to reduce musculoskeletal stresses. Initial results support our hypotheses, showing differences in COM positioning and limb joint angles between walking and climbing in R. norvegicus.

Genetic and genomic tools for biomedical and evolutionary research using veiled chameleons.

Natalia Shylo, Andrew Price, Sofia Robb, Zoe Griffin, Richard Kupronis, Paul Trainor

Squamata is the largest order of reptiles, comprising over 10,000 species, which have radiated and adapted to a variety of ecological niches across the globe. The molecular and developmental mechanisms that facilitated these events, however, remain unknown. We recently sequenced, assembled and annotated a high-quality veiled chameleon (Chamaeleo calyptratus) genome allowing us to begin to genetically address fundamental questions in evolution, ecology and developmental biology using this non-traditional research organism. For example, we have determined the unique molecular components of the left-right patterning in veiled chameleons and identified species-specific differences in the evolution of EGF-CFC genes in amniotes. In parallel we established CRISPR/Cas9-mediated genome editing, generating F0 knock-outs of Tyr and Shh genes in pilot experiments, validating the genetic tractability of veiled chameleons. Using these new genomic resources and techniques, we recently identified the putative XX/XY sex determination region on the terminal end of chromosome 5, which appears to be conserved across the Chamaeleo genus. We have now begun knocking out candidate male-sex determination genes, anticipating loss-of-function will lead to phenotypic females. Additionally, preliminary work is underway to establish transposon-mediated transgenesis to fluorescently label cells for improved live imaging and cell tracking of developmental events. Our studies in chameleons can therefore provide novel insights into the evolution of squamate genomes and the molecular mechanisms and cellular processes driving development, phenotypic variation and ecological adaptation.

Design and simulation of soft, multi-legged robotic swimmer for shallow water locomotion

Abu Nayem Md. Asraf Siddiquee, Ishmael Auqui, Yasemin Ozkan-Aydin

While most aquatic robots use propulsion systems inspired by fish or squid, animals possess a diverse range of swimming mechanisms. This study presents a bioinspired, soft, multi-legged robot designed to mimic the powerful, leg-driven locomotion of semiaquatic animals, which can navigate complex watery environments. The robot features a hollow, rectangular body with pneumatically actuated silicone legs attached via adjustable holders. This design allows for precise positional and angular adjustments (45° and 90°), enabling the modulation of thrust and leg retraction. To characterize the performance of a single leg, we measured hydrodynamic forces using a force-torque sensor across different leg orientations and actuation cycles. At 45°, average thrust per leg was 25% higher and lift 40% lower than at 90°, indicating better energy efficiency for forward motion. We tested three distinct leg configurations: four legs at the rear corners, two pairs spaced apart, and two legs at the rear centerline. The two-leg rear configuration at 45° achieved a maximum speed of 11.5 mm/s and a turning rate of approximately 7.2°/s. Forward speed and turning rate were 4–8% higher at 45° across tests, while the 90° configuration caused less disturbance and was less affected by boundary effects. This robot's unique, leg-driven locomotion allows it to effectively navigate cluttered environments, making it ideal for search and rescue missions in debris- or vegetation-filled shallow waters.

Simulation and design of the sea star-inspired robot ray

Abu Nayem Md. Asraf Siddiquee, Martín Castillo Gonzalez, Yasemin Ozkan-Aydin

A sea star's ray combines a complex arrangement of variable collagen tissue and a hydrostatic skeleton, enabling highly flexible, versatile locomotion and powerful, localized force generation. Inspired by this mechanism, we present the design and simulation of a novel robot ray that mimics sea star morphology to achieve complex locomotion and directional steering. A single-stage, inverted double-helix structure was initially selected as a foundational model for design optimization. Its bending and compression performance under loads from 5 N to 15 N was evaluated using Finite Element Analysis (FEA) in Abaqus. While the model maintained structural integrity up to 10 N, loads beyond this threshold led to internal bulging and helix interference, indicating structural instability. To address these limitations, a two-stage design was developed and fabricated. This optimized structure enhanced performance by improving compression uniformity and enabling collision-free bending. Experimental validation confirmed its structural integrity, with the prototype successfully withstanding 15 N without failure. The 109.5 mm long ray exhibited 15±0.15 mm (13.7%) compression and 35±1 mm (32%) inward displacement under a 15 N load. Additionally, single-cable actuation at 7.5 N induced 23°±1° bending, 7±0.09 mm (6.4%) compression, and 20 mm (18.3%) inward displacement. The strong correlation between experimental and simulation results confirms the design's accuracy and validates the predictive capabilities of our modeling approach.

Escape tactics by blanched lesser earless lizards (Holbrookia maculata)

Daanya Siddiqui, Kaera Utsumi, Maria Eifler, Douglas Eifler

How prey choose to escape predators depends on factors ranging from predator type to habitat characteristics. Examinations of escape behavior usually entail direct pursuit and measurement of flight initiation distance (FID). The effect of prolonged predatorial pursuit on escape sequences has not been well-studied. We examined escape sequences by adult lesser earless lizards (Holbrookia maculata) in the Salt Basin Dunes (SBD) of Guadalupe Mountains National Park. Their blanched coloration is an adaptation to the SBD, characterized by open sand and sparse vegetation. To evaluate escape behavior during prolonged pursuit, we followed an individual directly until they stopped moving, disappeared from sight, or 2 minutes elapsed. If individuals disappeared, we considered the escape successful. We recorded time to trial end, FID, the length of moves made while escaping, total distance moved during the trial, and vegetation used. FID varied with starting habitat, with lizards beginning on exposed wood having the longest FID. The sexes differed in their move lengths: females made more short moves, while males made more long moves. Sage (Artemisia filifolia) was the vegetation used most often, with 39% of trials beginning near sage and 71% of the trials ending within sage; larger sage bushes supported longer escape sequences. Our study highlights the importance of vegetation as refuges during prolonged escape, emphasizing the ecological significance of the SBD dune-plant landscape for H. maculata survival.

Characterizing Schistosoma mansoni-infected Biomphalaria glabrata tissue

Himat Sidhu, Mary Wallingford, Sarah Kerr, Kate Rawlinson

Schistosomiasis is a debilitating parasitic disease affecting 250 million people globally with 750 million at risk. It is caused by the human blood fluke Schistosoma mansoni which proliferates via asexual reproduction in the intermediate host Biomphalaria glabrata (a freshwater snail) where it is supported by largely undefined mechanisms. The parasite miracidium infects the snail and becomes a mother sporocyst, which produces daughter sporocysts (DS) that migrate to the snail's inner whorl organs, the hepatopancreas and ovotestis. The DS embed, grow, multiply, and mature into human-infective cercaria larvae. A single miracidium can produce more than 10,000 cercariae. We aim to understand how DS are supported within the snail's hepatopancreas at the molecular level in order to determine molecular targets that could prevent the parasite's amplification. We optimized multiple techniques to compare uninfected and infected snail tissue, including fixation, paraffin embedding, and visualization of both host and parasite mRNA targets through HCR in situ hybridization, imaged using fluorescence and confocal microscopy. B. glabrata genes included vitellogenin (mature oocytes in the ovotestis), a vitellogenin receptor candidate (early oocytes in the ovotestis), and LOC106073914 (hepatopancreas cells). S. mansoni genes included a calcium ATPase transporter and MEG-6, a tegument gene. Work is ongoing to continue to identify cell-type specific expression patterns of molecules that may participate in the host-parasite interaction and define the S. mansoni niche within the snail.

Assessing color vision in the Atlantic mud crab *Panopeus herbstii* using cardiac response

Maryia Sikirzhytskaya, Madison Janakis, Daniel Speiser

The ability to distinguish between the wavelengths of light received by photoreceptors forms the basis of color contrast detection in many animals. Color vision can be a useful modality for crustaceans in shallow aquatic environments, where they may not be able to rely on achromatic cues to detect predators, prey, and conspecifics due to disruptions from the flicker of the water. To test if crabs may visually use overhead chromatic cues, we used cardiac response as a proxy for perception. This experiment implemented an innovative approach of integrating looming stimuli with heart rate measurements to ask whether the Atlantic mud crab Panopeus herbstii has color vision. Randomized stimuli were such that the colors appeared equally bright to the crabs, ensuring a reliance on chromatic contrast rather than achromatic contrast for detection. We found that when behavioral evidence of stimulus perception is insufficient, cardiac responses can be used as a reliable indicator. Our results demonstrate that Atlantic mud crabs may be capable of responding to colorful cues; achromatic contrast elicits a significantly stronger response. While they may detect chromatic signals, achromatic signals may be more reliable for animals like this crab, which inhabit spectrally narrow conditions. Visual contrast can be achieved using different properties of light, but further investigation will be needed on how more than one property is used at once.

Curvy spines and lateral lines: how a spinal deformity affects *Poecilia sphenops* lateral line

Leila Silva, Katie Nickles, Aubree Jones

The lateral line system is a sensory system found in all fishes that is made up of neuromast receptor organs. Neuromasts detect local water flows, which

are crucial for key behaviors including predator avoidance, prey detection, and navigation. Diversity in lateral line morphology has been documented in several lineages of bony fishes, but genetic factors influencing neuromast distribution largely remain to be elucidated. Therefore, utilizing morphotypes targeted for breeding in aquarium trade fishes allows for deeper understanding of how skeletal changes impact lateral line morphology. This study is a novel description of the lateral line in Poecilia sphenops (molly fish) for both regular mollies and a phenotype referred to as "balloon belly." This phenotype is caused by naturally occurring genetic mutations that result in dwarfed fish with curved, malformed spines. Thus, to determine whether skeletal malformations impact lateral line morphology, vital fluorescent staining (4-Di-2-ASP, mitochondrial styryl dye) was used to visualize the neuromasts in both body types of mollies. The distribution of neuromasts was documented based on the fluorescent micrographs, and neuromasts were counted within lines and among body regions. Preliminary data suggests that ventral trunk neuromast numbers trend towards reduction with the ""balloon belly"" spinal malformation. Therefore, this study demonstrates that skeletal malformations affect neuromast number and distribution.

Ecophysiology and evolution of leaf-litter lizards in the Atlantic Forest of northeastern Brazil

João Pedro Silva Climaco, Leildo Machado Carilho Filho, Iuri Ribeiro Dias

Although processes of persistence and diversification of evolutionary lineages are widely studied for various taxonomic groups, their relation to ecophysiological traits is still poorly known, especially in centers of endemism, such as the southern Bahia region of the Atlantic Forest in Brazil. The genus Leposoma, a group of small leaf litter lizards from the Gymnophthalmidae family, may help in shortening this knowledge gap. Encompassing six species, some of which have wide ranges (e.g. L. scincoides and L. annectans) and others which are microendemic and preferably occur on high-elevation sites (e.g. L. nanodactylus), the genus reflects a diversification process of cryptic phenotypes in intimate correlation to climate refuges. In this study, we collected traits related to thermal and hydric ecophysiology in L. scincoides, L. nanodactylus and L. annectans in different localities in southern Bahia's Atlantic Forest. We used statistical and phylogenetic comparative methods, gathering data from the superfamily Teioidea. We found low tolerance to high temperatures and high sensibility to water loss in the microendemic species L. nanodactylus, in contrast with the more flexible traits in species with broader distribution, such as L. scincoides and L. annectans. These differences might indicate that species in the genus evolved under distinct environmental contexts and reveal their potential for being used as models to explore distribution patterns and their relations with evolutionary processes through species' ecophysiological traits.

Disentangling the environmental triggers of seasonal quiescence in Astrangia poculata

Elizabeth Silver, Jayde Waibel, Catherine Hernando, Anna Dormitzer, Danielle Moloney, Randi Rotjan, Justin McAlister

The temperate coral, Astrangia poculata withstands cold temperatures in coastal waters of New England by entering a period of dormancy known as quiescence. During quiescence, A. poculata exhibits minimal activity, indicating reduced energy expenditure towards growth, feeding, and metabolism. Low temperatures and reduced zooplankton food availability are environmental factors that are associated with winter conditions; however, it is currently unknown whether one of these factors or their combination is the key trigger for quiescence in this heterotrophic coral. By altering both temperature and food availability and measuring coral performance during this dormant state, it may be possible to disentangle the influence of these two factors on seasonal quiescence. We investigated quiescence by assessing the performance of individual polyps through measures of respiration rate, polyp activity, and growth (change in buoyant weight and tissue surface area over time). While A.poculata is facultatively symbiotic and can exist with variable levels of symbionts, we exclusively examined aposymbiotic polyps because they rely primarily on heterotrophy for energy acquisition. Identifying the direct and interactive environmental triggers that regulate quiescence will permit future lab-based studies on the role and nature of quiescence in temperate coral biology. In light of rapidly changing ocean conditions, the loss of quiescence due to rising ocean temperatures or changes in zooplankton abundance, or the combination thereof, may be more fundamentally impactful than previously understood.

Relationship between reproductive state and vasotocin in the brains of female Upland chorus frogs

Kaya Simmons, Carlie Anderson

Neuromodulation, the process by which signaling molecules alter neuronal activity, can regulate behavior by changing neural or physiological responses. Vasotocin is hormone that can act as a neuromodulator and is highly implicated in amphibian social behaviors. Current research on the role of vasotocin in behavior is largely focused on males. However, studies on female frogs across genera suggest a strong role of vasotocin in female proceptivity to male acoustic signals, which is a prerequisite for sexual motivation during female mate choice. The aim of this study is to map vasotocin immunoreactivity in the brains of gravid and non-gravid female Upland chorus frogs (Pseudacris feriarum) to gain a better understanding of its distribution and possible role in driving the seasonal changes in female receptivity. We extracted brains from 12 wild-caught frogs, including 6 females in reproduction condition (with eggs) and 6 females in non-reproductive condition (without eggs) and used immunofluorescent staining to identify vasotocin distribution in target brain regions related to social behavior. We hypothesize there will be differences in the distributions of vasotocin between gravid and non-gravid females, particularly in areas associated with female reproductive behavior. This work will not only contribute to the body of work describing variation in the neuroanatomical distribution of this nonapeptide, but also reveal the more about the neural mechanisms that drive female social and reproductive behavior.

Cost-effective and collaborative resources for wildlife disease and conservation research

Molly Simonis, Amanda Vicente Santos, Matthew Chumchal, Daniel Becker

We often face monetary challenges in order to collect individual-level samples in the field for disease and conservation research, particularly for cryptic species. In turn, this can hinder our ability to characterize infection and conservation risks, and target management actions to protect wildlife populations. To combat the challenges and financial burdens associated with obtaining individual field-based samples pertaining to wildlife health, it is critical we build cost-effective methods and increase collaborative capacity across researchers, agencies, organizations, and institutions for wildlife conservation and disease research. Here, we provide examples and resources for initial cost-effective assessments and capacity building for wildlife research in three ways: a conversion factor that could be used for initial risk assessment of bat mercury concentrations when funds for individual-level sampling are scarce; bloodborne pathogen discovery using commonly collected bat wing biopsies; and an online sample registry (batsamples; sites.google.com/view/batsamples) for finding collaborators globally. We encourage fellow wildlife researchers to use similar approaches presented here, and continue to build new cost-effective methods and broad collaborative networks crucial for disease and conservation research.

Beyond Broader Impacts: Making curriculum-based outreach last past your grant completion

Lauren Simonitis, Jamie Knaub, Tricia Meredith

The Berlin Family Bioimaging Lab at FAU Lab Schools is a unique take on an imaging core facility, rooted equally in university research and K-12th grade education. Based in a K-12 school, the Lab serves as hub for research, mentoring, and teaching. We operate as a typical core imaging facility but, in lieu of charging a monetarily, our research collaborators contribute their time through Community of Research and Education (CORE) Options, ranging from guest lectures to mentorship to creation of STEM curriculum. The lab is also a training hub for dual-enrolled high school students where they conduct publication worthy research. Additionally, we collaborate with K-8th grade teachers

to infuse current research into their science curriculum. We bring K-8 students into the lab to interact with imaging equipment and data as they engage in hands-on, research-infused lab activities. We also work with collaborators to design, implement, and measure the outcomes of their broader impacts. Here, we offer a unique perspective on how biological imaging can integrate with K-12 education and facilitate high school research. We hope to serve as a model for how the biological imaging community can effectively interact with students and teachers, train and work with high school researchers, and rethink the current model for core imaging facilities. We also identify key disconnects between the K-12 world and research world and propose potential solutions.

Impact of gut yeasts on insect phenotypes

Brent Sinclair, Yanira Jimenez-Padilla

We explored the role of gut yeasts in modulating egg-adult development time and chill coma recovery time (CCRT; a well-established proxy for fly cold tolerance) in Drosophila melanogaster. We generated flies with a range of gut microbiota conditions: axenic (microbe-free), with their native microbiota, or gnotobiotic flies with a mono-association with live or heat-killed yeasts (Saccharomyces cerevisiae [not normally associated with Drosophila guts] and Lachancea kluyveri [which has been recovered from Drosophila guts in nature]. We found that gut yeasts reduced egg-adult development time substantially, and that although the effect was nutritional for the first two larval instars, the yeasts had to be alive during the 3rd instar, implying a biotic interaction that may be mediated through a change in feeding rate. Female axenic flies had slower CCRT than their counterparts carrying their native microbiota, but the delay was fully rescued by interaction with live L. kluyveri, but not with S. cerevisiae or heat-killed yeasts. The effect was sex-specific, dose-dependent, rapid. We confirmed that the yeasts can survive and reproduce in the fly gut, supporting a true symbiotic interaction. We conclude that gut yeasts can have as much influence on some Drosophila phenotypes as the entire gut microbiota. This suggests that yeast symbionts may contribute to natural phenotypic variation, and that yeasts may have other wide-ranging impacts on host phenotypes.

From conflict to expression: the role of mitonuclear incompatibility in protein homeostasis

Akansha Singh, Omera Matoo

Mitonuclear genome incompatibility between mitochondrial (mt) DNA and nuclear (n) DNA is often acccompained by desregulation of protein homeostasis (protesostasis) . However, the exact molecular mechanisms (or lack thereof) of proteostatis remains less clear. To investigate this , we used a panel of four novel (mtDNA); nDNA genotypes generated by substituting divergent mtDNA from closely related Drosophila sister species. Previously , we have shown that in one specific (mtDNA); nDNA genotype (simw501);OreR the gentic incompatibility resulted in elevated reactive oxygen species (ROS), lactic acidosis and reduced mitochondrial membrane potential compared to matched genetic controls. In the current study , we tested the hypothesis this mitonuclear incompatble genotype will exhibit reduced proteostsis compared to control genotypes. Specifically , we quantified (a) expression of candidate genes in mitochondrial Unfolded Protien Response (UPRmt) pathway, and (b) enzyme activity of ubiquitin-proteosome chaperon system (UPS). Our data showed the mitonuclear incompatible genotype exhibits, (1) upregulation of stress responsive transcription factor (dATF4) indicative of UPRmt pathway activation and (2) changes in mitochondrial heat shock gene expression (mt-Hsp22 and mt-Hsp60), suggesting changes in mitochondiral protien folding machinery. We also observed a cooredinated reduced expression of E3 ubiquitin ligase (PARKIN) gene as well as decreased proteosomal enzyme activity , indicative of compromised protein degradeation . Our findings provide mechanistic insights into how mitonuclear incompatbilities could potentially perturb protesostasis , triggering proteotoxic stress and reduced fitness.

Corticosterone dosing verification in the Italian Wall lizard *Podarcis siculus*

Amber Singh, Matias Fraser, Taylor Glaser, Alyssa Head, David Ensminger, Kinsey Brock

Stress physiology and behavior is best understood by inducing specific controlled hormonal cascades and measuring performance. Glucocorticoids, such as corticosterone (CORT) in reptiles, are a common group of hormones that are manipulated in model organisms to study stress physiology. As CORT responses are unique to taxa, the ecologically relevant dosage of CORT must be verified for each new model species. Here we present our findings for experimentally determining the ecologically relevant dosage of CORT for the Italian Wall Lizard (Podarcis siculus), a widely studied Lacertid species. We produced a predictive model based on the dosing curve at three different dosages of dermally applied CORT and the maximum CORT elevation seen after a 5 min chasing stressor. Our findings suggest the ecologically relevant dosage is significantly lower in Italian Wall Lizards than dosages previously tested and widely used in other closely related Lacertid lizards. This is further evidence that CORT dosages should be verified to produce ecologically relevant elevations in each study species.

Squid funnel-inspired passively flexible nozzles for underwater propulsion

Paras Singh, Daehyun Choi, Gourav Samal, Halley Wallace, William Gilly, Saad Bhamla, Chandan Bose

In nature, cephalopods, particularly squids, achieve exceptional maneuverability and propulsive efficiency by combining fin activity with jet propulsion. Their fins undulate or beat synchronously or independently to provide thrust and lift, while rhythmic mantle contractions coupled with a flexible funnel generate pulsed jets. Funnel deformability and traveling waves modulate vortex-ring formation, jet entrainment, and exit-pressure impulse - mechanisms that enable squid to enhance thrust for efficient propulsion. Inspired by biological funnel, we design passively deforming flexible nozzles for underwater propulsion and conduct three-dimensional strongly coupled partitioned fluid-structure interaction simulations based on the Arbitrary Lagrangian-Eulerian framework. Our study probes how nozzle flexibility and geometry govern wave propagation, vortex dynamics, and hydrodynamic impulse. By varying nozzle stiffness, shape, and thickness profiles, we quantify vortex circulation and pinch-off timing, added-mass entrainment, and momentum and pressure contributions to the impulse. Flexible nozzles sustain travelling waves that synchronize with emerging shear layers, accelerating jet ejection, delaying vortex pinch-off, and increasing entrainment, yielding improved impulse and propulsive efficiency compared to the rigid counterparts. Additionally, nonlinear deformations and wave reflections induce wake interactions that can amplify or diminish thrust depending on flexibility and jet-cycle timing. These findings reveal the underlying fluid–structure mechanisms by which cephalopods leverage funnel flexibility to balance thrust and propulsive efficiency, and provide design principles for underwater vehicles that exploit compliant structures to achieve efficient and agile jet-based locomotion.

Do parental feeding rates affect cytokine expression of nestling Eastern Bluebirds (*Sialia sialis*)?

Vansh Singhal, William Kirkpatrick, Salvador Barraza-Del Barco, Erin Sauer, Ashley Love, Sarah DuRant

Parental care, particularly provisioning, plays a critical role in nestling survival and development in birds. While provisioning is known to influence growth, its role in the early development of the immune system is less well understood. In this study, we investigated whether variation in parental feeding rates is associated with nestling immune gene expression in Eastern Bluebirds (Sialia sialis). We monitored nests at an agricultural research farm in Northwest Arkansas during the 2025 breeding season. Parental provisioning was measured using video cameras inside nest boxes, and nestling size and weight was measured on days 5 and 10. On Day 10, blood samples were collected to assess cytokine expression using qPCR, providing a measure of immune condition. Preliminary data demonstrated that a higher feeding rate was associated with an increase in growth rate. Data analysis is underway, but expectations are that increased

adult investment (i.e., higher feeding rates) will be associated with lower levels of pro-inflammatory cytokine production. Our findings will highlight the role of parental feeding rates not only in growth but also in shaping immune system development.

Mechanisms of transparency in adult fish species

Miranda Sinnott-Armstrong, Emily Brady, Christine Cao, Sonke Johnsen

Although full-body transparency is ubiquitous among the larvae of pelagic fish, transparency in the adult form is exceedingly rare. Transparency becomes much more challenging in larger-bodied organisms, and requires modifications to the skin, muscle, and vasculature in order to reduce light scattering and absorption. Previous work has shown that selective placement of red blood cells (RBCs) in the liver (glass frogs, Centrolenidae) or away from the abdomen (glass shrimp, Palaemonetes pugio), reduces scattering of light from RBCs and facilitates transparency. Transparent fish, especially in larger adult forms, must additionally overcome the challenge of muscle opacity. We used a combination of spectroscopy, optical modeling, and light and electron microscopy to characterize the muscle architecture in adult fish of several species, including Danionella cerebrum, Kryptopterus vitreolus, and Pristella maxillaris. We compare the results in transparent species with several of their opaque close relatives, in order to generate a first understanding of the mechanisms leading to transparent musculature in adult fish.

Nutritional stress leads to developmental dysregulation in southern flounder

Laura Sisk-Hackworth, Cynthia Faulk, Audrey Truong, Savvy Cornett, Becca Young, Lee Fuiman, Hans Hofmann

Flatfish cultivation commonly results in pseudoalbinism which diminishes survival upon release and hinders conservation efforts. Multiple nutritional, rearing, and environmental factors have been implicated in pseudoalbinism. Given the variety of causes, pseudoalbinism has been hypothesized to result from different stress responses that dysregulate cell differentiation. Here, we used docosahexaenoic acid (DHA) dietary supplementation, which reduces pseudoalbinism rates in flatfish, to investigate mechanisms through which nutritional stress leads to developmental dysregulation in Paralichthys lethostigma (southern flounder). We conducted bulk RNA sequencing of trunk samples and single-nuclei RNA sequencing of brain samples from pre-, mid-, and late-metamorphic fish fed diets with or without DHA enrichment. We found that nutritional stress (lower DHA levels) resulted in the greatest changes in the brain transcriptome during mid-metamorphosis, including in thyroid, insulin, and circadian signaling in the hypothalamus. However, the largest changes in the trunk transcriptome due to nutritional stress were seen in late metamorphosis and indicate that lack of DHA increases oxidative stress, DNA damage, and dysregulation of circadian and thyroid signaling in the body. We conclude that nutritional stress due to lack of DHA alters the neural control of developmental pathways, potentially through mechanisms involving circadian, thyroid, and insulin signaling. These results point to possible mechanisms through which nutritional stress induces pseudoalbinism in aquaculture as well as the potential of DHA supplementation in minimizing developmental stress responses.

Comparing superficial markers to implanted markers for XROMM analyses on a chicken carcass

Brian Skillman, Matthew Bonnan, Kristyn Voegele

X-Ray Reconstruction of Moving Morphology (XROMM) is an integral method for furthering our understanding of the kinematics of living organisms. Of the two current standards in this field, the markered method involves the use of invasive, surgical implantation of submillimeter diameter X-ray-dense beads into the bones of interest, resulting in accurate and timely collection of kinematic data. In contrast, the scientific rotoscoping (SR) method does not involve the use of these beads and thus is less invasive, but requires manual intervention. Herein, we analyze the accuracy of an intermediate method for conducting XROMM that prioritizes non-invasive procedures while still allowing partially automated tracking of the beads. To compare the accuracy between both methods, both superficial and implanted markers were attached to the pelvis, femur, and tibiotarsus of a chicken carcass which was puppeted. The mean residual error between the implanted and superficial markers was calculated based off strictly the automated placement of the bones by Maya Autodesk based on the XMA data. This resulted in a translation error range of 0.7-2.2 cm and a rotational error range of 4.7-5.7° among the tibiotarsus and pelvis respectively for each. Manual manipulation further reduced this error. The ability to accurately and reliably model kinematics with superficial markers opens the possibilities for XROMM longitudinal studies of growth and with smaller organisms for which surgical marker implantation is difficult.

Urbanization and the evolution of innate immune genes in house finches

Joel Slade, Katherine Moua, Oscar Sanchez, Emmanuel Okposio

Urbanization reshapes ecosystems by fragmenting habitats, restricting gene flow, and altering host–pathogen interactions, all of which can influence the evolution of immune genes. In this study, we are investigating how urbanization affects immunogenetic diversity in house finches (Haemorhous mexicanus), focusing on four Toll-like receptor (TLR) loci (TLR2B, TLR3, TLR4, and TLR15). We sampled finches from urban, suburban, and rural sites in Fresno and Madera Counties, California, to test whether allele frequencies, genetic diversity, and signatures of selection differ across these environments. We have extracted DNA and successfully amplified most loci with PCR, and we are now conducting sequencing and downstream analyses. We predict that urban populations will show reduced TLR diversity due to restricted dispersal and environmental homogeneity, while suburban and rural populations may retain higher variation. At the same time, we expect TLRs to show evidence of diversifying selection, suggesting that pathogens continue to shape immune gene evolution across all environments. By comparing immune gene variation across urban, suburban, and rural habitats, we aim to determine whether selection maintains functional diversity even when gene flow is limited. This study will advance urban evolutionary ecology by connecting molecular evolution to anthropogenic environmental change and provide new insights into the resilience of bird populations facing ongoing urban expansion.

Values of oxygen-18 isotope enrichment of North American megaherbivore body water reflect a spectrum

Katherine Slenker, Jenny McGuire, Mark Clementz

Climate change threatens modern mammalian communities as drought differentially affects species. Megaherbivores exhibit different adaptive strategies to efficiently process and retain water, leading to differential sensitivity to water deficit among species. However, it can be difficult to assess that sensitivity through behavioral observations alone. The most vulnerable species obtain water primarily from surface waters (classified as evaporation-insensitive (EI)); species at the other extreme derive water from plants (classified as evaporation-sensitive (ES)). These classifications are based on the oxygen-18 isotope enrichment in body water (δ18Obw) values observed in the species. ES taxa are expected to have greater variability of δ18Obw values due to sensitivity to changes in 18O-enrichment of plant water following changes in evapotranspiration driven by aridity. We compare the evaporation sensitivity of six North American megaherbivores: bison, pronghorn, bighorn sheep, horse, elk, and mule deer. We determine the degree of evaporation sensitivity using a steady-state mass balance model of oxygen isotope fluxes in body water to differentiate the influence of physiological, dietary, and environmental factors, and compare the slope of species' values of 18Obw against relative humidity. Our results thus far indicate that bison and pronghorn represent the extremes of the spectrum of evaporation sensitivity, and that bighorn sheep fall intermediately. Species' evaporation sensitivity both indicates species' drought tolerance and can facilitate the development of an oxygen isotope aridity proxy for North America.

Physiological performance of juvenile Pacific cod under ocean warming and acidification

Emily Slesinger, Erin Tyler, Thomas Hurst

The Gulf of Alaska (GOA) supports many ecologically, economically, culturally important fish species. Recently, the GOA has been experiencing changing ocean conditions, including warming and acidification, which could negatively affect important fish species, including Pacific cod (Gadus macrocephalus). To assess how Pacific cod respond to combined warming and acidification, we exposed juvenile (age-0) fish to a cross of three temperatures (3, 9 and 15°C) and two pCO2 levels (ambient; high). We measured resting metabolic rates and hypoxia tolerance to generate parameters needed for calculating the oxygen supply capacity and Metabolic Index. With increasing temperature, resting metabolic rate and oxygen supply capacity increased while hypoxia tolerance decreased. There was not an overt effect of acidification but there was an interaction with high pCO2 and warm temperature (15°C) on hypoxia tolerance and oxygen supply capacity where both metrics decreased with respect to ambient pCO2 conditions at that temperature. Throughout the experiment, young Pacific cod could not be fasted during the trial, which led to a confounding, yet interesting, influence of stomach fullness on the metrics. We discuss the meaning of stomach fullness with respect to hypoxia tolerance data, as well as the implications and use of Metabolic Index while assessing current and future conditions within the Gulf of Alaska nursery areas for age-0 Pacific cod.

Harnessing machine learning for long-term monitoring of beaver dams in satellite imagery

Harris Sloan, Bret Tobalske

Beaver dams are crucial ecological structures that shape hydrologic patterns, influence biodiversity, and serve as indicators of environmental change. Traditional field surveys for dam locations are labor-intensive and limited in scale, necessitating automated approaches for large-scale, long-term monitoring. This study applies machine learning (ML) to detect beaver dams in more than a decade of satellite imagery. Leveraging convolutional neural networks and using time-series analyses for interpretation, we tracked spatial distribution and persistence of beaver dams in a 1000 km2 region of West Yellowstone, Montana USA. Our approach integrates multi-spectral and high-resolution datasets to distinguish beaver dams from similar features in riparian zones. We evaluate model performance against ground-truthed data, and explore trends in dam proliferation and persistence. This work demonstrates the potential of ML-driven remote sensing for ecological monitoring, and offers insight into how beaver engineering influences landscapes over time.

Influence of captivity on raccoon (*Procyon lotor*) craniodental allometry

Christina Sluka, Mark Clementz, Merav Ben-David

The domestication syndrome aims to describe trait similarities observed across domesticated species. Previous research on Siberian foxes illustrated the development of these traits through artificial selection for docility. However, these and other studies failed to assess the source populations for similar morphological trends and/or failed to assess how captivity and diet alone could influence morphology without selective breeding. To trace variation to one of these three sources, we assessed the craniodental allometric relationships of 25 captive fur-farm-bred raccoons (Procyon lotor) and 25 wild-caught raccoons held in captivity compared to their wild counterparts. Of the 19 craniodental measures assessed, most scaled as expected with skull size. However, 7 measures showed that raccoons sourced from Iowa and surrounding states are generally smaller than those from Colorado and Wyoming, although their allometric relationships remained the same. We also identified 2 measures in the oral region where the allometric lines for the captive-bred animals inverted slope and diverged significantly from both their wild counterparts and animals from the mountain west. This shift, seen only in the animals from a captive-breeding context and not from wild caught animals even if held in captivity, suggests an effect of selective breeding on raccoon craniodental allometry independent of captivity and diet. These results are consistent with other evidence of the domestication syndrome in Siberian foxes and American mink under similar fur-farm breeding conditions.

An ecomorphometric comparison of McKittrick and Rancho La Brea coyotes and dire wolves

Valor Smallwood, Robin Trayler, Sora Kim, Patricia Holroyd, Crisanto Ilijic-Manzanera, Geneva Easton, Kara Weeks, Mairin Balisi

Individuals of the same species can vary morphologically by location based on multiple ecological factors, such as competition, available prey, and climate. We measured skulls and jaws of dire wolves (Aenocyon dirus; n = 200) and coyotes (Canis latrans; n = 297) from two Pleistocene-age asphalt seep localities in California: McKittrick in the Central Valley and various pits representing different time periods at Rancho La Brea (RLB) in Los Angeles. We estimated body size using the length of the lower first molar (m1L) and further calculated three indices – jaw robustness, grinding area, and blade length – as proxies for dietary specializations including carnivory and bone-cracking. Coyotes were significantly larger with more robust jaws, longer blades, and larger grinding areas at McKittrick relative to RLB, suggesting that McKittrick coyotes were more durophagous and carnivorous. Similarly, McKittrick dire wolves were significantly larger. These differences suggest greater competition for resources at McKittrick and selective pressure for larger body size and jaw robustness. We hypothesize that access to marine inputs in coastal environments and/or differences in the terrestrial prey base provides wider prey options, reducing the intensity of competition at RLB. Future work will include correlation of morphometrics with data on tooth fracture and wear, as well as geometric morphometric analyses.

Coinfection and the Red Queen

Emily Smith, Jessie Chen, Maisy Christians, Caroline Kim, Levi Morran

While coevolution between hosts and parasites has been shown to be capable of persistently favoring outcrossing, studies have often been limited to single host-parasite pairings and have only been able to maintain outcrossing when coevolving parasites are highly virulent. One way in which outcrossing might be maintained with less virulent parasites is through coinfection. In this experiment, we introduced a small number of self-fertilizing individuals into populations of obligately outcrossing C. elegans and experimentally coevolved these host populations with two parasites, S. marcescens and N. parisii. We exposed C. elegans host populations to parasites in single parasite infection environments and parasite coinfection environments and tracked selfing rate over the course of the experiment to determine whether outcrossing or selfing was favored across time. We found that the rate of selfing increased in all treatments, but increased more rapidly in treatments that included infection with N. parisii. This result indicates that N. parisii has a detrimental effect on outcrossing in C. elegans. While our test concludes that C. elegans coinfected with N. parisii and S. marsecens does not favor outcrossing, this conclusion may not be representative of coinfections in general.

Linking neural activity and behavior: gabapentin's sublethal impact of freshwater crayfish

Grace Smith, Caden Harleton, Noah Greiner, Daniel Bergman

Gabapentin is widely prescribed as a medication for neuropathic pain and seizure disorders. It functions by binding to α2δ-1subunits of voltage-gated calcium channels, thereby reducing excitatory neurotransmitter release. Its increasing use, coupled with inconsistent removal from wastewater or improperly disposed of medications has led to its presence in aquatic environments. The ecological effects of this contamination on non-target species is not well understood. Crayfish, a neurochemically sensitive organism and ecologically important keystone species, may be particularly susceptible to gabapentin contaminants. This study examines the sublethal effects of gabapentin on crayfish locomotor behavior and neurophysiology. We quantified behavior by measuring time spent moving before and after gabapentin exposure. To assess neural activity, we recorded extracellular motor neuron activity. These combined metrics allowed us to evaluate whether gabapentin influences fundamental aspects of locomotor control. Preliminary results

suggest measurable changes in both behavior and neural function following exposure. By linking behavioral and physiological endpoints, this research may provide insight into how pharmaceutical pollutants affect aquatic organisms. Our findings support the potential of crayfish as a model species for studying environmental neurotoxicology related to emerging contaminants like gabapentin. Additionally, this work highlights the importance of considering sublethal effects when evaluating ecological risk of pharmaceuticals in freshwater systems, with implications for future environmental monitoring and regulatory policies.

Size matters: smaller bottle nipple dimensions improve preterm Infant feeding performance

Harlow Smith, Elska Kaczmarek, Helaina Callis, Cate Pradhan, Ani Smith, Maressa Kennedy, Hannah Shideler, Dylan Anderson, Thomas Stroud, Christopher Mayerl

Size affects every facet of an organism's life, especially with how they interact with their environment. For infants, feeding interactions occur between their oral anatomy and the nipple they are feeding on, as successful feeding requires infants to latch onto a nipple and generate suction to acquire milk. Thus, any mismatch between nipple and infant size may result in decreased performance. This could especially be possible for preterm infants, most of which experience feeding challenges often associated with decreased abilities to generate suction. Yet, this possibility remains untested, as feeding pathophysiology in premature infants is typically regarded as a neurologic condition. Here, we tested the potential for a smaller nipple, scaled to preterm oral anatomy, to improve feeding performance in preterm piglets. Piglets were raised on either a standard-sized or reduced-sized nipple, with feeding performance assessed at 13 days of age using high-speed biplanar videofluoroscopy synchronized with intraoral suction. Pigs raised on smaller nipples had greater suction generation, milk acquisition rate and formed larger boluses than pigs raised on standard size nipples. These differences were driven by variation in tongue kinematics. Our data demonstrates that the environment an animal interacts with (here the size of a nipple) strongly impacts feeding performance, and adjusting nipple size can ameliorate many of the challenges faced by preterm infants.

Evolution of spider "jaws" (chelicerae) from CT scanning and muscle modeling

Kiley Smith, Hannah Wood, Corinthia Black, Jeffrey Shultz

The orientation of spider chelicerae (functionally similar to "jaws") has shifted over the evolutionary history of spiders and has been categorized into three discrete forms: parallel, opposing, and in an intermediate position. While these categories have been useful for classifying spiders, the detailed morphology of this transition and functional repercussions have never been examined. To understand these variations in spider morphology, we performed micro-CT scans of four specimens, each representing a major group and the different cheliceral categories. The resulting digital image stacks were used to place landmarks at relevant areas in order to model muscle function for seven different muscles that operate the cheliceral bases. Results showed an overall conserved plan of muscle origin, although some shifts in both area of muscle origin and insertion were observed. These changes may correspond to functional shifts. Since muscle layout was conserved across spiders, our results imply that cheliceral reorientation occurred at the fang joint, rather than the cheliceral base, and that differences in cheliceral use are due to neuromuscular plasticity among spiders, rather than skeletal-muscular anatomy.

Trabecular bone confers different functional advantages across body size in Eulipotyphla (Mammalia)

Stephanie Smith, Nina Kent, Joseph Guillen, Kenneth Angielczyk, Tristan Stayton

The relative contributions of trabecular (spongy) and cortical (compact) bone to bone strength and stiffness are poorly understood across mammalian body size. Some small mammals have notably reduced their vertebral trabecular bone structure, resulting in mostly hollow medullary cavities. To assess the importance of trabecular structure to mechanical properties of small mammalian vertebrae, we conducted finite element analysis on lumbar vertebrae of 46 species of eulipotyphlan mammals weighing 2-1100g. We analyzed two sets of models: vertebrae with trabecular structure intact (full), and vertebrae with all trabeculae excised from the centrum (hollow). All models were scaled to the same load-to-surface area ratio. With the cranial end of the centrum immobilized, a 1N craniocaudally-oriented load was applied to the caudal end of the centrum. We measured mean von Mises stress (MVMS) to capture strength, and total strain energy (TSE) to capture stiffness. MVMS and TSE decrease as body size increases, and hollow models experience higher stresses and strains than full models. With increasing body size, the difference in TSE between full and hollow models increases, but the difference in MVMS increases faster. This may be due to volume allometry: in larger species, trabecular volume comprises a greater percentage of total bone volume, so its removal has a larger effect on strength. These results suggest different functional selective pressure in very small and larger mammalian bones.

When is it too hot to sing? Linking song output to temperature in an arid zone songbird

Tamara Smith, Kayci Messerly, Tara Empson, Michael Gilchrist, Elizabeth Derryberry

Rising temperatures and more frequent heat waves can alter the performance of fitness-related behaviors, including communication. In songbirds such as zebra finches (Taeniopygia castanotis), males must balance thermoregulation with song production, a central feature of mate attraction. Previous studies suggest that males sing less at high temperatures, but the temperature at which song output begins to decline—and whether this decline is consistent across individuals—remains unclear. We predicted that song output would decrease with increasing ambient temperature, with the steepest declines at the highest temperatures. To test this, we exposed males to five temperature treatments (between 27 and 44°C) in a within-subjects, balanced design. This approach allowed us to evaluate both the average ambient temperature at which song output is reduced and the degree of individual variation in performance in heat. Because females prefer males that produce more songs, individual variation in song performance at high temperatures could be a target of sexual selection, while any population-level declines in output may reduce overall signal efficacy. By linking thermal conditions to song performance, this research will clarify how heat influences avian communication and sexual selection in a warming climate.

Amelogenesis and enamel breakdown in vampire bats

Tim Smith, Valerie DeLeon

There are conflicting reports on the presence of enamel in vampire bats. If these bats lack enamel in adults, they share this trait with tusks of elephants. Here, we examine two late fetal or perinatal vampire bats, Desmodus rotundus and Diphylla ecaudatus. Heads of each species were histologically sectioned and stained with Gomori Trichrome procedures, which reveals dentin and enamel layers of mineralizing tooth crowns. In both specimens, a tall internal enamel epithelium is present adjacent to the mineralizing maxillary replacement tooth crowns. In the lingual side of all teeth, no enamel is present. On the buccal side, a distinct enamel layer is present over part of the developing crown. Near the cervix the enamel is lacking; progressing toward the mid-cervico-apical level enamel gradually thickens and becomes more intensely stained. In both bats, the crown enamel of all teeth again begins to thin toward the cusp tip, and staining intensity decreases. Along the apical half of the tooth large multinucleate cells are seen on the surface of enamel, most numerous in Diphylla. Our results demonstrate that amelogenesis occurs in the replacement teeth of fetal and perinatal vampire bats, but enamel is reduced at the apical side of the crowns in association with multinucleate cells (likely odontoclasts). The discrepancy in prior findings most likely reflects variable remnants of enamel on young adult teeth.

The impacts of increasing temperatures on the escape response of cunner

Hannah Snayd, Andrew DeBois, Ethan English, Shannon Gerry

Cunner, Tautogolabrus adspersus, are a temperate species from the family Labridae that inhabit the Western Atlantic. This species experiences temperatures ranging from 0oC to 25oC in Long Island Sound. Once temperatures drop below 10°C, cunner find shelter and enter into extended torpor. We have previously shown that colder temperatures slowed the escape response. As temperatures are rising and cunner are starting to shift poleward, our goal was to examine the effects of warming temperatures. We hypothesized that cunner will exhibit a faster escape response at higher temperatures. We recorded the predator escape response at 250 frames s-1 from 4-6 cunner at each acclimation temperature (20°C, 22°C, 24°C, 26°C). We compared peak, minimum, and average center of mass (COM) velocities and accelerations among temperatures as well as peak, minimum and average angular velocities and accelerations. As predicted, velocity increased with increasing temperatures. Angular velocity decreased with increasing temperature, similar to our previous study. The increased speed at higher temperatures should make cunner less susceptible to predators and able to capture prey items. Thus, these behaviors may have implications at multiple trophic levels.

Tracking 20 years of genomic microevolution in a non-native lizard

Anthony Snead, Anna Thonis, Eve Manen, Aiden Virell, Russell Burke, Kristin Winchell

As global change accelerates, understanding how populations respond to novel conditions at microevolutionary timescales is essential for predicting species' futures. Non-native species provide powerful opportunities to evaluate the repeatability of evolutionary change in response to rapid environmental shifts. The Italian wall lizard (Podarcis siculus), native to southern Europe, was introduced to Long Island in 1964. From a single introduction event, this species has spread widely across Long Island and New York City, making it an exceptional system to study rapid, contemporary microevolution. To assess evolutionary dynamics across this introduction, we leverage temporal sampling spanning two decades. We use genetic material collected from four populations across the non-native range in 2005, alongside contemporary samples collected in 2025. This paired design allows us to directly quantify genetic shifts in response to the novel conditions of the non-native range. Specifically, we use whole genome resequencing to examine changes in genetic diversity, population structure, and differentiation, and then scan for signals of natural selection driven by novel climatic regimes and urbanization gradients. By integrating historical and contemporary genetic datasets, we directly assess the temporal dynamics of microevolution in a non-native species exposed to both novel climatic regimes and anthropogenic activities.

Variation in venous cell size and shape facilitates the development of seasonal forms in Lepidoptera

Skylar Snow, Kenneth McKenna, Richard Gawne

The wings of moths and butterflies contribute to fitness in a wide variety of ways, ranging from flight capabilities, to aposematic signaling and camouflage. Because of this, it is reasonable to expect that the size and shape of wings will show high levels of robustness within species. To test this conjecture, we assembled a dataset of specimens from eight genera within the butterfly family Nymphalidae. The fore- and hindwings of samples were decomposed into a series of venous compartments, whose size and shape were individually measured using custom ImageJ software. Analysis of this dataset revealed a surprisingly high level of intraspecific variation, and allowed for the identification of patterns of correlated growth that seem to function as a constraint on the shape of the adult wings. Given that the species chosen for inclusion in the dataset exhibit distinct wet and dry season wing morphologies, we were also able to identify specific developmental changes that are necessary for the attainment of highly derived seasonal forms. Finally, we provide preliminary evidence that competitive interactions between anterior and posterior compartments of the wing are a key determinant of its final size and shape. Overall, the results obtained in this study provide a foundation for future experimental research by elucidating the developmental 'decisions' that are necessary for the formation of specific wing morphologies.

Do felids defy the rules? Size-related shifts in posture from cats to tigers

Porter Snowden, Daniel Schmitt, John Hutchinson, Alexis Wiktorowicz, Jesse Young

Most terrestrial mammals mitigate size-related increases in bone stresses by moving on more extended limbs at larger sizes, thereby reducing joint moments and the muscle force required to maintain posture. Existing evidence suggests that felids differ by not changing joint postures as size increases, but prior studies used video data only and focused on touchdown and mid-support. As part of a long-term study, we collected synchronized force and kinematic data to quantify support-phase postures and moments in forelimb and hindlimb joints of domestic cats (Felis sylvestris; N=17 trials across 2 animals; mass: 3.7kg) and tigers (Panthera tigris; N=10 trials across 2 animals; mass: 169kg). We found that tigers used more extended elbow, wrist, knee, and ankle postures at touchdown and mid-support (all $p \leq 0.028$), leading to greater effective forelimb and hindlimb lengths across steps (shoulder/hip to paw distance, scaled to limb length; $p \leq 0.041$). As a result, tigers demonstrated reduced peak relative elbow ($p=0.053$) and knee ($p=0.042$) moments (scaled to the product of body mass and limb length). Peak relative joint moments did not differ between species at other limb joints ($p \geq 0.314$). Our results suggest that large felids may follow the common mammalian pattern of increasing joint extension at larger body sizes, though such changes in posture may not be sufficient to completely mitigate size-related increases in limb bone loading, necessitating positive allometry of cross-sectional properties.

Artificial light at night elevates activity and spatial use in zebrafish.

Sean Snyder, Piyumika Suriyampola

Global urbanization has spread the presence of light pollution across the globe. This artificial light is a known disruptor of circadian rhythms and animal behavior. This study investigated the effects of extended light exposure on the locomotor activity of Danio rerio (zebrafish). Fish were maintained under either a conventional 14:10 light:dark cycle or an ALAN simulating 17:7 cycle. Using an open-field assay, velocity, distance traveled, and area covered were digitally tracked and quantified for use as indicators of exploratory behavior and activity. Zebrafish exposed to the ALAN cycle exhibited significantly higher velocity, traveled greater distances, and explored more of the arena compared to control individuals. These results support the conclusion that extended light exposure increases locomotor activity and alters spatial use in zebrafish, potentially impacting ecological interactions. Our findings emphasize that even modest shifts in light cycles can have measurable behavioral alterations, underscoring the importance of considering light pollution as a relevant ecological stressor in both laboratory and natural aquatic systems.

A kink in the armor: effects of an S-shaped posture on the fast-start response in juvenile poachers

Jacob Sobol, Yohan Sequeira, Megan Vandenberg, Cassandra Donatelli, Jake Socha

Juvenile northern spearnose poachers (Agonopsis vulsa) make frequent forays off the bottom and swim holding an unusual S-shaped configuration. This postural behavior is largely lost in the benthic adults, which only occasionally journey off the bottom, more often employing a conventional straight shape. It is unclear why juvenile poachers hold a curved posture when swimming and how this behavior changes over ontogeny. We hypothesize that juveniles form an axial curve to complete an escape response faster by preloading an initial shape. To test this hypothesis, we elicited escape responses in juvenile poachers at rest to compare potential performance differences arising from variations in curvature. Ten juvenile poachers were allowed to acclimate in a 40 x 20 cm tank before releasing a weighted rod that acts as the stimulus. The response was filmed at 1000 fps using an Edgertronic high-speed

camera. We predict that individuals with higher curvature reach peak velocity within a shorter duration than fish that are less curved. It is also possible that the unusual S-shaped posture of juveniles does not play a biomechanical role in fast-start locomotion. Further experiments that explore hypotheses surrounding its possible cryptic functionality or station holding ability will help lend insight into the role of axial curvature in the life history of a highly armored species.

An introduction to synchrotron imaging for biologists

Jake Socha

Synchrotron imaging has found widespread application across science and engineering, in fields ranging from biology to material science. However, it still not particularly well used as a tool for organismal biologists. The purpose of this talk is to give SICB members an introduction to synchrotron imaging for samples ranging from plants to animals, conducted at the Advanced Photon Source (APS) of Argonne National Laboratory, the US's premiere synchrotron light source facility. Beamtime at the APS is free, obtained by proposal in three cycles per year. Full-field phase-contrast imaging enables a researcher to visualize static or dynamic internal or external morphology with high spatial resolution (photon-limited; ~1 micrometer) and high temporal resolution (camera-limited; 100,000+ fps), with work conducted at beamline 32-ID. Full-field tomography provides three-dimensional imaging of structures with sub-micrometer resolution and fast scan times (seconds to minutes) that match or exceed commercial lab-based devices, with work done both at beamline 2-BM and beamline 32-ID. Lastly, tomographic imaging with very high resolution (~20 nanometers) can be achieved on very small samples (FOV, ~100 micrometers) using transmission x-ray microscopy (TXM) at beamline 32-ID. This work was performed on numerous APS beam time awards from the Advanced Photon Source, a U.S. Department of Energy (DOE) Office of Science user facility operated for the DOE Office of Science by Argonne National Laboratory under Contract No. DE-AC02-06CH11357.

Does parental favoritism bias a songbird's access to motor learning?

Keith Sockman, Emma Reinhardt, Nicolas Frasson, Alexa Soderman

The trill elements of many bird species' songs are thought to be honest sexual signals due to a performance-based trade-off between frequency bandwidth (bandwidth) and rate of syllable production, both of which may be biomechanically constrained by portions of the vocal tract, including the bill. Compared to species with large bills, those with small bills tend to produce higher-performance trills from more rapid syllable-production rates relative to bandwidth. However, it is not clear whether within-species variation in bill size affects trill performance and, if so, how such variation arises. We caught and banded free-ranging Lincoln's sparrows (Melospiza lincolnii) in Colorado, estimated body and bill size, and analyzed recordings of their song. We discovered that, when controlling for body size, adults with large bills produced lower trill performance than those with small bills, and this was driven primarily by selective use of syllable types according to bandwidth rather than by modulation of syllable-production rate or within-syllable-type bandwidth. This suggests that bill size restricts use and thus motor learning of some syllable types. We also experimentally delayed nestling oviposition relative to sibling nestmates and discovered that it increased their bill size, which itself predicted adult bill size. This raises the possibility that parental favoritism—typically biased by oviposition—affects access to learned syllable types through a developmental constraint involving bill size.

Effects of environmental exposure to sertraline on goldfish (Carassius auratus)

Md Didaruzzaman Sohel, MD Rahman

Anthropogenic activities enhance environmental pollution. Freshwater aquatic organisms are impacted by pharmaceuticals, mainly by antidepressant medications (e.g., sertraline). Controlling the use of antidepressants and reducing pollution are the most public health concerns. Adverse effects of antidepressant drugs are well documented in aquatic freshwater organisms, and sertraline effects on animal fish models are known. The use of model organisms, such as goldfish (Carassius auratus), is used in a variety of research that greatly improves knowledge regarding the biological sciences. The recent experiment was mainly concerned with the effect of sertraline, which was exposed to low dose at 0.5 µg/L and high dose at 5.0 µg/L for 2 weeks. Histopathological study indicated widespread damage in both gills and kidneys. In addition, histopathological analysis in goldfish kidneys showed widespread tissue disarray (e.g., shrinking of Bowman's capsule, deposition of melanin pigment, etc.). Furthermore, sertraline exposure changes the morphology of the gill architecture and mucus production on the gill tissues. Immunohistochemical analysis provided insight into the expression of molecular biomarkers in tissue. Sertraline-treated fish showed a significant ($P < 0.05$) change in 26S proteasome expression in both tissues. Overall, these results show that sertraline exposure causes changes in the morphology of goldfish tissues, which may lead to impaired physiological functions.

Floral microclimates and foraging preference in a solitary bee

Lukas Sokalski, Meredith Johnson, Kendra Greenlee, Joseph Rinehart, Steven Travers

Bee pollinators are influenced by multiple interacting factors when choosing flowers to forage on, such as flower color, shape, and odor. Differences in floral morphology can also alter the microclimates of flowers, potentially affecting insect behavior. Alfalfa (Medicago sativa) produces flowers of various colors including blue, purple, yellow, and white. While some bees prefer darker-colored alfalfa flowers, the underlying mechanisms remain unclear. We hypothesize that the alfalfa leafcutting bee, Megachile rotundata, may select flower microclimates associated with color and morphology. In field conditions, we measured internal temperature, humidity and nectar concentration of alfalfa flowers. We subsequently conducted a foraging preference test using flower cuttings from the field. Our results revealed small, yet significant differences in floral microclimates. Darker flowers were approximately 1.5 to 2.5 °C warmer than lighter flowers, whereas lighter flowers had slightly higher humidity (~2% higher). Nectar sugar concentrations did not differ between colors. In laboratory tests, bees visited intermediate-colored flowers more frequently but spent more time foraging on darker-colored flowers. This preference for darker flowers may aid in thermal balance during flight. Future tests should investigate whether higher ambient temperatures might shift pollinator preference towards lighter-colored flowers to further facilitate thermoregulation.

Histological characterization of mechanoreceptors in bluegill fins

Amanda Solano, Eric Tytell, Margot Schwalbe, Anabela Maia

Previous work has shown that bluegills have mechanoreceptors in their dorsal fins, and that the spiny and soft portion respond differently to bending and brushing. Bluegill with numbed fins also have a harder time maintaining stability. To determine how this information is collected, we characterized the mechanoreceptors of bluegill fins using immunohistochemistry. Spiny and soft portions of dorsal fins in addition to anal and caudal fins were harvested from adult bluegills. Fins were incubated with a primary antibody against cytokeratin 20 produced in mouse and secondary antibody and imaged under an epifluorescence Nikon microscope. Cytokeratin 20 has been reported to be expressed in animal mechanoreceptors including fish and other vertebrates. Our results show similar density of cytokeratin 20 labeled putative mechanoreceptors in the spiny and soft dorsal fins, no mechanoreceptors in the caudal fin and lower densities in the anal fin. Mechanoreceptors are overall larger in the spiny dorsal fin and appear to be of two types, small receptors located in clusters and more prevalent in the fin web and larger mechanoreceptors – potentially encapsulated – in the spines, especially more proximally. The soft portion of the dorsal fin appears to have mostly clusters of smaller receptors. These data support the electrophysiological recordings of the spiny dorsal fin responding to bending and brushing while the soft dorsal fin responds only to brushing.

Sexual selection is a path to ecological innovation

Ummat Somjee, Justin Havird, Michael Ryan

Sexual selection is a powerful evolutionary force, but its ecological consequences are only beginning to be appreciated. Traits such as frog calls, manakin displays, the elaborated claws of fiddler crabs and carotenoid-based coloration in birds are built on complex physiological machinery, including hormonal regulation, metabolic performance, and tissue-specific development. Because sexually selected traits may be elaborate, energetically demanding and conspicuous, they often mediate how organisms interact with their environments. Sexual selection can shape sensory physiology, drive niche exploitation, and foster ecological novelty. By emphasizing the interplay of physiology, energetics, and ecology, we argue that sexual selection is not only a driver of reproductive success but also a catalyst of ecological innovation. We highlight new opportunities for linking sexual trait evolution to broader patterns of biodiversity. This perspective underscores the need to integrate physiology, ecology, and evolutionary biology in diverse organisms to develop a broader understanding of how sexual selection generates novel phenotypes and shapes ecological dynamics.

Low cost and open-science tools as a path forward for integrative organismal research

Yash Sondhi, Thomas Franzem, Brett Seymoure

Studying animal behavior in the field is often hindered by environmental variability and the high cost or inaccessibility of monitoring equipment. Fortunately, many tools have been developed recently that utilize the development and application of low-cost, open-source sensing technologies, such as Arduinos, Raspberry Pis, and 3D-printable tools for automated data collection. However, as these tools and resources are developing so quickly, many researchers may not know how to incorporate these methods into their research programs, or worse, not know that they exist altogether. In this presentation, we first give a brief overview of the history of open-science and integrative biology, then we highlight the current state of open-science and low-cost tools for monitoring organismal biology emphasizing resources useful for integrative biologists. Lastly, we turn our focus to the work of presenters in this symposium: SICB Open-science and low-cost tools. In highlighting open-science and low-cost tools, we aim to bring together interdisciplinary researchers to explore how these tools can increase accessibility, enhance replicability, and support large-scale behavioral and ecological studies. We hope this talk and accompanying symposium will foster discussion throughout the conference on methods and tools that researchers can use to monitor and measure organismal biology during these times of rapid environmental change and biodiversity loss.

Metabolic responses to order-dependent environmental challenges in two species of nomadic finch

Benjamin Sonnenberg, Jessica Karr, Jamie Cornelius

Understanding the intra- and inter-specific metabolic variation involved in responding to environmental uncertainty is a critically important issue in ecology. The frequency and severity of extreme weather events and their associated resource disruptions are projected to increase in response to climate change, but how wild animal populations respond to these disruptions remains largely unclear. Here, we tested the responses of two nomadic finches (red crossbills and pine siskins) to two types of simulated environmental challenges (food restriction (FR) and cold exposure (CE)) administered in an order-dependent design (Group A: CE -> FR; Group B: FR -> CE). We predicted that crossbills would exhibit more resiliency (lose less mass and exhibit larger increases in thermogenic capacity) compared to smaller-bodied pine siskins. Additionally, we anticipated that CE, if administered first, would improve the response to FR through improved resource assimilation capacity. We found that across FR, animals from Group A exhibited a higher decline in body mass in the first 24 hours compared to Group B, and that siskins maintained a higher rate of decline across the entire treatment. During CE, animals showed little to no change in mass but increased summit metabolic rates (Msum) in response to decreased temperatures across treatment groups, with crossbills generally showing higher Msum than siskins. Our findings demonstrate that order of environmental challenges does matter, particularly for smaller species.

Mitochondrial genome diversity tracks the rapid spread of the invasive spotted lanternfly in the USA

Katilyn Sookoo, Sofiia Korotka, Juhi Rawal, Nicolas Largotta, Brenna Levine, Matthew Kamiyama

Mitochondrial genomes provide a valuable marker for tracing invasion history and dispersal in non-native species. The spotted lanternfly (Lycorma delicatula), native to China, was first detected in the United States in 2014 in southeastern Pennsylvania, where early mitochondrial analyses of just 10 individuals revealed a single haplotype. To test whether this pattern has persisted during the species' rapid range expansion, we sequenced complete mitochondrial genomes from 294 spotted lanternflies collected across 24 U.S. populations between 2023 and 2024. In contrast to the initial homogeneity, our broader sampling reveals 50 distinct haplotypes now present across the invasive U.S. range. This dramatic increase in haplotype diversity may reflect previously unsampled variation in the original introduction, the arrival of additional mitochondrial lineages during spread, or signatures of rapid population growth and range expansion. By integrating large-scale mitochondrial sampling across space and time, this work provides new insight into how genetic variation accumulates during invasion and establishes a foundation for tracking future spread of this destructive insect.

Quarry-based mariculture of the herbivorous Caribbean king crab in support of coral reef restoration

Brandon Sosa, Morgan Jarrett, Mark Butler IV

Macroalgal overgrowth on Caribbean coral reefs, driven in part by the loss of herbivores, continues to inhibit coral recovery. To address this, the Florida Keys National Marine Sanctuary plans to stock over 400,000 invertebrate grazers (long-spined sea urchins, Diadema antillarum; Caribbean king crabs, Maguimithrax spinosissimus) onto reefs targeted for restoration, but land-based hatchery production remains costly and labor-intensive. Our work focuses on the crab, M. spinosissimus, and explores quarry-based mariculture as a scalable grow-out approach that leverages semi-natural environments to reduce ex situ infrastructure demands. We tested this concept through multiple trials in saltwater quarries in the Lower Florida Keys. Juvenile crabs reared in quarry cages exhibited survival and growth comparable to those in laboratory systems, demonstrating that low-labor quarry environments can support culture as effectively as intensive facilities. Performance was consistent across multiple quarries and maternal clutches, but higher cage density reduced survival and slowed growth. Seasonal surveys of algal canopy height and water quality provided ecological context, highlighting how quarry environments reflect natural variability while still supporting culture at meaningful scales. These results validate quarry-based mariculture of juvenile M. spinosissimus as a viable grow-out method. Quarries can function as controlled in situ systems that bridge ex situ larval culture and reef deployment, helping to ease production bottlenecks and advance large-scale grazer supplementation as a strategy to support coral restoration.

Behavioral assays to determine oviposition and host preferences of *Anopheles stephensi*

Medhini Sosale, Noah Rose

Anopheles stephensi is a mosquito species and urban malaria vector native to much of South Asia and the Arabian Peninsula. It has recently invaded multiple African countries and islands in the Indian Ocean, and the World Health Organization Global Malaria Program identified this species as a pending malaria threat for its invasive range. It has also been observed to breed successfully in artificial containers, a concern for those in urban environments. Understanding oviposition and host preferences of this species is crucial to predicting its behavior in the invasive range, which can aid in developing interventions to prevent the spread of malaria. Therefore, to evaluate whether preferences for human hosts and artificial breeding habitats have contributed to the successful invasion of this species into Africa, I am developing two behavioral assays to quantify oviposition and host preferences. The oviposition assay involves observing whether the amount and/or type of water in an egg cup, as well as the cup material itself, affects patterns in An. stephensi egg laying. The host preference assay involves presenting mosquitoes with

a choice between a human or guinea pig host by placing them in a chamber that splits into two paths. Together, oviposition and host preferences of An. stephensi, coupled with population genomic analysis, can be used to investigate the extent to which they may threaten humans in the invasive range.

Evaluating microplastic digestion times in European starlings (*Sturnus vulgaris*)

Maria Soukup, Mike Butler

Microplastic pollution is an emerging threat to the health of many species. Birds are frequently found with microplastics in their digestive systems, but because digestive transit times have not yet been evaluated, it is unclear how these microplastic loads correlate to timing of microplastic ingestion. This project will evaluate microplastic fiber transit time in a controlled environment, as well as monitoring changes in fiber size and surface texture. We plan to utilize a group of captive European starlings (Sturnus vulgaris) as a model for granivore digestive systems and provide them with a known amount of re-identifiable microplastic fibers. By digesting fecal samples and using microscopy, we aim to determine if microplastic fibers are accumulating in the digestive system and if they are being physically damaged during transit through the digestive system. Both effects may demonstrate an increased threat to the health of bird species, as fibers may accumulate to dangerous levels or develop larger surface areas, magnifying their negative health impacts.

Cognition and reproductive performance: insights from a detour-reaching task in wild tree swallows

Josiah Southern, Sara Isgate, Kim Rosvall

Anthropogenic change introduces novel problems for wild animals, and cognitive abilities may aid in facing these challenges. Inhibitory control, for example, is an animal's ability to suppress its preferred behavior for a more context-appropriate one. Still, the relationship between inhibitory control and fitness remains understudied in the wild. Here, we measured inhibitory control in wild adult tree swallows (Tachycineta bicolor) during nestling rearing, using a detour-reaching assay in which focal subjects had to alter their typical flight path to avoid a transparent barrier and successfully enter their nest box to provision their young. We scored trials using BORIS event recording software, focusing specifically on the subject's latency to provision as a measure of their cognitive performance. We also examined relationships between cognitive performance and proxies of reproductive performance, including nestling body mass, adult body mass, and fledging success. Insights from this research will deepen our understanding of the factors shaping cognitive performance in wild animals.

Bergmann's and Allen's rules in North American hummingbirds (Trochilidae) following range expansion

Sierra Sowa, Derrick Groom

New climates are expected to lead to morphological changes following ecogeographical rules. Endotherm body mass is expected to increase and appendage length is expected to decrease under cooler climates following Bergmann's and Allen's rules, respectively. Prior research has focused on decreasing body sizes associated with warmer temperatures under climate change, but invasion into cooler climates is less explored. Two western North American hummingbird clades that have invaded either cooler or warmer climates, making them a natural experiment to test these rules. Anna's hummingbirds (Calypte anna) have experienced a range expansion over the last 60 years from their historic upper limit in Northern California into the Pacific Northwest and British Columbia, Canada. In southern California, a sedentary sub-species of Allen's hummingbirds (Selasphorus sasin sedentarius) colonized the mainland from the Channel Islands and expanded their range into warmer, urban areas since the 1970s. I hypothesize that both Anna's and Allen's hummingbirds will demonstrate opposing morphological patterns along Bergmann's and Allen's rule. We have completed measurements from more than 200 museum specimens from the 1960s to the present day. Data will be analyzed using linear models and principal components analysis. Finding connections between body size changes and our changing climate in birds is a demonstration of species ability to respond in the face of uncertain or permanently altered climate conditions.

Sleep interrupted: effects of sleep disturbance on physiology and performance in the Green Anole

A. Sparks, Simon Lailvaux, Jerry Husak, Bernard Rees, Samantha Brieske

All animals sleep, yet its physiological role and consequences in reptiles remain underexplored. In endotherms, sleep loss is known to impair physical performance, disrupt hormonal regulation, suppress reproduction, and alter mitochondrial function. Because even slight movement can provoke arousal, chronic disturbance may carry significant consequences, especially if it impacts ability to evade and defend from predators. The green anole (Anolis carolinensis) sleeps on exposed arboreal perches and is a model organism for studies of ecology and evolution, offering a valuable species for investigating sleep fragmentation effects in reptiles. We experimentally fragmented sleep by delivering hourly 10-second mechanical vibrations during the night to experimental green anoles over a six-week period. We assess whether this controlled, chronic disturbance produces physiological costs that mirror patterns established in endotherms. Specifically, we measured changes in physical performance (bite force, sprint speed, endurance); stress levels (corticosterone); reproductive investment (testes mass in males; ovary mass, and follicle count in females); and mitochondrial function in brain tissue, a proposed driver of sleep pressure. By integrating behavioral, hormonal, reproductive, and cellular metrics, this study explores the potential hidden costs of sleep loss in a reptile, contributing to a broader understanding of sleep's role across vertebrates.

Pectoral fin shape changes during stationary-holding in wobbegong sharks

Chris Spear, Mark Westneat, Melina Hale

Station-holding in benthic elasmobranchs represents acritical ecological adaptation, allowing for energy conservation, predator avoidance, and prolonged occupancy of key feeding or ambush sites. Wobbegong sharks possess relatively large, flat, and flexible pectoral fins – more similar in pliability to the fins of rays than the rigid fins of pelagic sharks. This likely permits subtle, fine-scale adjustments during benthic station-holding. Using high-speed camera analysis, this study aims to characterize how flexible, broad pectoral fins are adjusted for maintaining stability on bottom substrate in varied flow speeds. At low flow speeds, station holding seems to primarily rely on substrate friction and body posture, requiring minimal fin adjustments to maintaining position. With increased water flow, fins create more dynamic concave shapes, larger surface area deformation, and greater variability in fin flexion. These findings suggest that wobbegong shark pectoral fins are evolutionarily specialized for manipulating lift and drag, enabling stable benthic station holding through fine-scale behavioral changes. Funding:ONR N00014-22-1-2187 to MEH.

Material properties facilitate shock wave damping by helmet-like orbital hoods in snapping shrimp

Daniel Speiser, Mia Kazel, Rebekah Cammack, Alexandra Kingston, Ahmed Alshareef, Tarek Shazly

Shock waves are supersonic high-amplitude pressure waves that can cause severe barotrauma when they transfer kinetic energy to neural tissues. Snapping shrimp (Crustacea: Decapoda: Alpheidae) damp the shock waves they produce and use as weapons with a helmet-like structure termed the orbital hood. Here, we ask how structural and material properties contribute to shock wave damping by orbital hoods in Alpheus heterochaelis. Using tensile mechanical testing, we find orbital hoods are approximately half as stiff as carapace and have twice the capacity for viscous energy dissipation. Microstructural features likely contribute to tissue-specific mechanical properties: the endocuticles of orbital hoods have almost twice as many lamellae as those of carapaces despite being half as thick, suggesting a mechanism for enhanced material mobility underlying viscous behavior. Using material properties from mechanical testing and geometric data from microCT, we

developed finite element simulations of interactions between shock waves and orbital hoods. These simulations predict orbital hoods reduce shock-wave-induced strain and stress in the neural tissues of shrimp by 28% and 22%, respectively. Orbital hoods appear optimized for shock wave damping: simulated increases or decreases in their material properties reduce their protective capabilities. We conclude that structural and viscoelastic properties contribute to shock wave damping by orbital hoods, a promising step towards bio-inspired improvements to contemporary armor systems that currently underperform in preventing blast-induced neurotrauma in humans.

Surf's up: protection with stingray-resistant materials in a surf booty

Keira Spiller, Jasmin Dudley, Benjamin Perlman

Round stingrays (Urobatis halleri) commonly occur along the coastlines of Southern California in nearshore sandy habitats. As a defense mechanism, round stingrays will strike their tails to impale their target subject with their needle-like barb. Humans wading in these nearshore habitats are often targeted by stingrays due to accidentally stepping on these benthic creatures. To reduce beach injury caused by round stingrays, DragonSkin® surf booties were created to protect those people who frequent the beach. The surf booty is comprised of two layers: an inner sock that rests inside a more rigid outer sock with differing regions of stingray-resistant materials to allow for foot mobility. To investigate the total surface area and percent protection of stingray-resistant materials, an Artec Space Spider 3D scanner was used to scan both the inner and outer socks of three booty sizes, creating digital models for each booty size. Using CAD (computer-aided-design) software, the digital scans were aligned and detailed to calculate the surface area coverage of stingray-resistant materials, offering a total percent protection against stingray strikes to individuals wearing the booty. The results will contribute to improving the overall design of the surf booty and to help reduce the risk from potential stingray strike injuries.

Odor complexity and encoding in the bumblebee *Bombus impatiens*

Jordanna Sprayberry

Chemical signals are a valuable information channel in both inter- and intra-species interactions. An improved understanding of olfactory encoding - i.e. the relationship between scent signal inputs and behavioral outputs - will help elucidate how chemical signals impact behavioral and ecological systems. Scent is a critical cue for many pollinating insects, and for bumblebees in particular. Scent plays a role in both communication between conspecifics (i.e. pheromonal signals in forager recruitment) and in interspecies interactions (i.e. floral scent attraction). A thorough understanding of bumblebee odor processing will translate to an improved ability to predict how pollination services could be disrupted in odor-polluted anthropogenic environments. However, odor encoding is dynamic: existing neurophysiological work on odor blends supports the idea that molecular identity is encoded by the nervous system for simple blends (2 components), termed 'elemental encoding'; while encoding of complex stimuli (4 components) is not a simple sum of the responses to its parts, termed 'configural encoding'. This study leverages the Compounds Without Borders method of computational odor representation to confirm and elucidate the transition of elemental to configural encoding in bumblebee olfactory processing. Current results indicate that odor complexity has an impact in odor-discrimination thresholds.

Biomechanical function of cranial sutures in headbutting goats

Ananth Srinivas, Connor Moody, Nicole Ackermans

Headbutting bovids present a unique model for studying the biomechanical strategies underlying cranial shock distribution. Repeated high-force impacts in these animals present a risk of traumatic brain injury, making their cranial adaptations vital to brain protection during combat. While previous research has explored the role of horns, horn cores, and frontal sinuses, the contribution of cranial sutures to force distribution remains under-appreciated in engineering-driven studies. Juvenile and female bovids with diminutive horns are still capable headbutters, suggesting horns are not the only defensive structures. Here we clarify the functional importance of cranial sutures in mitigating impact forces during repeated headbutting. Using a biologically inspired finite element analysis (FEA), we evaluated stress resistance in domestic goats (Capra hircus) to understand the importance of craniofacial sutures during dynamic impact loading. As variations in local bone material properties can affect mechanical performance and model validation, we developed both homogenous and heterogeneous suture and non-suture models. Initial results suggest that models with sutures exhibit reduced peak stresses, indicating that cranial sutures play a key role in stress distribution during headbutting. While horns and horn sheaths may contribute secondarily, our study aims to provide a more comprehensive understanding of headbutting biomechanics, potentially challenging the prevailing view that impact protection in bovids is dominated solely by horns.

Robophysical exploration of mole crab appendage kinematics

Chhayank Srivastava, Laura Treers

Legged burrowing in soft substrates is a complex and poorly understood mode of locomotion. Mole crabs, including the Atlantic mole crab Emerita talpoida, rapidly burrow into intertidal substrate using five leg pairs. Prior kinematic analyses have revealed that mole crab appendages travel in non-planar trajectories throughout burrowing, moving laterally during their "power stroke" and medially during their "return stroke" (Faulkes & Paul 1997). However, little work has sought to characterize the functional role of these out-of-plane motions in successful burrowing performance. In this work, we record appendage trajectories of four E. talpoida specimens in both the sagittal and frontal planes. We find that in a single cycle, the tip of the second leg pair translates 0.52±0.11 body lengths in the anterior-posterior direction, compared with 0.46±0.13 body widths in the medio-lateral direction; additionally, rotation of the dactyl tip occurs during the return stroke. To systematically test the role of both medio-lateral motions and dactyl rotation on resistive forces, we construct a robophysical model of a burrowing appendage, capable of generating 3D tip trajectories and limb rotation with a single actuator. Utilizing 3D Granular Resistive Force Theory to predict forces on this simplified appendage, we find that trajectories which include medio-lateral translation and limb rotation have a higher ratio of thrust to drag forces than trajectories which lie solely in the sagittal plane.

Microglia, behavior, and the brain: neuroimmune regulation of social behavior in house sparrows

Michelle St John, Alexandra Bentz, Jasmeen Kaur

Aggression is a complex social behavior that is regulated by multiple physiological systems, yet the role of immune signaling remains understudied. Microglia, the brain's resident immune cells, are key mediators of neuroinflammatory signaling, but may also impact aggressive behavior via synaptic activity modulation or cytokine production. Despite the mounting evidence of microglia's role in behavioral regulation, few studies document the causal relationship between microglia and aggressive behavior. Here, we investigate neuroimmune regulation of social behavior in wild-caught male house sparrows (Passer domesticus), by comparing levels of aggression and microglia abundance between control (n=5) and minocycline-treated (n=6) birds. We administered minocycline, an antibiotic that inhibits microglial activation, to treatment birds for seven days, while control birds remained minocycline-free. We used standardized simulated territorial intrusions to quantify aggression in all birds before and during this period. To directly link microglia abundance and aggression, we collected whole-brain tissue from all birds post-treatment, labeled microglia using immunohistochemistry, and quantified microglia abundance in brain regions implicated in social behavior and aggression. Preliminary results indicate that minocycline had region-specific effects on microglial abundance and produced bidirectional effects on aggression. These results provide novel evidence that immune signaling via microglia can shape aggressive behavior in a naturalistic vertebrate model, and highlight the context- and region-dependent nature of neuroimmune regulation of social behavior.

The immediate and long-term consequences of a storm-induced mass mortality event

Maria Stager, Phred Benham, Nathan Senner, Robert Fitak, Kay Denmead, Keith Andringa, Jacquelyn Grace, Joe Siegrist, Anna Forsman, Donna Dittmann

Extreme weather events are increasing in frequency, resulting in a greater number of mass mortality events for plants and animals. The unpredictable nature of such weather events though, makes it difficult to quantify the effects of resultant mass mortality and its long-term consequences for populations. Recent unseasonable storms have coincided with the mortality of thousands of birds on multiple occasions across the country. For instance, in February 2021, Winter Storms Uri and Viola resulted in the loss of a substantial portion of early arriving Purple Martins (Progne subis) across the southcentral U.S.. The carcasses of many of these individuals were collected by natural history museums, and we used these carcasses to investigate the physiological, demographic, and ecological bases of this event. By combining morphological data with whole-genome resequencing, arrival timing and nesting data, we found that the storms resulted in marked allelic and phenotypic signatures in the population. By 2024, several trait values had returned to the long-term mean, yet demographic recovery could take several years or even decades. Our results indicate that extreme weather events can have significant measurable effects, but that populations may be able to recover over relatively short time periods depending on the structure of the population and the frequency of such events.

Transgenerational and sex-specific effects of microplastics and phthalates in an insect

Zach Stahlschmidt, Jacob Lee, Richard Choi, Leah Chapman

Over 400 million tons of plastic are produced each year, making microplastics (MPs; plastic particles ubiquitous in virtually every ecosystem. Microplastics release phthalate ester (PAE) plasticizers that make plastics more flexible and durable, and PAEs have endocrine disrupting effects in vertebrates. Yet, we lack a comprehensive understanding of the combined effects of MPs and PAEs, which may entail additive or synergistic costs to important traits, such as reproduction. Environments exhibit long-term contamination by MPs and PAEs, so it is also important to characterize their transgenerational effects– that is, how exposure to one or both parents has carryover effects that influence offspring. Here, we used a factorial design and fed four diets (control [no additives], MPs added, PAE added, and both MPs + PAE added) to individually housed virgin variable field crickets (Gryllus lineaticeps). After crickets mated, we determined mating success and egg production, as well as transgenerational effects (incubation duration, hatching success, hatchling starvation resistance, and hatchling developmental rate). Preliminary results indicate that MPs exposure has a sex-specific effect on offspring production, and that parental exposure to PAEs alters the developmental life history of offspring. Our study will inform how different sexes and life stages respond to emerging pollutants.

Street Smarts: Understanding the role of animal cognition in behavioral responses to urbanization

Lauren Stanton

Urbanization dramatically transforms landscapes, creates novel challenges, and increases interactions between people and wildlife. For these reasons, urbanization has been linked to rapid phenotypic change and the decline of animal populations worldwide. Behavioral plasticity is frequently cited as central to an organism's ability to cope with urbanization by turning novel or complex obstacles into opportunities. This suggests that cognitive processes underlying behavioral plasticity, including perception, learning, and problem solving, may be especially important in urban environments and under selection for many species. Here we review recent investigations of the cognition of a successful urban adapter, the raccoon (Procyon lotor), and consider how its "street smarts" modulate flexible behavioral responses in the face of urban challenges. We also make inter and intraspecific comparisons of behavior and cognition to illustrate how different strategies appear to support urban adaptation. Finally, we consider how heterogeneity in urban environmental conditions stemming from societal inequities (e.g., food waste, pollution burden, impervious surface cover) might impact animal behavior and cognitive ability across neighborhoods. The results of this work not only contribute to our growing understanding of how urbanization shapes the cognition and behavior of wildlife, but can also help promote human-wildlife coexistence and conservation in cities.

Revealing diurnal rhythms in fecal glucocorticoid metabolites in white-faced capuchins

Walker Stanton, Jacinta Beehner, Juan Carlos Ordoñez, Elena Morera Saborio

Internal clocks regulate the secretion of many hormones. Glucocorticoids, which influence metabolism as well as immune and inflammatory responses, typically follow a strong circadian rhythm in most diurnal species, peaking near waking and declining throughout the day. This pattern is well-documented in plasma, saliva, and urine in humans and non-human animals. By contrast, evidence for such circadian rhythms in fecal metabolites remains limited. One challenge is the considerable lag-time between peak plasma glucocorticoid levels and peak fecal glucocorticoid metabolites (fGCMs) in many species, which may obscure fine-grained variation in glucocorticoids. However, evidence from our lab indicates that white-faced capuchins (Cebus imitator) show a relatively rapid increase in fGCMs following a strong stressor, with peak levels emerging within 3-4 hours. This opens the possibility of detecting circadian rhythms in downstream hormone metabolites. Here, we analyze six years of fGCM data collected from a wild white-faced capuchin population in Costa Rica. Using linear mixed-effects models and a reaction-norm framework, we find a modest but highly significant diurnal decline in fGCMs. While individuals differ in their baseline fGCMs, they do not vary in the slope of the diurnal decrease, as random slopes did not improve model fit. We discuss both within- and between-individual variation in these diurnal patterns and consider what they reveal about the stability and flexibility of glucocorticoid regulation across environmental contexts.

Multiple performance surfaces show different biomechanical rules for smaller Eulipotyphla (Mammalia)

Tristan Stayton, Stephanie Smith, Kenneth Angielczyk, Joseph Guillen, Nina Kent

Extant terrestrial mammals vary in mass across seven orders of magnitude. Such variation is necessarily accompanied by variation in the relative areas of supporting elements. This leads to some well-known allometric patterns, but such patterns are primarily derived from relatively large taxa. The smallest species have been the subject of far fewer studies, and with unique limits on trabecular size and vertebral shape, may follow different biomechanical "rules". Here we examine these patterns in Eulipotyphla (shrews, moles, hedgehogs), which includes many of the smallest extant mammals. We use two performance landscapes to test whether smaller taxa occurred in regions of morphospace associated with lower strain, rather than lower stress. The first landscape was developed from theoretical models of the centrum. The number, diameter, and orientation of simulated trabeculae were varied in otherwise-identical finite element (FE) models. Axial compression, unilateral bending, and torsion were modeled, and mean von Mises stress and total strain energy were extracted. The second, empirical, landscape was developed from a principal components analysis of shape data for a sample of over 80 Eulipotyphlan specimens. The surface was built from FE models of actual specimens and the same three load cases and performance measures. Preliminary data from both analyses indicate that smaller taxa are more associated with strain-minimizing morphologies, supporting the hypothesis that smaller mammals do evolve by different biomechanical rules.

Female reproductive state corresponds to brain gene expression and chromatin organization in guppies

Helen Stec, Grace Zhang, Ben Sandkam

In many vertebrates, reproductive cycles drive physiological changes that prime organisms engage in certain behaviors at specific times. Hormones are

central to this process, coordinating transitions between reproductive states. Although fluctuations in circulating hormones are known to correspond with differences in brain gene expression, the mechanisms linking reproductive cycles to transcriptional regulation remain unclear. One mechanism through which hormones alter gene expression is chromatin remodeling, which determines whether genomic regions are transcriptionally active or silent. As hormone levels fluctuate across the reproductive cycle, chromatin may become more or less accessible, potentially regulating gene expression. To test this, we measured chromatin accessibility, gene expression, and estradiol levels across three reproductive states (virgin, gravid, parturition) in female guppies (Poecilia reticulata). We found that chromatin accessibility varied strongly across reproductive states. Estradiol levels were negatively correlated with chromatin openness, with gravid females displaying lower estradiol but more accessible chromatin. Gene enrichment also varied with state, with gravid females enriched for chromatin condensation, while virgin and parturition females enriched for hormone secretion and signaling pathways. These results demonstrate that the reproductive cycle dynamically reconfigures chromatin accessibility, shaping gene expression that enables and constrains state-dependent behaviors.

Barred Owl range expansion and elevational segregation with Northern and California Spotted Owls

Sydney Steel, Lucas Kazmierski, Tanya Dewey

In August 2024, the U.S. Fish and Wildlife Service (USFWS) finalized its strategy for addressing the threat to northern and California spotted owl (Strix occidentalis caurina and S. o. occidentalis) survival and recovery from invasive barred owl (Strix varia) competition: the lethal removal of roughly half a million barred owls across Washington, Oregon, and California. However, the mechanisms of barred owl range expansion and the rangewide consequences of this new competitor for the endangered spotted owl remains relatively unexplored. We hypothesized that barred owl range expansion would show temporal patterns consistent with climate warming and that the two species would occupy different elevational ranges where they co-occur. Using Global Biodiversity Information Facility (GBIF, gbif.org) data, we created occurrence maps of the distributions of each species in roughly 50 year intervals from 1838-present. We then conducted a t-test of the elevational range of each species and found strong support (p-value < 0.001, mean difference = 677.3 meters) that barred owls (n = 195,771) occur at lower elevations than spotted owls (n = 31,379). Additionally, we demonstrated that the barred owl's range expansion was spatiotemporally consistent with historical warming trends in the northern boreal forests. We believe this highlights the importance of future research into the influence of variations in vegetation or physiographic conditions on competition between barred and spotted owls.

Methylene blue increases survivability and inhibits blastema regeneration in Dugesia tigrina

Jordan Steele

Methylene blue is a synthetic organic compound that is widely used in clinical settings. Its applications include surgical staining, treatment for cyanide poisoning, and therapy for methemoglobinemia. The compound's physicochemical properties, including its low molecular weight, polarity, and ability to act as a redox-active electron carrier, enable it to interact with mitochondrial pathways and cellular signaling mechanisms. These features have made MB a potential candidate for addressing mitochondrial dysfunction and neurodegenerative diseases. In this study, we evaluated the effects of MB on regeneration and survival in Dugesia tigrina. Planarians are a well-established model for regeneration research due to their ability to restore complex tissues, including the central nervous system. To assess the influence of MB on regeneration, we exposed decapitated planarians to varying concentrations of MB and monitored the blastema area. The new growth starts as a blastema, a mass of undifferentiated cells capable of dividing into specific tissues, such as neurons and eyespot photoreceptors. To better understand the properties of MB, we also observed the long-term survivability of the worm in varying concentrations of MB without decapitation. Our results suggest that MB may enhance tissue regrowth by increasing blastema size and improving survivability throughout regeneration. These results support the hypothesis that MB promotes neural regeneration, potentially through mitochondrial or redox-associated mechanisms.

Early social manipulations test behavioral mechanisms of phenotypic development in a cichlid fish

Eliyah Stern, Ailinh Nguyen, Bernice Sule, Adya Patil, Alyssa (Aly) Alvey, Tessa Solomon-Lane

Early-life social experiences impact behavioral phenotypes later in life. We examined the behavioral mechanisms underlying social and neuroendocrine development in the highly social cichlid, Astatotilapia burtoni. We previously showed that the number of social partners and stability shape development. Here, we manipulated social partner number (1-2 vs. 6-8), group size (pairs vs. groups), and stability (stable; familiar: known individual re-introduced every 5 days; socialized: novel fish introduced every 5 days). Juveniles developed in treatment groups for five weeks, followed by individual behavioral assays (open field exploration, social cue investigation, dominant and subordinate behavior) and water-borne hormone collection. We expect juveniles with more social partners to engage in higher levels of investigation, exploration, and interaction when dominant. We also expect juveniles that experienced more social change to display lower cortisol and higher dominance scores, and to spend less time in the territory. Familiar tanks investigate whether the effects of social change are reliant upon social partner novelty. If social change drives development, for example, we expect juveniles in familiar pairs to resemble socialized pairs. If social partner novelty drives development, however, we expect familiar pairs to more closely resemble stable pairs. We do not expect an effect of group size. This study tests the effects of specific, nuanced early-life experiences, contributing to our understanding of early-life social complexities and their long-lasting effects on phenotype.

Using photobehavior to identify branchiopod crustacean luminance and color neural circuits

Brian Stevens, Paige Huffman, Maria Gaughan, Nicolas Lessios

Studies to date show branchiopod crustaceans most likely have four spectral photoreceptor classes ranging in sensitivity to light from ultraviolet to red wavelengths in their compound eyes. Branchiopod crustaceans are well known to use light cues in their habitats for orientation and positioning behavior. Here, we present behavioral results that support multiple spectral photoreceptor classes are used for phototactic behavior. We present results from Streptocephalus mackini, a species of fairy shrimp crustaceans (Anostraca), as well as from Triops longicaudatus, a tadpole shrimp crustacean (Notostraca). Behavioral tests examined the responses to wavelength and intensity from crustaceans reared in a greenhouse with natural sunlight including ultraviolet light. We tested crustaceans in testing chambers made of UV-transmissive plastic (PetG). Light stimuli came from a 300 Watt Xenon arc lamp, and was filtered using interference, and neutral density filters. Our results indicate positive phototaxis (movement towards a light source) in tadpole shrimp responses to ultraviolet light, but this switches to negative phototaxis (movement away from a light source) when broad spectrum light including both ultraviolet and visible light is used. These results suggest there are most likely dedicated luminance vision neural circuits from ultraviolet photoreceptors in branchiopod crustacean visual systems, and that more work is needed to understand how they process ultraviolet visual responses when visible light is also detected.

The eyes have it: manipulating sensory input affects neophobia in house sparrows

Kathryn Stewart, Allison Morales, Christine Lattin, Marquise Henry, Victoria Coutts

House sparrows (Passer domesticus), an invasive songbird and human commensal, provide a model for investigating how sensory processing shapes behaviors such as neophobia, or novelty avoidance. Avian brains are highly lateralized, with near-complete optic nerve crossover, allowing us to test hemisphere-specific responses to novel stimuli. Prior work suggests the right

hemisphere (left eye) specializes in processing threatening and novel stimuli, while the left hemisphere (right eye) supports routine tasks. Here, we tested how temporary monocular occlusion influences neophobic behavior in house sparrows. Immediately before novel object trials, opaque cloth eyepatches were placed over the left eye, the right eye, or on top of the head (as a control) and sparrows exposed to several days of neophobia trials where food dishes were presented with novel objects (or food alone for controls). After 1 h trials, eyepatches were removed. Each sparrow was tested with both control and either left or right eyepatches, in random order. Preliminary findings show that left eye occlusion significantly reduced neophobia compared to control eyepatches, while birds with a right eyepatch did not behave differently than controls. Feeding behavior when food dishes were replaced without novel objects was not affected. This study suggests that sparrows that were unable to assess novel objects using their left eye no longer perceived these objects as novel/threatening, highlighting the role of lateralized sensory perception in animal behavior.

Inferring 'the sister to the stinger' using phylogenetic methods at the cell-type level

Marina Stoilova, Michael Connelly, Jasmine Mah, Paulyn Cartwright

The stinging cells (cnidocytes) of cnidarians (corals, jellyfish, and anemones) are an evolutionary novelty of the clade. These cells contain explosive structures called cnidocysts, which often deliver a cocktail of toxins upon firing. The morphology, contents, and function of cnidocysts are highly diverse, but the precise evolutionary and developmental origin of cnidocytes remains uncertain. Cnidocytes and neurons share developmental regulators, as well as the presence of sensory structures and electrophysiological activity. Additionally, the secretory payload of cnidocytes resembles that of digestive gland cells. This suggests that cnidocytes could share evolutionary history with other sensory and secretory cell types in cnidarians. Single-cell transcriptomics has provided a wealth of information about animal cell type diversity. This has given rise to comparative methods that aim to disentangle the relationships between different cell types. One such approach infers cell phylogenies by using principal components (PCs) from single-cell RNA sequencing datasets (scRNA seq) as phylogenetically informative characters. Here we report the progress of such analyses, adapted to disentangle the relationships between sensory and secretory cell types across cnidarian cell atlases. This phylogenetic approach to investigate cell type origins can help to better understand how novelties arise and provide a new framework to test fundamental questions in the evolutionary history of distinct cell types.

How do breeding behaviors and reproductive success vary with parental age in a free-living songbird?

Emily Stonecipher, Samuel Lane, Rachel Bockrath, Emma Moerke, Hailey Wimberly, Bethany Bespoyasny, Britt Heidinger

Parental care is well studied in avian behavior and is known to play a critical role in the reproductive success of individuals. However, we still don't know how aging affects the expression of this behavior. Older adults likely have greater experience than younger adults but may also be physically compromised by senescence. Additionally, many studies examining age's role in animal behavior have used a cross-sectional structure, limiting our understanding of how behavior and reproductive success change as an individual ages. Longitudinal studies that follow individuals throughout their lifetime are necessary to determine how aging impacts parental care behaviors. In the current study, we followed individual house sparrows (Passer domesticus) across years and collected behaviors for known-age individuals that were banded as nestlings in the focal population. Each year during the breeding season, we recorded parental care and reproductive success to study the effects of aging on behavioral and fitness. This study will add insight into the impact of breeding experience and aging on parental care behaviors in house sparrows and allow us to compare cross-sectional and longitudinal changes in animal behavior.

Aquarium-based conservation breeding of critically endangered *Pycnopodia helianthoides*

Tallulah Story, Elora López-Nandam, Mariah Evin, Jessica Witherly, Margarita Upton, Kylie Lev

Beginning in 2013, sea-star wasting disease (SSWD) caused widespread mortality among various Asteroid species, including the keystone kelp forest and intertidal predator Pycnopodia helianthoides. Wild populations have declined by up to 99% in their native range along parts of the Pacific coast as SSWD continues to threaten the species' persistence. In response, a multi-institutional conservation breeding and rearing program has been initiated to support future restoration efforts of the species. The first aquarium-spawned cohort of the initiative, derived from two wild-sourced individuals, were raised under varying larval densities (1 larvae/ml, 2 larvae/ml, 5 larvae/ml, and 15-20 larvae/ml) to assess the effects of rearing conditions and husbandry practices on juvenile fitness, settlement, and survival. Stars raised in the highest density treatment displayed a lower settlement rate and were significantly smaller than the other density groups at 10 months old, but showed no significant difference in flip time, a measure of fitness. Additionally, measurements of diameter, weight, and arm count across modern and historical juvenile and adult stars indicate that P. helianthoides experience exponential weight gain as they grow in length, with corresponding asymptotic growth in arm count as they grow in length. These findings will inform best practices for the aquarium propagation of P. helianthoides and will contribute to broader efforts aimed at reestablishing populations in the wild.

Effect of temperature extremes on blood glucose levels in Eastern Bluebirds

Sunny Stout, Sarah Knutie, Jennifer Houtz

Climate change has increased the frequency of unpredictable extreme weather events, such as cold snaps and heat waves. Warmer temperatures occurring earlier in the spring signal to birds to initiate egg laying earlier. Earlier incubation dates put altricial nestlings at an increased risk of experiencing stochastic weather events. Wild birds can deal with variable temperatures by changing physiological processes that underlie metabolism and growth such as blood glucose levels. Nestling birds may be more susceptible to temperature depending on the developmental point of exposure. For example, temperature fluctuations during the early nestling stage before feather growth may influence hematological parameters and nestling growth dramatically. I experimentally raised and lowered nest temperature from hatch day to day 10 of nestling development to simulate stochastic weather events during the nestling stage in Eastern Bluebirds (Sialia sialis). I hypothesized that post-hatch temperatures influence the development of physiological traits (e.g., blood glucose) vital for thermoregulation. I predicted that lower temperatures post-hatch would decrease blood glucose levels, while increased temperatures would increase blood glucose levels. There was no effect of post-hatch temperature on nestling glucose levels. This research may offer a deeper understanding of how wild birds may physiologically adapt to temperature extremes, aiding in future conservation efforts for species particularly susceptible to climate change.

Using hydrodynamic analysis of a North Atlantic Right Whale to identify optimal tag locations

Joseph Stoveken, Brooke Flammang, George Loubimoc

The North Atlantic Right Whale (NARW) is considered critically endangered, with fewer than 370 individuals left in the population. Conservation efforts have been largely constrained by difficulties in obtaining accurate real-time tracking of individuals for a number of reasons, including limited attachment times achieved by state-of-the-art tag models. Tag attachment locations are mostly opportunistic and dependent upon factors like animal position, sea state condition, and tagging method employed. Based on our previous work looking at the fluid dynamics of a blue whale, we hypothesize that there are optimal locations for tag placement on the NARW that could greatly extend tag attachment times. Experimental analysis of currently employed tags gave us data on the hydrodynamics, using particle image velocimetry, and measured lift and drag forces that result in tag attachment failure at a range of angles of

attack. Then, using computational fluid dynamic analyses, we explored the three-dimensional velocity and pressure fields around the body of a static model of a NARW to determine the locations that would offer the best hydrodynamic conditions to extend tag attachment time.

Digging up trouble: complex relationships between fossorial behaviors and extinction risk in mammals

Sarah Strassberg

As anthropogenic climate change and habitat destruction proceed, it is increasingly important to understand the ecology-extinction susceptibility relationship, which remains largely enigmatic in tetrapods. Mammalian fossoriality has been posited as a universal buffer against extinction because digging facilitates access to novel food sources, shelter from climatic extremes and predation, and protection for offspring. However, it is well documented that ecological generalists often outsurvive specialists during mass extinctions and environmental upheavals, necessitating further inquiry into potential drawbacks of fossorial specialization. Here, I survey degree of fossorial specialization (non-fossorial, semifossorial, fossorial, and subterranean categories as a proxy for morphological and behavioral specialization), ""exploitative fossoriality"" (i.e., utilization of existing burrows, crevices, etc.), IUCN Red List status, population trend, body size, geographic range size, and sociality across 3,389 extant terrestrial mammal species. Phylogenetic regressions conducted using Bayesian inference indicate that subterranean species are uniquely poorly documented but the least at risk among well-studied species, whereas exploitative fossoriality is universally protective. Rodents tend to drive overall patterns and exhibit different trends than other clades: rodent fossors are at lower risk overall, whereas low to moderate degrees of fossorial specialization are associated with elevated risk status and population decline among non-rodents. These non-linear, clade-specific relationships between fossorial behaviors and extinction risk indicate a need for a heterogeneous approach to identifying at-risk groups and conserving ecologically crucial fossorial mammals.

Stimulating multisensory descending interneurons in Drosophila modulates wing and haltere stroke

Amy Streets, Jennifer Lai, Benjamin Gorko, Marie Suver, Sung Soo Kim, Jessica Fox

During navigation, flying flies need visual and mechanical feedback to control their body in a turbulent environment. Visual feedback provides optic flow, and mechanical feedback is provided by the antennae, which detect airflow, and the halteres, a pair of reduced hindwings. Descending visual input activates the haltere steering muscles, and recent behavioral data suggests that antennal mechanosensation may also drive haltere muscle activity, modulating the state of the halteres and altering sensory feedback. However, the identities and activities of the descending interneurons that stimulate the haltere motoneurons are unknown. Using the connectome, we identified a pair of descending neurons, DNp22, which receives visual and antennal mechanosensory information and sends information to the wing and haltere steering muscles. Using optogenetics, we activated and silenced DNp22 in flying flies while measuring their head, wing, and haltere movements with high-speed video. We also performed two-photon calcium imaging to measure DNp22 activity during flight. We found that DNp22 activation results in changes in wing amplitude, as well as head movement and haltere stroke changes. Additionally, activating DNp22 causes quiescent flies to move their halteres. Calcium imaging experiments showed that DNp22 is active during saccade-like maneuvers in tethered flight. Taken together, these results suggest that DNp22 may actively mediate multi-sensory integration between the antennae and halteres, and can be used to control wing-steering behaviors that result from this sensory input.

Methodological considerations in the use of mandibles as a proxy for vertebrate feeding mode

Catherine Strong, Stephanie Pierce

Given the different fluid properties of water versus air, aquatic versus terrestrial environments require different strategies for food capture and ingestion. Consequently, the vertebrate water-to-land transition ~380 Mya is typically construed as a shift from aquatic suction-feeding to terrestrial biting-based feeding. To study this transformation, quantitative studies of early tetrapod feeding mechanisms often use the mandible as a proxy for overall feeding mode, reconstructing broader trends in form and/or function using morphometric and/or biomechanical data collected from two-dimensional mandibular silhouettes. However, this widespread approach raises key methodological questions, specifically concerning the utility of 2D versus 3D models, morphological versus functional data, and mandibles themselves as a reliable proxy for overall feeding mechanisms. In this study, we provide a 'ground-truthing' of these methods via an ecomorphologically-diverse dataset of extant vertebrates (n ≈ 100 species of fishes, salamanders, and turtles) exhibiting various feeding modes. Using both 3D meshes and 2D silhouettes of each specimen, we first assess whether 2D datasets entail any inherent loss of morphofunctional signal. Next, we compare morphological versus functional data, to determine whether these inputs provide consistent and informative signals regarding transitions in feeding mode. Finally, we discuss the overall utility of mandibles in deciphering water-to-land transitions, with our dataset revealing complex one-to-many and many-to-one mapping across clades. Altogether, our research provides rigorous methodological grounding for future studies of mandibular form and function.

A multi-species field study of Arnold's morphology-performance-fitness paradigm

James Stroud

Arnold's morphology-performance-fitness paradigm provides the theoretical foundation for studying adaptation in the wild, yet comprehensive field tests of this complete framework remain rare. Most field studies of natural selection examine only morphology-fitness relationships, bypassing the critical performance component and interpreting results through assumed form-function relationships. However, natural selection acts on performance capacities rather than morphology directly, making performance measurements crucial for understanding the actual targets of selection. Additionally, field studies of multiple coexisting species that differ in ecomorphology are needed to understand how species with different ecologies and morphologies experience adaptation—whether they face selection on the same or different traits, experience different performance demands, and how these processes generate and maintain biological diversity. Here, we conducted a comprehensive investigation of the entire morphology-performance-fitness paradigm across a community of five coexisting Anolis lizard species with distinct morphology-performance relationships. We quantified multivariate morphology (limb lengths, head shape, toepad size, and claw morphometrics), measured four ecologically relevant performance traits (sprint speed, clinging force on rough [bark] and smooth [leaf] surfaces, and bite force), and determined fitness via survival in 761 wild individuals. This study provides a multi-species field test of Arnold's complete paradigm, revealing how morphology-performance-fitness relationships vary among coexisting species. Our findings reveal the mechanisms underlying natural selection in complex multi-species ecological communities and demonstrate the importance of integrating performance measures into evolutionary field studies.

Aquatic and terrestrial locomotor forces in the common snapping turtle (Chelydra serpentina)

Thomas Stroud, Dylan Anderson, Mikayla Struble, Kaelyn Gamel, Henry Astley, Alice Gibb, Christopher Mayerl

Successful locomotion is achieved through interactions between propulsive structures and the external environment. Between water and land, changes in external loading regimes facilitate shifts in the mechanics and functional roles of forelimbs and hindlimbs. Generally, limb-based aquatic propulsion is driven by forelimbs during swimming, whereas hindlimbs typically drive terrestrial

walking. Disentangling the impact of the environment from the impact behavior on locomotor function can thus be challenging, suggesting a need for a model in which similar structures and movements are used in both environments. Turtles represent an excellent model to explore this, as some species employ a walking gait in both environments. We collected synchronous kinematics and forelimb and hindlimb force generation of the common snapping turtle (Chelydra serpentina) during terrestrial and aquatic locomotion. We found that on land the forelimbs produced braking and laterally oriented forces, whereas the hindlimb produced propulsive and medially oriented forces, with similar vertical forces for both limbs. Patterns were similar in water, albeit with reduced vertical and mediolateral forces. These results indicate that while underwater walking may qualitatively resemble terrestrial walking, there is variation in locomotor function that results from the interaction between how vertebrates interact with both the higher density and viscosity of water compared to land.

Behavioral plasticity and fitness of dark-eyed juncos in post-wildfire coniferous forests

Yiran "Ryann" Su, Jacob Johnson, Thomas Hahn, Andrew Sih

Large-scale wildfires are major ecological disturbances that alter resource availability and community structure. Animals that survive in post-fire habitats may adjust their behavior to mitigate fitness challenges. In this study, we investigated how post-fire environments affect the behavior and fitness of dark-eyed juncos (Junco hyemalis), a generalist songbird species. From male juncos in post-fire and undisturbed coniferous forests in northern California, we collected behavioral (aggressive response frequency and flight initiation distance), morphological (body size and mass), and reproductive (offspring number) data. Results show that, while juncos in the two types of habitats had similar body conditions and reproductive success, those in post-fire habitats were significantly more aggressive toward simulated territorial intrusions and more risk-prone toward simulated predator encounters. The heightened aggression and boldness may provide advantages in territory defense and competition for limited food resources in post-fire forests, highlighting the role of behavioral plasticity in compensating for environmental disturbances.

Patterns of character congruence shed light on the diversity of the bony palate in extant birds

Giles Sukkert, Corwin Sullivan

Molecular studies of avian phylogeny have confirmed the existence, reflected in older, morphology-based classifications, of two major monophyletic lineages, Paleognathae and Neognathae. Traditionally, zoologists emphasized differences in the bony palate between the two groups, with paleognaths described as having a plesiomorphic, 'reptilian' palate and neognaths as having a variety of derived palatal configurations, termed aegithognathous, desmognathous, and schizognathous. The neognath palatal types are homoplastically distributed, in that they are not synapomorphic for clades within Neognathae. We mapped individual osteological characters that contribute to defining the four avian palatal types onto a recent molecular phylogeny. Some states associated with the paleognathous condition, such as the presence of fully developed basipterygoid processes, are also seen in a variety of neognath taxa. States associated with schizognathy and desmognathy, such as the absence or presence of a median contact between the maxillopalatines, similarly fail to map neatly onto clades appearing in the phylogeny. However, new complexes of palatal features are recognized that characterize Paleognathae, Galloanserae, and Neoaves, but do not correspond to the traditional palatal types. Furthermore, the neoavian palate has been further modified to produce distinctive configurations in some subclades within Neoaves, notably Passeriformes, Pelecaniformes, and Piciformes. The diversity of palatal morphologies ultimately arose through the reconfiguration of dermatocranial, chondrocranial, and splanchnocranial elements among avian lineages, and we further examined these reconfigurations in the light of phylogeny.

Testing the role of thyroid hormone signaling in regulating opportunistic breeding

Ella Summers, Jonathan Perez

While seasonal breeding mechanisms have been intensely studied, opportunistic breeding mechanisms remain underdescribed posing barriers to understanding how these organisms may respond to rapidly changing environmental conditions. Localized modulation of thyroid hormone signaling has emerged, across seasonally breeding vertebrates, as a key regulator of reproduction. Specifically, activity of deiodinase enzymes type two (DIO2) and three (DIO3) control levels of bioactive T3. In seasonal breeders DIO2 increases in response to long days. However, it has been unclear if changes in deiodinase activity play a role in opportunistic breeders. Previous work from our group showed an increase in DIO2 expression when breeding was suppressed by water restriction in Zebra Finches. The Zebra Finch, (Taeniopygia guttata) is a well known opportunistic breeder, making it the ideal species for characterizing the role of thyroid signaling in regulating the reproductive axis within opportunistically breeding organisms. In this study, we utilize administration of exogenous T3 to breeding zebra finches to pinpoint the causal effects of increased T3 on reproductive physiology. Based on preliminary data, we expected that addition of T3 will alter hormones responsible for breeding such as GNRH-I, LH, and FSH resulting in reduced rates of egg laying.

Integrative taxonomy of five new carnivorous sponge (Demospongiae, Cladorhizidae) species

Samantha Surges, Camille Leal, Allen Collins

Progress in characterizing deep sea Porifera is being enhanced by recent collections and new technologies alongside the application of old techniques. While most sea sponge species possess an aquiferous system for filter feeding, the deep-sea carnivorous sponge family Cladorhizidae exhibits modified feeding techniques for low-productivity benthic environments. Microscopic silica skeletal appendages, known as spicules, allow these sponges to capture prey that is subsequently engulfed. Spicules are also the basis for taxonomic descriptions and diagnoses within the family. Five specimens sampled from various cruises associated with Deepwater Horizon Mesophotic and Deep Benthic Communities restoration and NOAA Ocean Exploration projects in Puerto Rico, Alaska, Key West Scarp Strait, and off the western coast of Florida were used to assess taxonomy. Spicule morphology and skeletal organization were documented, measured, and microphotographed with a Scanning Electron Microscopy (SEM) to diagnose and describe the species. Phylogenetic analyses were also conducted, using the nuclear ribosomal large subunit (28S), the mitochondrial cytochrome oxidase (COX1) gene, and ultraconserved elements (UCE), generating phylogenetic hypotheses. Integrating these morphological and genetic results, we diagnosed and described five new distinct Chondrocladia species. One species may belong to its own new genus according to its distinct morphological structure and our phylogenetic tree results. Accurate taxonomy is the foundation for understanding deep-sea ecosystems and can help guide conservation and restoration activities.

Thermoregulation during the natal molt of northern elephant seals (*Mirounga angustirostris*)

Rachel Survilas, Halley Carson, Heather Liwanag

A vital life history stage for many animals is molting, or renewal of the outer layer (feathers, hair, skin, or shell). Like other pinnipeds (seals, sea lions, walrus), northern elephant seal (NES) pups are born with lanugo (neonatal fur) that they molt into a juvenile coat after weaning. The transition between pelts is likely to affect the thermoregulation of these pups. One thermoregulatory strategy available to NES is to increase blood flow to specific body regions (called "thermal windows") to help dump excess heat. The goal of this study was to examine whether NES pups use thermal windows to facilitate their natal molt. To investigate this, we used a thermal imaging camera to take thermograms of molting NES pups at the Piedras Blancas rookery. We recorded concurrent environmental variables (wind speed, air temperature, solar radiation, and substrate temperature) to determine which factors impacted molting pup thermal profiles. We found that pup thermal windows were not associated with

molted regions; thermal windows were found primarily in low insulation areas (head and flippers) and randomly along the trunk. Wind speed negatively affected the presence of thermal windows, whereas higher ambient temperature and solar radiation increased overall surface temperature. This is the first study to investigate thermoregulation during the natal molt in NES. Future work will compare these results to the catastrophic molt of older age classes.

Spin scaling in grasshoppers and crickets

Gregory Sutton, Shannon Harrison, Chloe Goode

Grasshoppers and crickets use different methods to actuate their spectacular jumps. Grasshoppers use a ' latch mediated spring actuated' mechanism, which first stores mechanical energy in a hard cuticular spring, and then releases the energy to actuate the jump. In contrast, crickets jump by using their muscles to actuate their legs. We examine the effect of the jumping mechanism (muscle actuated or spring actuated) on jumping Grasshoppers (Schistocerca gregaria) and crickets (Mecopoda elongata) over 2.5 orders of magnitude of size (10 mg to 2.5 g) ability to generate spin. In both insects, the angular velocity was smaller for larger insects, (grasshopper angular velocity scales with mass^-0.24; cricket angular velocity scales with mass^-0.12). Analysing how energy was distributed revealed an invariant between the two species: Both insects (of all sizes) had 1.3% devoted to rotational kinetic energy and 98.7% of their energy devoted to kinetic energy. Moreover, this 1.3% can be reduced to 0% by adding a small amount of mass to the animal. Based on this data we suggest that spin is a desirable outcome for a jumping insect. Moreover, there is an optimal amount of spin, such that the spin is 1.2-1.3% of the energy of a jump

How does a bird brain respond to a cold world? Transcriptomic insights from Dark-eyed Juncos

Serina Suzuki, Maria Stager, Cory Elowe

Dark-eyed juncos (Junco hyemalis), commonly known as ""snowbirds,"" exhibit remarkable capacity for cold acclimation. Previous studies have revealed that their peak oxygen consumption under cold exposure (Msum), a proxy for thermogenic capacity, increases significantly within one week of cold acclimation, reducing hypothermia risk. While peripheral mechanisms supporting this acclimation ability have been studied—including enhanced cellular aerobic capacity—the central neural mechanisms orchestrating these adaptations remain understudied. We investigated brain-level mechanisms underlying cold acclimation by exposing wild-caught juncos to temperatures of either 25 , 15 , 5 or -5 for one week. Juncos were housed in metabolic phenotyping chambers. During acclimation to temperatures below 25 , Juncos increased oxygen consumption, elevated food intake, and maintained body weight and body temperature. Building upon these peripheral responses, we characterized gene expression of the hypothalamus, the primary thermoregulatory center in vertebrates. We conducted RNA-sequencing of hypothalamic tissue and identified differential gene expression between temperature treatments. Additionally, we employed immunohistochemical techniques to assess neurogenesis and neuroactivity markers, combining transcriptomic and protein expression data for comprehensive analysis. This integrative approach examines whether rapid peripheral cold acclimation responses are coordinated by specific hypothalamic gene expression networks and whether cold exposure induces structural neural plasticity through neurogenesis. Understanding these central mechanisms is crucial for comprehending avian adaptation to climatic conditions and provides insights into environmental challenge responses.

Bloom battles: bacterial regulation of the Emiliania huxleyi microbiome

Sophia Swaddipong, Aasha Page, Naren Pedirappa, Maia Poremba, Kristen Whalen

Phytoplankton bloom dynamics are shaped by mutualistic interactions with bacteria, which supply nutrients and vitamins in exchange for host-derived organic carbon. Chemical information between species is exchanged in the microenvironment surrounding phytoplankton hosts, termed the phycosphere. These complex, chemically-mediated interactions between bacteria and phytoplankton significantly impact host health. However, the identity of these infochemicals remain largely unknown. This study examines interactions between the global coccolithophore Emiliania huxleyi and associated bacteria, Sulfitobacter, Marinobacter, Phaeobacter, and Pseudoalteromonas species. Marine Pseudoalteromonas species prey on phytoplankton, dominate late-stage E. huxleyi blooms, and produce secondary metabolites that affect host growth and microbial community dynamics. This study seeks to identify bacterial or host metabolites boosting Pseudoalteromonas fitness in the phycosphere. From 1,500 bacterial isolates, we selected 12 representatives of the E. huxleyi phycosphere. Antagonism between Pseudoalteromonas sp. (A757) against competitors was assessed via agar-based plate assay. Here, the optimal relative cellular ratio between competitive bacteria was determined by measuring zones of inhibition and/or changes in A757 morphology. Next, permeable membrane assays determined effects of non-contact, chemically-mediated exchanges on A757 and competitor populations. Finally, tripartite interactions between bacteria and host were monitored in plate and liquid cultures, elucidating chemically-consequential exchanges for exploration by metabolomic screening. This work aims to identify the chemistry that regulates pathogenicity in phycosphere communities and determine the influence of algal host's physiological state on bacterial lifestyle.

Getting a head in the deuterostomes

Billie J. Swalla

Chordata evolved within the Deuterostomia, and the extant invertebrate chordates would suggest that the vertebrate head evolved only in the Vertebrata. However, in examining the Hemichordata, the adults have collagenous gill bars and anterior structures that express genes corresponding to the forebrain, midbrain and hindbrain. The midbrain genes are expressed in the neck region, where the mouth is located and the hindbrain genes are expressed in area of gill slits, in the abdominal section of the Enteropneusta. Therefore, all the anterior regions that specify the vertebrate brain regions were likely present in the Deuterostome ancestor. Hemichordates have collagenous gill bars and a proboscis skeleton that may be remnants of more extensive skeletons, such as is found in the Echinodermata. Therefore, the Deuterostome ancestor anterior was likely more complex and extensive than the present day invertebrate chordates, Branchiostoma lancelets (Amphioxus) and Tunicata. I will summarize the present research in this area and suggest where further studies are likely to be fruitful.

Cultural evolution of introductions in Williamstown Savannah sparrow songs

Kate Swann, Hannah Cumming, Heather Williams, Henry Alexander

Savannah sparrow (Passerculus sandwichensis) songs are an ideal model for studying cultural evolution, the population changes in socially learned traits. Male Savannah sparrows learn song components from various tutors. Each song has an introductory segment that varies between birds in interstitial notes (softer notes sung between the loud introductory notes), duration, and spacing. We analyzed changes within the introductory segments of a Savannah sparrow population in Williamstown, Massachusetts from 2005 to 2025. We scored the number of each interstitial note-type in each interval in the introductory segment. Low-pitched "chuck" notes, present since 2009, and three-peak amplitude "x" notes, present since 2005, increased in frequency over time. Two-peak amplitude "px" notes, present since 2005, decreased in frequency. Px notes declined significantly in the ante-penultimate interval, where they were replaced by chuck notes. The proportions of x and px notes remained constant in the final two intervals, where chuck notes are rarely present. In a playback experiment, male Savannah sparrows responded more aggressively to songs that included two or three introductory intervals with chuck notes. Savannah sparrows may be building complexity in their songs by including an additional note type, chucks, in interval two, while maintaining x and px notes in intervals zero and one. Our playback results suggest that increased complexity in the introductory segment of a Savannah sparrow song may improve a male's reproductive fitness.

Metabolic rates, body temperature and overwinter survival in Dark-eyed Juncos

David Swanson, Chelsi Marolf, Sampath Kumar Anandan

Flexibility in metabolic rates and body temperature (Tb) may influence winter energetics and overwinter survival for birds in cold climates. Few studies, however, have examined direct relationships between metabolic rates, Tb, and overwinter survival. We addressed this question by measuring basal (BMR) and summit (maximum cold-induced, Msum) metabolic rates in dark-eyed juncos (Junco hyemalis) in early winter in South Dakota and tracking overwinter survival of marked birds. We also attached temperature-sensitive radio transmitters to the skin of the back to monitor skin temperature (Ts) to determine if juncos used hypothermia. We hypothesized that juncos with higher BMR and Msum, indicative of greater thermogenic capacities, would demonstrate higher overwinter survival rates. We also hypothesized that juncos would show greater reductions in Ts during colder nights than during warmer periods. Neither BMR nor Msum differed between birds surviving the winter and apparent non-survivors, so metabolic rates were not related to overwinter survival, thus failing to support our hypothesis. This result contrasts with some studies of other passerines in cold winter climates, suggesting that early-winter metabolic rates may not consistently correlate with overwinter survival in small birds. A few juncos showed some evidence for greater reductions in Ts at colder temperatures, but other juncos did not, suggesting that hypothermia is not a consistent strategy promoting overwinter survival in dark-eyed juncos, as it is for some other passerine birds.

Investigation of S. marcescens disruption by Bd metabolites

Morgan Swanson, Jacob Kerby

The amphibian pathogenic fungus Batrachochytrium dendrobatidis (Bd), the causative agent of chytridiomycosis, has been linked to amphibian declines on a global scale. The presence of strongly antifungal microbial symbionts on the amphibian's skin has been noted to be strongly correlated with amphibian survival. The bacterium Serratia marcescens has displayed strong antifungal capabilities via the production of the characteristic secondary metabolite prodigiosin, regulated via several processes including the swrR/swrI quorum sensing system. While the mechanisms through which S. marcescens are able to inhibit Bd have been previously described, the ability of Bd to evade or reciprocally inhibit S. marcescens has not been examined. Here, we examined the ability of Bd metabolites to induce phenotypic and expressional changes in S. marcescens, specifically in regards to prodigiosin. The production of prodigiosin was measured in live cultures of S. marcescens grown in media containing metabolites isolated from live Bd cultures using UV-Vis spectrophotometry, and the expression patterns of the swrR/swrI quorum sensing operon, as well as closely associated genes, were measured using RT-qPCR. In the presence of Bd metabolites, a notable reduction in prodigiosin occurred as well as expressional changes in genes associated with the swrR/swrI system, indicating that Bd is capable of inducing behavioral changes in a noted antifungal symbiont.

Isolation and characterization of anti-Bd symbionts from L. pipiens

Morgan Swanson, Valeria Olivia, Evy Osterloo, Jacob Kerby

The fungal pathogen Batrachochytrium dendrobatidis (Bd) has caused mortality events in numerous species of amphibians and has been linked to population declines on a global scale. The disease infects via zoospores that populate the amphibian's skin and encyst, causing damage to the skin which can lead to ion transport inabilities, loss of heart function, and death. Since Bd infects cutaneously, a noted method of defense for the amphibian is the microbial symbionts it harbors on its skin. In South Dakota, amphibians have tested positive for Bd at sites across the state; thus, we expected there to be a high number of bacteria present in the microbiomes of these amphibians that are capable of inhibiting Bd growth. In this study, 18 Lithobates pipiens frogs were wild-caught at a single site in Southeast South Dakota. Skin swabs of the frogs were taken and allowed to proliferate on solid media to allow for colonies to be isolated. In total, 148 bacterial isolates were noted. Each isolate was screened for the ability to inhibit Bd growth via plate assay to measure zone of inhibition (ZOI) as well as via metabolite assay to examine which bacteria could produce metabolites capable of slowing Bd growth. Each frog sampled harbored bacteria that displayed some degree of anti-Bd capabilities, but several isolates displayed extremely strong anti-Bd capabilities, providing targets for future research.

Modeling the functional capabilities of the bat wing hair sensory network: Can bats fly by feel?

Sharon Swartz, Brooke Quinn, Noah Eckstein, Manoj Srinivasan

In flying animals, locomotor performance depends on the capacity to sense the external and internal environments and to respond with precisely timed, calibrated activation of muscles. However, the four lineages of flying animals vary in the relative importance of specific sensory modalities. The critical importance of hearing and vision for bats is well established, but we know less about the functional role(s) of the extensive network of sensory hairs on bat wings. To explore the potential of the bat wing hair network to function as an efficient sparse sensor system, we developed a modeling approach to test how variously distributed "sensors" might capture flight-relevant information. We created a 2D finite element model of an elastic membrane based on the material characteristics of bat wing skin and estimated local strains on the membrane during a simplified flapping motion. Positing that the hair sensors can sense these membrane strains, we show that a sparse collection of these noisy sensors is sufficient to estimate the aerodynamic forces on the wing. We consider wings of diverse shapes and sizes, and different numbers and distributions of the hair cells, and predict the effect on the overall accuracy of the estimated forces. Having an estimate of wing forces could help the nervous system obtain a better real-time estimate of body state, enabling dynamic flight control despite noisy muscles and neurons.

Re-examining the impact of phenotypic integration on convergence

Donald Swiderski, Miriam Zelditch

Phenotypic integration has often been proposed as a potential cause of morphological convergence. However, only one plausible mechanism has been proposed: iterative evolution along a conserved line of least evolutionary resistance, which would yield parallelism rather than descendants that more closely resemble each other than their ancestors did. Nevertheless, a recent study concluded that phenotypic integration can and does yield convergence. But that study analyzed evolutionary not phenotypic integration and in the analysis of evolutionary integration assumed Brownian motion, a model that fits two of the three empirical cases exceptionally poorly. We reexamine one of those empirical cases, mandibular shape of squirrels, using generally the same methods but applying them to phenotypic as well as evolutionary integration: fitting multiple models of modularity, then estimating the strength of integration within modules as well as the mean value of convergence module by module. We find no relationship between the strength of phenotypic integration and convergence; both the most weakly as well as most strongly integrated modules converge, but modules that do not differ in the strength of integration can differ in whether they converge. Moreover, even though tree and ground squirrels do not differ in their strength of phenotypic integration, convergence occurs only in the tree squirrel lineage. Evolutionary integration sometimes coincides with phenotypic integration, but it also fails to predict convergence.

Measurement and meaning of phylogenetic signal, with an example from ground squirrels

Donald Swiderski, Miriam Zelditch

It is well known that closely related species tend to be more similar than distantly related species, but it is much less clear what that pattern (phylogenetic signal) means for the interpretation of evolutionary transformations in a lineage. Assuming trait evolution fits the Brownian motion model, it is relatively easy to determine how well phylogenetic distances between species predict differences in trait values. The commonly used metrics (Pagel's λ and Blomberg's K) quantify how well the observed trait differences fit the expected

values. For both metrics, values different from 1 indicate departure from the Brownian motion model, but provide little additional information about that departure (e.g., are departures uniformly distributed or concentrated on particular branches). For high-dimension data like shape, there is also the possibility that some dimensions have more signal than others. In this study we examine phylogenetic signal for mandible shape in North American Marmotini. We previously showed that marmotine mandibles evolved in multiple directions and occupy five distinct adaptive peaks. Here we use recently developed methods to investigate differences in phylogenetic signal between subgroups and the implications of those differences. We find that the taxa that are most distantly related are the most different in mandible shape, but among close relatives, shape can be far more different than predicted, implying short-term departures from the general trend.

Parental care across embryo development in stable and newly transitioned males in *Lythrypnus dalli*

Abbie Symanietz, Samuel Issak, Makenzie Reed, Anthony Hinders, Jesus Venegas, Devaleena Pradhan

Parental care is a fundamental behavior for reproductive success and often emerges as an innate trait in nature. The bluebanded goby (Lythrypnus dalli) is a bidirectionally sex-changing marine fish that lives in harems composed of a single dominant male and multiple subordinate females. Males maintain dominance over a nest and perform all parental care, tending to embryos through waggling and rubbing behaviors. In all-female groups, the absence of a male triggers the dominant female to undergo sex change, leading to initiation of parental behaviors and a morphological shift in the genital papilla (from rounded in females to conical in males). We compared the behavior of stable (experienced) males and newly transitioned (inexperienced) males at two stages of embryo development. We defined early-stage development as 12–24 hours post-fertilization, corresponding to cleavage and blastula stages, and late-stage development as 24–48 hours prior to hatching, when embryos reached the pharyngula stage. To have early or late-stage embryos, experienced males took 4-14 days, while inexperienced males took 7-19 days. The delay in inexperienced males is due to time taken for nest acquisition and sex change. Our preliminary data show that by the early stage of embryo development, inexperienced males already display parenting behavior patterns statistically similar to experienced males. These results provide novel insights into the rapid onset of parenting associated with offspring developmental stages

MothBox: inexpensive, open-source, automated light trap for nocturnal insect monitoring

Hubert Szczygiel

Most of the world's species are insects, and most of those insects are active at night. However, cost-effective tools for monitoring nocturnal insects at landscape-scale remain limited. With biodiversity declining around the world, this kind of monitoring will be essential to track population dynamics and validate the success of conservation and restoration efforts. To address this gap, we developed the MothBox, an open-source, automated light trap that leverages low-cost hardware and computer vision. Designed for portability, low cost, and durability in harsh environments, MothBoxes have been deployed across hundreds of nights at dozens of sites in 8 countries. We have also been developing a custom 'Mothbot' machine learning image processing platform to process the large Mothbox datasets. Our initial versions were oriented around DIY principles, so that people could make their own Mothboxes anywhere in the world. Our latest iteration prioritizes mass production to facilitate landscape-scale monitoring. I also present a case study: deploying MothBoxes across an elevation gradient from sea level to over 1500 m. In addition to revealing ecological patterns, the data highlight the tool's potential for behavioral research. As trail cameras transformed mammal monitoring and AudioMoths revolutionized acoustic biodiversity surveys, MothBox aims to become a foundational tool for insect research and conservation.

Organismal robustness and resilience influence the ability to cope with cold snaps

Conor Taff, Daniel Ardia, David Chang van Oordt, Jennifer Houtz, Nicole Mejia, Thomas Ryan, Ryan Shipley, Jennifer Uehling, David Winkler, Cedric Zimmer, Maren Vitousek

Coping with challenges often requires maintaining performance during poor conditions (robustness) and reestablishing normal performance following disturbance (resilience). Trade-offs between performance under normal and challenging conditions may generate variation in stress coping capacity, but there is little empirical data from wild populations. We studied robustness and resilience to temperature in tree swallows (Tachycineta bicolor) using a 39 year dataset that included >75,000 hours of behavioral data. Cold snaps had profound and sustained impacts on fitness; effects on nestlings were mediated by the behavioral robustness and resilience of parents. Parental robustness was predicted by developmental cold exposure and current endocrine state. As expected, trade-offs between peak performance and behavioral robustness influenced susceptibility. Selection on trade-offs may generate population differences in vulnerability to changing temperature regimes.

New insights on the functional morphology of the pelvic fins in the northern spearnose pocaher

Natalia Taft, Marquanis Turner

Poachers (Family Agonidae) are a group of heavily armored, negatively buoyant fishes that routinely use their pelvic fins for a variety of weight-bearing behaviors, such as "perching" on their extended pelvic fins. Here, we use microCT scans of the northern spearnose poacher, Agonopsis vulsa, to investigate potential adaptations of the pelvic fins and girdle associated with routine weight-bearing behaviors. This species has two fin rays in the pelvic fin, one medial, one lateral, that articulate directly with the postero-ventral surface of the pelvis. The most lateral fin ray is actually composed of two separate but closely articulated structures, a soft fin ray and a superficial pelvic spine. The spine is significantly reduced, and serves primarily as an enlarged proximal head for the soft ray. The head has two condyles, separated by a narrow groove on its anterior surface. There is a corresponding tab-like projection on the pelvis with concave facets on either side. We predict that when the pelvic fin is extended, the anterior condyles on the head of the ray fit directly into the facets on either side of the tab on the pelvis. The tab fits directly into the groove between the condyles. We hypothesize that this "tab-and-groove" articulation serves as a mechanism to lock the pelvic fin into place, which stabilizes the fin when it is extended.

High protein diet increases susceptibility of Desert Locust, Schistocerca gregaria to Metarhizium bi

Syeda Tahir, Tamir Lichaa, Stephanie Nunez, Vu Mai Thy Nguyen, Nicholas Rolig, Reid Shniderman, Stefan Jaronski, Jon Harrison, Arianne Cease

Locusts are grasshoppers that exhibit density-dependent phase polyphenism and can migrate long distances in massive groups, causing devastating impacts on agriculture. Fungal Metarhizium spp. biopesticides may be a viable alternative to synthetic pesticides; however, challenges in their efficacy remain. Previous studies have shown diet-dependent effects of protein (p) to carbohydrate (c) ratios on immune responses and survival in locusts and grasshoppers infected with Metarhizium, but with conflicting outcomes. We tested the effects of macronutrient balance on the ability of the desert locust, Schistocerca gregaria, to combat and survive Metarhizium infection. Infected and control final instar locusts were restricted to carbohydrate-biased, protein-biased, or balanced diets. We measured phenoloxidase and prophenoloxidase activity, longevity, fungal sporulation, and quantified trehalose, glucose, and protein. Infected locusts restricted to a protein-biased diet died sooner and had the most fungal sporulation. Strikingly, they also had nearly two times less protein in the hemolymph compared with controls on the same diet, whereas differences were minimal on carbohydrate or balanced diets. These results suggest that high-protein diets may enhance the nutritional status of Metarhizium fungus at the expense of host survival, highlighting a strong interaction between host diet and pathogen success.

Impact of life cycle variation on feeding system musculature in salamanders

Morgane Taillades, Isabelle Toussaint, Vivien Louppe, Morgane Fournier, Anthony Herrel, Anne-Claire Fabre

Urodeles display remarkable diversity in their life cycle strategies, ranging from species with obligate metamorphosis to those with facultative or complete loss of metamorphosis. These developmental differences are often tightly linked to ecological transition and morphological transformation, influencing how salamanders exploit habitats, access resources, and feed during their lifetime. To investigate how life cycle variation and associated ecological transition affect morphological changes in salamander, we focused on their feeding structures. The feeding system provides a key functional link between life cycle variation and ecological adaptation, as cranial muscles attach directly to the bone of the head and directly mediate prey capture and processing. To do so, we conducted detailed dissections of the feeding system muscles and shape analyses of the bones in 24 salamander species representing different life cycles, ecological transition and morphological transformation. Our results revealed no consistent myological and morphological differentiation attributable solely to life cycle variation, indicating that factors such as body size may play a stronger role in shaping muscle and morphological architecture. These findings suggest that while life cycle diversity is central to salamander evolution, its impact on feeding system may be indirect, mediated through ecological and allometric constraints. Future work should broaden taxonomic sampling, integrate cranial and muscular traits, and examine the evolutionary pathways by which life cycle variation interacts with functional morphology in Caudata.

Reproductive costs of prior and current pathogen infection vary between sexes

Katherine Talbott, Arietta Fleming-Davies, Francis Tillman, Dana Hawley, James Adelman

Novel pathogens are emerging in wildlife populations with increasing frequency, often reducing survival probability for infected individuals. These pathogens likely also impose reproductive costs on their new hosts, though few studies have probed for such effects. Here we investigate the reproductive costs of pathogen exposure in wild house finches (Haemorhous mexicanus) infected with the bacterial pathogen Mycoplasma gallisepticum ('MG', emerged in the 1990s), while controlling for season of exposure.

MG circulates year-round in wild finch populations, exhibiting seasonal epidemics. MG reduces host survival in the wild, yet many finches survive initial infection and can become reinfected as immune protection wanes. However, whether MG infection during the winter and/or spring decreases reproductive capacity remains unknown. We inoculated MG-naïve finches twice, first while held on a winter (non-breeding) photoperiod, and again while on a spring (breeding) photoperiod. We found that 1) spring and/or winter infection reduces the probability of laying eggs and/or developing a brood patch in females, and 2) spring antibody levels are negatively correlated with reproductive function in females, but 3) males showed no differences in testosterone levels across treatments.

These results suggest the reproductive costs of past (winter) and present (spring) MG infection are substantial, but unequal between the sexes. Such differential reproductive costs have important implications for the selective pressures and population-regulating potential of this and other emerging infectious diseases.

Decoding Desmostylia: an ecomorphological analysis of *Behemotops proteus*

Kevin Talbott, John Orcutt

Desmostylians were highly specialized marine mammals from the late Oligocene to the mid-Miocene. With no living descendants and fossils found exclusively along the northern Pacific Rim, debates abound regarding desmostylian paleobiology. Notably, it is uncertain whether desmostylian locomotor mode was more aquatic or terrestrial. Previous morphological and paleoecological interpretations of certain taxa have reconstructed locomotor modes ranging from alternate pectoral paddling propulsion and hindlimb steering, as in polar bears, to more active marine swimming, as in pinnipeds. A partially complete skeleton of the Oligocene desmostylian Behemotops from the Sooke Formation of British Columbia, including a humerus and scapula, provides an opportunity to reconstruct locomotion in a taxon not previously analyzed. We calculated functional indices based on measurements of the distal scapula and proximal humerus for Behemotops and for modern aquatic, semiaquatic, and marine mammals. In a principal components analysis of these indices, Behemotops clustered with marine taxa, notably Enhydra lutris, Zalophus californianus, and Trichechus manatus. These taxa are differentiated from others by a relatively circular shape of the glenoid fossa, possibly associated with a wider range of motion in the shoulder. This supports the reconstruction of desmostylians as active swimmers. An expanded morphological data set including a larger sample of modern species as well as more desmostylian taxa, accompanied by paleoecological analyses, will shed further light on the locomotion of these enigmatic mammals.

OsmiaCAM: a low-cost, open source, automated monitoring system for solitary bees

Acacia Tang, Victoria Salerno, Jorge Mora Sibaja, Magda Argueta-Guzmán, Baltazar Chávez, Steve Peterson, Quinn McFrederick, Marilia Gaiarsa, James Crall

While social bees are the primary focus of research and monitoring efforts among pollinators, most pollinator species are solitary. Foraging decisions for solitary pollinators impact individual fitness directly, as consequences of foraging performance are not buffered by averaging across a colony. Solitary pollinators thus provide an ideal system to study fitness effects of individual variation in pollinator performance (e.g. thermal tolerance, foraging behavior, etc). This could improve our understanding of the plant-pollinator mutualism: its evolution and maintenance, and potential impacts anthropogenic change. Specifically, reed-nesting bees (e.g. Osmia spp. and Megachile spp.) progressively provision pollen in cells within hollow stems: each cell contains one offspring, chronologically provisioned from back to front. Continuous monitoring of individual foraging behavior and nest-provisioning rates would be informative, but is prohibitively labor-intensive using traditional methods like manual field observations. Here we introduce OsmiaCAM, a low-cost, open-source, automated monitoring system for nest-provisioning behavior of reed-nesting bees. Using only open-source electronic components (e.g. Raspberry Pi and consumer electronics components), this system continuously monitors foraging and nest-provisioning of reed-nesting bees, and local environmental conditions (i.e. temperature, air pressure, and humidity). We discuss the system's design and possible adaptations for different reed-nesting solitary bee species. We also showcase its use at multiple Californian sites to study the effect of temperature and habitat on O. lignaria foraging activity and nest provisioning rate.

UCE phylogeny of the former ant tribe "Dacetini" and the evolution of trap-jaw mechanism

Kit Lam Tang, Josh Gibson, Manuela Ramalho, Corrie Moreau, Andrew Suarez

The ultra-fast trap-jaw mechanism for prey capturing in ants serves as an interesting model for the study of evolution. The repeated parallel evolutions of similar mechanisms across multiple lineages give us invaluable insight into adaptation and species radiation. The former Dacetini tribe from the subfamily Myrmicinae (now synonymized with Attini but remains monophyletic in most subsequent analyses, excluding genus Strumigenys) consists of eight genera, five of which are known to possess power-amplified mandibles. All eight genera are tropical and subtropical, each restricted to either Neotropical, Afrotropical or Australasia regions. We sampled 44 species across all eight genera to create an updated phylogeny using ultraconserved elements (UCEs). This improved phylogeny allows us to examine morphological evolution and assess whether the trap-jaw mechanism has multiple origins within this lineage.

How do bat foraging guilds partition prey in Afrotropical forests?

Iroro Tanshi, Sharlene Santana

Bite force is a measure of feeding performance that is constrained by body size and may limit the spectrum of consumed prey. Larger insectivorous bats with high bite forces are expected to consume a wider range of prey sizes and toughness, whereas smaller species pack less force and are expected to consume smaller prey, providing a basis for resource partitioning. Insect prey type and size varies in space, and size distributions differ among bat foraging guilds (open, edge, clutter), raising questions about bite force scaling in each group. Edge bats are small and fill a narrow size range, unlike clutter and open space species. Is body size and bite force positively related across the three bat foraging guilds? We trapped bats across 10 sites in the Gulf of Guinea forests, and collected biometrics and maximum bite force from 189 individuals spanning 22 species and seven families. We found a significant positive bite force–size (body mass, forearm and head length) relationship in clutter space bats. Open space bats exhibit a marginally significant positive relationship, but edge bats showed a negative relationship i.e., smaller bats bite more forcefully, suggesting that other traits may be more important for predicting bite force in this group. Our results highlight potentially different mechanisms of prey partitioning among bat foraging guilds.

Carnivoran hind limb morphology and the locomotion type of extinct species Borophagus

Evelyn Tanzil, Emily Bogner

The carnivoran hind limb, composed of the femur and tibia, propels species through their environment. But with an order of mammals containing over 300 species and seven locomotor types, it is the smallest morphological differences within these bones that allow adaptation for a wide range of movements. Those differences can be influenced by a variety of factors including phylogeny, locomotion, and body size. The extinct genus Borophagus has few recovered postcranial elements, making its locomotor type difficult to assess. This study provides the largest morphological comparative sample of the hind limb bones of Borophagus to get a better understanding of their unresolved locomotor type. We utilized 3D geometric morphometrics to analyze the shape of the femur, tibia, and patterns relating to locomotion type, body size, and phylogeny across all extant terrestrial carnivorans and Borophagus. Results indicate that Borophagus shares the same morphospace as mustelidae for femoral morphology and the same morphospace as hyaenidae for tibial morphology. It was also observed that phylogenetic convergences took precedence over locomotor morphological differences for canidae and mephitidae families, but Borophagus grouped separately from extant canidae. Locomotor type also has some influence in hind limb morphology for the remaining families as most semifossorial, cursorial, and semiaquatic carnivorans were able to be differentiated but the remaining locomotion types such as scansorial and terrestrial were not due to having more generalized functions.

Hide and beak: historical demography of the elusive Hubbs' beaked whale and Ziphiidae

Emma Tashi, Samuel Bogan, Lesley Lugardo, Jenell Webber, Lori Boston, Jane Grimwood, Alex Harkess, Joanna Kelley

Beaked whales (Ziphiidae) are among the least understood marine mammals due to their elusive nature and deep-sea foraging. Consequently, their population sizes and demography are largely unknown. Here, we present a chromosome-scale and haplotype-phased genome assembly for the Hubbs' beaked whale (Mesoplodon carlhubbsi), the second-rarest marine mammal. By integrating this new resource and genomes of three other beaked whales, we investigated historical demography across Ziphiidae and measured heterozygosity to assess present-day genetic diversity. We tested whether M. carlhubbsi possessed lower heterozygosity compared to other beaked whales and whales, and if heterozygosity correlates with the frequency of species occurrences across Ziphiidae. We then evaluated the possibility that the elusiveness of M. carlhubbsi and other beaked whales might arise from small population sizes. Lastly, we reconstructed historical effective population sizes (number of breeding individuals) in M. carlhubbsi and other Ziphiidae. These approaches allow us to determine if M. carlhubbsi populations are at risk of bottlenecking or have maintained small but stable sizes over time. Our findings provide genomic insights that advance our understanding of beaked whale populations, their evolutionary histories, and the conservation status of M. carlhubbsi.

Gene gain and loss events inform the evolution of symbiosis and lineage-specific traits in Cnidaria

Olivia Tatro, M Pankey, Hannah Pare, David Plachetzki

Diverse body plans, complex life histories, and ecologically significant symbiotic relationships characterize cnidarian biodiversity. Comparative genomic studies have highlighted the importance of gene gain and loss in the origins of novel traits. We used phylogenetically informed approaches to characterize orthogroup gain and loss throughout cnidarian diversification using genome-scale data from 72 cnidarian species. Our analyses of gene gain highlight a significant burst of innovation in the lineage leading to Anthozoa, which are enriched in functions related to amino acid transport, cell communication and adhesion, and immunity, possibly underpinning adaptations for complex symbiotic relationships. The lineages leading to Hexacorallia and Ceriantheria experienced a significant depletion of orthogroups involved in translation and metabolism, which could be linked to an increased reliance on symbionts. The Endocnidozoa are a parasitic lineage exhibiting reduced morphological complexity. We observe a significant depletion of orthogroups involved in protein transport, metabolic processes, and signal transduction mechanisms, congruent with their reduced organismal complexity and host dependence. Other significant gains involved in energy production and translation occurred in the lineage leading to Medusozoa, possibly associated with increased biosynthetic demands of the medusa stage. We integrate our findings with a comparative scRNA-seq dataset comprising five cnidarian species representing major clades. Our results suggest hypotheses on the timing, genomic mechanisms, and cellular context for the evolution of symbiosis and other complex organismal traits, as exemplified in Cnidaria.

Molecular analysis of bladder tumors in the aging mouse reveals distinct transcriptomic signatures

Danielle Taylor

Aging is associated with structural and molecular remodeling of the bladder, and we have identified previously uncharacterized cell masses arising within the bladders of aged C57BL/6J mice. These structures raise important questions about age-associated pathological remodeling in the lower urinary tract. To investigate their molecular identity and potential biological significance, we are employing a combination of transcriptomic and histological approaches. Preliminary data suggest an upregulation of circadian genes within these cell masses, and we hypothesize that all bladders containing masses will show an upregulation of sensory and cancer-related genes. Ongoing three-channel in situ hybridization assays will target B lymphocyte markers, uroplakin II (UPK2), and mechanosensory ion channels such as PIEZO and TRPV channels to assess cellular composition and potential functional relevance. Complementary hematoxylin and eosin (H&E) staining will characterize tissue architecture, cellular density, and inflammatory markers. We aim to determine whether these age-associated cell masses reflect benign remodeling, chronic inflammation, or neoplastic transformation, offering new insights into the molecular pathology of the aging bladder. This work may reveal novel biomarkers or mechanisms underlying bladder dysfunction and tumorigenesis in aging.

Aging disrupts diurnal bladder-brain signaling underlying nocturia in mice

Danielle Taylor

Nocturia—waking to urinate two or more times per night—affects over 70% of adults over 65 and significantly impacts sleep quality, physical health, and well-being. Despite its prevalence, the mechanistic basis of nocturia remains poorly understood. Here, we establish the aging mouse as a translational model for

nocturia and uncover a circadian disruption in bladder-brain signaling that may drive age-associated mistiming of urination. Bladder fullness is detected by stretch-sensitive neurons in the urothelium that express the mechanosensitive ion channels Piezo1 and Piezo2, which relay signals to the ventrolateral periaqueductal gray (vlPAG), which signals the pontine micturition center (PMC) to trigger a void. Preliminary data support our hypothesis that in healthy adult mice, Piezo1 expression in the bladder and c-Fos activity in the vlPAG exhibit an opposing diurnal pattern. When Piezo1 levels are low, greater vlPAG activity is required to reach the neuronal threshold for voiding. We propose that this relationship becomes dysregulated with age, contributing to mistimed urination. Additionally, we are testing whether diurnal differences in vlPAG neural activity are Piezo-dependent by administering the Piezo inhibitor GsMTx4. Together, these findings aim to identify a novel age-related disruption in circadian bladder-brain communication, suggesting that targeting peripheral sensory mechanisms may represent a new chronotherapeutic avenue for treating nocturia and other age-associated urinary disorders.

Nematodes and non-targets: Biocontrol nematodes increase mortality in the native Pacific banana slug

Emily Taylor, Indira Kulkarni, Dana Howe, Casey Richart, Rory Mc Donnell, Dee Denver

Gastropods are the largest class within Mollusca, with over 60,000 described species. Despite this diversity, much scientific focus has centered on pest species, with less attention paid to native fauna inhabiting diverse ecosystems and facing additional risks from human interventions. One such intervention is the use of malacopathogenic nematodes, sold as biocontrol products to manage crop-damaging pest slugs. Pellioditis hermaphrodita (Nemaslug ®) and Pellioditis californica (Nemaslug 2.0 ®) are two types of commercially available products. While P. hermaphrodita lethality in pests is well-studied, there is less knowledge of the effects on non-target gastropod species, such as Ariolimax columbianus, the Pacific banana slug. A. columbianus is an important decomposer in forest ecosystems and serves as a familiar cultural icon of the Pacific Northwest. In this study, the potential impact of P. hermaphrodita and P. californica on two life-stages of A. columbianus was investigated using laboratory infectivity trials. Kaplan-Meier survival curves with log-rank tests, adjusted using a Bonferroni correction, revealed that both nematode species increased mortality of A. columbianus as compared to negative control groups. While juveniles were susceptible to both nematode species, adult survivorship was only significantly affected by P. hermaphrodita. Our results highlight the need for comprehensive non-target testing in evaluating the potential impacts of biocontrol organisms, and suggest that Pellioditis nematodes might negatively impact native terrestrial gastropod biodiversity in North America.

From branch to air: advancing our understanding of axial twist in flying snakes

Joshua Taylor, Joshua Pulliam, Jeffery Anderson, Jake Socha

Arboreal environments are discontinuous, requiring animals to cross gaps to survive. Most arboreal snakes employ a cantilever crawl, extending outward while maintaining contact with the substrate. By contrast, flying snakes (Chrysopelea) and related bronzeback snakes (Dendrelaphis) cross larger gaps using dynamic movements, including jumps. Central to the most advanced jumping behavior is the "J-loop", performed only by Chrysopelea. In this behavior, the snake projects its head forward, feeds the front of its body into the gap by forming a "J" shape, and then propels itself up and away. Previous studies show that loop depth increases with gap distance, and preliminary data suggest that a consistent feature of the J-loop is a twist along the spinal axis. However, the role of this twist in gap-crossing remains unknown. Initial observations suggest that Dendrelaphis, a less proficient jumper than Chrysopelea, employs a less pronounced axial twist in its pre-takeoff loop. We hypothesize that the axial twist aligns the body so larger, epaxial musculature produces upward movement, improving gap-crossing ability. This study tests this hypothesis by addressing two questions: Do flying snakes modulate axial twist to control jump performance? Do snakes that are less proficient jumpers twist differently? To address these questions, we recorded dynamic gap crossings at varied distances using 3D motion capture. These results may provide insight into how limbless organisms propel their bodies using twisting movements.

Effects of energetic state on male mate preferences in Poeciliid fishes differing in mating strategy

Katherine Taylor, Zachary Culumber

Reproduction is an energetically costly process, making condition (i.e. energetic state) a potential factor in shaping reproductive behavior. However, its role in male mate choice remains largely unexplored. Males may adjust preferences based on female condition or on their own condition, and these effects could vary with mating strategy (e.g. coercion vs courtship). Poeciliid fishes, which vary in mating strategy across species, provide an excellent system for comparatively exploring these ideas. Here, we investigate condition-dependent effects on male mate choice in one coercive species (Gambusia affinis) and one courting species (Xiphophorus hellerii). Diet treatments were used to generate females of high and low condition, and these were used to produce animated video stimuli. Male condition was similarly manipulated, and male preferences were measured in dichotomous choice tests using the female animations. A repeated measures experimental design was used, such that each male's preferences were measured under both the high and low condition diet treatments. Using this design in a comparative context, this research aims to clarify how variation in energetic state affects male mating decisions. This presentation will discuss how condition and mating strategy interact to shape male mate choice and its implications for understanding the evolution of mating systems.

The fundamental importance of egg cold tolerance in the biparental care system of seabirds

Liam Taylor, Kayla Lichtner, Sarah Chapman, Mark Haussmann, Robert Mauck, Patricia Jones

While most birds keep their eggs consistently warm to protect their sensitive, developing embryos, some seabirds neglect their eggs (i.e., leave them cold) for days or even weeks. Here, we combine field data and computational modeling to examine the role of egg cold tolerance in seabird reproduction. Using field data from a 70-year study of Leach's Storm-Petrels (Procellariiformes: Hydrobatidae: Hydrobates leucorhous), we measure the frequency, limits, and consequences of egg neglect. Using a computational model of storm-petrel incubation, we show that neglect is an inevitable outcome of biparental care in seabirds, which requires both parents to travel long distances between the nest and foraging grounds. The model quantifies how hatching success is highly sensitive to the evolution of egg cold tolerance in this system. Even good parents in good environments can fail to reproduce if the egg is not cold tolerant. We discuss how convergent evolution in two independent lineages of seabirds (Procellariiformes and Charadriiformes) provides the opportunity for phylogenetic and genomic analyses of egg cold tolerance. Overall, our study highlights how the physiology of offspring—as opposed to the behavior of parents—is a critical determinant of reproductive outcomes.

Undulatory wall-following in the centipede *S. subspinipes*

Malaika Taylor, Darren Tan, Wesley Dyar, Christopher Pierce, Simon Sponberg, Daniel Goldman

Invertebrates that live in dark, cluttered environments use mechanical cues from their antenna to navigate, allowing them to perform controlled tasks like wall following. In cockroaches, where wall-following has been studied extensively, studies show that the head-to-wall distance is constant along a flat wall, controlled via antennal sensing, and inversely related to speed (Cowan et al., 2006). However, unlike hexapodal cockroaches, elongate centipedes locomote using both waves of body undulation and limb-stepping; consequently, the centipede's head oscillates as it walks. This raises the question of how these myriapods wall-follow, when their locomotion pattern potentially precludes a constant wall distance. We recorded Vietnamese Centipedes (Scolopendra subspinipes) performing wall following along a flat wall (L=40cm) and a wall with a 3.4 x 7.0 x 5.4 cm3 triangular prism protrusion in 13 trials with 3 individuals. We observed that the animals preferred to remain near walls during

locomotion and maintained contact with their antenna. Specimens followed flat walls with speeds of 8 to 32 cm/s and average head-wall distances of 1.4 to 2.5 cm. Higher speeds were correlated with larger following distances. When the centipedes encountered the wall protrusion, the head-wall distance increased while speed decreased. We hypothesize that this change in the distance-speed relationship is a consequence of both the unique body mechanics and the difference in how centipedes and cockroaches modulate their wall-following behavior.

Behavior-linked loci in hybrid chickadees resist introgression and show differential expression

Scott Taylor, Amber Rice, Timothy Roth

Natural hybridization has long been recognized as a window on evolutionary process, allowing the study of factors promoting or eroding species boundaries. Unravelling the genetic mechanisms that reduce hybrid fitness is key for understanding the broader mechanistic basis of postzygotic isolation, but we know relatively little about the genetic architecture of such mechanisms in wild organisms. Here we combine captive behavioral experiments, genomic tools, and data from naturally occurring hybrids to examine genetic factors underlying reduced fitness in hybridizing black-capped and Carolina chickadees. These species hybridize in a narrow but geographically expansive hybrid zone that is moving northwards following increasing minimum winter temperatures. While several mechanisms of hybrid disadvantage (e.g., reduced metabolic performance and impaired cognitive abilities) have been proposed, the genetics of these mechanisms remains elusive. We use a combination of whole genome sequencing and gene expression data from 90 birds raised under common garden conditions to conduct a genome-wide association study on several phenotypic traits relevant to hybrid breakdown, and to examine connection between phenotype-associated genes and differential expression. We further compare these genes of interest to those exhibiting geographically consistent restricted introgression in the chickadee hybrid zone. We discuss our findings in the context of how selection can operate on polygenic phenotypic traits and propose a putative mechanism that can structure patterns of prevalence in ancestry classes in chickadees and other species.

Scaling thermal behavioral ecology with DeepLabCut: detecting avian thermoregulatory responses

Shomari Taylor, Juan Zuluaga, Elizabeth Derryberry

Quantifying behavior is essential for understanding how birds respond to environmental stressors, yet current methods often rely on manual observation, requiring substantial time and expertise, which can limit scalability. As efforts to assess behavioral responses to climate change expand, scalable approaches are needed to study thermoregulatory behaviors critical for heat dissipation. We are developing a machine learning tool with DeepLabCut to automatically detect thermoregulatory behaviors in birds, focusing on panting, wing-spreading, and postural changes. Our model identifies panting bouts by detecting characteristic motion patterns such as beak movements. The tool processes standard video formats (e.g., .mp4, .avi) and outputs data formatted for behavioral analysis (i.e., proportion of time spent engaging in behaviors, occurrences of behaviors). We trained the model on videos of Least Terns (Sternula antillarum) and Zebra Finches (Taeniopygia guttata), and the approach is adaptable to a broad range of species and behaviors. By reducing observer bias and manual workload, this machine learning framework enhances the consistency, speed, and scalability of behavioral studies on heat. Ultimately, such tools enable high-throughput behavioral research and deepen insights into the generative principles underlying animal responses to environmental change.

Relating body kinematics to muscle co-contraction during tandem walking

Skylar Taylor, Ilana Plager, Marcus Garcia, Bryan Alvarez, Monica Daley, Alexandra Voloshina

Walking involves consistent fundamental mechanical dynamics, yet individuals vary greatly in their motor control strategies to achieve these tasks due to the motor abundancy of the human neuromuscular system. Here we investigate the sources of individual variation in balance control strategies during tandem walking, relating quantitative measures of balance performance to muscle coordination and co-contraction. Previous work by Beveridge et al. (2020), found that amateur drummers had greater co-contraction and less even drumming than their expert counterparts, suggesting that co-contraction decreases with increased skill at task performance. We hypothesize that foot center of pressure (COP) and torso sway (TS), measures of balance performance, are inversely related to ankle plantar-dorsiflexor muscle co-contraction. Six subjects performed a tandem walking task for 50 minutes while we collected motion capture kinematic data. and muscle electromyography across 8 lower limb muscles. Using a linear mixed effects model, we found that increases in COP variation and TS were not correlated with muscle co-contraction. Individual subjects showed significant differences in COP, TS, and co-contraction, but these variables showed limited differences across variables across different walking speeds. Our data show that individuals can exhibit “loose” (high TS, high COP variability) and “stiff” walking patterns, but these are not correlated with ankle co-contraction. This suggests that other factors like morphology, musculoskeletal capacity, experience with the task, or even proprioceptive function influence motor control. NSF-DBI-2319710

A neurotransmitter mediates symbiotic organ development in the Hawaiian bobtail squid

Briana Tell, Elizabeth Heath-Heckman, Camille Boucaud, Kyle Davis, Alice Walker

The establishment of symbiosis between the Hawaiian bobtail squid (Euprymna scolopes) and its bacterial partner Vibrio fischeri offers a tractable model for studying the intersection of immune, neuronal, and developmental pathways. Here, we investigated the role of the neuropeptide FMRFamide in modulating symbiont-induced tissue remodeling in the juvenile light organ. Using immunocytochemistry (ICC), we found that the FMRFamide peptide localizes to neurites throughout the light organ and to the interior of the anterior appendage. FMRFamide production was upregulated in symbiotic animals, and exogenous FMRFamide exposure induced apoptosis in epithelial tissues, even in the absence of symbionts. Hybridization chain reaction fluorescence in situ hybridization (HCR-FISH), paired with hemocyte-specific staining, further confirmed the presence of FMRFamide propeptide and receptor transcripts in hemocytes, which migrate into the blood sinus of the anterior appendage during the onset of symbiosis, suggesting that these immune cells produce FMRFamide and then secrete it into the blood sinus within the light organ appendage. Functional assays using nitric oxide (NO) inhibitors revealed that FMRFamide may act upstream of NO attenuation, a key step in initiating apoptosis of the appendage; however, further study is needed. Together, these findings suggest that bacterial cues activate hemocyte-driven neuropeptide signaling to direct tissue remodeling. This reveals a novel immune-neural pathway and positions the squid light organ as a model for studying microbe-induced neurodevelopment.

Complicated Carnivory: Separating predatory diets alters analysis of evolutionary rates in mammals

Michael Tene, Wynn Meyer, Derrick Um

Mammalian diets are diverse, with different specialized and generalist strategies having evolved multiple times over the clade’s nearly 200 MY history. These repeated dietary shifts provide an opportunity to identify genes whose evolutionary rates depend upon selection related to diet. We here examine diet-associated shifts in molecular evolutionary rates of protein-coding genes, using RERconverge and HyPhy Relax. We implement these tests using 16,209 filtered protein-coding amino acid alignments from the Zoonomia Consortium, generated from the genome sequences of 154 mammals.

While much prior work has considered carnivores as a cohesive class including both vertivores and invertivores, we have identified genes whose evolutionary rate distributions vary among these classifications. Through comparing RERconverge/HyPhy results from an analysis including a “combined carnivory” category with results from an analysis using separate vertivore and invertivore categories, we have found that combined-carnivory results reflect molecular

rate shifts within invertivores more than shifts within vertivores. This has implications for the interpretation and communication of such findings, given the lay association between 'carnivore' and vertivores.

Our findings include that amino acid and lipid metabolism are under more relaxed constraint in herbivores than invertivores and vertivores, although different genes drive these patterns in herbivore-invertivore and herbivore-vertivore comparisons. Many of these lipid metabolism genes are more conserved in invertivores but not vertivores relative to herbivores, potentially reflecting increased lipid content in invertebrate-based diets.

Phenotypic plasticity in Pieris rapae butterflies: I swear this spot was bigger last time I saw it

Elizabeth Teng, Saige Pompura

Pieris rapae butterflies exhibit a distinct wing melanization patterning. Melanization in butterflies is thought to be critical for thermoregulation. We hypothesized that increases in global temperature over time due to climate change will lead to a decrease in wing melanization. This is under the assumption that increases in melanization decrease heat absorption, which is less beneficial in warmer climates. This is especially in Europe, where warming is found to be more rapid and will likely accelerate changes in melanization. To test our hypothesis, we used 60 digitized museum samples from iDigBio that were collected from North America and Europe between 1820 and 2000. We measured the melanization of the apex and M3 spots using ImageJ. Our results showed a moderate positive correlation between melanization and year (r^2 = 0.64), which does not support our hypothesis, and implies that melanization might have increased with time. Nonetheless, our t-test analysis revealed a statistically significant relationship between melanization and continent. Although melanization may not have notably changed over time, it seems to be related to region, so it will be beneficial to continue studying the variation of phenotypes for Pieris rapae in relation to higher geography and temperature. Perhaps the lack of relation between melanization and time could signify that other mechanisms, such as mating and reproduction, are a stronger driving force of melanization patterns in Pieris rapae than thermoregulation.

A deep learning model for avian bioacoustics requires region-specific training

Karinne Tennenbaum, Ian Becker, Mason Maron, Andrea Contina

Billions of birds embark on biannual migrations between northern breeding grounds and southern wintering sites. More than 400 bird species travel through the Lower Rio Grande Valley (LRGV), a region where the Central and Mississippi Flyways intersect. Monitoring migration is critical to characterizing the avian life cycle and mitigating a global decline in migratory birds. However, studying avian migration is challenging since most birds migrate nocturnally. Identifying nocturnal flight calls (NFCs)—short, high-pitched vocalizations emitted at night—using passive acoustic monitoring and machine learning algorithms is a promising approach. Nighthawk is a deep learning model trained to detect and identify the vocalizations of nocturnally migrating birds. Yet geographically limited training data may compromise NFC identification in other regions. Data acquired by the Southern Ornithology Network for Applied Research (SONAR) was validated using Audacity. We analyzed avian vocalizations from 16 five-hour recordings from two sites—South Padre Island (10) and Brownsville, Texas (6)—during May 17-26, 2025. Brownsville appeared to exhibit more avian vocalizations and greater family richness than South Padre Island. Additionally, the two sites appeared to differ in top avian callers. Nighthawk exhibited high rates of missed vocalizations, non-existent vocalizations, and misidentifications, suggesting it has limited ability to identify NFCs from the LRGV. These findings underscore the importance of human validation and region-specific training in the development of machine learning algorithms for avian bioacoustics.

Dispersal, warming, and adaptation in a rapidly expanding invasive crab population

Carolyn Tepolt, Rayna Hamilton, Sara Shapiro, Brian Turner, Todd Seamons, Emily Grason, P. Sean McDonald

The European green crab (Carcinus maenas) is a high-profile invasive species, with populations spanning a broad range of temperate environments. Its success in the northeast Pacific, where it has spread across >2,200 km of coastline since its initial detection 32 years ago, has been facilitated by periodic ocean warming conditions which have increased in recent years. While C. maenas appears at first to be a classic example of the "genetic paradox of invasion", with low overall genetic diversity, the founding population retained variation at a supergene (likely a chromosomal inversion) associated with thermal tolerance that evolved in the species' native range. This supergene shows strong latitudinal selection in green crabs spanning central California to Alaska, against a background of high dispersal. We will present ongoing work demonstrating the importance of ocean warming in shaping dispersal and persistence in a complex seascape, with a focus on the role that selection plays in this rapid expansion. We will also describe initial insights into the the nature and gene content of this supergene, based on a newly-developed draft genome for C. maenas. We suggest that the green crab's success may be due in part to variation at a few key genomic regions that evolved in the native range to promote persistence across variable thermal environments despite high gene flow.

The effect of sensory pollution on neophobia and nest visitation in Ash-throated flycatchers

Marlen Terrazas, Jennifer Phillips, Eva Moylan, Sara Lipshutz, Clinton Francis

As urbanization expands and pollutants such as noise and light penetrate natural areas, it has become increasingly important to understand how changes in a sensory environment can impact avian nesting behavior and diversity in human-dominated landscapes. Previous studies have found that urban areas select for bold behaviors; although, it remains unclear how much of this shift can be attributed to noise versus light pollution, as their combined effects are rarely tested outside the confounds of urban landscapes. We conducted a two-season field study along a sensory pollutant gradient in northwestern New Mexico, a unique setting where chronic noise from natural gas wellpads permeates the landscape and artificial light is experimentally introduced at half of the nestboxes, enabling us to examine the effects of noise and light pollution without confounding influences. Here, we investigated neophobia in nesting Ash-throated flycatchers (Myiarchus cinerascens ; N = 40 nests). Using linear mixed-effects models, we found a significant interaction between noise and novel object presence where visitation rates increased with noise when a novel object was present but declined with noise in control trials. This suggests that birds in noisy environments exhibit a more exploratory behavioral phenotype, quickly returning to investigate novel objects, while birds in quieter sites are more cautious. This variation in behavioral phenotypes within species may enable certain individuals to persist in anthropogenic environments.

Model-based analysis of honeybee communication during aggregation and food exchange

Richard Terrile, Golnar Gharooni Fard, Anna Rahn, Orit Peleg, Liz Bradley

Honeybees exhibit remarkable division of labor in managing a diverse range of tasks within the hive, including the exchange of food via a process known as trophallaxis. The associated communication mechanisms remain largely unexplored. We leverage data obtained from laboratory experiments to study the communication mechanisms involved in food distribution via trophallaxis. We employ computer-vision techniques and convolutional neural networks to detect food exchange and scenting behaviors (vigorous wing-flapping to propagate pheromones directionally) in video images, allowing us to study the impact of scenting on bee aggregation and food distribution. We demonstrate that honeybees can communicate through scenting, form aggregations around food sources, and distribute the food. This is an example of extended classical stigmergy: Instead of depositing static information in the

environment, individual bees can communicate by perceiving and manipulating the physical fields of chemical concentration and airflow. Using insights from these experiments, we build an agent-based model that incorporates directional scenting and use it to study aggregation patterns and food distribution times. We find that directional scenting makes the model a better match to experimental observations and speeds food homogenization. Overall, these findings demonstrate that scenting is an effective communication mechanism for locating moving targets (i.e., food sources) for food exchange in honeybee groups.

Assessing copepod metabolomic responses to multiple stressors using a novel in vivo NMR approach

Caroline Terry, Ella Purvis, Katrina Steiner, William Wolff, Peter Costa, Daniel Lysak, Andre Simpson, Wes Dowd

Predictions of biological responses to multiple stressors can be limited by insufficient knowledge of the mechanisms driving non-additive stressor interactions. Here, an interdisciplinary collaboration led to development of a novel approach to quantify metabolites of living marine animals exposed to multiple stressors. We applied this technique to Tigriopus californicus, a copepod inhabiting splashpools of the high intertidal zone. T. californicus tolerates dramatic and co-occurring heat and salinity changes in splashpools; in fact, it unexpectedly survives higher temperatures when also under high salinities. The mechanisms responsible for this non-additive response are unclear, but similarities between the timeline of increased heat tolerance and accumulation of free amino acids (FAAs) in response to hypersalinity suggest that organic osmolytes may play a role. However, this mechanism – or a role for non-FAA osmolytes – has yet to be directly investigated. We applied a novel two-dimensional in vivo nuclear magnetic resonance (NMR) spectroscopy approach to assess non-targeted metabolomic responses to changes in salinity, increases in temperature, and simultaneous high-salinity and heat stress. Principal component analysis revealed differentiation of metabolite profiles among treatments, primarily driven by betaine, TMAO, lactic acid, taurine, proline, and alanine. Of these, proline and taurine were further investigated to evaluate their roles in elevated heat tolerance. This study demonstrates the feasibility of in vivo NMR in marine organisms, which holds great potential for more powerful future marine metabolomic studies.

Tadpole feeding ecology & interspecific variation: Is breakfast the most important meal of the day?

Christopher Terry, Cris Ledón-Rettig

Early life conditions not only influence early development but can also have effects that persist into or manifest during an organism's later life. For instance, feeding on different diets may influence which brain regions are prioritized in development and could carry over into later life stages. However, it is unknown whether such "carry-over" effects, if consistently experienced, ultimately contribute to interspecific variation in brain morphologies. If so, variation in early life feeding ecology might predict interspecific variation in adult brain morphology. Anurans (frogs) are an ideal system for addressing this question, exhibiting a diversity of tadpole diets across species, ranging from carnivory to filter feeding to egg consumption. To examine the influence of tadpole feeding ecologies on adult frog cranial shape, we compared previously processed (Bardua et al.) CT scans of adult anuran skulls from the openVertebrate project with available literature on tadpole diets. Our preliminary results suggest that models predicting cranial shape variation from adult ecology are significantly improved by including tadpole feeding ecology. This highlights the importance of considering ecological pressures at all stages of an organism's life in shaping its morphological characteristics. More broadly, it provides another route through which developmental plasticity can contribute to diversification.

No clean slates at metamorphosis: How environmental legacies shape evolutionary outcomes in anurans

Christopher Terry, Dante Nesta, Eleanor Shell, Alex Shephard, Lauren Shinn, Cris Ledón-Rettig

Developmental environments shape trait expression in ways that often persist into, or only become evident during, later stages of an organism's life. These "carry-over" effects are well documented across taxa, even in species that undergo dramatic remodeling during metamorphosis. Among these, anurans (frogs) enjoy a rich literature documenting carry-over effects, especially effects that stem from early life competition and predation. Despite this wealth of information, key questions remain about how carry-over effects influence anuran evolution and how such effects, themselves, evolve. In this review, we first explore how carry-over effects are predicted to shape later-life traits and fitness, and whether these outcomes differ fundamentally between metamorphosing and non-metamorphosing organisms. We then synthesize empirical studies assessing carry-over effects in anurans, evaluate how well these findings align with theoretical predictions, and identify environments and traits that warrant further study. Lastly, we highlight a series of unanswered questions that could guide future research. Our overarching goal is to synthesize existing knowledge and motivate new research on this influential yet incompletely understood driver of adult traits and fitness variation in a taxonomic group increasingly challenged by environmental change.

Stress-induced innate immune responses in adult red-eared sliders

Jen Terry, Isabella Davis, Virginie Rolland, Lori Neuman-Lee

Organisms are resource limited and allocation toward physiological processes may shift with context, such as stress. The immune system comprises diverse components with unique structures and roles, which are likely differentially prioritized. Because immune defenses are critical to an individual's survival but are energetically costly, modulation of immune components may vary across individuals in a population. We aimed to assess how stress-induced innate immune responses vary by metrics of individual variation in adult male and female red-eared slider turtles (Trachemys scripta elegans). We collected baseline and stress response blood samples from 85 female and 61 male turtles in May/June 2024. We used differentially manipulated blood serum+buffy layer in microbial killing assays against Escherichia coli, Staphylococcus aureus, and Candida albicans to assess innate immune component contribution and overall function. We found that females and males varied in microbial killing ability (MKA) across the stress response, with females generally having lower E. coli and C. albicans killing, but higher S. aureus killing than males. Within sexes, we also investigated if and how individual characteristics (i.e., plastron length, body condition, MKA variables) influenced each MKA metric. We provide evidence of differential immune component prioritization strategies across the stress response within a population. These findings deepen our understanding of reptilian immunology and can be applied to future research questions and conservation efforts.

How does physiology influence turtle survival?

Jen Terry, Lori Neuman-Lee, Virginie Rolland

Physiological strategies, such as responsiveness to stress and immune function, often have tradeoffs between survival and reproduction. These strategies may vary within a population based on context, including environmental factors and life history traits. Though there is interest in combining physiology and population dynamics, there is a paucity of research that uses physiological metrics at the individual level to inform vital rates at the population level. These questions can be challenging to address because they require long-term datasets on populations amenable to repeated sampling. Because freshwater turtles face numerous environmental challenges (e.g., disease), and population stability requires persistence of reproductive adults, understanding how individual physiology influences turtle population persistence is necessary. As an abundant species, red-eared slider turtles (Trachemys scripta elegans) are a suitable model for such an integrative approach to population studies. We captured and processed 186 female, 265 male, and 54 juvenile wild red-eared slider turtles in Arkansas, USA from 2019–2024 to

create a capture-mark-recapture dataset. We also collected blood samples and conducted hormone and immune assays to generate physiological data for each capture event. We estimated annual survival and assessed whether survival is associated with stress responsiveness, sex steroid concentrations, and immune function. This effort will fill gaps in our understanding of physiological strategies and population dynamics across taxa.

Disease avoidance by large-brained hosts counteracts the immunity costs of expensive tissues

Carolyn Tett, Faith Rovenolt, Noah Leith, Sadie Evanov, Tabea Schneider, Cameron Braswell, Vineet Nayak, Rina Zambetti, Mariam Azizbekyan, Ashka Patel, Naomi George-Hall, Shannon Sneed, Niclas Kolm, Jessica Stephenson

Large brains and the immune system are both energetically costly to hosts, so evolutionary investment in one trait should result in a decreased investment in the other. Investment in large brains may therefore increase host physiological susceptibility to socially transmitted diseases. Limited evidence suggests that large-brained individuals may offset these costs through more effective behavioral defenses, such as avoiding infected conspecifics. How this relationship affects disease spread in group settings, though, is entirely unexplored.

We tested these dynamics using guppies (Poecilia reticulata) artificially selected for large or small brain size. In 7-day experimental epidemics, we introduced one female infected with the ectoparasite, Gyrodactylus turnbulli, into groups of five uninfected conspecifics of the same brain-size line, and quantified parasite loads and behavior daily. Large-brained groups transmitted less in the early stages of the epidemic. However, parasite prevalence did not differ between brain size lines by the end of the epidemics.

To disentangle behavioral from immunological effects, we infected individual guppies housed in isolation and found that indeed large-brained guppies exhibited weaker innate immunity than their small-brained counterparts, carrying higher infection loads in early infection stages. The transmission rates from the behavioral trials must then be attributed to host behavior. Combined, these results strongly indicate that large brains, while detrimental to individual-level immune functions, foster behaviors that forestall disease spread in social groups.

Lower but not upper thermal tolerance differs with opportunity for thermoregulation in lizards

David Tevs, Winsor Lowe

Environmental pressures that can be alleviated behaviorally are less likely to elicit physiological responses than those that cannot (i.e., the Bogert effect). For semi-fossorial lizards, the warmest conditions are caused by direct solar radiation and can be avoided by accessing subsurface retreats. But the coldest conditions often occur when there is little thermal heterogeneity, reducing opportunities for behavioral mitigation. Therefore, we hypothesize that lower thermal tolerance, but not upper thermal tolerance will differ in western skinks (Plestiodon skiltonianus) occupying habitats that differ in availability of warm and cold temperatures – southern v. eastern aspects. We placed operative thermal models that recorded temperatures in the open, in shade, and under rocks on each aspect. We also captured lizards to assess thermal tolerance in the lab. Variance in temperature increased with maximum temperature, which was higher on southern aspects, supporting greater opportunity for behavioral thermoregulation. Likewise, southern aspects had more temperatures above this species' preferred temperature range and fewer temperatures below this range. Despite differences in frequency of both suboptimal warm and suboptimal cold temperatures, only lower thermal tolerance differed with aspect: lower thermal tolerance was greater in lizards from southern aspects than those from eastern aspects. These results suggest that behavioral thermoregulation can mitigate suboptimal warm temperatures but not cold temperatures, highlighting the importance of assessing how organisms respond to both heat and cold stress.

Neural basis of alternative mating behaviors in swordtails

Sunishka Thakur, Ngoc Tuyet Tra, Molly Cummings

Sexual selection leads to complex mating systems in many species, such as species where male types performing alternative reproductive tactics (ARTs). What are the mechanisms that govern these varying mating behaviors within the same species? Most mechanistic studies come from species where ARTs are plastic depending on age or social environment, thus any differences in gene expression or physiology may be confounded by these factors. To understand the mechanisms underlying alternative mating behaviors specifically, we use a swordtail species, Xiphophorus nigrensis, that has fixed mating tactics. One male only performs courtship and the other only performs coercion (chasing the female and attempting forceful copulations). We collected brain tissue of both male types in two conditions, a mating condition (with one female) or a social condition (with a juvenile). The biggest difference in gene expression is seen between male types, while the differences between males in different conditions were more subtle. This allowed us to narrow down on genes involved in courtship/coercion when compared to males in the social condition. We were also able to find genes whose expression was directly associated with mating behaviors such as the number of displays and chases performed per minute. This study thus helps us to disentangle the neural pathways involved in the specific mating behaviors of courtship and coercion from those that are involved in social behaviors in general.

Warming up to you: how heat-adaption of symbiotic squid bacteria impacts recruitment

Malcolm Thieme, Diya Vakil, Michele Nishiguchi

The importance of beneficial bacteria throughout the animal kingdom is a well acknowledged phenomenon where microbes contribute to host fitness. Under current anthropogenic warming conditions, the behavior of beneficial microbes can provide insight into the holobiont (host + symbiont) thermal response. The amenability of the sepiolid squid-Vibrio association for laboratory and field experimentation makes it an ideal system for measuring symbiotic thermal adaptation. Four strains of V. fischeri were isolated from the light organs of various species of Euprymna (E. scolopes- Hawaii; E. tasmanica-Australia; E. albatrossae- Philippines; and E. morsei- Japan). These symbionts were experimentally evolved in culture under three temperature regimes: low (18ºC), mid (25ºC), and high (32ºC) for 2000 generations. Single and dual infection experiments were conducted in naive E. tasmanica to compare colonization competency of experimentally evolved V. fischeri against their ancestor, providing a window into the impact of thermal stress on symbiont fitness. Evolved bacterial that out-compete their ancestral lines may imply that adaptation to novel temperatures increases symbiont fitness, and therefore improves the overall fitness of the association, but a reduction in host colonization proficiency relative to the ancestor may be a sign of a developing breakdown in cooperation, or dysbiosis. Abiotic factors can therefore have dramatic effects on symbiotic bacteria, which provides insight into how environmental change directly impacts the overall health of animals and their beneficial microbes.

Circuit mechanisms for discrete and analog control of Drosophila flight

Kyle Thieringer, John Tuthill, Osama Ahmed

Insect flight is one of the most ubiquitous forms of locomotion in the animal kingdom, yet we know little about the premotor neural circuits that control flight muscles. Historically, there was thought to be a separation of control: steering muscles fine tune wing motion and power muscles oscillate the thorax to quickly start or stop flight. Recent work has begun to unravel the neural control of steering muscles, but little is known about how premotor circuits control the power muscles. To address this, we analyzed connectomic datasets of the Drosophila central nervous system to identify genetic driver lines for neurons presynaptic to the dorsal longitudinal muscle motor neurons (DLMns) and the dorsoventral muscle motor neurons (DVMns). We optogenetically activated or inhibited these neurons while recording wing kinematics and DLM/DVM motor neuron activity. Activation of some GABAergic premotor neurons, for example, reduced wingbeat frequency as much as 70Hz (30%) during stable flight, while

activation of other premotor neurons abruptly stopped flight. Conversely, we did not identify any premotor neurons that increase wingbeat frequency above baseline, suggesting the fly is operating close to the biophysical limit on power output. Our results support at least two different modes for flight power control (analog vs. discrete) within the premotor network alone. These circuits reveal a more nuanced neural architecture for flight control beyond the historical view of power muscles.

Pregnancy paparazzi: daily activity in gravid *Crotalus horridus* using time lapse photography

Natalia Thomas, Divia Feinstein, Mary O'Donnell

Pregnancy in timber rattlesnakes is time consuming and costly. Female snakes modify their behavior to promote the development of healthy offspring while occupying gestation sites over the course of the summer. Snakes use gestation environment and basking behaviors to modulate their body temperature throughout the day and season to remain within the thermal range needed to promote gestation. Using trail camera time lapse photography settings, we studied 8 gravid female Timber rattlesnakes (Crotalus horridus) in 3 locations in northcentral Pennsylvania. We investigated the daily activity patterns of gravid females from date of first encounter at gestation sites in June through birth or departure from the gestation site to see how differences in temperature, sunrise time, and other environmental triggers influenced behavior. For snakes which maintained occupancy of the gestation site through parturition, activity of the postpartum female and neonates was also investigated. After recording snake behavior and movements within the gestation site, patterns emerged in time of first emergence from shelter following sunrise, duration of basking, and timing of basking. Because all the individuals in the study occupied sites within a historical farmstead in a highly managed public park, differences in canopy cover, presence of farm building remnants, and human disturbance may be influencing behavior in gestating and postpartum snakes.

Tree frogs adjust jumping behavior based on substrate orientation and compliance

Parker Thomas, Zoe Byrnes, Greg Byrnes

Locomotion in animals is influenced by the properties of the substrates that they interact with. In arboreal habitats, animals must move over substrates that vary in both orientation and compliance by modulating locomotor forces, maintaining balance, and gripping substrates effectively. These challenges could be even greater in leaping or jumping animals that move by producing large magnitude but transient forces on the substrate during take-off and landing. We explore the interactive effects of substrate orientation and compliance on the jumping performance of tree frogs (Polypedates leucomystax). Frogs were observed jumping from both horizontal and vertical substrates of two different stiffnesses. High-speed video analysis was used to capture takeoff angles and the trajectory of the jumps. Along with video analysis, substrate reaction forces were measured during take-off. In general, frogs reduce the take-off angle relative to the substrate on compliant surfaces, compared to rigid ones, minimizing energy loss to the substrate. However, on vertical compared to horizontal substrates, they jump at greater angles from the substrate for both stiffnesses. In addition, frogs appear to modulate substrate reaction forces less in response to substrate orientation or compliance than take-off angles. Our data give further evidence that branch compliance exerts a cost on locomotion that animals try to minimize, but the frogs in this study appear to balance locomotor costs with maximizing jumping performance.

Stronger together: Building coastal marsh resiliency with mutualistic fungal endophytes

Camille Thompson, Jeremiah Henning

Coastal salt marshes face the simultaneous impacts of sea-level rise, increasing salinity, and disturbance from increasing tropical storms and urban development. Restoration of coastal marshes following disturbance is critical to maintain ecosystem services; however, restoration is hindered by the uncertainty of ongoing climate change. To improve the resiliency and stability of coastal marshes, inoculation of native fungal endophytes on marsh grasses may increase their ability to withstand biotic and abiotic stress, like salinity tolerance and pathogen protection. However, fungal endophytes are not currently considered in marsh restoration practices. To understand the relationship between native endophytes and salt marsh grasses, we isolated and identified several fungal endophyte strains from Spartina alterniflora growing on Dauphin Island, AL. To test the salinity tolerance of our strains, we inoculated ten strains on malt extract agar (MEA) plates ranging in salinity from 0 to 40 ppt. We found that all strains grew best at 10-20ppt salt concentrations. Our second experiment tested if strains provided salinity tolerance to plant hosts by inoculating five strains on S. alterniflora seedlings and grown in a salinity gradient ranging from 0 to 40 ppt. We measured plant growth, survival, and final biomass over four months. Our goal is to identify endophyte strains that increase plant resilience and can be integrated in coastal salt marsh restorations to support plant stress tolerance.

Head size allometry supports differences in digging ability between sexes in a semi-fossorial lizard

Gwendalyn Thompson, David Tevs

In lizards, sexual dimorphism in head shape has commonly been studied from a male perspective, with larger heads being associated with greater fighting ability during male-on-male combat or for displaying colored throats. However, reductions in overall head size and length are also associated with adaptation to a fossorial lifestyle. Consequently we hypothesize that reduced female head size in sub-surface nesting lizards may also confer greater digging ability and provide greater freedom when selecting suitable nest sites. We collected western skinks (Plestiodon skilontianus) by turning rocks on dry-pine slopes in the Bitterroot National Forest (Montana, USA). For each lizard, we recorded snout-vent length and head length, width and height. We also recorded the embedded depth of rocks we found observed lizards under. After correcting for differences in body size, the head width, length and height of female lizards were smaller than that of males. Female head length and width, but not height, also grew at a slower rate relative to body size compared to males. Finally, although the average embedded depth for both sexes was similar, female embedded depth measurements were more variable and had a larger maximum depth than that of the males. These findings support reduced head size in female lizards beneficial for accessing a wide range of nesting depths and suggest that selective pressures acting on lizard head shape differ between sexes.

The role of nest depth in bumble bee colony performance

Preston Thompson, T'ai Roulston

Climate change poses threats to bumble bee populations, with rising temperatures potentially exceeding critical thermal thresholds for larval development. Workers can tolerate temperatures up to 52°C, brood mortality occurs at just 36°C, making nest thermoregulation crucial for colony survival. This study investigated how nest depth affects temperature regulation and colony performance in the common eastern bumble bee (Bombus impatiens).

Ten experimental colonies were established at Blandy Experimental Farm, with five placed at surface level and five buried at 60 cm depth. Temperature loggers monitored nest and brood temperatures, while trail cameras recorded worker behavior including fanning and incubating. RFID tags tracked individual foraging patterns, and brood cells were counted and assessed over six weeks.

Results demonstrated that deep colonies maintained lower temperatures, averaging 27.86°C compared to 30.34°C in surface nests. Deep colonies spent 62.4% of time within optimal brood temperature ranges (28-32°C) and never required fanning behavior, while surface colonies spent 38.9% of time above optimal temperatures requiring active cooling. Deep nests produced significantly more brood cells (48.47 ± 2.48) compared to surface nests (26.9 ± 1.09). Structural equation modeling revealed that surface nests closely tracked ambient temperatures, while deep nests were effectively buffered against temperature fluctuations.

These findings suggest that nest depth provides critical thermal refugia for bumble bee colonies under warming conditions, with implications for efforts targeting pollinator resilience to climate change.

Understanding fungus among us: exploring salt's effect on amphibian disease chytridiomycosis

Ryan Thompson, Emily Le Sage

We are studying an aquatic pathogenic fungus, Batrachochytrium dendrobatidis (Bd), as it has caused population declines and extinctions in hundreds of frog species. Prominent literature in our field suggests that treating aquatic areas with salt could eradicate this pervasive invasive pathogen. However, other work shows that salt could have adverse effects on both Bd and amphibia, as roadside salt inhibits frog growth and leaves anurans more susceptible to ranavirus. To assess how Bd responds to salt exposure, we used Growth Inhibition Assays (GIAs). Additionally, to determine how anurans naturally interact with salt we surveyed for Bd prevalence and infection intensity in several field sites that were close to and distant from salted roads. Our findings will improve amphibian population management and regulate the use of road salt.

Larval crabs as indicators of acidification stress via microCT

Joel Tibbs, Lane Barron, William Ballentine, Kit Yu Karen Chan

Ocean acidification (OA) poses a significant risk to the health of marine ecosystems. Organisms with calcium carbonate structures, including calcified zooplankton, are particularly vulnerable. The formation and maintenance of calcified structures can be energetically demanding, and hence, their thickness, density and integrity can reflect and record environmental conditions. The carapaces of larval crabs and the soft tissues within them could be used as a proxy of the acidification stress experienced. By comparing the zoea and megalopae collected through different seasons and locations in Puget Sound, an area of seasonal upwelling, through micro-computed tomography (µCT), we are developing a novel bioindicator of OA stress. While pitting on the carapace has been recorded on megalopae, we hypothesize that shorter-lived zoeal stages have less pitting due to limited exposure. However, there may be tradeoffs between ephemeral calcified structure building and development of soft tissues. This tradeoff may present as a decrease in the volume of the digestive track and/or muscle in larval crabs collected during periods of high pCO2. Our work will enhance our understanding of organismal responses to acidification and provide a novel tool to monitor the impact of environmental changes.

Function of bristled appendages during take-off from the air-water interface

Snigdha Shiuly Tikader, Spandana Bharadwaj, Margaret Byron

Many animals across taxa use appendages covered in fine, bristle-like structures for various functional behaviors. Aquatic insects such as diving beetles, backswimmers, water boatmen, et al. have metathoracic legs lined with hydrophobic setae; these legs function as flexible paddles during underwater swimming and levers that launch from the air-water interface during take-off. These microscale setae have been studied in single-phase environments (air or water), particularly in propulsion (swimming/flying) and sensing (olfaction). However, their role in facilitating take-off from the air-water interface remains less explored. Inspired by the bristled metathoracic legs of aerial-aquatic insects, we idealize the setae as a uniformly spaced array of parallel cylinders. Using a generalized robotic platform, we experimentally investigate how the cylinder array deforms the air-water interface and generates vertical forces when the Bond number is around unity (that is, when both buoyancy and surface tension are nontrivial). Using high-speed imaging and Particle Image Velocimetry, we examine how cylinder spacing, wettability, and geometric alignment affect the dynamic response of the deformed interface. Additionally, we use scanning electron microscopy to explore the morphology, dimensions, and inter-setal spacing for several representative species. We find categorical differences in setal arrangement between Dytiscidae vs. Nepomorpha (possibly reflecting their evolutionary distance), despite similar swimming strategies/performance. Our results provide insight into the interfacial dynamics of setae-laden structures, leading to design inspiration for small-scale bio-inspired aerial-aquatic robots.

How cryptic are cryptic species? A case study using the clownfish-hosting sea anemones

Benjamin Titus, Catheline Froehlich, Estefanía Rodríguez

Sea anemones (Cnidaria: Anthozoa: Actiniaria) have simple body plans, no hard parts, and few morphological characters that are useful taxonomically. Phenotypic traits such as tentacle and body color, tentacle shape, tentacle pattern, tentacle length, and solitary vs. clonal growth patterns have long been considered too variable to reveal meaningful patterns at shallow evolutionary timescales. Compounding these issues is that sea anemone mitochondrial genomes evolve slowly and rendered DNA barcodes functionally useless for differentiating between closely related species at a time when biodiversity scientists were using these tools to discover and delimit cryptic species. Genomic approaches are now revealing the degree to which sea anemone biodiversity is under described, but we are poorly equipped to understand whether any phenotypic traits may be useful for making reasonably accurate field identifications. To begin to determine just how cryptic cryptic sea anemone species are, we conducted genomic species delimitation analyses for the bubble tip sea anemone Entacmaea quadricolor and followed up these analyses by phenotyping each individual. We find that three cryptic species of E. quadricolor have consistent phenotypic differences where they co-occur in Japan. We follow up this analysis with phenotypic profiles of E. quadricolor throughout its remaining range using citizen science databases to begin to circumscribe major phenotypic patterns and attempt to estimate how many cryptic taxa may be left to discover within this species complex.

Mechanisms of knot formation in filamentous bacteria

Ishant Tiwari, Zongxin Yu, Vishal Patil, Saad Bhamla

Topological self-entanglement is common in living systems and may confer functional benefits, yet the mechanisms that generate micron-scale knots in cellular collectives remain largely unexplored. We investigate knot formation in filament-forming bacterial colonies, focusing on a model organism (Trichococcous flocculiformis) that produces long, unbranched filaments capable of tying under shaking culture. We present a microfluidic imaging protocol that enables continuous observation of colony growth under defined shear and nutritional regimes, and we outline image-based procedures to identify and characterize putative knotted states (crossing number, loop geometry, and stability over time). We use these tools to probe candidate pathways for knot initiation, including growth-driven loop capture and motility-assisted knotting, and to map qualitative regimes as a function of shear rate and nutrient density. Comparative observations on motile filamentous cyanobacteria provide context for distinguishing organism-specific from geometry-driven effects. Taken together, these results aim to refine when knots occur, how they persist or resolve, and whether any functional signatures emerge under laboratory conditions.

The food- and temperature-dependent proteomic heat stress response in the mussel Mytilus

Lars Tomanek, Frank Fabela, Melissa May

The effect of food availability on the stress response has received limited attention. We acclimated the intertidal mussel Mytilus californianus to four conditions of low–high food, nearshore (low) and aquaculture (high) phytoplankton levels, combined with low-high (20°C and 30°C) aerial temperatures. We simulated circadian and circatidal rhythms, before exposing mussels to an acute 33°C 6 h aerial heat stress and allowed for 1 h and 24 h recovery. We then identified the food-dependent proteomic changes in gill in response to heat using liquid-chromatography and mass spectrometry. Our results demonstrate the fundamental role of food in affecting core carbohydrate and one carbon metabolism, indicating the folate and methionine cycles as central hubs for providing precursors for histone methyltransferases. Food levels affected chaperones (chaperone-containing T-complex) responsible for folding cytoskeletal proteins, which accompanied changes in actin stress fiber and cell adhesion proteins. Specific ubiquitin receptors changing proteasome activity, proteins affecting DNA structure and RNA synthesis, transport and processing showed food-dependent responses. Food also affected p38 MAPK and stress-activated protein kinase signaling. While low temperature-low food

(LTLF) mussels induced a comprehensive stress response, both low temperature-high food (LTHF) and high temperature-low food (HTLF) did not require it, while high temperature-high food (HTHF) mussels showed an in-between stress response, demonstrating the importance of food levels for modulating the acute stress response.

Determining effects of nutrition on growth in the symbiotic sea anemone Aiptasia in a CURE course

Frances Tor, Payton Maszy, Virginia Weis, Nathan Kirk, Carmen Harjoe

Cnidarians form highly productive symbioses with photosynthetic algae, but this partnership can break down when stressed. The symbiotic sea anemone Aiptasia, a model system for coral symbiosis, was used to determine how energy stores and host-symbiont regulation affect host growth and survivorship. We kept adult anemones either in the light and fed them or in the dark (preventing symbiont photosynthesis) and starved them for a month and then generated asexual buds (lacerates) by surgically excising tissue from the pedal disc. We allowed the lacerates to recover in one of four treatments: light to light, dark to light, light to dark, and dark to dark. We hypothesized that starved animals would have higher mortality and lower growth rates when switched to the light, because immune repression during host development disrupts host-symbiont regulation, leading to dysbiosis when nutrition is limited. Data were collected by students in a large enrollment introductory biology course (n=1054) and repeated by two undergraduate fellows to determine data quality from the large class. In the light, lacerates cut from starved parents developed significantly fewer tentacles and had higher mortality compared to those from fed parents. This pattern was also seen in the follow-up experiment, but it was not significant due to smaller sample sizes. Students in the class also felt that the CURE was highly engaging and helped them prepare for future careers.

Many tools for the job: Elucidating stories within gray whale hormone data through a collaborative and multidisciplinary approach

Leigh Torres

Collection of fecal samples from wild cetaceans for hormone metabolite analyses has become a common non-invasive approach to gain physiological insights about these difficult to study animals. While this sample type enables detection of hormone variation, it is challenging to understand the underlying drivers of the observed patterns, which is frequently the overarching goal of monitoring hormones in wild cetacean populations. To study the physiological stress response of gray whales to multiple stressors, we collected 402 fecal samples over 10 years from gray whales foraging off the coast of Oregon, USA and assessed concentrations of glucocorticoid (GC), progesterone, testosterone, and thyroid metabolites. Initial exploration of GC data revealed high variation in metabolite concentrations that were difficult to interpret. Yet, clarity, patterns, and new knowledge emerged once analyses incorporated contextualized data from (1) photographs identifying individual whales and presence of injuries and epidermal health, (2) drone images for photogrammetric assessment of body length and condition to estimate age and nutritive health, respectively, (3) demographic information on sex and reproductive state, (4) environmental and prey conditions, (5) ambient noise levels, (6) behavioral observations, and (7) day of year. Using advanced statistical tools, such as Bayesian state-space models and multivariate normal mixture models, capable of handling non-linear relationships and missing values, this multidisciplinary and collaborative approach revealed that gray whale GC are negatively correlated with body condition, and positively correlated with vessel traffic and ocean noise with a 24 hour lag; all four hormones are positively correlated and vary with demographic unit and reproductive stage; progesterone levels are generally elevated in pregnant females; mature males significantly increase testosterone levels toward the end of the foraging season as they prepare for reproduction; and calving probability is positively related to body size and condition, yet negatively correlated with GC concentrations. Our scientific advances demonstrate how integration of many tools, partnerships, and analyses can elucidate the stories within cetacean hormone data.

Testing the impact of metamorphosis and size on the feeding kinematics of the Iberian ribbed newt

Isabelle Toussaint, Anthony Herrel, Anne-Claire Fabre

Metamorphosis is an ontogenetic process involving abrupt morphological changes separating larval from adult stages. Despite being energetically costly, its widespread occurrence across the animal kingdom suggests that the benefits provided outweigh the associated costs. The adaptive decoupling hypothesis assumes that metamorphosis breaks the correlations among the phenotypes expressed at the different life stages, enabling their independent evolution. Each stage, in turn, expresses a distinct phenotype adapted to its specific ecological and physiological demands, thereby reducing interstage competition. If this hypothesis holds, this should also be reflected through differences in the performance of functions linked to body parts that are remodeled during metamorphosis. However, other developmental factors, such as changes in body size throughout ontogeny, can also influence functional performance. We investigated the influence of metamorphosis and size on suction feeding kinematics in larval, and adult Iberian ribbed newts using high-speed video analyses. Our findings show that size significantly influenced nearly all kinematic variables. Surprisingly, developmental stage had no significant effect, despite extensive restructuring of the feeding apparatus during ontogeny, including gill slit resorption, which transforms the feeding system from unidirectional to bidirectional flow and likely alters intraoral pressure during suction. Nevertheless, suction feeding kinematics remained consistent across stages. This may be due to the fact that the fundamental biomechanical requirements of suction feeding are conserved among vertebrates, regardless of their morphology or evolutionary lineage.

Effects of sublethal cadmium exposure on a dung beetle (*Onthophagus sagittarius*)

Miranda Towse, Rebecca Westwick, Armin Moczek

Heavy metals have been shown to have a wide range of harmful effects in vertebrates broadly, but comparatively less is known about sublethal effects on invertebrates. As environmental pollution increases, invertebrate decomposers may be particularly prone to such effects as they contribute to vital ecosystem services. This three-part study investigates how exposure to cadmium – an environmentally abundant and almost universally toxic heavy metal – affects the behavior, health, and development of a dung beetle (Onthophagus sagittarius) First, we assessed whether O.sagittarius displays avoidance behaviors when cadmium is present in their food and environment. Second, we determined whether chronic exposure to cadmium during the adult stage affected cognition, aggression, fecundity, and lifespan. Lastly, we tested whether cadmium exposure during immature stages (larva, pupa) affected developmental outcomes including morphology, symmetry, cognition, fecundity, and lifespan. This study improves our understanding of how decomposers respond to toxic environmental pollutants like heavy metals. In particular, our findings provide new insights into how exposure to sublethal doses of environmental toxins affects phenotypes such as behavior and fecundity, which are vital to an organism's success and ecological function, but have received comparatively less attention than studies on mortality events.

The right tool for the job: ontogenetic shifts in morphology and early sea turtle dispersal

Samantha Trail, Jeanette Wyneken

As hatchling sea turtles emerge from nests, they exhibit an innate hyperactive state: rapidly crawling to the water, followed by almost continuous swimming for 24-48 hours. This "frenzy" is dominated by powerstroking – characterized by bilateral "flapping" of hydrofoil-shaped flippers. Sea turtles continue using the powerstroke less vigorously in the open ocean. However, loggerheads (Caretta caretta) find refuge in floating mats of seaweed opportunistically feeding and hiding from predators, while leatherbacks (Dermochelys coriacea) prefer the open in search of gelatinous prey. We hypothesize these different behaviors correspond with species-specific morphometrics and flipper kinematics. To test these hypotheses, loggerhead and leatherback hatchlings were collected on the day of emergence, measured, and tethered in a sea water-filled tank to swim. Swimming video and force data were

collected synchronously to measure thrust in concert with flipper motions as hatchlings and after 4-16 weeks of growth. Corresponding morphometrics were taken at both time points. Our results demonstrate that both species exhibit similar patterns between hatchling and neonate life stages (i.e., allometric growth between flipper and body length, increased flipper aspect ratio, and increased mean peak force per stroke). Despite these similar growth patterns, leatherbacks and loggerheads differ significantly in morphometrics and thrust production patterns at both life stages. We propose these species-specific differences are best explained by their differing post-frenzy dispersal behaviors and microhabitat preferences during that time.

Oxytocin drives social affiliation and avoidance through distinct neural pathways

Brian Trainor

Oxytocin is a well-known modulator of social behaviors and is best known for its effects on affiliative behaviors. However, in many cases oxytocin induces social avoidance. How can one neuropeptide have such divergent effects on behavior? Studying the monogamous California mouse we set out to answer this question. Using a combination of pharmacology, assessments of neural activity, and morpholino based knock-down approaches we determined that distinct neural pathways using oxytocin modulate different behavioral responses. Oxytocin produced in the posterior regions of the paraventricular nucleus promote social approach, as do oxytocin receptors in the mesolimbic dopamine system. In contrast oxytocin produced and released within the extended amygdala promote social avoidance and vigilance. Ongoing analyses are investigating whether there are different types of oxytocin producing cells that are responsible these effects. This presentation will also highlight the value of studying different species and integrating experimental findings from different fields to understand the neural mechanisms that modulate behavior.

Sink or Swim: Investigating the relationship between fish scales and trophic position

Sean Trainor, Kory Evans

The defensive arms race between predator and prey has been an ongoing struggle for over 600 million years. Armor, first seen in invertebrates, eventually appeared in vertebrates during the Silurian period of the Paleozoic era. Specifically in fishes, armor is sometimes viewed as a tradeoff between defense and speed. Different shapes and weights of these armors have been shown to influence penetrative resistance, the ability to resist water currents when immobile, and faster overall swim speeds. Additionally, different life histories may have different defensive demands, and thus species may distribute themselves along different ends of the armor spectrum. Here, we use stable isotope analysis, three-dimensional geometric morphometrics and finite element analysis to investigate the relationship between scale shape and trophic position and test for whether scale shape specifically influences penetrative resistance. We hypothesize that there will be a significant relationship between scale shape and trophic position, with lower trophic positions exhibiting larger and thicker scales that better resist penetration, while higher trophic position fishes will exhibit smaller, thinner scales that reduce drag while swimming.

Splitting hair(cells): Investigating the cranial lateral line in Cyprinodon diet specialists

Charles Tralka, Feña Palaminos, Ronald Agwamba, Christopher Martin

The lateral line detects fluid movement and mediates important behaviors such as prey capture and social behaviors. However, there is a major gap in understanding how changes in the cranial lateral line affect feeding performance in diet specialists. Cyprinodon pupfish present a unique opportunity to study how the cranial lateral line diverges within a recent adaptive radiation of diet specialists on San Salvador Island that is composed of a generalist, a molluscivore, and a scale-eater. To investigate cranial lateral line diversity across these species, I imaged 15 individuals from each species using the fluorescent dye, DASPEI. I then compared superficial and canal neuromast counts across cranial regions including the nasal, mandibular, infraorbital, supraorbital, and preopercular. We found that the molluscivore has elevated numbers of superficial neuromasts in the nasal region, suggesting that this region may be important for invertebrate prey detection. Scale-eaters show increased asymmetry of superficial neuromasts in the infraorbital region compared to the other members of the radiation, suggesting that this region may play a role in lateralized scale-biting. We find these species have rapidly adapted to divergent dietary ecology by changing the abundance of superficial neuromasts in the cranial lateral line system.

Do anemones regulate zooxanthellae density based on food intake or reactive oxygen species levels?

Xuan-Anh Tran, Lisa Crummett

Cnidarians may regulate zooxanthellae symbiont density by controlling nutrient transfer to their symbionts and/or symbiont expulsion. Cnidarian symbiont expulsion is well-studied under stressful conditions whereby it has been associated with excess reactive oxygen species (ROS) in the host. However, cnidarian symbiont expulsion under normal conditions, as a means of symbiont density regulation, is relatively understudied. Under relatively normal conditions, do cnidarians regulate symbiont density using ROS or antioxidant levels as a proxy for symbiont density? Does host nutritional status influence symbiont density regulation? We examined if nutrient input (fed vs. unfed) in the aggregating anemone, Anthopleura elegantissima, was correlated with symbiont density, growth rate, or expulsion. We also examined if host ROS and catalase (antioxidant) levels were associated with symbiont density, growth rate, or expulsion in fed/unfed anemones. Symbionts in fed anemones had a higher growth rate than unfed anemones. ROS levels were positively correlated with symbiont density in both fed and unfed anemones, and ROS was positively correlated with catalase (antioxidant) in both fed and unfed anemones. Surprisingly, symbiont density/µg host protein was drastically reduced and catalase units/µg host protein significantly increased over three weeks in fed and unfed anemones. However, symbiont expulsion remained relatively constant over time in fed and unfed anemones, with unfed anemones expelling more symbionts than fed anemones. These findings provide information to better understand cnidarian regulation of zooxanthellae density.

Measuring light environments; open source, low cost solutions for spectral measurements and hyperspectral imaging under low-light

Jolyon Troscianko

The spatial and spectral properties of the light environment underpin the appearance of scenes and objects. As such its measurement is crucial for understanding many aspects of animal behaviour, ecology and evolution. The escalating threat of artificial light at night (ALAN) presents unique challenges for measuring the visual impact of light pollution, requiring measurement at low light levels across the human-visible and ultraviolet ranges, across all viewing angles, and often across enormous dynamic ranges. Here I present three novel low-cost solutions for measuring key aspects of the light environment, and examples of their use in my own ALAN research across birds, moths and isopods. This includes a high sensitivity lux-meter (~£15), low-light spectroradiometer (~£250), and a low-light hyperspectral imaging system (~£350). All three systems can be powered and operated from smart phones; they are built with 3D printed parts and off-the-shelf electronic components; they operate down to light levels typical of ALAN research, cover the spectral ranges required for animal vision, and lend themselves to data logging. These systems provide researchers with valuable tools for investigating the complex relationships between light, behaviour, ecology, and biodiversity, with further potential uses in many other fields.

Radiation in jaw morphology of early ray-finned fishes after the Late Devonian extinction

Emily Troyer, Zachary Lyons-Weiler, Rodrigo Figueroa, Robert Higgins, Benjamin Igielman, Richard Dearden, Abigail Caron, Michael Coates, Stephanie Pierce, Sam Giles, Matt Friedman

Ray-finned fishes (Actinopterygii) are the most diverse group of vertebrates, possessing an unparalleled diversity of morphologies, ecologies, and life history strategies. Despite their overwhelming success today, they display low levels of abundance, richness, and diversity from their origin in the Devonian until diversity levels explode during the Carboniferous. This drastic change has been interpreted as an adaptive radiation following the Devonian/Carboniferous (D/C) extinction, potentially driven by the opening of novel ecological niches. Here, we integrate continuous and discrete trait data (e.g., tooth shape, ratio of tooth height/jaw depth), functional measurements, and 3D data from CT scans of exceptionally well-preserved mandibles to formally test the hypothesis that a radiation in lower jaw morphology of ray-finned fishes was associated with the D/C boundary. Compared to Devonian ray-finned fishes (n=17), Carboniferous species (n=58) possess a greatly expanded repertoire of jaw morphologies, including tooth plates, sigmoidal dentition, beak-like oral jaws, and even edentulate jaws. Additionally, disparity through time increases considerably after the D/C boundary, with highest levels seen in the Gzhelian (303.7-298.9 Ma) and Moscovian (315.2-307 Ma), pinpointing the timing of bursts of diversity and ultimately setting the stage for their future success. Both 3D and discrete trait datasets show similar overall patterns; however, the largest increases in disparity appear when analyzing discrete trait data. This work was supported by NSF-EAR grants 2218892, 2219069, and 2219007; and NERC NE/X016633/1.

The oviduct of a polymorphic salamander: a link of microanatomy and transcriptomics

Ana Trujano, Lizbeth Gomora, Mataya Woodard, Ronald Bonett

The oviduct is a major feature of female reproductive anatomy, important for the passage and sometimes maturation of eggs. It produces secretions such as fluids, nutrients, and egg-jelly, which play a main role in the protection and development of the embryo. The production of egg-jelly involves glands found in different segments of the oviduct. In some species, the number of egg-jelly layers is attributable to different regions or gland types of the oviduct. We used transcriptome sequencing and histology to evaluate the relationship between microanatomy and gene expression of secretory cells across three oviduct regions. Our analysis focused on three different reproductive stages: 1) pre-oviposition, 2) post-oviposition, and 3) non-reproductive, as well as two different life cycle modes. The results show microanatomical changes on the epithelial wall in different regions of the oviduct as well as the upregulation of mucin genes on different reproductive stages.

Hot wings: climate change impacts on near-infrared reflectance of Vanessa cardui

Ashlyn Trujillo, Amanda Carter

Understanding organismal responses to climate change is crucial for mitigating biodiversity loss, especially in species that provide ecosystem services, like pollinators. Approximately 75% of plants rely on pollinators, with insects such as butterflies playing a major role. Therefore, it is imperative to understand how butterflies might respond to rising temperatures. Butterfly wings are composed of millions of scales containing pigments and structures that play major roles in absorbing or reflecting wavelengths of light. These structures affect body temperatures by influencing near-infrared (NIR) light, a wavelength that strongly contributes to heat gain. Studies show that dorsal scales enhance heat absorption, while ventral scales prevent overheating. We wanted to determine if NIR reflectance differs between dorsal and ventral surfaces across different wing regions in response to climate change. We analyzed 509 museum specimens of Vanessa cardui across 109 years, focusing on individuals collected within the North American overwintering range – a region they return to annually and where they are consistently exposed to rising temperatures driven by climate change. We measured NIR reflectance on dorsal and ventral wings – parsing proximal and distal regions – and thorax. We hypothesize that NIR reflectance will increase over time, and that ventral-proximal and thorax regions will have higher reflectance than distal regions. Our findings will enhance understanding of butterfly thermal biology and inform predictions of pollinator persistence through climate change.

Juvenile hormone and the evolution of insect metamorphosis

James Truman, Lynn Riddiford

The increasing complexity of life histories during insect evolution has been accompanied by expanding roles for juvenile hormone (JH). In a basal, non-metamorphic species, such as Thermobia domestica, the developmental functions of JH are restricted to embryogenesis where JH mediates the transition from morphogenetic growth to terminal differentiation. With the shift to incomplete metamorphosis, JH acquired the postembryonic function of maintaining the form of the juvenile (the nymph), and preventing metamorphosis. The movement of JH into the postembryonic realm likely followed the new morphogenesis supporting wing formation in the nymph. This reuse of JH during wing morphogenesis likely resulted in the production of a protective wing pad, rather than a winglet. The disappearance of JH was then required for the differentiation of a mature wing at metamorphosis. The shift to complete metamorphosis, with its larval, pupal and adult stages, was accompanied by a second, brief JH peak during the formation of the pupa. Analogous to its role in nymphs, JH maintains the larval form during growth, but also acts on persisting embryonic primordia to prevent their morphogenesis while allowing their growth. JH loss late in larval growth then allows these primordia to undergo morphogenesis and cell determination. Whether the transient return of JH in the prepupa provides a recapitulation of a late embryonic environment for these differentiating imaginal primordia remains to be resolved.

Leveraging a CURE to perform functional genetic testing of chill coma recovery in *Drosophila*

Ellie Tushar, Adam Haddad, Shelly McCain, Jimmy deMayo, Greg Ragland

Functional genetic testing of candidate genes is a common method employed to elucidate physiological mechanisms underlying a trait of ecological or evolutionary interest. However, such tests can be time-consuming and may often require repeated experiments to validate. We have designed a Course-based Research Experience for Undergraduates (CURE) that allows students to test the effects of different genes on a trait in Drosophila melanogaster and allows our lab to implement such experiments repeatedly across class sections and semesters. We specifically use a GAL4/UAS system to knock out gene function in specific tissues, then test for effects on chill coma recovery time, a common assay for cold hardiness in invertebrates. In this paper we report on several years of CURE data. We assess the quality and noisiness of the data, discuss challenges and pitfalls, and discuss what we've learned about some specific candidates, e.g., various HSP genes and the immune-associate Turandot A. We also briefly mention the educational benefits of the CURE and how we balance those against the goal of gaining new scientific insights.

Eusocial bumble bees reveal hidden capacities for thermal acclimation in physiology and behavior

Tamara Tyner-Swanson, Amy Toth, Eric Riddell

Bumble bees are declining on a global scale leading to ecological and economic losses, with some studies suggesting that bumble bees may be physiologically vulnerable to warming temperatures. In response to environmental variation, organisms may reversibly acclimate physiological and behavioral traits to increase performance. Although bumble bees have shown a limited capacity to acclimate as individuals, bumble bees often work in a eusocial nest structure, adjusting physiological and behavioral traits as a "superorganism". To assess the capacity of eusocial nests to acclimate to thermal stress, we performed thermal acclimation experiments on commercially reared Bombus impatiens nests. The nests were first subjected to an initial thermal ramp with acute temperatures of 10°, 20°, 25°, 30°, and 35°C during which behavior and metabolic rate were recorded. Nests were then

randomly placed into an acclimation chamber at 10°, 20°, or 30°C for a period of three weeks and subsequently remeasured in the thermal ramping experiment. We found significant effects of acclimation and acute temperature treatments across physiological and behavioral traits, indicating that bees from cool nests maintain nest temperature through active physiological and behavioral regulation, whereas at warm temperatures bees show a reduction in movement and generate less metabolic heat. These results demonstrate that bumble bees acclimate to thermal variation as a superorganism and fundamentally alter our perspective on responses to climate change in eusocial organisms.

Phylogeny and evolution of fissiparity in asterinid sea stars using genome skimming

Abigail Uehling, Maria Granquist, Edgardo Ortiz, Lisa Mussoi, Christopher Mah, Christopher Meyer, Gustav Paulay

The family Asterinidae (Echinodermata:Asteroidea) is a globally distributed and ecologically important group of sea stars that contains several large understudied tropical radiations as well as the model species Patiria miniata. Within Asteroidea, asterinids have the greatest known diversity of life history strategies. Species can have a range of egg size and buoyancy and subsequent larval type can be either planktotrophic (feeding) or lecithotrophic (nonfeeding). Fertilization strategies can also range from planktonic, benthic and intragonadal. Asterinids also heavily utilize asexual reproduction via fissiparity, or cloning via body fission and subsequent regeneration. Preliminary phylogenies based on cytochrome c oxidase I (COI) mitochondrial sequence data suggest that fissiparity has evolved independently multiple times across asterinids. Within the genus Aquilonastra, 10 species are known to be fissiparous. Sequenced fissiparous lineages often fall sister to non-fissiparous lineages, indicating the recent and frequent emergence of fissiparity in this family. However, little molecular work beyond COI has been published, and current phylogenies do not include large samplings of taxa with recent radiations, such as Aquilonastra. In this study, we used genome skimming of museum specimens to reconstruct asterinid phylogeny and investigate the evolution and diversification of asterinids, as well as the multiple transitions of fissiparity.

Physiological and behavioral responses of *B. schlosseri* to hyposalinity stress

Monica Urias, Dietmar Kueltz

Colonial tunicates such as the star ascidian, Botryllus schlosseri, are known for their short generation times and ability to opportunistically reproduce both sexually and asexually, facilitating their successful widespread invasions. Moreover, they have impressive tolerance levels to a wide range of environmental conditions. To better understand the physiological and behavioral effects of acute exposure to hyposalinity stress in B. schlosseri, a series of acute range finding experiments was performed on multiple B. schlosseri genotypes to identify which level and duration of hyposaline stress induced sublethal but significant effects in laboratory-raised colonies. Changes in budding rate, pigmentation, zooid size, and siphon activity were measured to provide a comprehensive view of the response of B. schlosseri to decreased salinity. Budding rate, zooid size, and siphon activity in response to stimulation started to decrease after exposure for 3 days to a salinity of 15 ppt, while pigmentation increased. These experiments establish salinity conditions that are stressful but not lethal to B. schlosseri and can be used in future experiments directed at dissecting molecular pathways of hyposalinity stress resilience, including quantitative proteomics and functional enrichment network analyses. Furthermore, the conditions revealed in these experiments can now be applied for repeated exposure experiments to test for transgenerational stress hardening, a phenomenon that may contribute to the high invasiveness of B. schlosseri in new environments. Funded by NSF Grant MCB – 2127516.

Incubation effort and telomere dynamics in Leach's Storm Petrels

Axel Uribe, Sarah Chapman, Kayla Lichtner, Tori Chace, Samuel Neirink, Liam Taylor, Robert Mauck, Patricia Jones, Mark Haussmann

Avian embryos cannot regulate their own temperature, necessitating parental thermal buffering to stabilize developmental conditions throughout incubation. Many pelagic seabird pairs take turns between incubation and foraging during the breeding period. However, because of unpredictable food resources and fluctuating environmental conditions, breeding pairs often differ in how they divide parental tasks. This variable parental care during the incubation period may impose a physiological cost, which can be investigated using cellular biomarkers. Telomeres—the protective, terminal caps on linear chromosomes—are one biomarker of organismal cellular health. In previous studies of seabirds, shorter telomeres have been linked to improved reproductive performance, which could suggest that decreased energy expenditure towards self-maintenance has a cellular cost on telomeres. Here, we examine the impact of incubation effort on telomere dynamics in Leach's storm petrels (Hydrobates leucorhous). To assess changes in telomere length, blood samples were collected from adults approximately 10 days post-egg lay date and 3 days before expected hatch date (average incubation period: 41.7 ± 2 days). Erythrocyte telomere length was measured using the telomere restriction fragment assay. We will discuss telomere length changes at both the individual and pair level to evaluate how incubation effort may trade off with somatic maintenance. This study improves our understanding of the physiological costs of parental investment during incubation, with potential long-term effects on organismal physiology and future reproductive outcomes.

Propeller principles: accounting for Strouhal number and the pike-tuna, vulture-swift spectrum

Jim Usherwood

Efficient propulsion, whether with a fin, fluke, wing or propeller, requires that the foil move across the fluid at a specific velocity V in relation to the forward velocity U. If the foil is too slow, it cannot produced thrust; if too fast, it produces thrust with excessive power demand. For foils of high lift:drag ratio, optimum efficiency is achieved at V=U, equivalent to a Strouhal number of 0.5. Reported Strouhal numbers for cruising animals appear too low for optimal mechanical efficiency; however, the deviation from optimal efficiency may be small, and there are physical and physiological advantages to relatively low amplitudes and frequencies for swimming and flapping flight.

The same propeller principles can be applied to calculating optimal foil properties as functions of forward speed and motor power availability. In order to approach the efficient V=U condition at low forward velocities or high motor power supply, foils of relatively high area and/or high lift coefficient are required. This accounts for the relatively broad caudal fins of pike and wings of vultures, and may indicate the function of the separated emarginate primaries as high-lift mechanisms – both features that have long been argued as adaptations for take-off rather than soaring. At higher speeds, lower foil area and/or lower lift coefficients are necessary, consistent with the narrow foils of tuna and swift.

'Legs as linkages': predictions for muscle properties, and application to robot design

Jim Usherwood

The structures and actions of animal legs during steady locomotion can be reduced to two functions: weight support during translation with low mechanical work demand; and economical supply of mechanical work. The hindlimb of mammals and birds can be modelled as serial 6-bar linkages that facilitate both functions without compromise. Here, predictions of muscle structure and action are presented within this conceptual framework. The potential for applying these principles to robot legs will be discussed, and latest mechanical demonstrators and simple robots presented.

Quantifying ultrafast microscale displacement fields with a novel optical system

Abhinav Vaduri, Clare Cook, Melody Young, Roarke Horstmeyer, Sheila Patek

Capturing rapid, three-dimensional displacements in small biological systems remains a longstanding challenge in biomechanics. Existent systems face an inherent trade-off between spatial resolution and field of view. For example, the laser doppler vibrometry method offers high precision but only at single points, lacking spatial coverage. Conversely, digital image correlation achieves larger fields of view, but requires complex multi-camera setups that lack the optical angles needed to resolve displacements in small specimens. We present a novel imaging system, an ultra-high speed Fourier Light Field microscope capable of resolving micron scale three-dimensional displacements across millimeter fields of view. This device introduces 3-6 array lenses placed between the primary objective lens (used to magnify the specimen), and the sensor. This allows for synchronous capture of 3-6 unique angles of the specimen without potential synchronization lag that affects multi-sensor systems when filming at ultra-high frame rates (e.g., upwards of 100kHz). We validated the capabilities of this new optical device by resolving the tiny displacement fields (~40 microns) across the exoskeleton of a trap-jaw ant head (field of view: 2 mm) during an ultrafast striking event. Our new device is highly modular, allowing the setup to be adapted to the spatial and resolution requirements of different specimens and experimental contexts. This approach lays the groundwork for future studies requiring precise, volumetric tracking of ultrafast motion at microscale resolution.

Complementary roles for gene expression and exon usage in heat shock response of splashpool copepod

Rujuta Vaidya, Isabelle Neylan, Brant Faircloth, Maheshi Dassanayake, Morgan Kelly

Understanding the mechanisms by which organisms adapt to variation in temperature is key to explaining their distribution across environments and to predicting their persistence to changing climate. Recent studies have also shown cellular response to heat shock can be quantitative (changing the magnitude of expression) or qualitative (differential usage of exons originating from the same gene). We examined the gene expression and exon usage changes in response to heat shock at four post–stress timepoints in a splashpool copepod, Tigriopus californicus. We detected signatures of both gene expression and exon usage changes across all timepoints. The magnitude of this response was higher at timepoints closer to heat shock and decreased with time post–heat shock. We observed that heat shock predominantly induced changes in gene expression in genes coding for heat shock proteins, cellular growth, and differentiation. In contrast, we found that genes coding for peptidases and chitin synthesis showed both altered expression levels and exon usage. Genes associated with cellular metabolism and cytoskeletal elements primarily showed changes in exon usage. These ontology–specific response mechanisms provide new insights into the temporal landscape of heat shock response in Tigriopus and highlight the need to integrate qualitative and quantitative changes in gene expression to fully understand organismal responses to heat shock.

Variation in orbit-to-semicircular canal orientation in the North American river otter

Dominik Valdez, Austin Bay, Hansan Jones, Celeste Delap, Heather Smith, Christopher Heesy, Leigha Lynch

The vertebrate vestibular system encodes gravicentric information, i.e. on the gravity vector relative to body position, crucial for maintaining body position during locomotion as well as dynamic oculomotor function. Interspecific comparative data on the cardinal angular relationships among the semicircular canals of the bony labyrinth of the vestibular system is suggestive of substantial variation in morphology that, nonetheless, remains challenging to link to function. Here we approach the problem by quantifying geometric intraspecific variation in the orientation of the semicircular canals as well as of the orbits (extraocular position). We focus on five populations of Lontra canadensis (North American river otter) representing differing watersheds across North America to evaluate whether variation within water systems correlates with orbit-to-semicircular canal orientations. 3D landmark data on orbit and canal morphology were collected from complete cranial µCT scans using Avizo and Checkpoint. We find that whereas orbit orientation varies intraspecifically as expected for a carnivoran for its relative skull size, the orientations of the left and right lateral (or horizontal) semicircular canals from the median plane as well as bilaterally vary approximately six times more. This surprising level of intraspecific variability between the orbital and vestibular systems makes functional explanations linking these systems elusive. Future research correlating these orientations to water system properties, however, may provide clarity.

Limitation of increased crosslinking in aged tendons

Miles Valencia, Hanna Chow, Manny Azizi

The process of aging degrades the musculoskeletal system through processes like sarcopenia and tendinopathy. With aging, the accumulation of Advanced Glycation End-products (AGEs) form crosslinks between collagen fibers that increase tendon stiffness. This process is not limited to tendons as AGEs can also alter the mechanical properties of intramuscular connective tissues making it difficult to isolate the effects of crosslinks within tendons on the integrated performance of the muscle-tendon unit (MTU). We can isolate the crosslinking effects of tendons on MTU function by utilizing an exogenous cross-linking agent called genipin. We injected genipin into the Achilles tendon of young adult and old rats and allowed one week for recovery. We then use an in situ preparation of the medial gastrocnemius to quantify the mechanical interactions between muscles and tendons during a series of isometric contractions at varying lengths. For comparison, we replicated these tests for a control group in both age cohorts. Our preliminary results suggest that genipin successfully induced increased tendon stiffness in young rats while not affecting the maximum elastic energy storage capacity. Contrarily, old tendon showed a slight decrease in stiffness with a large reduction in elastic energy storage following genipin treatment. Our results suggest that the cross-linking effects of genipin vary as a function of age due to the accumulation of existing crosslinks in older tendons. Supported by NSF DBI 2319710.

System identification informs viscoelastic structure of tendons, muscle-tendon units and muscles

Miles Valencia, Hanna Chow, Katelyn Manross, Manny Azizi, Richard Casler, Kiisa Nishikawa

The current paradigm of muscle physiology and associated Hill-type models view muscles as motors and tendons as linear springs with a compliant toe region at short lengths. We used ramp stretch experiments and system identification to investigate the viscoelastic structure of muscles, muscle-tendon units and tendons. System identification enables the exploration of a large number of possible structures as well as estimates of linearized viscoelastic parameter coefficients around operating points at which ramp stretch experiments were performed. Previous studies have demonstrated that muscles have structure that is well fit by two Kelvin-Voigt (K-V, spring and damper in parallel) elements in series. While tendons have been modeled as both springs or quasi-linear viscoelastic materials with strain-dependent stiffness and damping, we found that tendons are well fit by a structure consisting of a single KV element in series with a spring. Interestingly, both the stiffness and damping of the KV element depend on stress, so that the time constant for stress-relaxation increases as the stress decreases. Muscle-tendon units exhibited a mixture of muscle and tendon properties, with structure similar to muscles alone, but with viscoelastic properties that depend on stress, like tendons. The results suggest that both muscles and tendons are characterized by mechanical elements that allow for the storage and recovery of elastic energy over physiological relevant time-scales. Supported by NSF DBI 2319710.

Paleontological insights into the formation of the Central American frog fauna

Maria C Vallejo-Pareja, Jason Bourque, Jonathan Bloch, David Blackburn

Central America has long served as a corridor for biodiversity, contributing to the dispersal and diversification of multiple clades through geological time.

Anurans (frogs and toads) are today among the most diverse land vertebrates in Central America. The origin of these 13 anuran families can be traced back to North or South America, but the timing of their dispersal, establishment, and diversification remain unclear. Here we use the available fossil record to contextualize the temporal, taxonomic, and geographic aspects of the formation of the anuran fauna of Central America. We include the oldest known fossils from the early Miocene (~19 Ma) of Panama as well as the youngest from the late Miocene (~6 Ma) of Honduras. We found that the oldest representatives in the fossil record are six South American families which likely dispersed northwards in the early Miocene before the completion of the Isthmus of Panama. A single North American family was recovered from the late Miocene. The fossil record indicates that dispersal may have occurred earlier than estimated from time-calibrated molecular phylogenies, and suggests that in contrast to other terrestrial vertebrates, North American anurans took longer to disperse southwards into Central America. Our findings highlight the importance of fossils for understanding modern faunas, and the need for more intensive sampling of the fossil record of Central America.

DNA transfer and its relationship to reproductive biology, particularly across protist taxa

Julia Van Etten

Like sexual reproduction, DNA transfer between species via horizontal processes like gene transfer and organellogenesis is a major mechanism of generating genetic novelty. This phenomenon has been studied extensively in the prokaryotic domain but less so in eukaryotes and not at all across communities. Here, work to identify the genome-to-genome connections created by recent DNA transfers across a single geothermal microbial community (including eukaryotes), detected by an alignment-free method co-opted for the first time for use on metagenomic data, will be presented. Additionally, a new framework for deriving new meaning from DNA transfers that considers how they drive and are driven by ecological interactions will be discussed. Further, this presentation will highlight reproductive strategies across the eukaryotic domain of life (mainly protists) that discusses the interplay and outcomes of sexual reproduction and horizontal gene transfer as mechanisms for creating new genetic variation within populations.

Do fish eggs rotate in the flow? a biomechanical analysis and biological implimentations

Maya Van Gelder, Uri Shavit, Roi Holzman

Pelagic fish eggs are small (~1 mm dia) spheres suspended in ocean flows. Their survival depends on oxygen exchange with the surrounding water during their rapid embryonic development. Traditionally, eggs are assumed to drift passively, moving as a parcel of water. Consequently, the transfer of oxygen into the egg was attributed only to diffusion. Here we challenge that assumption by testing whether relative rotational motion exists, making advection relevant to mass transfer.

We exposed gilthead sea bream (Sparus aurata) eggs to controlled rotational flows, simulating upper-ocean turbulence. Flow was quantified with Particle Image Velocimetry, and the egg's orientation and motion were simultaneously tracked. Eggs displayed two behaviors: steady-orientation, where eggs remained at a constant angle, and full rotation, where eggs rotated slower than the rotated cylinder. Both behaviors producing relative motion of the eggs relative to the water.

Modeling egg behavior using Euler's equation revealed that these dynamics stem from the eggs' non-uniform mass distribution: the heavy embryo at the bottom and buoyant oil globule at the top shift the center of mass, generating a restoring moment opposing external torque.

Because such relative motion was ignored in past models, the transfer of oxygen into fish eggs (and of waste products out) were likely underestimated. Recognizing advection's role has implications for egg survival under realistic ocean conditions and potential aquaculture applications.

Impact of avian malaria on the gut microbiome and immune response in white-crowned sparrows

Tricia Van Laar, Alejandra Valenzuela, Joel Slade

Understanding how parasitic infections influence host immunity and the gut microbiome is essential for revealing eco-immunological tradeoffs in wild animals. We investigated relationships among haemosporidian infection, immune response, and gut microbiota in migratory white-crowned sparrows (Zonotrichia leucophrys) during the wintering season. Infection status was determined via molecular diagnostics, host physiology was assessed using hematological measures, and gut microbiota was characterized via 16S rRNA sequencing of cloacal and fecal samples.

Birds with mixed infections exhibited elevated white blood cell (WBC) counts, parasite loads, and polychromasia, indicating heightened immune activity. Gut microbial communities were dominated by Actinobacteriota, Proteobacteria, Firmicutes, and Bacteroidota, with composition varying by infection status and sample source (fecal or cloacal). Although Shannon and Simpson diversity indices did not differ among groups, observed richness was significantly greater in birds with mixed infections. Beta diversity patterns were primarily influenced by sample source and year, with infection status exerting limited effects. Differential abundance analysis did not identify taxa significantly associated with infection status. However, modeling microbial composition against continuous physiological traits revealed strong associations between ASV abundance and heterophil-to-lymphocyte (H/L) ratio, parasite load, and polychromasia.

These findings emphasize the importance of physiological context when examining host–microbiome–parasite interactions. Our study emphasizes the value of winter fieldwork in capturing immune and microbial dynamics often overlooked in migratory research, highlighting how overwintering ecology contributes to understanding infection-related changes in host biology.

Diet impacts weapon and armour quality in a puncture-weapon-bearing bug

Noraly van Meer, Christina Salerno, Janice Yan, Christine Miller

Over 80% of animal species rely on exoskeletal cuticle for stabilization of the body and protection against the environment, predators and conspecifics. Cuticle layers can be deposited during juvenile development and into adulthood. The exoskeleton should be thick to function as armour against puncturing teeth, spurs or spines and/or to function as a weapon. The combination of weapon and armour fortification should be especially important in species with intraspecific competition. We will present recent discoveries showing that the structural integrity of exoskeleton can depend on nutrition. Our work focuses on the leaf-footed cactus bug, Narnia femorata (Hemiptera: Coreidae), as males of this species compete for territories, resources, and females by kicking and grappling one another with their spiny hind legs. Given the intense combat exhibited by these bugs, a robust cuticle should be especially important. Injuries, including puncture, are common in N. femorata. This species also experiences drastic changes in their natural nutrition. N. femorata preferentially feed on cactus fruit, but fruit availability varies seasonally. We show that diet impacts cuticle thickness, mass, and exoskeletal puncture resistance. We also discovered that injury resistance of hind-leg spines, used heavily in fighting, can be impacted by cactus fruit availability and quality. Our results demonstrate that nutrition can dramatically impact cuticle, which can have a myriad of important implications for male-male competition and sexual selection in natural populations.

Simulations of water flow through geometrically simplified models of filter-feeding mouth cavities

Sam Van Wassenbergh

Understanding the mechanics of filtration and clogging resistance in filter-feeding fish can pave the way for future designs of fish-inspired filters. One of the model organisms for bio-inspired filtration is the paddlefish, a ram-filter feeding species. However, the hydrodynamic processes involved in plankton filtration are still not fully understood. When water enters the mouth, it first encounters the plate-like branchial arches arranged in a step-like pattern. Deeper inside slots in between the adjacent branchial arches, gill rakers form

a comb-like porous layer. In this study, flow is simulated in morphologically simplified models of mouth cavities, including realistic flow dynamics at the porous layer using Ansys Fluent software. The simulations show that multiple filtration mechanisms are at play: from ricochet filtration at the level of the medial flow passing the branchial arches to both cross-flow and dead-end sieving near the porous layer modeled after the gill rakers. The models also indicated that the rear slots draw in water in significantly different ways and are more likely to become clogged. Further research on models with a more realistic shape and with backwash flows is needed to fully understand the feeding mechanism of paddlefish.

The evolutionary history of poachers (Cottoidea: Agonidae) dermal armor form and function

Megan Vandenberg, Adam Summers, Zachary Heiple, Dahiana Arcila, Cassandra Donatelli, Thaddaeus Buser, Matthew Kolmann, Luke Tornabene

Armor has evolved repeatedly across teleost fishes, with incredible morphological diversity appearing in over 30 distinct groups. We need evolutionary hypotheses of armored lineages to understand how these diverse forms and functions have changed across time. Poachers (Agonidae) are an unusual family of benthic, heavily armored fishes in the superfamily Cottoidea, and their close relatives are often scaleless or have reduced scales. Agonidae is traditionally defined by the presence of dermal armor; however, the inclusion of unarmored or lightly armored taxa like sea ravens (Hemitripterinae) and Irish lords (Hemilepidotinae) makes the group morphologically ambiguous. Using a broad sampling of 54 poacher species and 24 outgroup representatives, we used shotgun genome sequencing to infer a molecular phylogeny for the group. Our analyses recover a strongly supported Agonidae clade originating in the Late Eocene. Morphological character mapping and ancestral state reconstruction support the redefinition of Agonidae to include only the fully armored taxa. This revised taxonomy reflects clear synapomorphies and functional groupings, and highlights the repeated evolution of armor within Cottoidea. Further we show how armor traits such as morphotype, spine shape, and body aspect ratio change across the phylogeny. These characteristics have established functional consequences, so this new analysis reveals how performance and ecological niche have changed over evolutionary time.

Polar partitions: genetic diversity of cumaceans from the West and East Antarctic

Victoria VanderBrandt, Sarah Gerken, Kevin Kocot

Cumaceans are small but ecologically important crustaceans inhabiting marine sediments around the world, including the extreme environment of the Antarctic. Despite their abundance and broad distribution, their biodiversity and population structure remain poorly resolved in the Southern Ocean. Here, we compare cumacean populations from the West Antarctic Peninsula (WAP) and East Antarctic using the mitochondrial COI marker to assess genetic diversity and evaluate if population structure is present.

Phylogenetic analyses of the COI dataset consisting of high quality DNA sequences from the East and West Antarctic, revealed strong biogeographic patterns in many taxa. Of the lineages with sufficient sampling from both regions, several populations (n= 7) exhibited robust East–West separation, supported by high bootstrap values, indicating pronounced genetic divergence. Additional groups displayed structure within a single region, pointing to localized diversification. Haplotype network analyses, conducted within species boundaries determined by Assemble Species by Automatic Partitioning (ASAP) analysis, further illustrated these patterns showing distinct, non-overlapping haplotype clusters for most East–West pairs and highlighting cryptic diversity in multiple taxa.

These results provide one of the most comprehensive genetic comparisons of Antarctic cumaceans to date, combining tree-based and network-based evidence to reveal hidden regional diversity. This new baseline offers critical insights into the biogeography of Antarctic benthic communities and their potential responses to future environmental change.

When squirrels fly: a networked CURE for assessing flight initiation distances

Johanna Varner, Laurie Dizney, Lorelei Patrick, Jennifer Duggan, Hayley Lanier, Elizabeth Flaherty, Dylan Klure, Christopher Yahnke, Patrice Connors, Cady Sartini

Escape behaviors are an important way for animals to avoid threatening situations or stimuli. However, an animal's sensitivity to an approaching threat depends on various factors, including habituation, perceived severity of the threat, and distance to safety. Here, we describe a hands-on activity in which students measure the flight initiation distances (FID) by approaching an individual animal and then recording the distance at which the animal initiates an escape behavior. As part of the Squirrel-Net network, this activity focuses on squirrels, which are diurnal, charismatic, easily identified, and present in many habitats, including many college campuses. After completing the measurements in the field, students submit data to an aggregated national database containing observations from students across the country. This shared dataset permits students to explore questions of risk tolerance across a broader variety of habitats and species than would be possible at any single institution. This lesson can be implemented as a single laboratory period or adapted into a multi-week course-based undergraduate research experience (CURE). It can also be scaffolded with other Squirrel-Net CURE modules, allowing students to investigate questions of risk tolerance using different methods. Finally, CUREs offer extended and authentic research experiences in the classroom, expanding the range of students who gain these experiences and providing an opportunity to teach other professional skills like collaboration and communication.

Variation in mechanical properties of pycnogonid (sea spider) exoskeletons

Rebecca Varney

Arthropods rely on their exoskeletons for protection and mechanical support. The material properties of an arthropod's exoskeleton impact the environmental conditions it can withstand. Pycnogonids (sea spiders) are a class of arthropods represented in a wide array of marine habitats, from shallow tropical waters to Antarctic depths. Families of pycnogonids vary widely in size and shape, but the extent to which this variation is reflected in the material properties of the cuticle is not well understood, in part because collecting pycnogonids from extreme environments is challenging. Thus, a systematic review of exoskeleton properties across size classes, taxa, and environments is lacking. Here, I investigate pycnogonid cuticles across a range of locations and depths. Using a combination of microCT, SEM-EDX, and confocal microscopy, I highlight differences in thickness, strength, and composition and map them to environmental parameters and to maximum body size. More broadly, I discuss how differences between pycnogonids and other arthropods inform thinking in both habitat availability and bio-inspired design.

Understanding the basis of adaptation to hurricanes in a Neotropical lizard

Princeton Vaughn, Shane Campbell-Staton, Douglas Menke, Andrea Rummel, Aaron Griffing, Jonathan Losos, Colin Donihue, Anthony Herrel

Understanding the genetic basis of adaptive evolution is a central goal in evolutionary biology, but inherently requires the integration of ecological, genetic, phenotypic, and functional data to link trait shifts to their proper ecological context. Hurricanes are powerful, unpredictable storms that can also drive evolutionary change. In 2017, immediately following surveys of Anolis scriptus on two islands of the Turks and Caicos, the study populations were hit by Hurricanes Irma and Maria. Returning to the islands, researchers found that several phenotypes shifted just 3 weeks after the storms. Specifically, they found that femur length, body size, and fourth toe length decreased, while humerus length and forelimb and hindlimb toepad area increased after the storms. To understand the genetic basis of these shifts, we searched for genes under selection and loci associated with the trait shifts, revealing that one gene, hs6st1, displayed accelerated rates of evolution post-storm and was highly associated with fourth toe length. We then knocked out this gene and found that these mutants displayed shorter fourth toes. To assess how

fourth toe length relates to performance, we conducted a high wind clinging experiment, in which we found that individuals with shorter toes could hold on longer in high wind conditions. Together, these results suggest that hs6st1 is a parallel target of hurricane-induced selection that allows for enhanced hurricane survival ability.

Phylogenetic Inferences from the gill arches of Toadfishes (Batrachoidiformes: Teleostei)

Diego Vaz, Eric Hilton

Gill arches are a fundamental structure in the biology of fishes. They provide skeletal support for gill filaments (gas exchange) and gill rakers (filtration). Gill arches form the floor of the mouth and support the tongue. They also act on food processing by manipulating their prey with the pharyngeal jaws. Gill arches often bear strong phylogenetic signal throughout diversity of fishes. The order Batrachoidiformes, commonly known as toadfishes, is a small group of coastal fishes adapted to benthonic life. Despite the general acceptance of the monophlyly of this order, intraordinal relationships are still unresolved. The morphological diversity of the gill arches of toadfishes is also not known. This study examined gill arches of 66 species (out of 82) of Batrachoidiformes looking to describe its morphological diversity and look for potential phylogenetic signal that could help clarify the phylogenetic relationships among toadfishes. 52 new morphological characters with potential phylogenetic signal were found. We reported high degree of individual variation, including absence of bones in just one of the antymeres. Despite such variability, we reported shared similarities in the hypobranchial one across representatives of Batrachoidinae, Thalassophryninae, Porichthyinae and the genera Allenbatrachus, Batrachomeus, and Halophryne, potentially rendering the subfamily Halophryninae paraphyletic. A phylogenetic tree based solely on gill arch variation is presented and optimization of its characters will be discussed.

Elucidating the consequences of perturbations during snake slithering

Christine Vega, Kelsey Garner, Henry Astley

A key challenge during locomotion for most terrestrial animals is supporting body weight and controlling their inertia via contact with the substrate at several discrete points (e.g., feet). Snakes, however, have an elongate, limbless body plan that can maintain continuous contact with the substrate, and their locomotion is typically dominated by frictional rather than inertial forces. Coordinating body posture across hundreds of vertebrae to control the reaction forces across many push points is a significant challenge, yet the potential responses to perturbations during snake slithering remain untested. We examined the response to the sudden loss of contact, mirroring “tripping” tests in limbed animals. We recorded kinematics as snakes slithered through a rigid, flat substrate with equally spaced vertical pegs, a subset of which will break free when triggered. When contact is lost, a local area of the snake’s body no longer has a peg to push against and continues to slide past the peg hole. We characterized the responses of snakes using slip angle (angle between velocity and body tangent vectors), total body slide distance (lateral movement), and body contact angle (angle between body and forward direction at peg). Preliminary analysis suggests that despite variability in body posture and lost contact location, disturbance effects propagate posteriorly. Insights into these perturbation responses have implications for the potential differences in locomotor control in limbed versus limbless taxa.

Following Fire: Surveying native bees at two former fire training sites

Danielle Velazquez, Harmonie Lo, Jesse Cortez, Robert Schroeter, Alicia Fox

At Allan Hancock College (AHC), located in the southern central coast region of California, we have been participating in a study on native bees (The BUZZ) with multiple community colleges. In this study, we surveyed native bees on our college campus as well as at a local reserve, Sedgwick Reserve. In 2024 at Sedgwick, our wild site was bulldozed for a fire break. Following this, non-native grasses took over the site in 2025. Two fire training sites at Sedgwick were chosen to replace our original wild site: 1) a 1-year post-fire site where the initial dominant flowering plant was Whispering Bells, Emmenanthe penduliflora; 2) a 2-year post-fire site where Acmispon glaber (Deerweed) was the dominant flowering plant. These 2 fire training sites provided us an opportunity to observe the presence of native bees in areas recovering from fire. We plan to continue monitoring these sites in the future as they continue to recover, as well as our original wild site that is recovering from the removal of vegetation and the current presence of non-native grasses.

Genotype-specific metabolomic and transcriptomic responses to temperature in an invasive marine crab

Yaamini Venkataraman, Sara Shapiro, Sarah Zuidema, Julia Kelso, Lauren Stephenson, Carolyn Tepolt

European green crabs (Carcinus maenas) are a prolific invasive species that negatively impact species important for tribal food sovereignty and commercial shellfish production in North America. Their success is due in part to broad population-level thermal tolerance across short and long timescales, as well as high thermal plasticity. Recent discovery of a temperature-associated putative inversion suggests that there may be a genetic basis for the broad thermal tolerance that facilitates invasion. We tested how genetic background at this region influenced individual C. maenas physiological and molecular responses to temperature stress in crabs from Washington, USA. Crabs were exposed to cold (5ºC), ambient (15ºC), or warm (25ºC) temperatures for six weeks, and monitored weekly using time-to-right and respirometry. Righting response and rate of oxygen consumption slowed at 5ºC compared to 15ºC, but there was no change between 15ºC and 25ºC. Interestingly, these physiological differences were not associated with supergene genotype. Metabolomic and transcriptomic changes were investigated to determine if different genotypes used distinct biochemical pathways to maintain homeostasis. Across temperature treatments and over time, changes in metabolite pathways were associated with differential energy usage. Additionally, certain genes had expression patterns correlated with supergene genotype. This work illustrates how investigating phenotype across biological hierarchy can provide a mechanistic understanding into the fitness of an invasive species.

Identifying patterns of shape convergence in brachycephalic domestic dog breeds

Stella Venn, Nicholas Hebdon, Kelly Diamond

Brachycephaly in domestic dogs (Canis lupus familiaris) results from artificial selection for a shortened snout, producing a more juvenile appearance. Other than its clinical relevance, particularly with regard to brachycephalic obstructive airway syndrome (BOAS), little is understood about how brachycephaly relates to post-rostral morphology. Brachycephalic breeds are not monophyletic, but instead have been convergently selected across different dog breeds to produce brachycephalic morphologies. We hypothesize that brachycephalic breeds share convergent post-rostral morphology that is largely the result of structural constraints associated with a shortened snout. Using CT scans from 100 individuals across 44 dog breeds and 10 wild species, including 18 brachycephalic specimens, we analyzed cranial shape variation both across all breeds and within the brachycephalic subset. We found consistent structural features in brachycephalic breeds, including rounding of the zygomatic arch, stability of the cranial base, and paedomorphic foreheads, suggesting that breeds may rely on the same structural and developmental modifications to produce their characteristic snout morphology and overall juvenile appearance. Morphological convergence of brachycephaly is not simply the result of similar snout lengths, as we identified evidence of convergence throughout the post-rostrum.

Understanding the neural control of acoustic communication across *Drosophila* species

Alexandra Venuto, Aniket Darp, Kendall Lipsteuer, Jacob Grodeon, Christa Baker

Courtship behaviors are essential to reproductive success and vary across species. For example, fruit flies produce highly divergent, species-specific

courtship songs by extending and vibrating their wings. In the traditional model species Drosophila melanogaster, males sing pulse and sine song via unilateral wing extension, and silent females use these songs to inform mating decisions. In contrast, D. virilis is one of a handful of Drosophila species where the females sing back to the males, creating an acoustic duet. D. virilis females and males use bilateral and unilateral wing extensions, respectively, to generate sex-specific pulse songs. The duetting behavior in D. virilis provides the opportunity to investigate how neural circuits evolve to produce divergent acoustic communication behaviors.

Song production is controlled by the male-specific P1 neurons in multiple Drosophila species. To test whether P1 neurons also drive singing in D. virilis males, we generated a genetic line targeting P1 neurons in D. virilis and confirmed expression in male-specific neurons with morphology consistent with that of P1 neurons in other species. We next found that optogenetic activation of P1 neurons via CsChrimson drove wing extensions in solo D. virilis males, confirming the role of these neurons in song production. Ongoing work will quantify the wing angles and sound parameters generated by P1 activation. These experiments provide novel insights into the neural control of species-specific courtship song.

How does agricultural land use shape amphibian disease immunity?

Rachel Verdi, Corinne Richards-Zawacki

Infectious diseases pose a substantial and widespread threat to wildlife. Moreover, this threat is increasing as global change stressors impact habitats. Variable environments and resource availabilities can negatively impact organismal fitness, resulting in decreased immune response capabilities and increased disease susceptibility. Additionally, these variable conditions can create selective pressures on populations leading to decreases in immunogenetic diversity overtime and ultimately increased disease susceptibility. Although human influence can permeate and affect many aspects of habitats, our understanding of how wildlife immune defenses vary across human altered landscapes, specifically, remains largely unclear. Further, the mechanisms and consequences of decreases in immunogenetic diversity in altered habitats is poorly understood. Towards understanding how host immunity and disease susceptibility are influenced by human altered habitats, we focus on amphibians and the disease chytridiomycosis, caused by the fungal pathogen Batrachochytrium dendrobatidis (Bd), as a model system. We collected amphibians from 16 populations along a gradient of agricultural land use in northwestern Pennsylvania, USA, and measured Bd infection and aspects of both constitutive disease immunity (microbiome and anti-microbial peptides) and genetic disease immunity. This work will inform our understanding of how amphibian immunity is influenced by agricultural land alterations. Further, it will help elucidate the relationship between human influence and disease immunity and identify consequences for wildlife facing disease in altered habitats.

Construction of semi-natural field enclosures to characterize hantavirus infection in deer mice

Joel Verkruyse, Richard Dolman, Michelle Haynie, Christopher Goodchild

Emerging zoonotic diseases highlight the intersectionality of 'One Health' and connections among humans, animals, plants, and their shared environment. Yet, for many emerging zoonotic diseases, the underlying mechanisms that mediate transmission within host reservoir populations are unclear. For instance, hantaviruses are an emerging global public health threat and can cause severe illness in humans, with approximately 30,000 global cases annually and mortality rates of 60% in some outbreaks. Further, hantavirus is a regional concern for Oklahoma, evidenced by a recent case of hantavirus infection that resulted in the death of a farmer. Unlike many infectious diseases, hantavirus (Sin Nombre Virus) is not vector-borne but is transmitted from reservoir host species (e.g., Peromyscus spp.) to humans through human contact with excreta and secreta. Given the global and regional public health threat of hantaviruses, it is critical to develop a more complete mechanistic understanding of hantavirus horizontal transmission within reservoir host species. We constructed semi-natural enclosures and deployed a telemetry array to collect high-resolution conspecific interactions among infected (i.e., donor) and uninfected (i.e., susceptible) deer mice (Peromyscus maniculatus).

A manakin hybrid zone reveals genetic sources of telomeric variation

Ben Vernasco, Kira Long, Michael Braun, Jeff Brawn

Telomere lengths and telomere dynamics can correlate with lifespan, behavior, and individual quality. Such relationships have spurred interest in understanding variation in telomere lengths and their dynamics within and between populations. Many studies have identified how environmental processes can influence telomere dynamics, but the role of genetic variation is much less well characterized. Here, we longitudinally sampled individuals across a narrow hybrid zone wherein two Manacus species characterized by contrasting genome-wide heterozygosity interbreed. We measured individual and population differences in genome-wide heterozygosity and, among hybrids, amount of genetic admixture using RADseq-generated SNPs. We tested for population differences in telomere lengths and telomere dynamics. We then examined how telomere lengths and telomere dynamics covaried with genome-wide heterozygosity within populations. Hybrid individuals exhibited longer telomeres, on average, than individuals sampled in the adjacent parental populations. No population differences in telomere dynamics were observed. Within the parental population characterized by relatively low heterozygosity, higher genome-wide heterozygosity was associated with shorter telomeres and higher rates of telomere shortening – a pattern that was less apparent in the other populations. All of these relationships were independent of sex, despite the contrasting life histories of male and female manakins. Our study highlights how population comparisons can reveal interrelationships between genetic variation and telomeres, and how naturally occurring hybridization and genome-wide heterozygosity can relate to telomere lengths and telomere dynamics.

What predicts pairbond strength of barn swallows during laying and incubation?

Sarah Verner, Mira Allen, Madeleine Campbell, Toshi Tsunekage, Iris Levin

In ninety percent of bird species, pairs are socially monogamous. However, many of these species are sexually polygamous and participate in extra-pair copulations (EPCs). This often leads to mate guarding, which can trade-off with foraging and the pursuit of EPCs. While the effect of male phenotype on mate guarding has been studied extensively, the predictive power of male and female phenotypes separately and together on mate guarding or pairbond strength is less well understood. We videoed barn swallow (Hirundo rustica erythrogaster) nests during laying (females fertile) and incubation (females no longer fertile) periods and analyzed these videos for mate guarding behavior. Additionally, we quantified adult ventral color, a sexually-selected plumage trait in this species. Reproductive success was determined via paternity analysis including all the nestlings produced in the study year and every adult present at the site. We predicted that less attractive males (paler ventral plumage) and those in better condition would guard more, and that higher condition and more attractive (darker ventral plumage) females would be guarded more. We predicted that males that guarded more would have more within-pair offspring in their own nest. Additionally, we calculated daily breeding synchrony for the population and predicted that males would guard less during periods of high synchrony when they may prioritize seeking EPCs.

Wolf spider locomotion and route choice on obstacle fields

Jack Vice, Milan Arado, Leo Feng, Star Mertzman, S. Tonia Hsieh, Suzanne Kane

Many terrestrial spiders are able to rapidly negotiate diverse complex terrain. Carolina wolf spiders (Hogna carolinensis) must traverse rocky desert habitats to find prey and shelter, and to avoid predators. We used high-speed 3D video to study how these spiders move through obstacle fields. Ten specimens were filmed running on a flat control substrate, a lattice of hemispherical obstacles ("boulders") spaced one diameter apart (1.5x legspan), and a smoothly-varying surface ('hills") with random heights and in-plane scales similar to those of the lattice. The boulder size was chosen so spiders could move along a trajectory without touching obstacles. Preliminary results indicate that a simple model of obstacle avoidance fails to account for their choice of paths. For example, on the "boulders" substrate, spiders were expected to follow paths approximately

equidistant from the edges of obstacles. Instead, their paths were most often broadly distributed throughout the regions in between obstacles. They also sometimes closely circumnavigated and even climbed over obstacles while dragging their side legs along the "boulders", presumably to sense their position. On the "hills" substrate, spiders did not preferentially run at lower elevations ("valleys") as predicted by obstacle avoidance. We interpreted these findings using a multiscale measure of path tortuosity to relate deviations from straightness to the presence of obstacles or changes in slope.

Adaptation to high sugar diets in Drosophila melanogaster through behavioral mechanisms

Austin Vick, Mark Phillips

High-sugar diets are known to cause symptoms similar to type II diabetes in flies. By exposing them to such diets, our goal is to generate populations that are resistant to diabetes. While most studies on high-sugar diets in flies focus on metabolic changes as an adaptation mechanism, I am more interested in exploring the potential for behavioral adaptation. We know that exercise can mitigate the negative effects of high-sugar diets in flies. My hypothesis is that adaptation may occur through alterations in activity levels, meaning that as populations adapt, individuals with higher activity levels will become more prevalent and display active behavior.

Getting salty: salt addition enhances the quality of low-quality nectar

Amanda Vieira da Silva, Avery Russell

How nutrients affect food preference is a central question in foraging theory. While diet selection often depends on net energy intake, the need for specific micronutrients means that foods are not always comparable in terms of their energy content. For pollinators, salt is thought to be a limited essential nutrient and its presence in floral nectar rewards may enhance their quality. In this laboratory study we investigated how bumble bee foraging was affected by nectar sucrose concentration and salt addition. Using artificial flowers, we manipulated salt presence (0 or 0.5%) and sucrose concentration (20 or 50%). Each bee was allowed to forage on flowers with either low or high-quality nectar, with or without salt. We found that bees were more prone to land and consume nectar from flowers with salt and this preference was stronger for flowers with 20% sucrose. However, floral constancy to salt vs no-salt flowers did not differ with sucrose concentration. Our results add to a growing literature that salt is an important micronutrient affecting nectar preferences of pollinators. We discuss implications for floral trait evolution and of anthropogenic increases in soil salinity.

Marine heat wave conditions alter ovarian steroidogenesis in the eurythermal sheepshead minnow

Isabel Villafuerte, Sean Lema

Anomalous marine heat wave events are becoming more frequent and severe due to climate change. These extreme events can have drastic impacts on the state of marine systems; this is especially true for estuaries and salt marshes which are prone to environmental variability. In this research, we examine how ovarian steroidogenic pathways related to reproduction are impaired by a simulated marine heat wave in the eurythermal Sheepshead Minnow, Cyprinodon variegatus. Adult minnows in mixed sex groups were exposed to a fluctuating thermal regime that oscillated daily from a morning low of 25-26°C to an afternoon high of 29-30°C. After 62 d under these baseline temperatures, a subset of minnows was exposed to ecologically relevant marine heatwave conditions for 8 d by increasing temperature fluctuations by 5°C. Female minnows that experienced the heat wave conditions had significantly lower ovarian gonadosomatic index (GSI) values, as well as lower blood plasma 17β-estradiol levels (E2). Females exposed to heat wave conditions also exhibited reduced relative abundance of mRNAs encoding for cholesterol side-chain cleavage enzyme (p450scc), 3β-hydroxysteroid dehydrogenase (3βhsd), and ovarian aromatase (cyp19a1a). Male minnows were unaffected by marine heat wave conditions, as shown by the unchanging testicular GSI and blood plasma 11-ketotestosterone (11-KT) levels. Overall, these findings reveal that marine heat wave events can negatively alter ovarian steroidogenic pathways which are crucial for successful fish reproduction.

Xiphister atropurpureus increases gut length and carbohydrase activities with a shift to omnivory

Isabel Villafuerte, Valentina I. Peña Gonzalez, Donovan German

The digestive system must maintain some level of plasticity to correspond with dietary changes in species that undergo ontogenetic dietary shifts. The intertidal fish, Xiphister atropurpureus (Stichaeidae) undergoes an ontogenetic dietary shift from carnivory to omnivory. Although previous studies on X. atropurpureus have demonstrated ontogenetic shifts in gut size and digestive enzymatic activity at specific size classes (35 mm standard length, SL, vs 70 mm SL), a broader size range is needed to fully characterize the scope of developmental digestive change since this fish species tends to consume proportionally more algae as it grows. Thus, we examined the relative gut length (gut length/body length) and digestive enzyme activities in the stomach and intestine of wild-caught X. atropurpureus ranging from 55mm SL to 203mm SL. The activities of a suite of enzymes including carbohydrases (amylase, maltase), proteases (trypsin, aminopeptidase), and lipase are being measured, and stomach contents are being assessed. Preliminary results demonstrate that the gut gets proportionally longer as the fish grows. Similarly, enzymatic assays show increases in amylase and maltase activities as the fish matures and consumes more substrates for these enzymes. Taken together, these results suggest that ontogenetic diet shifts require X. atropurpureus to alter its digestive strategies by increasing both gut length and carbohydrase activities.

Developmental stress alters corticosterone but not its receptors in budgerigar vocal learning region

Alondra Villalba, Jodie Jawor, Tim Wright

Chronic stress during development can disrupt physiological regulation and alter neural pathways essential for vocal learning and production. While prior research has examined circulating glucocorticoids, less is known about the distribution and regulation of its glucocorticoid receptors (GR) and mineralocorticoid receptors (MR) in the brain. In this study, we tested the hypothesis that chronic developmental stress alters both the endocrine stress response and receptor expression in brain regions for vocal learning. We predicted that individuals exposed to early-life stress would exhibit reduced corticosterone responses and changes in GR and MR expression. To investigate this, we measured circulating corticosterone levels and measured the expression of GR and MR receptors across eight brain regions crucial in vocal learning, vocal production, and regulation of the hypothalamic-pituitary-adrenal (HPA) axis in juvenile budgerigars. Birds were subjected to a 21-day chronic stress protocol involving an unpredictable stressor during the juvenile period. Stressed juveniles exhibited a lower stress-induced corticosterone response compared to non-stressed controls. However, no significant differences in GR or MR expression were observed between treatment groups. These findings suggest that the developing brain may possess a buffering mechanism that protects neural glucocorticoid receptor systems from the effects of early-life stress, potentially acting as a protective mechanism that preserves the integrity of neural circuits involved in vocal learning and production during critical periods of neurodevelopment.

Genetic energetics of frog calling

Jesus Villalobos, Jasmine Morris, Adam Stuckert, Adolfo Adelgado

Attracting mates and securing reproductive opportunities is a strong source of selection in nature, one that has shaped the life histories of many species. In many species, males will group together and produce elaborate or energetically expensive displays to try and attract females to mate with them. However, very little is known about the mechanism supporting the costly signaling behaviors. In this study, we looked at Hyla gratiosa and Hyla squirella, two sympatric species of frogs native to Florida. During the mating season, males attract potential mates by inhaling into their thorax/vocal sac and contracting their abdominal muscles to produce a chorus. This process

continues throughout the night, and previous work has demonstrated that it is incredibly energetically expensive. In this study, we investigated the molecular energetics of male calling in choruses by examining gene expression in H. squirella and H. cinerea. To do this, we collected RNA-seq data from two skin patches associated with call production (the vocal sac and the lateral line) and compared them with a patch of skin on the back that was unrelated to call production. We also assembled and annotated a chromosome-level genome assembly for H. squirella, which we used for gene expression analyses.

Biomechanics of high-speed locomotion on lateral inclines in spiders

Holly Visser, Lauren Schneider, Heiko Kabutz, Kaushik Jayaram

High-speed locomotion on complex terrains, including lateral inclines, is an open challenge for both animals and robots alike. To compensate for the effects of gravity, we hypothesize that multilegged organisms adapt their gait and posture during locomotion. Here, the terrestrial arachnid, Schizocosa mccooki, was encouraged to laterally traverse a runway inclined at angles 0°, 15°, 30°, 45°, and 60°. To discourage wall-following behaviors, we developed a novel trackway with pneumatic jet 'airwalls'. Using high-speed videography and markerless tracking, we quantified kinematic and gait parameters as a function of inclination. Preliminary results showed a significant decrease in speed, from 16.67 cm/sec at 0° to 2.88 cm/sec at 60°, and lateral accelerations, from 147 cm/sec2 to 45 cm/sec2 over the same range. Notably, 61% of this decrease occurred after 45°, with limited changes in stride frequency (4-8 Hz). Qualitative postural observations indicate that unilateral leg adjustments across the sagittal plane become increasingly obvious on steeper gradients. The up-slope legs (legs that are elevated relative to the body) exhibited greater flexion, while the down-slope legs demonstrated greater extension. Additionally, we observed significant widening of the base of the support polygon, suggesting the need for increased stability at steeper inclines. Further investigating these biomechanical strategies across laterally inclined surfaces will not only provide insight into distinctive balance control techniques but will also inspire multilegged robotic designs and control architectures.

Resilience and robustness: from sub-organismal responses to communities

Maren Vitousek, Conor Taff, Jessie Williamson

Coping with challenges is essential to life on earth. Determining the processes that generate resilience and robustness to disturbance across levels of biological organization is increasingly important as the pace of global change accelerates; however, to date, multiscale models have primarily focused on population to ecosystem scales. Here we present a unified a framework of resilience and robustness that combines conceptual models from different fields and explicitly links sub-organismal responses with higher level outcomes. This framework predicts that interactions among sub-organismal response components, including their temporal dynamics, and the plasticity of homeostatic regulatory networks, are key drivers of current and future resilience.

Heads or Tails: Kinematics driving prey flipping in *Amia ocellicauda*

Emily Volpe, Katrina Whitlow

Food transport, or the manipulation and movement of prey items into the esophagus, is crucial for survival. Many predatory organisms, like fishes, swallow prey whole without shearing teeth or an independently mobile tongue. One striking behavior we recently described in Amia is that prey items are often captured tail-first, then flipped 1-5 times prior to swallowing. This ensures that the prey is being swallowed head-first rather than tail-first, yet the mechanisms driving this remain unclear. Here, we used high-speed biplanar videofluoroscopy to examine the kinematics of prey processing in Amia ocellicauda. We expand on previous findings; comparing the kinematics of flips to those employed during processing sequences that reposition, but do not rotate, the prey item. The degree and timing of cranial bone rotation during prey flipping was highly variable. Preliminary results did not indicate a clear difference between Amia kinematics during full flips (approximately a 180° rotation of the prey's orientation) and partial flips (prey item orientation changed, but visibly less than 180°). However, full flips were generally associated with larger prey translations than partial flips. Several flips occurred quite rapidly (ranging from 34 ms to 275 ms) as compared to prey repositioning (75 ms to 900 ms). These findings expand on our limited understanding of prey processing in predatory fishes and provide a basis for future comparative studies examining large prey manipulation.

What's the point?: barb morphology of the Round Stingray (*Urobatis halleri*)

Sol Vu, Luci (Danny) Herrera-Lopez, Dylan Baldiviezo, Ruben Santos, Benjamin Perlman

Round stingrays (Urobatis halleri) are commonly found along the Southern California coast. Many beachgoers are injured each year during encounters with round stingrays due to stingray strikes. The severity of injury is influenced by various factors, one of which may be due to the differing morphological features of the venomous barb, located on the tail of the stingray. The location of the barb and the morphological characteristics of the barb vary across stingray species; however, detailed studies are lacking on how certain morphological characteristics may vary within and across stingray species. We quantified n=12 morphological features from n=28 barbs from various individuals of the round stingray. Barb features included tip sharpness, thickness, second moment of area, and the number of lateral serrations. We collected round stingrays from Seal Beach, CA, USA, where their barbs were clipped before releasing the stingrays back into the ocean. The barbs were micro-CT scanned, and using the program Slicer, we compared the 3D morphological features across the different barbs. We found there was variation across all of the characteristics measured. We aim to expand our work by exploring how barb morphologies may change throughout ontogeny and between sexes. We also plan to compare barb morphologies beyond the round stingray and conduct interspecific comparisons of stingray barbs to better understand the phylogenetic relationships of stingray barb uses.

Multiscale evaluation of focal muscle vibration effects on proprioception and movement dynamics

Vanson Vu, Emma Blalock, Lauren Infantino, Monica Daley, Manny Azizi

Muscle spindles are critical sensors for assessing body position and controlling motor coordination. Previous studies have used focal muscle vibration (FMV) to manipulate spindles function. While some clinical studies have used vibration to restore gait function in compromised populations, mechanistic studies focused on understanding spindle function in shaping muscle-tendon dynamics remain limited. In this study we develop a three-pronged experimental approach: (1) reflex testing with applied FMV to assess timing and magnitude alterations in spinal-level responses, (2) isolated ankle proprioception task with plantarflexor or dorsiflexor vibration to determine changes in positional sensing, and (3) multi-joint hopping tasks to investigate the role of FMV on muscle activation dynamics and changes in whole leg stiffness. Preliminary results, from ankle proprioceptive tasks reveal inter-individual variability in FMV-induced improvements in joint position sensing, with different apparent effects between ankle flexors and extensors. In hopping tasks, participants exhibited varied leg stiffness adaptations between control and vibrational conditions, at prescribed and natural hop frequencies. Additionally, the onset of muscle activation relative to the hop cycle demonstrated participant-specific differences between control and experimental conditions. The findings highlight the potential complexity of the underlying FMV effects on sensorimotor control. NSF DBI 2319710

Using machine learning to decode mobbing calls of the American crow, *Corvus brachyrhynchos*

Douglas Wacker, Sophia Orme, Isabella Wichert, Griffin Harlow, Max Fisher

American Crows (Corvus brachyrhynchos) emit a variety of calls. The most common call type consists of one or more caw syllables, and varies in its

duration, frequencies, and loudness. The functional relevance of this variation in cawing is not fully understood. We recorded calls from groups of crows in western Washington and Oregon state in two behavioral contexts, 1) after stimulation with a model owl and crow distress call to induce mobbing and 2) in pre-roosting aggregations. Recording equipment, input levels, and distances to calling crows were controlled across recordings. Using over 2400 caw syllables from over 1000 recorded calls, we constructed two balanced random forest models using 29 acoustic variables, one model considering syllables independently and another multisyllabic calls. Our models yielded out of bag error rates of 6% (syllables) and 8% (calls), reflecting better than 90% model accuracy. A separate set of calls recorded using the same protocols, but from different locations were used to validate each model. Our models achieved 87% and 86% accuracy in predicting whether syllables or calls (respectively) from the validation set were emitted from mobbing vs. pre-roosting crows. Variable importance plots derived from the mean decrease in Gini impurity show that acoustic variables related to loudness were most important in differentiating calls between these two contexts. These findings will inform future playback studies.

The slimy properties and snotty diversity of fish skin mucus

Dylan Wainwright, Gabriela Garcia, Matthew Kaboolian, Hana Larkins, Kendra Erk

Fishes are covered in a layer of mucus that provides an initial defense against infection and biofouling while also increasing hydrodynamic performance. Although mucus plays these important roles, we know relatively little about the basic material properties of mucus which are likely to impact performance. To learn about mucus material properties and species diversity, we characterized mucus from different ray-finned fishes using multiple methods. We measured the amount of mucus produced across 13 species to assess if species generate different amounts of mucus. We also collected data on water content, viscosity, and viscoelastic properties of mucus from three species to understand how the rheological properties of mucus differ across species and preparation methods. We found that species show diversity in the amount of mucus produced, even when corrected for surface area of the fishes sampled. We also confirm that fish mucus is shear-thinning, and we demonstrate that mucus has very different viscoelastic properties across three species (gar, eel, and koi). For example, both viscosity and viscoelastic moduli show order-of-magnitude differences among species. In addition, we found that fresh mucus gave more consistent data compared with frozen or refrigerated preparations, highlighting the ephemeral nature of mucus properties. These results show that mucus material properties can vary widely across species, and that diversity in mucus may be an unrealized but important axis of diversity for fishes.

Characterization of light organ innervation in Hawaiian bobtail squid

Alice Walker, Madison Emery, Elizabeth Heath-Heckman

While bacterial symbionts have been shown to have profound effects on cellular processes in their hosts, it is still unclear how bacteria influence neuronal development and remodeling. Upon hatching, juvenile Hawaiian bobtail squid (Euprymna scolopes) are colonized by their bioluminescent bacterial symbionts (Vibrio fischeri), which initiate substantial developmental changes in the squid's symbiotic light organ (LO), most notably the regression of external ciliated appendages. However, as of yet the neuronal landscape of the LO and its response to symbiosis is unknown. As serotonergic signaling genes are symbiosis-regulated, we first localized serotonin+ neurons in the LO using an anti-serotonin antibody, which revealed a dense plexus of serotonin-immunoreactive (5HT-IR) neurites throughout the LO, as well as multiple 5HT-IR neurites that project into the anterior appendage. To determine if these processes originate in the LO, we employed an antibody to a pan-neuronal nuclear antigen, NeuN. We observed multiple soma near the base of the appendages, suggesting that appendage neurites may originate from cells intrinsic to the light organ. However, the scarcity of soma throughout the LO suggests that much of the serotonergic innervation may be extrinsic. Finally, we used a novel Golgi-Cox staining protocol to visualize the complete morphology of LO neurons, which revealed several bipolar neurons near the base of the appendage. Future experiments will interrogate the effects of colonization on host squid neurons over symbiosis initiation.

Coral confinement: microbial mysteries in pet stores

Nia Walker, Eridaly Basave, Evelyn Chavez-Gonzalez, Denise Jie Yi Chen

Corals in pet stores experience environmental conditions that differ dramatically from those in the wild, potentially altering their microbiomes and impacting their overall health and disease susceptibility. This study specifically investigated microbiome shifts in common soft corals sourced from pet stores in Southern California, using 16S rRNA sequencing to characterize bacterial and fungal communities associated and ITS2 sequencing to determine Symbiodiniaceae distribution across locations and coral genera. Given the frequent use of antibiotics in aquaria, we screened for antibiotic resistance genes to explore possible links between captivity, microbiome alterations, and antibiotic resistance. We also conducted a CBASS-style thermal stress assay on a subset of corals to evaluate relationships between thermal tolerance, microbiome, location, and genera. Understanding how captivity impacts coral microbiomes and stress responses is critical not only for the aquarium trade, but also for coral husbandry in research and conservation facilities, where microbiomes can influence survival. These findings may also offer broader perspectives on coral health management. This work contributes to a growing body of research on how artificial environments alter host-microbe interactions, with implications for aquaculture and conservation.

Squid-inspired flexible nozzles improve thrust in rotary propulsors using a multi-fidelity approach

Halley Wallace, Saad Bhamla, Daehyun Choi, Paras Singh, Gourav Samal, Chandan Bose

The flexible nozzles of cephalopods such as squid exhibit unsteady flow-structure interaction that are strongly governed by the wave dynamics propagating along compliant membranes. Inspired by this mechanism, we investigate how flexible nozzles can improve propulsion in underwater vehicles equipped with rotary propulsors, focusing on both thrust enhancement and energy efficiency. We fabricated nozzles with outlet diameters ranging from 30 to 80 mm and varying stiffness, using elastomeric materials with Shore A hardness values of 30A, 40A, and 50A. The nozzles were produced through additive manufacturing and molding techniques and tested using a custom-built dynamometer thatsimultaneously measures thrust and power consumption at a fixed propeller speed of 1000 RPM. While prior studies have shown that flexible nozzles can outperform rigid designs, most have focused on both-end-clamped configurations, where the nozzle is fixed at both inlet and outlet, restricting deformation. To address this gap, we developed a multi-fidelity Bayesian optimization framework integrating experimental measurements with high-fidelity computational fluid dynamics modeling to characterize and optimize nozzle performance. The propeller jet geometry was captured through 3D scanning and incorporated into a strongly coupled fluid–structure interaction (FSI) solver with Large Eddy Simulation (LES) to resolve vortex dynamics, jet entrainment, and flow-induced deformation. This experimental and computational approach reduces design time, identifies nozzle geometries that improve thrust and efficiency, and provides insight into wave-driven propulsion

Modeling ecological niches in disjunct populations of an at-risk butterfly under global change

Rachel Walsh, Robert Guralnick, Jaret Daniels, Akito Kawahara

Understanding the habitat requirements and spatial distributions of at-risk species is essential for effective conservation. Moreover, assessing how distribution of suitable habitat changes over time can help explain past declines and predict future range shifts. Here, we used ecological niche models (ENMs) to predict suitable habitat for the Loammi skipper (Atrytonopsis loammi). Using tuned bioclimatic predictors and alternative delimitations of accessible areas, we found evidence for ecological differences between two disjunct populations in north and central Florida. To refine predictions, we integrated consensus land cover data from EarthEnv, combining climate and remotely

sensed landscape features to evaluate how expansion of the built environment may further reduce and fragment habitat. Further, we reconstructed past habitat suitability by backcasting niches onto paleoclimatic landscapes to locate regions of historic habitat loss that may underlie present disjunctions. We then forecasted future distributions under multiple climate scenarios to assess potential future range shifts. Our models identify possible refugia that can guide management by informing corridor design, reintroduction, and assisted movement. Ongoing work will integrate population genomic data to assess whether observed ecological differences are mirrored by genetic differentiation among populations. Detecting such patterns could suggest local adaptation and justify population-level conservation actions. Together, this research offers a framework that combines climatic, land cover, and genomic data to inform conservation planning for at-risk species under conditions of rapid environmental change.

A theoretical morphospace of wings: Analysing the evolution of function in extinct wing forms

Benton Walters

Within vertebrates, there are at least four separate originations of wings. Apart from in birds, however, the fossil record of these early wings is poorly defined, leading to unanswered questions about the development of modern wing planforms and the flight ability of early membranous-winged flyers. Theoretical morphospace is a valuable tool for examining this development and the functional parameters of fossil wings by transitioning analysis of performance from empirical shapes to a global landscape of theoretical forms. This permits the identification of functionally optimal shapes. Using this tool, alongside the existing fossil record of early flyers, we interpret the functional performance and evolutionary trajectory of wings. Examining bats, we identify the optimal wing planform shapes for agile hawking flight and propose a rapid evolutionary towards optimally agile planforms over the course of the Eocene. Theoretical morphospace analyses also allow for testing of how our biases in reconstructing fossil wing forms influence our understanding of the flight ability of extinct groups. This is particularly valuable for pterosaurs and scansoriopterygids where direct extant comparison is impossible. Our study of reconstructed pterosaurs shows published interpretations underrepresent the variability of pterosaurs and function poorly for flight. With theoretical morphospace we can piece together constraints on the evolution of wing shape and more clearly determine whether flying animals are well formed for their niche in the skies.

Lizard sperm in a changing environment: Testing for adaptive plasticity and evolutionary divergence

Wayne Wang, Alex Gunderson

Understanding how organisms respond to rising temperatures is crucial for predicting species persistence under climate change. Two general mechanisms can buffer populations against rapid warming: phenotypic plasticity and evolutionary adaptation. While both are well documented at the whole-organism level, little is known about gamete level responses, even though reproduction, and sperm function in particular, is often compromised by heat stress. To address this gap, we first tested whether sperm in the brown anole (Anolis sagrei) exhibits adaptive thermal plasticity. We evaluated both pre-ejaculate plasticity, in which males acclimated to warm environments produce more heat-tolerant sperm, and post-ejaculate plasticity, in which ejaculated sperm exposed to sublethal heat stress trigger increased tolerance. We found neither mechanism was supported. Acclimation did not improve sperm heat tolerance, and mild heat shocks on ejaculated sperm did not enhance post-ejaculate performance. We then examined evolutionary responses across 25 lizard species using a phylogenetic comparative framework. We found that sperm heat tolerance varied substantially among species and was strongly aligned with adult thermal physiology, consistent with adaptive divergence. Moreover, sperm heat tolerance evolved more rapidly than adult heat tolerance. Together, these results indicate that sperm thermal tolerance has limited plastic capacity to buffer against rapid warming but retains evolutionary potential, highlighting the dual vulnerability and adaptability of male reproductive traits, with important implications for predicting species resilience under climate change.

Moths are robust against disturbing visual cues

Yaqing Wang, Simon Sponberg

Animals in natural environments encounter many sensory cues simultaneously, some relevant and others irrelevant to their current tasks. For example, Manduca sexta hawkmoths hover and track moving flowers to feed even in cluttered environments, where flowers in the background may provide disturbing visual stimuli. How moths prioritize competing visual stimuli remains unclear. A previous study reported that the moth's tracking performance of the target flower was impaired when a bright vertical bar oscillated on a background screen, with impairments occurring specifically at the oscillation frequency of the distractor. However, it remains unclear whether the bar impaired tracking because it acted as an object-like visual stimulus or because it triggered a background-following response in conflict with the target flower. To systematically investigate how visual distractors influence tracking, we introduced either a physical vertical bar (task-irrelevant) or an additional flower (alternative) as a distractor, placed in the same plane as the target, and oscillated them across a range of frequencies that were either the same or different from the target. In contrast to the earlier findings, our experiments revealed no significant impairment in flower-tracking performance compared to conditions without distractors. The invariance in performance indicates that moths are robust to these task-irrelevant visual cues under our conditions. This suggests that the moth's nervous system selectively attends to visual cues from the target while suppressing those from distractors.

Morphometric analysis of post-embryonic development in the model ctenophore *Mnemiopsis leidyi*

Yinghui Wang, Phillip Barden, Allison Edgar

The ctenophore Mnemiopsis leidyi is an emerging model for exploring the evolution of embryonic development, regeneration, life history, and the nervous system. M. leidyi experiences significant morphological changes during its post-embryonic development. The ctenophore hatches as the "cydippid" body plan and remains this shape at a small size (5 mm). As their size increases beyond this point, M. leidyi and other "lobate" ctenophores grow new feeding structures which replace the use of external tentacles. This cydippid-to-lobate transition does not correlate with sexual maturation according to previous research, which differs from typical metamorphosis. Investigating this transition could inform our understanding of the evolution of metamorphosis in animals due to ctenophores' early branching phylogenetic position. We followed the development of individual M. leidyi from hatching to the lobate stage at different temperatures to further elaborate the described staging of normal development in this species. Furthermore, we measured allometric growth across this time course to detail the ontology of anatomical structures at different temperatures. These data will serve as a critical resource and reference for understanding ctenophore life history and post-embryonic development.

Evolutionary adaptation of the olfactory system: a study of odorant receptor genes in Anurans

Zoya Wani, Adam Stuckert

An organism's ability to sense and adapt to its environment is essential for survival, enabling it to find food, mates, and avoid predators. This adaptability is driven by sensory systems, like olfactory receptors (OR), which are under strong selective pressures. As one of the most rapidly evolving families, ORs are proteins that serve as the molecular key to an organism's sense of smell. ORs consist of two main classes that detect either airborne or water-borne compounds. This division of ORs is key to understanding amphibians, given their dramatic biphasic transition. As an aquatic tadpole undergoes a complete physiological and anatomical restructuring to develop into a terrestrial frog, its sensory system must also adapt, making frogs an excellent model for this evolutionary study.

Despite extensive research on OR evolution in mammals and fish, there is a significant gap in our understanding of these genes in amphibians. I will analyze the gene repertoires of all public anuran genomes with diverse life histories to identify patterns of gene expansion and contraction. I predict that species with aquatic tadpoles and terrestrial adults will have a contraction

of Class I ORs (detect waterborne compounds), while Class II ORs (detect airborne compounds) will undergo an expansion. This study will provide crucial insight into anuran OR gene repertoire and the evolutionary basis of a sensory system's adaptation to a major ecological shift.

Developing a strong recruitment team to support STEM students

Andrea Ward, Megan Mullins, Salvatore Petrilli, Matthew Wright

The NSF Scholarships in Science, Technology, Engineering, and Mathematics Program provides scholarships and associated support structures for low-income students in STEM undergraduate and graduate majors. This program is aimed at increasing the STEM workforce. Adelphi University, a comprehensive university located on Long Island in New York, received a grant aimed at recruiting 25 students across two cohorts. One of the challenges with these programs is setting up an effective recruitment strategy. This involves an integrated approach involving admissions, financial aid, and the team overseeing the S-STEM program. At Adelphi University, we set up a working group with a key point person across the different areas to be able to quickly target potential students, review eligibility, and make offers. We then we able to help students evaluate their education options. Our collaboration resulted in successful recruitment of 25 students over 2 years. Having this well-defined working group is critical for successful recruitment into these specialized programs.

Evolution, development, and the incoherence of sex: A framework for multiple sex concepts

Karen Warkentin, Aramati Casper, Jay Falk

Sex is a subject of intense interest and contested meanings, and the word "sex" is used in many ways. Biological reality and social justice have both been used as supporting arguments for simple, restricted definitions of sex and for expanded, more complex understandings. However, a suite of biologically related but distinct concepts are called sex; intended meanings are often unspecified and sometimes ambiguous, in common language and in scientific communication. This makes communication about sex vulnerable to misunderstanding and misrepresentation. We suggest an organizing framework for multiple sex concepts—spanning from genetic and cellular processes to differentiated cell phenotypes to organismal traits and interactions—and use it to discuss some of the complexity within concepts and relationships among them. For some sex concepts, accounts or models of sex vary substantially. Some sex concepts are often applied narrowly to animals, even though parallel processes occur in other lineages. Different sex concepts are linked by evolutionary and developmental processes. However, evolution and development also generate organismal variation that can make sex-concept boundaries difficult to apply, generating variation in language use that may limit our ability to identify or address biological questions. Given the biological complexity of sex, we need an organizing conceptual framework to improve communication about sex, distinguish the kinds of discrepancies or incoherences at issue, and aid in identifying unanswered biological questions.

Salinity tolerance and embryonic survival thresholds in coastal lizards in the face of storm surges

Daniel Warner, Anthony Gilbert, Sydney Wayne, Chris Norris, Jillian Cate, Matthew Smith, Sabrina Alfaro Mata

The intrusion of saline water into terrestrial habitats, driven by intensifying storm surges and rising sea levels, is an increasingly severe threat to many taxa. As the occurance of hurricanes shift earlier in the year, these storms begin to overlap with summer reproductive seasons for taxa that rely on ground habitat for reproduction, such as reptiles. Reptillian eggs are often laid in nests susceptible to induction by storm surges, potentially exposing developing embryos to salinity levels that could alter embryonic developement or reduce offspring fitness. This study investigates the impact of saline conditions on the embryonic development of the brown anole lizard (Anolis sageri), a model species native to coastal and island environments. We designed an experiment to simulate storm flooding and incubation in nests saturated with saltwater. One sample of eggs was submerged in saltwater solutions across a range of salinity concentrations (5 to 28 ppt) before being incubated in sand mixed with freshwater, while a different saqmple was incubated directly in sand mixed with sqaltwater (5 to 20 ppt). We evaluated the effects of saltwater submersion and incubation in saline nests on embryonic survival, developmental timing, and hatchling morphology. By measuring embryonic survival and development under varying salinity leevels, we will identify the precise threshold for saltwater tolerence in brown anole embryos.

The other part of the attachment system: intra- and interspecific variation in gecko claw morphology

Benjamin Wasiljew, Anthony Russell, Austin Garner

Arboreal habitats are particularly demanding on their inhabitants because of their inherent complex three-dimensionality. As such, scansorial animals often exhibit morphological and functional adaptations that enable them to reversibly attach to surfaces. Geckos are widely known for their subdigital pads that generate temporary adhesion. Most geckos also possess claws, which can mechanically interlock with rough substrates, puncture soft substrates, and generate friction to enable reversible attachment, but their form and function have been largely overlooked. A recent study investigated variation in claw morphology of a padless genus of gecko, revealing intriguing inter- and intraspecific patterns. However, that study was limited to four congeneric species. This raises the question of whether such trends are exhibited by geckos more generally. Here we provide updated results of a morphologically comprehensive study assessing the intra- and interspecific variation in claw morphology more broadly across the Gekkota. Specifically, we took multivariate measures of claw morphology of all clawed digits of the left appendages of 16 species representing the six limbed gekkotan families. In addition, we sampled five species representing two limbed, lepidosaur outgroups. Preliminary findings reveal significant interspecific differences in claw size and shape, while intraspecific and intraindividual variation is more subtle. We report not only on the identification of general morphological patterns in gecko claws but also provide baseline data pertinent to future work on the ecomorphology of geckos.

Leaping lizards on pliable perches: jumping performance of anoles on compliant substrates

Benjamin Wasiljew, Sierra Weil, Maya Philips, Austin Garner

Urbanization is considered one of the most severe forms of human-inflicted habitat disturbance. Urban habitats differ from natural ones in temperature, humidity, lighting and habitat structure, often driving evolution of animal form and function to these new conditions. For example, urban Anolis exhibit larger body sizes, longer limbs, increased subdigital pad area, and more subdigital lamellae than their natural conspecifics. Another habitat characteristic that likely differs between urban and natural habitats is substrate compliance (flexibility). Previous studies demonstrated that increased compliance has substantial negative effects on jumping performance of A. carolinensis, reducing jump distance and takeoff velocity. Urban populations might be differentially affected by compliance because of their probable naïvete to highly compliant substrates. Here we use an experimental approach and high-speed videography to examine whether urban and natural populations of A. carolinensis and an urban population of introduced A. sagrei differ in jumping performance in response to variation of substrate compliance. In accordance with their long, muscular hindlimbs, A. sagrei jumped significantly farther than both A. carolinensis populations despite their takeoff velocity being disproportionately impacted by increased compliance. Surprisingly, however, the longer average hindlimb length in urban A. carolinensis did not result in a significant improvement in jumping performance compared to the natural population. Coexistence with A. sagrei and a counterproductive behavioral response might explain the lack of distinction between both A. carolinensis populations.

Comparative transcriptomics reveals diet-associated gene expression patterns in mammals

Harshal Wasnik, Gwendolyn Johnson, Nicholas DiVittorio, Allie Graham, Wynn Meyer

Mammalian species exhibit a remarkable diversity of dietary strategies, ranging from herbivory and carnivory to specialized behaviors such as frugivory. This diversity provides an ideal framework for exploring molecular signatures of diet-related evolution. In this study, we investigate liver transcriptomic variation across multiple dietary groups in mammals. We analyze publicly available RNA-seq datasets from liver tissue and quantify protein-coding transcript abundance using Salmon. To enable accurate cross-species comparisons, we identify orthologous genes across taxa using OrthoFinder. We then apply phylogenetically informed methods, including phylogenetic generalized least squares (PGLS), to test for associations between gene expression and dietary strategies while correcting for phylogenetic non-independence.

Our preliminary results suggest that genes related to fatty acid oxidation and bile acid metabolism are differentially expressed between carnivorous and non-carnivorous species, potentially reflecting metabolic adjustments to high-protein, high-lipid diets. Similarly, we find that genes involved in carbohydrate metabolism and lignocellulose degradation are differentially expressed between herbivores and non-herbivores, consistent with adaptation to plant-based diets. We also observe evidence that immune-related pathways, including Toll-like receptor signaling and toxin metabolism, exhibit distinctive expression patterns across dietary niches. By identifying candidate genes and pathways associated with dietary specialization, our work highlights expression changes accompanying metabolic evolution and provides insight into the physiological diversity and disease susceptibility shaped by diet across mammals.

It got to the other side: how the crested chicken crossed the road into teratological evolution

Akinobu Watanabe, Roenell Heerbrandt, Scott Landman, Sylvia Marshall, Abdullah Ansari, Mohit Shah, Todd Green, Paul Gignac, Meredith Taylor

Could evolutionary novelty emerge from pathologies adverse to humans? Congenital hydrocephalus affects 1 in < 1 000 human births and manifests as expanded brain and skull dysmorphologies. These phenotypic changes are the result of excess cerebrospinal fluid in the developing brain which leads to larger ventricular space. Congenital hydrocephalus has been proposed, but not demonstrated, as the etiological driver of unique brain and skull morphologies in crested chickens (Gallus gallus domesticus)—domesticated breeds selected for elaborate cranial feathers. Using diffusible-iodine contrast-enhanced computed tomography (diceCT) imaging on embryos collected at multiple ages, in situ three-dimensional reconstruction of brain and ventricles show substantial expansion of the ventricular space in crested chickens compared to the typical white leghorn chickens, whereas the brain tissue volume remains similar between the two breeds. These neuroanatomical results provide strong evidence for hydrocephalus as the primary cause of novel phenotypes in crested chickens. As such, this breed could serve as an effective model for studying hydrocephalus, and while crested chickens underwent strong artificial selection, it serves as an exemplary model organism for teratological evolution.

Connecting teachers with computed tomography: Research Experience for Teachers program in New York

Akinobu Watanabe, Kelsi Hurdle, Joseph Denninger, Shaolin Truett, Jaimi Gray, Morgan Chase

The increasing availability of 3D biological data presents powerful opportunities for both research and education. Online platforms such as MorphoSource make CT datasets and their derivatives broadly accessible, yet experience has shown that simply building large repositories does not automatically lead to their use by educators. To address this “Field of Dreams” fallacy, the Education & Outreach Community of the Non-Clinical Tomography Users Research Network (NoCTURN) has sought active collaboration between researchers and educators. Our efforts have focused on building direct connections with teachers, assembling a growing contact list, hosting regular discussions to understand classroom needs, and co-developing education kits suitable for middle and high school instruction. In Summer 2025, we expanded this work through a National Science Foundation (NSF) Research Experience for Teachers (RET) program at the American Museum of Natural History and New York Institute of Technology. Over seven weeks, two high school science teachers trained in CT imaging, embryology, and open data practices, generating chick embryo datasets, mesh models, and 3D prints of segmented structures. They also created two classroom modules and contributed to guidelines on designing effective lesson plans with CT data. By presenting these outcomes, we aim to demonstrate how structured researcher–educator partnerships can transform open datasets into classroom-ready resources, advance open science, and provide engaging, compelling models for integrating cutting-edge biological imaging into education.

Interpreting and comparing squamate physiotypes

Charles Watson

Here I discuss an approach to understanding physiological adaptation by treating a suite of physiological traits as a physiotype, akin to how morphological traits constitute a morphotype. This approach transcends single-variable analyses to interpret and compare a collective set of thermal and metabolic variables, including metabolic rate, thermal sensitivity, thermal preference, optimal and preferred temperatures, and critical thermal limits. Using a standardized methodology for establishing physiotypes of species and, potentially more interesting, populations, we can begin to better understand thermal adaptation at a much broader scale. I discuss each variable and work through some examples to explore potential interpretations considering ecological and biogeographical data. The ultimate goal is to provide a comprehensive framework for studying physiological adaptation that mirrors the manner in which we study morphological adaptations. I will also like to discuss the feasibility of developing a repository for these physiotypes and best practices for doing so as I continue to develop this idea.

Reward evaluation differs between bumble bee queens and workers

Sarah Waybright, Felicity Muth, Melanie Kimball, Smruti Pimplikar

Animals often evaluate rewards relative to past experience rather than in absolute terms, leading to phenomena like negative incentive contrast—where a previously accepted reward is rejected if it follows a better one. This kind of comparative evaluation is crucial for generalist foragers like bumble bees, which choose between flowers varying in reward quality. Bumble bee colonies consist of two female castes—queens and workers—whose distinct ecologies may shape their reward evaluation. Queens forage alone during early colony founding, making each foraging decision critical for survival and nest success. In contrast, workers forage cooperatively, distributing the cost of decisions across the colony. Consequently, inefficient foraging may be more costly for queens. While queens are known to outperform workers in learning tasks, little is known about their decision-making while foraging. We tested wild queens’ and workers’ incentive contrast responses by downshifting nectar rewards (from 40% to either 15% or 10%) under low or high satiation. Consistent with previous findings, workers frequently rejected lower-concentration sucrose after experiencing higher quality rewards. In contrast, queens were more likely to accept lower quality rewards, regardless of satiation level, suggesting caste-specific decision-making, potentially shaped by the higher energetic stakes queens face. As queens and workers forage on different floral resources at different times, these behavioral differences may influence the evolution of floral reward traits.

Brine & brood: the impact of salinity on egg survival of an invasive lizard

Sydney Wayne, Annabel Dawson, Chris Norris, Anthony Gilbert, Daniel Warner

Coastal populations of many terrestrial organisms are vulnerable to the effects of increased salinity caused by different global change phenomena (e.g., increased hurricanes, sea level rise). Importantly, landfall of hurricanes has shifted earlier into the year over recent decades, which coincides with

the reproductive season of many organisms. Due to flooding associated with these storms, species that rely on ground habitats for reproduction are particularly vulnerable, such as ground-nesting reptiles whose developing embryos would experience periods of seawater inundation and/or highly saline soils. Here, we examined the effects of saltwater submersion and substrate salinity on egg incubation of the brown anole lizard (Anolis sagrei), which often occurs in coastal and island habitats. We conducted a fully factorial experiment with three submersion treatments (no submersion, freshwater submersion, and saltwater submersion) and two egg incubation treatments (sand mixed with freshwater or saltwater), and showed that embryos cannot survive saltwater submersion or incubation in a saline substrate. In a complementary experiment, however, we show that the negative effects of submersion are mitigated when eggs are incubated in an artificial substrate. Overall, the negative effects of saltwater on embryonic development of A. sagrei have important implications for populations that inhabit islands and coastal areas.

Functional integration of horizontally transferred mitochondrial alternative oxidase in springtails

Ryan Weaver

Textbook depictions of the metazoan mitochondrial electron transport system typically emphasize a single canonical pathway for oxidative phosphorylation. Yet, over the past two decades, genomic surveys have revealed an alternative route via the nuclear-encoded mitochondrial alternative oxidase (AOX). Functionally equivalent to complex IV, AOX is resistant to cytochrome pathway inhibitors and is hypothesized to confer metabolic flexibility under environmental stressors such as hypoxia. Our recent work mapped AOX across the tree of life and identified multiple horizontal gene transfer (HGT) events into animals, including springtails (Collembola). Springtails occupy diverse habitats, often experiencing oxygen limitation depending on whether species live above or below ground. The soil-dwelling model springtail Folsomia candida has acquired AOX via HGT, whereas the above-ground species Orchesella villosa lacks it. This contrasting distribution suggests an adaptive role for AOX in hypoxic niches. Here, I present high-resolution respirometry experiments on isolated mitochondria to demonstrate functional integration of AOX in F. candida. I also compare mitochondrial responses of F. candida and O. villosa under hypoxic stress to directly test whether AOX plays a role metabolic flexibility. Together, these results link the evolutionary acquisition of AOX through HGT to measurable physiological benefits, supporting the idea that AOX may facilitate tolerance of environmental stressors.

Surface-specific gas exchange reveals skin vs lungs respond differently to a physiological trade-off

Savannah Weaver, Sneha Adayapalam, Karey Duvall, Talia DeStasio, Rayna Poudyal, Ales Carfaro, Danielle Mou, Eric Riddell

Gas exchange requires a surface that is thin, permeable, and highly vascularized, conditions that inherently lead to water loss. Amphibians are unique in their reliance on breathing across their skin, making amphibians especially vulnerable to desiccation. We hypothesized that amphibian skin plays a more versatile role than the lungs in responding to the threat of desiccation, moderating the trade-off between gas exchange and water loss. To assess this trade-off for the whole organism, skin, and lungs, we measured carbon dioxide production and evaporative water loss using flow-through respirometry on the whole animal, on a portion of the dorsum, and from the nares at two temperatures (22, 27ºC) and two vapor pressure deficits (1.4, 1.7 kPa), across three toad species (Anaxyrus americanus, Anaxyrus fowleri, Rhinella marina). For A. americanus and fowleri, the whole-animal measurements revealed a trade-off between respiration and resistance to water loss under cool conditions but not warm. Conversely, the trade-off occurred strongly in R. marina across all conditions. We found no trade-off for the lungs at any temperature or humidity, although the variation in both traits was substantially lower compared to whole-animal measurements. Our results suggest that the lungs serve a fixed role of respiration while skin permeability is more flexible and can respond to environmental variation.

Genetic evidence of unbiased sex-dispersal in the critically endangered yellow-tailed woolly monkey

Sofia Weaver, Melissa Zarate, Evelyn Pain, Sam Shanee, Fanny Cornejo, Christopher Schmitt

The Critically Endangered yellow-tailed woolly monkey (Lagothrix flavicauda) is endemic to the montane cloud forests of Andean Perú. Despite its conservation status and ongoing habitat decline, L. flavicauda is among the least studied non-human primates, with extremely limited population genetic data available. Evaluating dispersal patterns can provide important insight into the relationship between ecology, population structure, and conservation, such as whether effective gene flow occurs between fragmented habitats. Although behavioral data are too scarce to determine dispersal directly, sex-biased dispersal can be inferred from discrepancies in haplotype frequencies and geographic distributions of uniparentally inherited genetic markers. Using DNA extracted at the Wildlife Conservation Lab at Los Amigos Biological Station in Madre de Dios, Perú, from fecal samples collected from individuals across Andean Perú, we sequenced a region of the SRY gene on this species' Y-chromosome to assess genetic structure in Y-linked markers and compare it to available mtDNA. The sequenced SRY fragment showed insufficient variation to infer sex-biased dispersal. However, evaluation of a ~9.8 kb region of the mitochondrial genome suggests dispersal by both sexes, perhaps with males dispersing more, though sample size was too limited to detect significance. With expanded population data of whole mitogenomes, which our lab is generating, we aim to provide insight into population processes that will support conservation efforts to protect this species.

IgM hantavirus (Sin Nombre virus) ELISA for free-living deer Mice from northwest Oklahoma

Alex Webb, Richard Dolman, Michelle Haynie, Christopher Goodchild

Hantaviruses are an emerging zoonotic disease and are the etiologic agents of severe acute respiratory diseases: hantavirus pulmonary syndrome (HPS) or hantavirus cardiopulmonary syndrome (HCPS). Human hantavirus infection occurs through inhalation of excreta from reservoir hosts, which include rodents, shrews, moles, and bats. We are conducting a hantavirus (Sin Nombre virus [SNV]) surveillance in a free-living deer mice population located in northwest Oklahoma. To do so, we optimized an ELISA method for the detection of SNV IgM and IgG antibodies. The development of an SNV IgM ELISA complements another project that characterizes horizontal SNV transmission of wild-caught deer mice in a semi-natural enclosure.

Frankenshark: force and fluid interactions of dermal denticles on a bioinspired shark tail

Amani Webber-Schultz, Joseph Legris, Edwin Lopez Ramos, Jacob Brody, Alper Erturk, Christin Murphy, Brooke Flammang

Sharks are considered master swimmers, displaying a variety of dermal denticle shapes, caudal fin morphologies, and swimming styles that assist with moving through varied ocean habitats. Pelagic sharks, like great hammerheads (Sphyrna mokarran) are thought to have denticles specialized for drag reduction, whereas benthic sharks, like nurses (Ginglymostoma cirratum), have denticles specialized for abrasion strength. Such complex variation in morphology and swimming style suggests differences in swimming efficiency. This raises the question of which fluid interaction at the tail dominates: is it tail shape, denticle shape, or swimming kinematics primarily influencing efficiency? To investigate this, we selected three species with varying caudal fins, denticle shapes, and swimming styles: leopard (Triakis semifasciata), nurse, and great hammerhead sharks. We modeled a robotic shark tail after the leopard shark, an ecomorphological intermediate to the other species, to eliminate the effect of shape. Actuation of the tail was programmed to achieve motion patterns that matched the three selected species as determined through kinematic analyses using DeepLabCut. Then, the tail was overlayed with two different denticle layers from great hammerhead and nurse sharks and swam at biologically relevant amplitudes, frequencies, and velocities. Thrust production from hammerhead denticles was largely insensitive to

changes in frequency, amplitude, and velocity, whereas nurse denticles exhibited the greatest overall forces produced at species relevant lower amplitudes and higher frequencies.

Do host material properties drive the evolution of parasitoid wasps' ovipositor buckling resistance?

Abby Weber, Philip Anderson, Charles Roseman

Parasitoid wasps use an ovipositor to lay eggs in host insects whose exteriors are made of materials spanning from the soft membrane of caterpillars, to the intersegmental membrane of cockroaches, to the sclerotized cuticle of an adult beetle. It is presently unknown if this diversity in ovipositor morphology is a function of adaptation to the different material properties of host insects. Here, I ask the following question: Do host insect material properties influence the evolution of the ovipositor in the Braconid subfamily Euphorinae? Critical buckling force is the amount of force a column can withstand under compression before failure. We hypothesize that wasps who parasitize similar hosts have evolved similar critical buckling forces to complete a successful puncture during the oviposition event. To test this hypothesis, I calculated the critical buckling force for 30 species of wasps. I then fit a series of continuous phylogenetic comparative models exploring the relationship between critical buckling force and host insect using OUwie. The model support indicates the best fit is an Ornstein-Uhlenbeck model with multiple optima. This result indicates that host material properties may influence the evolution of ovipositor buckling resistance

Environmental Stress and Grooming Behavior in American Kestrels

Ashley Webster, Nicole Amedee, Claudia Gerecke, Martín Frixione, L. Michael Romero, Dale Clayton, Sarah Bush

Environmental conditions can impose significant stress on wild bird populations, influencing both their physiology and behavior. In birds, environmental stressors such as limited food availability, extreme climates, and habitat quality can trigger the release of corticosterone (CORT), the primary glucocorticoid involved in stress responses. CORT plays an important role in helping individuals cope with short-term challenges by mobilizing energy and supporting immune function. However, prolonged exposure to stress can disrupt this balance, leading to negative effects on body condition and overall health. Altered CORT levels may also influence important behaviors, including grooming. Grooming in birds is an essential behavior for maintaining plumage condition and defense against ectoparasites. To examine how differing environments shape this relationship, American Kestrels (Falco sparverius) were studied across two contrasting habitats: the arid, drought-stricken, resource-limited deserts of Baja California Sur, Mexico, and the tropical, resource-rich Puerto Rico. Using standardized focal observations, we quantified grooming rates and compared them alongside CORT levels and body condition. Our findings revealed that kestrels in Baja California showed significantly lower grooming rates, CORT levels, and poorer body condition. Our study suggests that environmental stressors may impose energetic trade-offs that influence both physiology and behavior.

Seasonal changes in the bat auditory cortex transcriptome suggests functional changes in hearing

Cara Webster, Michael Smotherman

Animals exhibit seasonal rhythms in their behavioral ecology, and these behavioral changes are typically accompanied by physiological adaptations of the senses. However, little is known about how sensory processing in the brain might also fluctuate. For echolocating bats, hearing is central to fitness and consequently their central auditory system is sharply tuned to each species' foraging and biosonar strategies, which can change across seasons. Tadarida brasiliensis is a widespread migratory bat species that undergoes dramatic seasonal variations in behavior and physiology. Here we report on the circannual fluctuations in gene expression within the auditory cortex (AC) of wild caught bats. AC samples were collected across all four seasons and total mRNA was sequenced and analyzed for differential gene expression. We focused on genes related to neural excitability, neurotransmission, and canonical molecular markers for cortical cell types with established functions in auditory processing. Additional analyses included functional enrichment (g:Profiler2) and clustering techniques to identify gene networks (WGCNA, mFuzz). Results revealed robust cyclical variations in major neural cell types and signaling pathways that may imply shifts in the functional organization of the cortical microcircuits used for processing biosonar echoes. This provides novel evidence that the mammalian brain may seasonally rewire itself to accommodate behavioral plasticity associated with seasonal change. Follow-up experiments include immunofluorescent labeling of cortical cell types of seasonal AC samples for comparison to expression data.

Them set me free: Interim report on the first outplanting of lab bred adult sunflower stars into a multi-species high density urchin site

Willem Weertman, Augustin Kalytiak-Davis, Bob Oxborrow, Chloe Schwab, Dalton Blackwell, Fiona Curliss, Jasper Nevis, Joseph Ullmann, Julia Knopf, Leila Sulentic, Pema Kitaeff, Rebecca Guenther, Walker Hobson, Taylor Frierson, Henry Carson, Jason Hodin

Disease-driven collapse of the predatory sunflower star's (Pycnopodia helianthoides) populations have been linked to rapid ecological shifts along the Northeast Pacific coast. We provide an initial progress report on the first outplanting of twenty nine 3-5 year old (30-60 cm diameter) lab bred sunflower stars into a multi-species high urchin density area in the Salish Sea (up to 15.7 urchins per square meter). A long-term goal of this work is to determine if these released stars will protect kelp from overgrazing through direct or indirect predatory pressure on urchins. To establish baseline ecological conditions, we conducted urchin and kelp surveys at the release site, as well as at nearby urchin removal and unmanipulated control sites that exhibited similarly high urchin density and threatened kelp conditions. To track the 29 stars, we are employing photo re-identification, as 2+ year olds have distinct and stable morphological features. Before release, we took high resolution photos that we have been using to re-identify encountered stars from high resolution photos captured by divers during post-release field surveys. Then using a combination of known site features and high resolution bathymetry maps we have been tracking the motion of the released sunflower stars across the site. We will share preliminary data on the project's progress, discuss our methodological findings and share our thoughts on implications for ongoing and future restoration projects.

Position in a population network affects host immune response in desert bighorn sheep

Luke Weinstein, Brianna Beechler, Brian Dolan, Anna Jolles, Clint Epps

Mechanistic links between landscape-scale parasite exposure profiles and immune function have rarely been characterized. In this study, we leveraged immune phenotypic profiles of 74 clinically healthy desert bighorn sheep from 15 loosely connected populations in the Mojave, CA, to investigate patterns, as well as environmental and host-related drivers of immunity in these free-ranging wild sheep. Our data suggest that heat and / or nutritional restriction may affect susceptibility and increase infection risks in wild desert bighorn; and more isolated populations at the periphery of the metapopulation network may be particularly vulnerable to infectious exposures when they do occur. Extreme heat events and record-breaking droughts are projected to increase in frequency in the Southwest, and infrastructure projects for transportation, energy development and border fortification are likely to continue to slice up the desert, reducing its permeability to animal movement. Desert fauna are well adapted to hot and arid environments – but the nexus of starvation, heat stress and infectious diseases may challenge even their physiological limits. We hope that future research may clarify which immune phenotypic traits are heritable and associated with heat tolerance and resilience to infection, allowing genetic mitigation of connectivity loss to be optimized in vulnerable bighorn populations.

Management and diagnostic implications of unique inflammatory profiles identified in bighorn sheep.

Luke Weinstein, Anna Jolles, Brianna Beechler, Brian Dolan, Clint Epps

Disease can be a major threat to species at risk. Understanding how pathogen dynamics lead to disease potential requires understanding host immune heterogeneity. Inflammation is a key process for clearance of pathogens within complex organisms. Cytokines are immune signals that indicate the type and severity of immune responses. Here we report cytokine reference values for six circulating cytokines derived from our sample of hundreds of wild bighorn sheep (Ovis canadensis) across different habitats, subspecies and populations in California. Our analysis identified three groups of outliers each with distinct inflammatory patterns: A subset of animals with coelevated levels of both TNFa and IL-10 (N=160), and two separate groups of bighorn had highly elevated levels of IL-6 (N=15) and IL-17a (N =52), respectively. We investigated potential causes and consequences of these striking patterns. While we observed some geographic patterns to the distribution of the groups, none of the other host or pathogen-related variables explained inflammatory status. Survival data were available for all sheep for up to five years following their initial capture. None of the inflammatory outlier groups had mortality rates that differed from other bighorn studied. When compared with cytokine levels observed in other wild and domestic species, the values observed here are extremely elevated. Our results demonstrate the impressive tolerance of wild bighorn to withstand potent immune activation without observable mortality effects.

Physiological mechanisms underlying bee behavioral response to climate change

Ren Weinstock, Karen Kapheim

Bees are facing rapidly shifting environments under climate change, including rising temperatures. Temperature is a key force influencing animal behavior, and in many bee species, social behavior is critical for ecological success and individual fitness. Our research investigates the stability of bee social organization under climate change by testing the effect of increased temperature on behavioral and physiological mechanisms of sociality in the facultatively eusocial sweat bee, Halictus rubicundus. We hypothesized that in social colonies, individuals across behavioral castes will respond differently to elevated temperature, with changes in aggression, reproductive physiology, and oxidative stress potentially destabilizing colonies. Using circle tube assays, we compared caste-specific aggression under temperature increases. We then measured lipid content and lipid peroxidation as potential mechanisms driving temperature-induced changes in behavior. To assess variation across environments, we repeated this study with Logan, UT and Gothic, CO populations of H. rubicundus, which differ in both social and ecological environment. Together, these results will provide mechanistic insight into how temperature shapes bee sociality and improve predictions of population resilience under climate change.

Effects of evolutionary and ecological factors on the microbiome of *Sceloporus* lizards

Stacey Weiss, Julio Rivera, Gonzalo Ramírez-Cruz, Erin Westeen, Alexi Ebersole, Marie Bunker, José Jaime Zúñiga Vega, A. Michelle Lawing, Emilia Martins

Symbiotic bacteria living in and on eukaryotic organisms can influence host health, behavior, and fitness. Because of these far-reaching effects, identifying factors that shape the microbiome has become a central focus in microbial ecology. One such factor is host evolutionary history, which can give rise to phylosymbiosis, a pattern where host phylogeny parallels host-associated microbial community relationships. However, there are a multitude of other drivers influencing microbial community structure including aspects of host ecology, physiology, and behavior. We examined the contribution of evolutionary and ecological factors to the microbiome of free-ranging Sceloporus lizards. Using cloacal swabs, we characterized the microbiome of 11 Sceloporus species from Washington, Arizona, Texas, and Oaxaca, and we related community structure to host phylogeny, geographic location, ecotype (e.g., arboreal vs terrestrial), species identity, and sex. We found only a weak and inconsistent phylogenetic signal, providing little to no support for phylosymbiosis in this group. In contrast, location, ecotype, species, and sex all strongly explained microbial variation. These results highlight the complexity of factors shaping host-associated microbiomes, with ecological variables at times outweighing phylogenetic history. Further work is needed to establish patterns and develop predictive frameworks for when phylosymbiosis is likely to arise.

House finches recognize ecologically relevant snakes

Alice Welch, Elena Gasiorowski, David Kikuchi

Predation is a strong selective force, necessitating recognition and response by prey. Birds respond to potential threats, but in most cases, we do not know the cues that trigger responses or how finely tuned those cues are to ecologically relevant dangers. House finches (Haemorhous mexicanus) are native to Western North American and, in Oregon, are often depredated by gopher snakes (Pituophis catenifer) but rarely by other snakes. To examine their ability to recognize a sympatric predator, we assessed responses of wild-caught, lab-maintained house finches to potential threats. We used a neophobia assay to measure how stimuli with different colors, patterns, and shapes influenced latency to feed when they were placed next to the birds' food dish. Stimuli included snake replicas painted with colors matching the spectral reflectance of real snakes, permutations of their color patterns, and other controls. We found that latency to eat was higher for snake-like stimuli compared to non-snake stimuli and, strikingly, highest for a gopher snake replica compared to other snakes. We found that house finches can not only recognize snakes but even distinguish between sympatric species that differ in ecological relevance. Our data suggest that they do this by integrating multiple visual cues like color and pattern.

Flight endurance declines with age in bumble bees (*Bombus impatiens*)

Ripken Wellikson, Jordan Glass, Michael Dillon

Aging alters behavior and ability across most species within the animal kingdom, often through a progressive decline in physiological function over time. Social insects offer a unique window into these processes as their lifespans are short enough for patterns to emerge quickly, yet long enough to capture meaningful changes across an individual's life. In bumble bees, one of the most energetically demanding behaviors, flight, is essential for survival, driving both foraging success and overall colony health. Despite its importance, how flight performance shifts with age is still poorly understood. Here, we tested the flight endurance of Bombus impatiens workers of varying ages by stimulating individuals to fly in controlled conditions until exhaustion. We found that flight duration did decline with age, but not in a simple, uniform way. Rather workers retained strong flight capacity across much of their lifespan before steeper declines later in life. These findings reveal that aging in social insects is not a steady unraveling but a nuanced process, with performance maintained during periods of peak demand. Understanding these patterns deepens our view of insect aging and highlights the ecological consequences of age-related declines for colony success.

Differential feeding and partitioning of picocyanobacteria by the appendicularian Oikopleura dioica

Camille Wendlandt, Terra Hiebert, Kelly Sutherland, Anne Thompson

Picocyanobacteria are abundant and diverse primary producers in the world's oceans. When mucous-mesh grazers like appendicularians feed on picocyanobacteria, they either shunt prey carbon to higher trophic levels (by digesting prey) or export prey carbon to ocean depths (by discarding mucous houses or feces). Here, we investigated how appendicularians partition picocyanobacteria into these compartments and whether partitioning varies across picocyanobacteria strains. We allowed 5-day-old appendicularians (Oikopleura dioica) to feed on a mixture of six picocyanobacteria strains (Prochlorococcus MED4, MIT9312, and NATL2A and Synechococcus CC9311, CC9605, and WH8102) and subsampled the house, gut, and feces from individual appendicularians after feeding. We used qPCR to quantify the prey strains in each compartment and found that O. dioica fed on all six prey

strains, with each strain increasingly concentrated by the house, gut, then feces. While houses did not show differential affinity for any strain, the gut and feces were enriched with Synechococcus CC9311 and CC9605. Our study confirms previous work that Synechococcus are generally more vulnerable to appendicularian predation than Prochlorococcus and further shows that strain-level differences between picocyanobacteria influence feeding selection by predators. Future research should address 1) what properties of CC9311 and CC9605 cause these strains to be favored in the guts of appendicularians and 2) what behavioral or anatomical traits allow appendicularians to select between picocyanobacteria.

Manipulation of mouse EDL muscles to mimic kangaroo rat hopping

Caden Werner, Kiisa Nishikawa, Carissa Mallonee, Craig McGowan

Mice (Mus musculus) do not habitually hop as a standard mode of locomotion, whereas kangaroo rats (Dipodomys deserti) move through complex 3-dimensional desert terrains via bipedal hopping. These differences in locomotion bring into question how the intrinsic muscle properties of these species may influence how they move. I hypothesized that the force-strain relationships of mouse extensor digitorum longus muscles (EDL) and kangaroo rat lateral gastrocnemius (LG) muscles will have minimal differences when scaled for mass and length, resulting in similar work loops and force outputs between the two species. EDL muscles of adult wild-type mice were surgically removed, suspended in an aerated bath of Krebs-Henseleit solution, attached by a fixed point on one end and a dual servomotor-force transducer on the other, and stimulated by platinum electrodes. The maximum force and optimum length of each muscle was determined. We used representative in vivo strain, activation, and electromyographic data from kangaroo rats hopping on a treadmill for ex vivo 'avatar' experiments using mouse EDL muscles. Each muscle was tested in a series of trials to simulate kangaroo rat hopping cycles. The scaled force data indicated that mouse EDL muscles accurately replicate the in vivo force profiles of hopping kangaroo rat LG muscles. Our results suggest that specialized gaits, such as hopping, do not require specialized intrinsic muscle properties. Supported by DBI-2319710 and NAU SMRT program.

Preparing for battle: impacts of pond water on tadpole microbiome, immune priming, and development

Rosemary Westcott, Sarah Woodley

Tadpoles acquire many of their microbiota from the environment in which they develop. Experimental manipulation of that environment has been found to alter their gut and skin microbiomes, which in turn impacts physiology and development. In other animals, these microbiota serve to prime the immune system, but little is known about the role of the microbiome in immune priming in tadpoles. Here, we analyzed the gut microbiome, immune priming via immune gene expression, and development in Xenopus laevis (African clawed frog) tadpoles raised in either autoclaved or natural pond water to establish low-diversity and high-diversity microbiomes, respectively. We used a known quantity of a bacterial spike-in during DNA extraction to allow for integrated bacterial density and absolute abundance analysis after 16S sequencing. We also analyzed key immune gene expression via direct mRNA detection with a custom NanoString code set and correlated expression with aspects of the microbiome. We found that tadpoles raised in autoclaved pond water have: 1) lower gut bacterial diversity but similar bacterial density, 2) altered immune gene expression, 3) a more rapid rate of development, and 4) more severe tail deformities compared to those raised in natural pond water. Establishing this microbiome manipulation model in this species will allow for the further use of molecular tools to better understand the effects of the microbiome on tadpole immunity at the molecular level.

Genetic approaches to understanding neurotoxin synthesis in bacteria

Samantha Westcott, Julia Walton, Nick Demski, Aretha Fiebig, Elizabeth Heath-Heckman, Heather Eisthen

Tetrodotoxin (TTX) is a potent, non-proteinaceous neurotoxin produced by bacteria associated with diverse animal hosts. TTX-bearing animals dramatically shape their ecosystems, yet the TTX biosynthesis pathway(s) remain completely unknown. Our research focuses on TTX production dynamics in newts from the genus Taricha and their TTX-producing bacteria. We are using newt microbial symbionts to identify the genetic pathways controlling TTX-biosynthesis in Taricha.

Our lab has isolated seven genera of TTX-producing bacteria from newts, and we have assembled complete genomes of eighteen distinct strains through short- and long-read sequencing. The genomes lack shared transmissible genetic elements or other clear gene candidates that are uniquely present across TTX-producing strains. We are therefore using two different forward genetic approaches to identify putative TTX synthesis genes. First, we are passaging TTX-producing strains over several hundred generations, exploiting observations suggesting that strains may lose the ability to produce TTX when passaged in the lab. Second, we have generated a barcoded transposon mutant library of a TTX-producing Aeromonas and will screen for mutants that are defective in TTX production.

By identifying components of the TTX biosynthesis pathway we can develop a greater understanding of how widespread the capacity for TTX production may be among bacteria associated with other animal hosts or in the environment. Additionally, our findings will facilitate understanding the mechanisms by which hosts may influence TTX synthesis by symbionts.

Transcriptomic connections between preference learning and memory in a butterfly

Erica Westerman, Kiana Kasmaii, Yiting Ter

Mate preference learning, where individuals change their mate preferences based on past social experience, occurs in a wide range of animal taxa. However, how a social experience translates into a change in future social decisions remains poorly understood, especially from a neurogenomic perspective. To explore connections between preference learning and memory, we utilized the butterfly Bicyclus anynana, a species that learns mate preferences for visual signals, particularly male forewing eyespot number and morphology. We conducted two transcriptomic studies, both comparing gene expression in females exposed to a trainer male relative to naïve females: one during a training event (while learning is happening) and one during later single-choice mating assays (while past experience is being remembered). We assessed differential gene expression in three tissues: brain, eyes, and antennae. We identified differentially expressed genes (DEGs) in all tissues in both contexts. However, while the eyes had the greatest number of DEGs during training (relative to naïve individuals), the antennae had the greatest number of DEGs between trained and naïve individuals during single-choice assays. The shared DEGs in these two contexts (training and single-choice assay) were very small in number, and primarily in the eyes. These results suggest that preference learning and memory retrieval utilize different neurogenomic pathways, and provide new candidate genes connecting these two cognitive processes.

Relationship of IGF1 signaling to growth rate variation in California yellowtail

Nola Weston, Victoria Miller, Olivia Martin, Gregory Schwartz, Sean Lema

Growth in fish is regulated by the growth hormone (GH)/insulin-like growth factor-1 (IGF1) hormone axis, and shifts in GH/IGF1 signaling are an important endocrine mechanism underlying growth variation. Here we examined how IGF1 signaling related to variation in somatic growth rate in California yellowtail (Seriola dorsalis), a carangid fish being developed for aquaculture. Young-of-the-year yellowtail were reared in tanks on the same closed recirculating system under similar per fish mass feed rations at either a low fish density (26 kg fish wet mass per m3 volume, at the time of sampling) or high fish density (50 kg per m3). Fish were measured and weighed to allow for calculation of

specific growth rate during the last 28 d prior to sampling. Liver tissue was then collected and processed to quantify the relative mRNA levels of igf1 and IGF binding proteins. Individual fish with higher specific growth rates had greater relative igf1 mRNA abundance in the liver. While liver igf1 mRNA levels were similar in fish from the low- and high-density conditions, mRNAs encoding IGF binding protein-1a (igfbp1a) were at higher relative abundance in fish at higher density. These findings point to individual differences in growth rate being connected to liver IGF1 production in California yellowtail and provide a foundation of future physiological studies evaluating the specific growth requirements of this species for optimal rearing for aquaculture.

Sex, body size, and brain gene expression are associated with cognitive variation in a dung beetle

Rebecca Westwick, Armin Moczek

Individual variation in behavior and cognition can have important consequences for an animal's ability to survive and reproduce. This variation arises from many factors, ranging from sex and nutrition to social interactions and the microbiome, among others. While quantifying the influence of each of these factors in isolation can be challenging enough, understanding their interactions is often beyond the reach of most studies, let alone accounting for how these factors might differentially affect different cognitive skills. I used the bull-headed dung beetle (Onthophagus taurus)—a species with nutritionally-cued alternate male reproductive morphs—to test whether sex, body size, and reproductive morph are associated with variation in performance on multiple cognition tests. I additionally assessed baseline brain gene expression in the same individuals using RNAseq. I found that males outperformed females (regardless of size and morph) on a spatial cognition assay. Conversely, I found that large (i.e. high nutrition) individuals outperformed small (i.e. low nutrition) individuals on a detour test regardless of sex. RNAseq results in turn allowed us to identify both distinct and shared brain gene expression repertoires across our groups. I conclude by contextualizing these results in light of their behavioral and ecological relevance for this species and discussing current work on the consequences of this cognitive variation in the context of an ongoing biological invasion.

Nectar traits and plant-pollinator interactions under varying temperature and humidity

Emory Wheeler, Kaysee Arrowsmith

Nectar plays a key role in attracting pollinators and facilitating pollen transfer. Its traits—such as volume and sugar concentration—are strongly influenced by environmental conditions, particularly temperature and relative humidity. However, the combined effects of these abiotic factors on plant attractiveness to insect pollinators remain poorly understood. This study investigated how temperature and relative humidity affect nectar volume and sugar concentration, and how these traits influence pollinator visitation rates. Research was conducted from July 2 to August 1, 2025, in three subalpine wildflower meadows in Gunnison County, Colorado. We surveyed plant–pollinator interactions, recorded ambient temperature and humidity, and sampled nectar volume and sugar concentration. Mixed-effects models revealed that increasing temperature significantly raised nectar volume but lowered sugar concentration. Similarly, higher relative humidity significantly increased nectar volume while decreasing concentration. Importantly, both higher relative humidity and greater nectar volume were significantly associated with increased pollinator visitation rates. In contrast, temperature and nectar sugar concentration showed no statistically significant relationship with visitation. These results demonstrate that environmental factors shape nectar traits in ways that influence pollinator behavior. As climate change alters temperature and humidity regimes, these findings underscore the need to understand the complex interactions between abiotic factors, nectar production, and pollinator responses. Such insights are essential for predicting future shifts in plant–pollinator dynamics.

Integrative taxonomy reveals a new species in the *Madracis myriaster* deep-sea coral complex

Monica Wheeler, Andrea Quattrini, Claudia Vaga

Stony corals (order Scleractinia) are the primary architects of both shallow and deep reef ecosystems. An accurate record of deep-sea community composition is critical to evaluating the biodiversity, yet mesophotic and deep-sea benthic species remain understudied due to difficulties in collection and classification. Scleractinia systematics has been historically hampered by interspecific hybridization, morphological plasticity and convergence, and slow evolutionary rates in mitochondrial genomes. Within Scleractinia, the genus Madracis comprises several species considered important framework builders in the Western Central Atlantic. Madracis myriaster was hypothesized to demonstrate cryptic diversity: two genetically distinct groups (herein referred to as group A and B) were discovered using nuclear ultra-conserved elements. Assembly of whole mitochondrial genomes subsequently revealed a pattern of higher basepair differences between the groups than within. Morphometric data of corallites taken by light microscopy produced statistically significant differentiation between groups A and B in both PCA and PERMANOVA (p-value < 0.003). Moreover, a morphological distinction was uncovered using Scanning Electron Microscopy (SEM): primary and secondary corallite septa were observed in group A but only primary septa were present in group B. Thus, integrative taxonomy aided the identification of species boundary criteria within the Madracis myriaster complex, delineating a new cryptic species. The data was incorporated into existing Madracis phylogenies, advancing knowledge of regional benthic community composition and informing future systematics research.

A kinematic comparison of enrichment-based feeding in captive Komodo dragons

Gwendlyn Wheeling, Melanie Richtar, Kelly Diamond

Animal welfare is an important component in the mission of accredited zoos. However, most research into animal welfare has focused on mammals, with reptile welfare more recently becoming a larger focus area. While zoos are able to mimic many aspects of an animal's environment, one area that is hard to replicate are feeding behaviors, especially for larger predators. In zoos, Komodo dragons (Varanus komodoensis) are fed primarily small prey items that fulfill nutritional needs, but do not elicit the natural feeding movements or behaviors in these large lizards. To evoke a more natural feeding behavior, two Komodo dragons at the Memphis Zoo were provided with an enrichment activity where a food item was elevated off the ground and connected to a force gauge. We predicted that more forceful pulls would involve larger movements of the entire body. To test this, we recorded dorsal and lateral views of dragons pulling on the enrichment activity for 30-minute trials once monthly for three months. We compared the angles between the head and front limbs and the angles of the major joints during pulling. These data will be compared to the forces produced during pulls. The results of this project will be used as evidence for the need for a wider range of reptile-focused enrichment activities in captive-animal facilities.

The life and death of dentition: tooth replacement and damage across diets (Stichaeidae)

Brian Whelan, Richard Hoover, Kassandra Ford

Dental function is partially based on morphology, with different teeth suited for different tasks like piercing, slicing, and crushing. However, dental function is mediated by the process of replacement and the damage that teeth undergo (loss, breakage, blunting, etc). This study investigates tooth replacement and damage across four species of prickleback (Stichaeidae), Xiphister mucosus, Xiphister atropurpureus, Phytichthys chirus, and Anoplarchus purpurescens. These species exhibit ontogenetic dietary variation and diversity in tooth morphotypes, both of which influence how teeth are damaged and how they are replaced. We used high resolution microCT to survey tooth replacement and damage across species and over ontogeny. We found that species display differences in tooth damage, as fish that have a crushing morphotype incur more damage than fishes with a piercing morphotype, but that replacement patterns are largely conserved across species. Finally, we compared

replacement and damage over ontogeny, and found evidence of changes in overall tooth count, replacement, and damage over ontogeny in some species. These findings suggest that, while tooth replacement remains consistent, the proportion of teeth undergoing replacement and the damage that teeth bear reflects the forces placed upon teeth during feeding. Our results expand upon holistic views of dental function, and may be useful for studies on factors that influence tooth developmental regulation, as well as discerning diets of rare or extinct species from tooth condition.

Unraveling the behavioral "building blocks" of social interactions in the socially flexible sweat bee, *Lasioglossum baleicum*

Michelle White, Scott Wolf, Kennedy Omufwoko, Joanna Shoubaki, Eli Wyman, Andrew Webb, Sarah Kocher

Pairwise interactions among conspecifics represent the "building blocks" of social groups. Interactions between non-social individuals can often be antagonistic or aggressive, but individuals living in social groups often display a mix of both aggressive and affiliative interactions. For example, individuals living in social groups frequently coordinate tasks among group members and can often rely on dominance hierarchies to establish and maintain a reproductive division of labor. To identify if and how behavioral interactions vary among social and solitary individuals, we examined differences in fine-scale, pairwise interactions in the socially flexible sweat bee, Lasioglossum baleicum (Hymenoptera: Halictidae). Individuals from a single population can exhibit both eusocial and solitary reproductive strategies, providing a unique opportunity to examine how the behavioral repertoires of social and solitary individuals vary within a single species. We examined L. baleicum across a range of social forms and contexts, including social pairs of social nestmates and social non-nestmates, pairs of solitary individuals, and social-solitary pairs. Our behavioral assays were conducted and filmed in a circular arena that facilitated tracking of fine-scale social interactions as well as individual identity. We used a deep learning platform, NAPS, to quantify the behavioral repertoires of individual bees in these pairwise assays. Our results provide exciting new insights into how fine-scale cooperative, tolerant, and aggressive behaviors vary depending on social context.

Built to bee tolerant? Thermal limits and evolutionary patterns of bumble bee decline

Sabrina White, Michael Dillon

Many studies have found strong correlations between increasing global temperatures and shrinking bumble bee populations. However, not all bumble bees are affected equally: some species thrive, while others teeter on the brink. Intriguingly, these differences often run along evolutionary lines. For example, the subgenus Thoracobombus contains more species in decline relative to other subgenera, whereas Pyrobombus seems relatively resilient. Yet the mechanisms behind these clade-level patterns in decline are unclear. One key suspect is thermal tolerance. We measured the minimum and maximum tolerated temperatures (CTmin and CTmax) of bumble bees from across the U.S. Mountain West and combined these data with published values to explore evolutionary trends. We found that heat tolerance varies surprisingly little among species, while cold limits show more flexibility. This rigidity at high temperatures may make some bumble bees especially vulnerable as the planet heats up, but other factors likely shape the broader patterns of decline. Our work sheds light on why some species survive while others fade, offering clues for protecting these vital pollinators in a warming world.

Stem-palaeognath flight capabilities sheds light on ratite dispersal and flight loss

Klara Widrig, Fabio Alfieri, Pei-Chen Kuo, Helen James, Daniel Field

Lithornithids are an assemblage of Paleogene fossil birds thought to represent stem-group members of Palaeognathae. Among extant palaeognaths, which include flightless ratites such as ostriches, only tinamous can fly, though only in anaerobic bursts. Despite their limited dispersal capabilities, the phylogenetic interrelationships and geographic distributions of palaeognaths imply that their early relatives were capable long-distance dispersers, although quantitative skeletal evidence has not been applied to this question. We investigate the flight capabilities and ecology of the Paleogene lithornithid Lithornis promiscuus using a three-dimensional geometric morphometric dataset spanning the avian crown group. Our models reject the hypothesis that Lithornis would have relied on tinamou-like burst flight, and show that its sternum morphology is consistent with a range of aerobic, flapping flight styles—closely resembling those of many extant birds exhibiting pronounced dispersal capabilities. Our results are consistent with inferences from lithornithid wing shape, supporting the hypothesis that at least some stem palaeognaths were capable of long-distance flight, helping to clarify the origins of the transoceanic distributions of extant flightless ratites.

Machine learning reveals the molecular evolution of the animal biomineralization toolkit

Jasmina Wiemann

Biomineralized tissues show a unique evolvability among animals. The drivers behind their evolution from non-biomineralized precursors are, however, obscured in the fossil record: biominerals rarely survive fossilization without alteration and originally soft tissues may attract secondary minerals. Due to the lack of a robust proxy for biomineralization, the timing of animal skeletal evolution and its potential covariance with environmental parameters is still unknown.

We analyze 150 modern and carbonaceous fossil metazoan hard and soft tissues that were sampled across Phanerozoic clades, in the search for a signature of original biomineralization. Our proxy targets remnants of the macromolecular template: Our sample includes 100 tissues with known biomineralization status and 50 samples with debated biomineralization status. A Random Forest (RF) model trained on Raman spectral fingerprints (Vis & NIR) was complemented with hyperspectral maps, and assessed via simulated data: the model classifies modern and fossil biominerals based on features of the macromolecular template and their fossilization products with >96% accuracy. Diagnostic features include coordinating ligands. Projection of the RF predictions on a principal component analysis reveals distinct clustering of biocarbonate and biophosphate templates, regardless of phylogenetic affinity. Incorporation of fossil unknowns reveals unexpected convergent origins of a variety of carbonate and phosphate biominerals.

Independently co-opted templates experience convergent functionalization that allows to precipitate certain mineralogies. Template optimization represents a prerequisite to the emergence of skeletons.

Quantification of xeno-transferred tonor quail germline stem cells within chicken host gonads using a qPCR assay

Kendall Wilcox, Kendra Roberts, Justine Simms, Thomas Jensen

Conservation of birds has relied mainly on captive breeding, artificial insemination, and artificial incubation. However, recent advances, including embryonic and adult germline stem cell transfer, promise new avenues for the introduction of novel germplasm into breeding colonies or for de-extinction. Our lab focuses on the xenotransfer of germline stem cells, using Coturnix quail (Coturnix coturnix) and chickens (Gallus gallus). We routinely use fluorescent microscopy to detect fluorescent protein (FP) expressing donor cells, or PCR using FP/species-specific primers to confirm successful xenotransfer. Here, we describe a qPCR method used to detect donor-derived germline stem cells within host gonads.

We used a cell sorter (Propel Labs) to sort 10 to 100,000 quail cells into 100,000 chicken cells, followed by gDNA isolation. We used quail and chicken-specific primers to detect donor-derived cells within the host gonad. The standard curve was derived using DCt with chicken as the reference.

The calculated qPCR standard curve: Cells=501,829*e-0.779*Ct R2=1 and DCt ranged from 14.3 to 2.06. 76.9% of host gonads were positive for donor-derived cells, ranging from 19 cells (0.02%) to 23,890 cells (23,9%) per 100,000 chicken cells. However, the majority (90%) of hosts had 1,600 or less donor-derived cells per 100,000 chicken cells. Our assay detected donor-derived cell numbers as low as 19 per 100,000. Most host gonads contained 0.1 to 1.56%, although one host gonad had 24%.

Evolutionary divergence and species boundaries in a vulnerable aerial insectivore, the Purple Martin

Victoria Wiley

Evaluating species boundaries is fundamental to understanding evolutionary mechanisms and employing conservation efforts for recently diverged populations. Steep global declines in aerial insectivore populations have been observed due in part to habitat loss, decreases in insect abundance, and toxicant exposure. Survival threats for long-distance migratory species are exacerbated. Purple Martins (Progne subis) are aerial insectivores and Neotropical migrants that face transhemispheric threats across their range in North and South America. Three subspecies are recognized, largely defined by their ecological breeding preferences in North America: the Eastern Purple Martin (Progne subis subis), Western Purple Martin (Progne subis arboricola), and Desert Purple Martin (Progne subis hesperia). While the nominal Eastern subspecies maintains a contiguous range throughout much of eastern North America, the Western and Desert subspecies breed in disjunct patches of high-elevation montane and Sonoran Desert regions of the West, respectively. Data elucidating the migratory pathway for each subspecies suggests geographic and phenological separation. Further, significant phenotypic differences have been documented between subspecies, namely size and female plumage. As such, gene flow may be minimal to nonexistent between subspecies. Here, I investigate genomic, bioacoustic, migratory-timing, and phenotypic divergence between subspecies to illuminate species boundaries within P. subis. Whole-genome sequencing, bioacoustic analyses, and phenotypic data from museum specimens will be utilized to assess whether current subspecies designations reflect distinct evolutionary lineages warranting species-level recognition.

The tortoise or hare? Temperature and developmental rate affect transcriptomes during development

Madison Wilken, Clinton Warren, Ryan Paitz, Rachel Bowden

The effects of warm incubation temperatures on ectothermic embryos are complex and include acceleration of developmental rate and a suite of post-hatch phenotypic effects among offspring when comparing offspring that experienced different developmental conditions. In a previous study using RNASeq, we found that on day 6, Trachemys scripta embryos incubated at warm temperatures (31°C) had 4357 genes differentially expressed compared to embryos at cool temperatures (26°C). Because of the design of the study, it was unclear if this difference resulted from embryos being sampled at different developmental timepoints or different incubation temperatures. To tease apart these early developmental and temperature effects, eggs were incubated at either 31°C±3 or 26°C±3 for 6 days and then swapped to the opposite temperature for an additional 6 days to produce embryos at the same developmental stage in each treatment. A second group of eggs was incubated at either 31°C±3 or 26°C±3 for 6 days and then all moved to an intermediate temperature of 29°C±3 for an additional 6 days. Preliminary results indicate that, as expected, experiment 1 produced stage matched individuals and experiment 2 did not. Transcriptomes will be compared to identify genes and processes most affected during these early time periods to better understand the complex effects of temperature on early development.

Uncovering hidden shifts in the Florida Keys: leveraging environmental DNA (eDNA) to assess diurnal

Mary Williams, Heather Bracken-Grissom

Coral reef ecosystems harbor rich biodiversity, with community composition exhibiting dynamic temporal patterns between day and night periods. Many reef species display distinct diurnal and nocturnal behaviors leading to temporal shifts in observable biodiversity. Traditional visual surveys often miss these temporal variations, potentially underestimating true species richness and ecological complexity. Environmental DNA (eDNA) provides a non-invasive tool for monitoring biodiversity by capturing material shed by organisms into their environment. This study investigates diurnal versus nocturnal biodiversity shifts on Florida Keys coral reefs using eDNA to help support traditional visual survey means. Water samples were collected from five reefs using a Smith-Root eDNA backpack sampler during both daylight and nighttime periods on the slack tide. Three genetic markers (uniCO1, 12s miFish, and 16s) were used to characterize community composition across sampling periods. Our objectives were to: (1) quantify differences in eDNA-detected biodiversity between day and night, and (2) identify species contributing to temporal community shifts and (3) supplement traditional biodiversity inventories with the addition of eDNA. Preliminary results indicate significant shifts in biodiversity profiles within the individual reef sites between diurnal and nocturnal periods, with additional variation observed across reef sites that may correlate with reef structural complexity and local habitat conditions. By sampling community composition over 24 hours, our approach reveals temporal patterns essential for comprehensive biodiversity assessments and ecosystem understanding.

How to live with a calculating cat: Implications of the elevated metabolic demands of felids

Terrie Williams, Sarah Huse

The hunting prowess of felids from 4 kg domestic cats (Felis catus) to wild 200 kg African lions (Panthera leo) has been well documented in both popular literature and scientific publications. Despite this, there have been comparatively few studies measuring the actual metabolic demands of felids that underly their exceptional predation behaviors. Here we used standard open-flow respirometry to measure resting and active metabolic rates, and energetic transport costs of two species of large felid, puma (Puma concolor, average mass = 65 kg) and African lions (average mass = 141 kg females, and 158 kg males). Both species were trained to voluntarily sit, stand and walk on treadmills at zoological facilities. We found a metabolic overhead rate (MOR; approx. 10 mlO2.kg-1.min-1 for African lions) while sitting and standing that was superimposed on predicted basal resting metabolism. These high inactive energetic costs resulted in elevated total transport costs during walking that were 2.0 times predicted values based on body mass for puma and 3.3 time predicted for the larger African lions. As “hypercarnivores”, felids must sustain these heightened metabolic demands with a diet comprised of > 80% protein. This combination of a highly specialized diet and high energetic demands at rest and during activity relative to other large carnivores likely contribute to the reputation of felids as fierce predators. (Supported by NSF)

Macrophages remodel the early gonad in a species with temperature-dependent sex determination

James Willoughby, Barbora Strakova, Boris Tezak

The early gonad has the unique ability to differentiate into two morphologically and functionally distinct organs, the testis and the ovary. Once the gonad acquires a sex, remodelers direct the organ’s structural differentiation. This step is well-studied in male mice, where gonadal macrophages help establish “testis cords.” However, it remains poorly understood in species with temperature-dependent sex determination (TSD), such as the red-eared slider turtle (Trachemys scripta). In TSD species, sex is established by incubation temperature rather than genetic factors, and the early gonad contains primitive sex cords – structures absent from the early mouse gonad. These differences suggest that remodeling into testes and ovaries may follow distinct mechanisms across vertebrates. To test whether macrophages assist gonadal remodeling in T. scripta, eggs were incubated at male- and female-promoting temperatures (MPT and FPT) and collected at the onset of sex differentiation. Macrophages were identified by immunofluorescence and in situ RNA hybridization. Manipulation experiments, which used estradiol to produce females at MPT, tested whether macrophage abundance depends on temperature directly or on gonadal sex. Surprisingly, macrophages were more frequent at FPT and colocalized with primitive sex cords. These results suggest that macrophages participate in breaking down primitive sex cords during ovarian differentiation. Our findings highlight a novel role for macrophages in turtles, which contrasts with their established function in promoting cord formation in mice.

Comparing morphological and mechanical properties of fast swimming fish vertebral columns

Jacqueline Wilson, Maria Laura Habegger, Marianne Porter, Aubrey Clark

Fish using their body and caudal fin (BCF) for locomotion have traditionally been grouped into four main categories — anguilliform, subcarangiform, carangiform, and thunniform—based on the number and size of body wavelengths generated for propulsion. However, recent kinematic and biomechanical studies have suggested that these categories may have less rigid boundaries than historically proposed as many species display intermediate characteristics or overlapping traits. Therefore, the goal of this research is to further evaluate this idea through a biomechanical comparison of carangiform and thunniform species. Vertebral morphology and mechanical properties were investigated along the vertebral column in four carangiform species - Almaco Jack (Seriola rivoliana), Greater Amberjack (Seriola dumerili), Jack Crevalle (Caranx hippos), and Mahi-mahi (Coryphaena hippurus)—and one thunniform species—and Blackfin Tuna (Thunnus atlanticus). Morphological measurements (height, width and volume) were taken for each vertebra and mechanical variables (Young's modulus, E, and second moment of area, I) were obtained through compression testing. Stiffness and second moment of area increased substantially towards the caudal fin regardless of swimming mode with no evidence of biomechanical regionalization. Morphological traits increased rostro-caudally, mirroring these biomechanical trends. Results indicate negligible biomechanical and morphological differences between carangiform and thunniform representatives. These conclusions suggest that further studies are needed to assess the BCF classification system, particularly by increasing the number of species and evaluating other variables influencing swimming modes.

A multi-disciplinary evaluation of chemical and biological components of ready-to-eat tuna products

Amanda Windsor, Sarah Stadig, Jennifer Fong-Sam, Jake Carter, Patrick Gray

Ready-to-eat tuna products are a convenient and economical source of lean protein and healthy fats necessary for a healthy diet. Currently, there are 14 species of fish classified as tuna by the Food and Drug Administration. Due to variation in habitat and feeding ecology across these species, there is potential for significant variability in mercury content in ready-to-eat tuna products. A convenience survey of 81 tuna products purchased online and in-store in the Washington, D.C. area was carried out to measure levels of mercury (Hg) and other elements and to develop methods for species identification with metagenomic shotgun sequencing. Elements were quantified by microwave assisted acid digestion and inductively coupled plasma-mass spectrometry (ICP-MS). The range of species from highest to lowest median mass fraction (ng/g) of mercury was albacore (266) > skipjack (160) > yellowfin (91.3) > light (84.8). However, significant variability was observed within species and across all products. Seventy products were successfully sequenced and taxonomic profiling with FDA's custom mitochondrial k-mer database resulted in genus or species level identification for each product. Identified taxa were consistent with product labeling and three cans labeled chunk light contained a mixture of two tuna species. These results are a part of an ongoing effort to better understand mercury variability in ready-to-eat tuna products across tuna species.

Genomic insights into the historical population demography of Eastern Pacific fin whales

Kaden Winspear, Sergio Nigenda-Morales

Industrial whaling led to a severe decline in fin whale (Balaenoptera physalus) populations across the Eastern Pacific, affecting both the Northern and Southern Hemispheres. Understanding the genetic health of these populations is crucial for evaluating the long-term impact of the whaling bottleneck. Previous studies have explored the genomics of North Pacific populations, but no research has focused on Southern Pacific fin whales in the Eastern Pacific, the most heavily hunted region throughout the Eastern Pacific. This study aims to comprehensively analyze Eastern Pacific fin whales, incorporating samples from across the entire region. By examining genetic diversity, population structure, and demographic histories, this research will provide a clearer understanding of both the recent and past demographic fluctuations and population dynamics along the Eastern Pacific coast, offering critical conservation insights. Additionally, it will trace events such as migration, growth, and bottlenecks over time. The expected outcome is a thorough understanding of Eastern Pacific fin whale populations, which will inform region-specific conservation priorities. This deeper understanding will be pivotal in supporting the recovery of Eastern Pacific fin whales as they face escalating challenges from climate change, pollution, and the looming threat of renewed whaling.

Hunting hatchlings: estimating the prey preferences of cannibalistic lizards (*Anolis sagrei*)

Jaycee Wisdom, Matthew Smith, Sydney Wayne, Chris Norris, Anthony Gilbert, John Rodgers, Daniel Warner

Most predatory animals hunt individuals that are of different species, but cannibalism is commonly observed throughout the animal kingdom. For example, male lions will eat cubs fathered by rival males to increase their own reproductive success, but in other cases, cannibalism occurs when food is scarce. In reptiles, cannibalism has been recorded in approximately 50 species. In the brown anole lizard (Anolis sagrei), cannibalism has been observed numerous times both in captivity and the wild, mostly involving adults eating juveniles. Field studies support the idea that hatchling survival drops when adult density is high, raising questions about whether A. sagrei prefers to eat hatchlings or if they can distinguish hatchlings from other prey while foraging. In this study, we evaluated the feeding preferences of adult brown anoles, hypothesizing that brown anoles exhibit cannibalism because they are unable to discriminate between moving prey items. Since brown anoles are sit-and-wait predators, we developed a moving prey assay that standardized the speed at which different prey items were shuttled in front of each lizard. Preliminary observations suggest brown anoles do not discriminate between insect or hatchling prey items, suggesting the frequency of cannibalistic interactions is more common in natural populations of small-bodied reptiles.

From birds to kites: Feather-inspired flow and flight control

Aimy Wissa

Bird wing feathers are multifunctional structures with several roles, ranging from thermal regulation and shape definition to noise control, as well as aerodynamics. The aerodynamic role of various feather groups has been studied by both biologists and engineers using live birds, cadavers, and simplified engineering models. In this presentation, we will discuss the exciting questions of whether bird feathers can inspire passive, reflexive, and active flow and flight control devices for engineered vehicles, and whether such devices can provide insights into the aerodynamic role of these feathers in avian flight. More specifically, we will focus on two feather groups: the secondary covert feathers and slotted primary feathers. Using force measurements, time-resolved flow fields, and data-driven models, we show how simplified engineered analogies of these feather groups can form new hypotheses about the role of these feathers during bird flight, but also inform the design of novel post-stall flow control devices for remote-controlled uncrewed aerial vehicles and innovative flight control effectors for unconventional

When fish take flight: Exploring locomotion at the interface through engineered models

Aimy Wissa

Exocoetidae, or flying fish, are a family of fish that is distinguished by excelling at fast and maneuverable swimming while simultaneously being capable of long-distance gliding flight. A single glide can cover up to 40 meters. Using a unique taxiing maneuver, where only the caudal fin dips below the surface of the water to propel the fish and produce enough speed for takeoff, can extend their glide up to hundreds of meters without reentering the water. Thus, flying fish represents a unique opportunity to study a high-performance locomotor behavior and to identify the fundamental principles underlying the physics of aquatic-aerial transitions. However, extensive field or lab studies of flying fish are challenging due to their speed and frequent transitions between different mediums. In this presentation, we show how engineering models,

both physical and simulation, can be leveraged to test hypotheses about locomotion at the interface and examine a larger experimental space than is possible with biological organisms. The presentation will focus on a robotic model organism (RMO) inspired by the flying fish and how it was instrumented to reveal the role of the asymmetric morphology of the caudal fin in the transition and locomotion at the interface. This case study highlights that RMOs are an invaluable tool for biologists seeking to understand animal locomotory dynamics and engineers looking to nature for design inspiration.

Where flow meets feathers: Effects of bioinspired wingtips on spanwise flow separation

Hannah Wiswell, Aimy Wissa

Harris's hawk-inspired wingtip devices incorporating biologically relevant degrees of freedom, either slots alone or slots coupled with flexion and twist, delay inboard stall propagation, effectively altering the spanwise lift distribution compared to a baseline wing. This global aerodynamic effect, so-called due to the affected region being the wing portion of a wing-wingtip system, results in effective control authority and an inboard rolling moment arm compared to a baseline wing across the angle of attack regime. The wingtips' consistent performance, particularly during stall, suggests that their global effect extends beyond the wingtip and outboard wing regions. However, there is no study which captures the full extent of the wingtips' spanwise aerodynamic effects. To better understand how bioinspired wingtips fundamentally alter 3D flow separation, we experimentally evaluate a full-span wing which incorporates biologically relevant wingtips. We investigate their aerodynamic effects by acquiring force, moment, and time-resolved stereoscopic Particle Image Velocimetry measurements of the separated 3D flowfield at Re = 2 x 105. Quantitative results of the surface topology away from and during stall help us understand how wingtip slots, flexion, and twist impact stall cell development, downwash, and tip vorticity, and we further quantify how effective bioinspired wingtips are as flow control devices.

Supra-resonant wingbeats in insects

Ethan Wold, Rundong Yang, Ellen Liu, James Lynch, Nick Gravish, Simon Sponberg

Powering small-scale flapping flight is challenging, yet insects sustain exceptionally fast wingbeats with ease. Since insects act as tiny biomechanical resonators, tuning their wingbeat frequency to the resonant frequency of their springy thorax and wings could make them more efficient fliers. But operating at resonance poses control problems and potentially constrains wingbeat frequencies within and across species. Resonance may be particularly limiting for the many orders of insects that power flight with specialized muscles that activate in response to mechanical stretch. Here, we test whether insects operate at their resonant frequency. First, we extensively characterize bumblebees and find that they surprisingly flap well above their resonant frequency via interactions between stretch-activation and mechanical resonance. We develop a biophysical model of stretch-activated muscle which demonstrates that supra-resonant wingbeats are possible but sub-resonant wingbeats are not. Using a work-loop analysis of stretch-activated wingbeats and robophysical experiments, we then show that resonance is actually a lower bound for rapid wingbeats in most insects because muscles only pull, they cannot push. Synthesizing our experimental results with measurements of resonant mechanics from the literature, we show that supra-resonance is a general principle of high-frequency flight across five orders of insects from moths to flies. Supra-resonance widens the phenotypic space for successful flight, enabling insects to specialize for efficiency or maneuverability free from the tight constraint of perfectly resonant wingbeats.

AmphibiaWeb: connecting amphibian lovers to data

Molly Womack, Rayna Bell, David Blackburn, David Cannatella, Jimmy Mcguire, Emma Steigerwald, Kyle Summers, Rebecca Tarvin

Amphibians are the most threatened vertebrate group on the planet and have been seen as harbingers of the Sixth Mass Extinction. It is with this alarm call that AmphibiaWeb was founded in 2000 and has been operating uninterrupted since then. AmphibiaWeb (amphibiaweb.org) is a non-profit initiative whose mission is to connect people around the world by synthesizing and sharing information about amphibians to enable research, education, and conservation. We do this by providing up-to-date scientific information on amphibian natural history, conservation, taxonomy, and global decline. The website amalgamates information from scientists and experts with the latest in biodiversity informatics. Features include: up-to-date tracking of newly described amphibian species, expert-based species accounts for over 30% of the world's amphibians, some in multiple languages; dynamic species range and occurrence mapping; detailed pages on amphibian declines and its causes with ongoing literature updates; community- contributed multimedia files (sound, video and photos); and a community of scientists responsive to the latest taxonomic and research developments in amphibian biology and conservation to any inquiries from the public. Here we will provide a guide to how to effectively use this amphibian resource and outline how herpetologists like you can contribute and share your knowledge and photos. Please come by and meet members of our steering committee!

Does metamorphosis make frogs jump out of their (tadpole) skin?

Molly Womack, Quang Pham, Leah Ormaechea, Marisol Hamada, Vero Penafiel

The idea that metamorphosis allows organisms to evolve distinct morphologies that are "decoupled" across life stages has fascinated evolutionary biologists and prompted many studies across varied taxa. However, few of those studies have focused on structures that are continuously present across life stages, which may not be able to evolve as independently as structures or traits that are only present in one life stage or that are completely restructured during metamorphosis. Frog skin is an organ that is present across metamorphosis, forming at a very early larval stage and continuously present for the rest of the frog's life. In both tadpoles and adults, skin thickness has been shown to vary dramatically among species and body regions, but few studies have compared skin at both life stages in the same species. Here we quantified variation in tadpole and adult epidermal and dermal skin thicknesses in both the dorsal and ventral body regions of a dozen species. Using these novel tadpole and adult skin data we tested whether skin thickness is evolutionary decoupled between larval and adult life stages despite continuous presence of the organ throughout metamorphosis.

Delayed gonadal fate commitment under intermediate incubation in a TSD turtle

Brandon Wong, Boris Tezak

Temperature-dependent sex determination (TSD) is a process in which an organism's sex is determined by incubation temperature. Most turtle species with TSD follow a cool-male (27°C) and warm-female (31°C) pattern. Studies investigating the molecular mechanisms of TSD usually focus on embryos incubated at constant male- or female-producing temperatures (MPT and FPT, respectively). However, much less is known about developmental rate and gonadal differentiation when eggs develop at intermediate temperatures (~29°C). In this study, we used the model TSD species Trachemys scripta to compare developmental rate and the timeline of key gonadal differentiation events. We explore morphological differences in structure as well as protein expression of previously identified key genes among embryos incubated at MPT, FPT, and intermediate temperatures. Immunofluorescence analyses reveal a delay in gonadal fate commitment at intermediate temperatures. This delay in gonadal differentiation may reflect a prolonged thermosensitive period of sex determination when embryos develop outside constant MPT or FPT conditions. Together, these findings provide new insight into the dynamics of gonadal sex differentiation under intermediate incubation temperatures, a common but often overlooked occurrence in natural populations.

Considering the past, present, and future of bio-informed design

Jasmin Wong, Christina Harvey, Vikram Baliga

To uncover the principles behind animal flight, we must integrate perspectives on physics, physiology, ecology, and evolution. Yet, the results and terminology in these different fields often remain siloed. Here, we present a framework for using a bio-informed approach to study flight, in which biological constraints and evolutionary analyses inform the development of engineering technologies and how engineered platforms can support hypothesis testing in biological studies. Using case studies, we explore how comparative studies can reveal fundamental flight principles, such as multifunctional constraints and adaptive versatility. These solutions would require highly-specific framing to be identified with conventional optimization methodology. We then outline best practices for integrating biological understanding into engineering, and vice versa, allowing researchers to identify robust patterns across taxa and incorporate multifunctionality and resilience into robotic prototypes. Embedding bioinformed thinking into engineering design can both expand the design space for aerial systems and enrich our understanding of how biology achieves adaptable flight.

Small but diverse: genomic signatures of introgression in the rapid radiation of bee hummingbirds

Jenny Wong, Alan Brelsford, Chris Clark

One of the central goals of evolutionary biology is to explain variation in biodiversity. Phenotypic novelty within recently radiated lineages is particularly interesting because it offers insights into the early stages of speciation and the mechanisms driving reproductive isolation. Previous studies have highlighted the role of introgression in generating novel traits, especially during adaptive radiations, with Darwin's finches serving as a classical example. Hummingbirds (family Trochilidae), comprising 366 recognized species, represent the second most species-rich avian family. Within this group, the tribe Mellisugini (bee hummingbirds) exhibits the highest rate of species accumulation, reflecting a recent radiation accompanied by extensive hybridization. Whether introgression has contributed to their rapid diversification remains unclear. Phylogenetic relationships often vary across the genome due to processes such as incomplete lineage sorting and introgression. Our previous work provided a whole-genome phylogeny for 29 bee hummingbird species, yet revealed topological discordance across genomic regions that may reflect introgression. In this study, we investigate gene-tree heterogeneity in bee hummingbirds and indentify regions of genomes that may experience introgression.

Toe-tilting tricks: how guinea fowl keep medio-lateral balance on sloped terrain

Junhyuck Woo, Alyssa Desamito, Samar Rana, Monica Daley

Animal locomotion in nature is often unsteady, yet most studies have focused on steady gaits. In recent decades, researchers have examined unsteady bipedal locomotion by altering ground conditions such as height, speed, or damping, but mainly in the sagittal plane, leaving mechanisms for mediolateral balance poorly understood. Here we investigate balance control in running guinea fowl (Numida meleagris) using a controlled slope perturbation. We designed a perturbation device with a foldable 15° slope that is manually triggered during the aerial phase, limiting visual anticipation. Ground reaction forces (GRFs) and high-speed videos were collected as guinea fowl ran along a straight runway with the perturbation at the midpoint. We hypothesize that the foot plays a key role in balance control by rapidly redistributing forces between medial and lateral toes, enabling rapid adjustment in frontal plane leg posture to maintain balance. Preliminary results indicate that mediolateral balance adjustments occur rapidly following foot contact, and the GRF vector maintains a frontal angle of approximately 105° relative to the slope. Ongoing analyses involve reconstructing 3D kinematics to examine the detailed foot-terrain interaction and development of a musculoskeletal model of the foot and distal muscles. Through a combination of experimental and computational approaches, we aim to develop a deeper understanding of the foot's role in maintaining balance in unsteady locomotion.NSF DBI 2319710

The role of hydraulic pressure in spider cheliceral function

Hannah Wood, Jeffrey Shultz

Recent µCT-based surveys of spider chelicerae highlight a problematic aspect of skeletomuscular function, that is, the absence of extrinsic muscles capable of projecting the chelicerae outward or forward. Instead, all appear to generate an inward or rearward force. Previous work by comparative anatomists assigned antagonistic functions to sets of extrinsic muscles, but no anatomically distinct pivot points within a lever-based system were specified and do not appear to exist. These observations led us to revisit the problem and to propose a significant role for internal hydraulic pressure in cheliceral movement. The hydraulic hypothesis predicts that unimpeded increase in internal fluid pressure should result in inflation of basal membranes resulting in movement that could be resisted and manipulated by extrinsic cheliceral muscles. Experiments on freshly killed spiders showed that increased hydraulic pressure causes both rotational (adduction, levation, etc.) and translational (projection) movements at the cheliceral bases, movements that are synergistic with predatory strikes. This suggests that the co-option of hydraulics into cheliceral function may have increased cheliceral biting forces. Hydraulic function also allows for the basal cheliceral articulation to simultaneously produce both rotational and translational movement, a challenge for a lever-based fixed articulation. The co-option of hydraulics into additional tasks may have contributed to the evolutionary success of spiders, compared to their arachnid relatives that use hydraulics solely for locomotion.

Caudal keel morphology in three species of lamnid sharks

Jake Wood, Klaudia Jarek, Michelle Passerotti, Marianne Porter

The Lamnidae (Elasmobranchii: Lamniformes) and Scombridae (Actinopterygii: Scombriformes) are groups of fast swimming fishes that have caudal keels, which are a dorsoventrally compressed and laterally expanded area directly anterior to the caudal fin. Caudal keels are thought to increase posterior body stiffness and thrust production that results in fast swimming and may assist with energy conservation. Here, we quantified lamnid keel morphology and stiffness among three species [N = 15; Lamna nasus (porbeagle, N = 4), Carcharodon carcharias (white shark, N = 2), Isurus oxyrinchus (shortfin mako, N = 9)]. Caudal keel second moment of area (I) was calculated along two axes: laterally (IL) and dorsoventrally (IDV). When IL:IDV equals one, the caudal keel is a circle. Ratios greater than one mean the keel is laterally expanded and dorsoventrally compressed; conversely, a ratio of less than one means the keel is laterally compressed and dorsoventrally expanded. All caudal keel ratios were greater than one indicating lateral expansion and dorsoventral compression. The shortfin mako and porbeagle had caudal keels with 15% more lateral expansion compared to the white shark. Future work will use contrast enhanced micro-CT scans to quantify the soft tissue morphology within the caudal keels and vertebral morphology. This research provides a morphological framework to understand caudal keel shape and gives insight into functional specializations that may benefit sharks with active pelagic lifestyles.

From hammers to saws: morphometric analysis of skulls reveals ecological utility in sharks

Jake Wood, Phillip Sternes, Kenshu Shimada

Sharks occupy multiple ecological niches and exhibit a wide range of lifestyle strategies. In this study, we examined the morphological diversity of skulls (neurocrania) of sharks using two-dimensional (2D) geometric morphometrics on almost all the known genera of extant sharks and several extinct taxa. Our analysis includes ~ 33% of all extant shark species (N = 178) and indicates that the rostral length and cranial width are the most variable parts of the shark neurocranium, where there appears to be only one general neurocranial morphology in sharks that is characterized by a relatively slender skull with a short rostrum. Whereas this morphological condition is regarded as plesiomorphic, our study reveals that the general neurocranial morphology could be evolutionarily modified in two different ways: elongating the rostrum or broadening the cranial width. Our study also indicates that, like the overall body form morphology, neurocranial morphology in sharks is tightly connected to their lifestyle. The skulls of most examined fossil sharks are represented by the generalized neurocranial morphology, but Lamniformes exhibit the

greatest neurocranial diversity among all the shark orders examined. By integrating taxonomic order, ecomorphotypes, and body types with neurocranial morphology, our study represents the most comprehensive survey of the morphological diversity of neurocrania in sharks to date, providing new ecological and evolutionary insights.

Flapping fast: Neural, mechanical, and thermal consequences of wingbeat frequency in moths

Leo Wood, Ethan Wold, Benjamin Doshna, Simon Sponberg

Flight imposes severe neural and mechanical constraints on animals, with tight timing requirements and high power demands that intensify as wingbeat frequency increases. What adaptations do flying animals make to accommodate these constraints? In this work, we leverage the model clade of Bombycoid moths, diverse insects with a more than 7-fold variation in wingbeat frequency. From a variety of techniques from lab recordings of flight motor programs to field thermal biology, we show how these large, diverse moths use a combination of neural and mechanical adaptations to meet demands of higher-frequency flight. We show that faster moths have more temporally precise motor programs, but neural scaling alone cannot accommodate wingbeat frequency. Instead, our results indicate physiological adaptations of flight muscle are necessary. Hawkmoths in particular are known to have unusually high core body temperatures of 45°C (and higher!) which aid power production, and we connect these prior findings to the motor program and muscle physiology. Utilizing novel measurements of temperature gradients in the field, we also extend these results, demonstrating extreme body temperatures are more ubiquitous than previously thought, and connecting body temperatures to wingbeat frequency and wing kinematics. Together, these results underscore how the frequency of locomotion constrains and defines the physiology of animals must operate, from processing information to generating action.

Stretch activation combats fatigue induced force loss in type II mouse skeletal muscle fibers

Philip Woods, Mark Miller, Douglas Swank

Stretch activation (SA) is a delayed increase in force following a rapid stretch and improves muscle performance in insect flight and cardiac muscles, but previously was considered physiologically irrelevant in skeletal muscle. However, our recent work showed that higher phosphate ([Pi]) increased SA in mouse soleus fibers, suggesting SA has a role combating fatigue. Fatigue increases [Pi], lowers pH and reduces calcium concentration ([Ca2+]). To test this, we measured SA during Control, High [Ca2+] Fatigue and Low [Ca2+] Fatigue conditions in type I, IIA, IIX and IIB skinned muscle fibers from mice. In type II fibers, calcium-activated isometric force (F0) decreased from Active to High [Ca2+] Fatigue to Low [Ca2+] Fatigue, as expected. Remarkably, SA tension (FSA) increased under High and Low [Ca2+] Fatigue compared to Control conditions. This results in SA's percent contribution to total tension production (FSA/(F0+FSA)) being much greater (58-114%) under fatiguing conditions. In contrast, FSA decreased for type I fibers during fatigue. To account for the different responses to fatigue we propose two myosin-based mechanisms, the main difference being that for some myosin isoforms and conditions, stretch causes a reversal of the myosin power-stroke. Our results show SA improves force production during fatigue in type II fibers. This could play an important role in increasing muscle endurance for muscles that are lengthened prior to shortening by supplementing calcium-activated force production.

Patterns of muscle strain in the abdominal escape muscles of American lobster

Drake Woody, Yordano Jimenez

American lobsters (Homarus americanus) evade predators by rapidly flexing the abdomen to swim away from danger. After the initial power stroke, lobsters extend the tail and begin using smaller, rhythmic movements to continue swimming. This escape, known as a tail flip, is powered by relatively large flexors and small extensors located in the ventral and dorsal regions of the abdomen, respectively. To investigate the function of the abdominal muscles, we used high-speed videography, muscle stimulation, and sonomicrometry on freshly euthanized lobsters to measure patterns of muscle tissue strain along the dorsoventral axis of the abdomen. We discovered a beam-like pattern of muscle deformation, where the strain in muscle tissue varies in proportion to the distance from the neutral axis of the exoskeleton. Without the appropriate muscle gearing, this strain gradient would result in variable shortening velocities that could reduce muscle power output. Our dissection uncovered a complex network of intertwining muscles. This system was previously described in crayfish as a fully muscular pulley system used for tail flexion, but it also features highly three-dimensional angles. We hypothesize that these complex fiber angles provide the necessary gear ratios for homogenizing the shortening velocity of muscle fibers, which would ultimately enhance the power output of the lobster's escape.

Site, sex, and tissue differences in microplastic load across the range of mangrove rivulus fish

Laney Woynaroski, Brooke Fitzwater, Eoin O'Hearn, Riley Wood, Ryan Earley

Elevated microplastic concentrations in natural environments can have myriad impacts on individual, species, and even whole ecosystem health. We explored multiple aspects of microplastic accumulation in mangrove rivulus fish (Kryptolebias marmoratus) across its geographical range. These fish exist predominantly as self-fertilizing hermaphrodites but can undergo sex change to male under stressful conditions. In most populations, males are incredibly rare (< 5%). One population in Twin Cayes, Belize, however, has abundant males. Many microplastics contain endocrine disrupting compounds or cause reproductive dysfunction after consumption, potentially contributing to variation in sex ratio between populations. We collected fish, water, and sediment at 10 locations spanning Florida and Belize that vary consistently in sex ratio. Fish were dissected, and microplastic loads in liver, brain, gut, gonad, and muscle determined using digestion and density separation methods. Preliminary results indicate that microplastic loads vary significantly: (i) across sites, with loads in one Twin Cayes population being very high; and (ii) across tissues, with muscle having much higher loads than any other tissue. However, there was no evidence for an association between microplastic loads and sex ratio, or sex differences in microplastic loads. Our findings emphasize a growing need to understand the diversity of factors that influence outcomes of microplastic pollution in vulnerable populations and ecosystems, and future analyses of water and sediment will shed additional light on these factors.

Strengthening students' scientific identity through authentic research internship experiences

Kasey Wozniak, Delverne Seaman, Makenzie Reed, Sonia Martinez, Devaleena Pradhan

An authentic research experience often leads to shifts in undergraduate science identity, retention in science disciplines, pursuit of higher education, creation of opportunities for students to view themselves as scientists, and explore their fit into the scientific community. Early intervention using science engagement practices with school-aged children can positively influence STEM participation. We have successfully provided authentic research experiences to enhance access to scientific research for high school students in Southeastern Idaho communities through internships in the Integrative Physiology Lab.

Over the past two years, we have implemented four-week authentic research summer internships consisting of four junior and/or senior high school students. Internships were advertised through flyers and interns were selected through an interview of applicants who had submitted a form. Under the mentorship of a community of lab trainees, interns chose research questions, performed

experiments, created own research posters, and finally presented research at a statewide conference. Afterward interns responded to prompts reflecting on their experience.

Post-internship results show interns strengthened their decision regarding future career paths, saw themselves as scientists and part of a scientific community, and have or planned to pursue higher education.

We aim to create inclusive learning exchanges, increase accessibility and exposure to science, and provide pathways to advance the pursuit of scientific careers by empowering and training the next generation of scientists to become independent researchers and critical thinkers.

Ecomorphology of the house geckos (genus: *Hemidactylus*)

Joseph Wu, Tim Higham

Geckos are known widely because of their hierarchical adhesive apparatus that permits movement on ecologically-challenging surfaces. There is considerable diversity in the morphology of toepads and the internal elements underlying the adhesive system. Despite their ecological diversity, the body form of pad-bearing geckos has remained relatively conserved and does not vary significantly with habitat. This is in stark contrast to anoles, a pad-bearing squamate clade known for repeatedly evolving into distinct ecomorphs. Instead of varying in overall body form, it has been proposed that ecologically relevant variation may occur at the level of the adhesive system in geckos. To investigate this, we measured morphological variation across 60 species of house geckos (genus: Hemidactylus, n=376 individuals), a speciose clade known for its widely-distributed human commensals. We categorized species as arboreal, terrestrial, saxicolous, or as generalists, and performed phylogenetic comparative analyses to assess differences. We also conducted additional analyses examining differences between urban and non-urban species. We found that body size and form varied significantly with respect to ecotype such that terrestrial species are significantly smaller and stouter-limbed than scansorial species. Unexpectedly, foot and toepad morphology did not vary significantly by ecotype, but instead by degree of urbanness. Our findings support the importance of microhabitat niche in understanding ecomorphological variation.

Effects of voluntary exercise on corticosterone in high runner mice

Kylie Wu, Marcell Cadney

This study investigates how voluntary exercise influences corticosterone (CORT) levels and other physiological traits in selectively bred High Runner (HR) mice compared to non-selected control (C) lines. A cohort of 48 mice were assigned at weaning into one of four groups defined by linetype (HR or C) and activity condition (Exercise or Sedentary). At eight weeks of age, exercise treatments began and continued for seven days. Exercise and sedentary mice were maintained under similar environmental conditions. At nine weeks of age, trunk blood was collected at dissection, plasma was separated, and CORT concentrations were measured using an Arbor Assays ELISA kit. Additional data on body mass, organ weights, and running activity (for exercise mice) were recorded. We hypothesized that voluntary wheel running would increase baseline CORT levels and that HR mice would exhibit higher CORT and distinct physiological responses compared to non-selected control mice due to their genetic predisposition for elevated voluntary activity. This research provides insight into how genetic predisposition for activity interacts with voluntary exercise to shape stress physiology and health-related traits.

Traffic rules in a blind society

Qinglin Wu, Katherine Meek, Atanu Chatterjee, Saad Bhamla

Termites are blind and confined to narrow tunnels, where choke points and sudden stressors often create bottlenecks. Faced with the urgent need to pass one another, they must communicate intent rapidly and unambiguously. Chemical cues diffuse slowly and require time to interpret, whereas brief physical signals generate sharp, attention-grabbing spikes that instantly convey information about intention and location. We investigate this problem in soldiers and workers of Coptotermes gestroi confined within a closed, finite, quasi-2D arena that mimics tight subterranean tunnels. By varying group size, we tune density to elicit transient clogs and traffic jams. High-resolution tracking yields individual trajectories, velocity profiles, and time-stamped contact events. By quantifying these events, we map flow regimes across density, measure clog dwell times and jam-resolution times, and extract decision rules that govern pass-yield statistics and outcomes. Our findings reveal how fast, contact-mediated signals regulate traffic in termite societies and provide compact rules for resolving congestion in crowded, confined collectives.

From clogs to flow: microscopic rules of termite traffic

Qinglin Wu, Katherine Meek, Atanu Chatterjee, Saad Bhamla

Groups of interacting active particles or individuals can form clogs that obstruct collective goals. This challenge is particularly relevant for social insects performing tasks such as food foraging, terrain exploration, and nest building in confined environments, where minimizing clogs is critical. Termites are blind and confined to narrow tunnels (~6.2 mm), where choke points and sudden stressors often create bottlenecks. Faced with the urgent need to pass one another, they must react and adopt strategies rapidly and unambiguously. Chemical cues diffuse slowly and require time to interpret, whereas brief physical signals generate sharp, attention-grabbing spikes that instantly convey information about intention and location. We investigate this problem in soldiers and workers of Coptotermes gestroi confined within a closed, finite, quasi-2D arena that mimics tight subterranean tunnels. By varying group size and terrain parameters, we tune density to elicit transient clogs and traffic jams. High-resolution tracking yields individual trajectories, velocity profiles, and time-stamped contact events. By quantifying these microscopic events, we map flow regimes across density, measure clog dwell times and jam-resolution times, and extract microscopic decision rules that govern pass-yield statistics and outcomes. Our findings reveal how fast, contact-mediated signals regulate traffic in termite societies and provide compact rules for resolving congestion in crowded, confined collectives.

Phylum-specific morphological strategies: collaborating sponges rebuff aggressors in other phyla

Janie Wulff

Mangrove prop roots in the Caribbean tend to be densely covered with sessile invertebrates, an apparent epitome of a space-limited, competition-dominated system. Sponges are the chief space occupiers, and unbroken sponge cover prevents access to the roots by isopods that bore into them and bryozoans that cover them, both resulting in damage and death to the mangroves. Long-term observations of multi-species sponge associations on roots provided no evidence of competitive elimination, suggesting that diffuse mutualism among sponges of different species could extend the life of their prop root homes by ensuring continuous sponge cover. Experimental sponge communities were constructed among mangrove roots to evaluate resistance of multi-species sponge associations to aggressive competitors. Tracking these experiments for several years has confirmed that the sponges do not competitively eliminate each other, but instead collaborate to impede access of root-damaging species and also aggressive competitors in phyla with very different morphological and life history strategies: encrusting bryozoans, compound ascidians, and clonal sea anemones.

Genome-wide transcriptomic and methylomic patterns in response to acute thermal stress in a lizard

Kelly Wuthrich, Carrie Alfonso, Karla Alujevic, Leah Bakewell, Ian Clifton, Samantha Fontaine, Jaden Keller, Yanileth Lopez, Nathaly Ponce, Alejandro Vivas, Claire Williams, W. Owen McMillan, Michael Logan, Christian Cox

Climate change is altering the mean and variance of daily temperature, which can be particularly problematic in the tropics where organisms have adapted to historically stable temperatures. Moreover, many tropical ectotherms are thermoconformers, rarely thermoregulating during activity, and thus must use other mechanisms to tolerate changes in environmental temperature. Our previous work on a tropical thermoconforming ectotherm, the slender anole (Anolis apletophallus), revealed that this species has a circadian rhythm in heat

tolerance with peak tolerance occurring at mid-day when they are most likely to encounter hot conditions. Exposure to acute thermal stress led to a plastic increase in the amplitude of this rhythm. Here, we explored the mechanistic basis of this change in heat tolerance amplitude by measuring genome-wide gene expression and methylation patterns over 36h after exposure to the acute heat stressor. Our findings reveal potential biological pathways that may be used in coping with short-term heat stress over the time course of the transcriptomic response to heat. Our results have implications for the capacity of tropical ectotherms to cope with rapid environmental change.

Trends in trait evolution on a total-evidence phylogeny of the Heteromyidae

Megan Wyatt, Tara Smiley

The Heteromyidae (pocket mice, kangaroo rats, and their relatives) are a rodent family in North America and northern South America with an extensive fossil record spanning over 30 million years. Heteromyidae species richness peaked in the middle Miocene (~15 Ma), a period marked by global warming, grassland expansion, and rapid tectonic activity across western North America. This dynamic interval provides an opportunity to examine how environmental change influenced evolutionary trajectories in small mammals. Preliminary analyses of body size trends reveal an expansion of heteromyid size disparity during the middle Miocene. After the middle Miocene, mean body size declined, but the absolute range of body size remains relatively constant, suggesting potentially shifting trait optima within the group. To further test hypotheses about trait evolution, we first constructed a total-evidence phylogeny in MrBayes by integrating previously published molecular and character data, including ~40,000 bp of molecular data and a 119-character morphological matrix of cranial, dental, and mandibular traits from both fossil and extant Geomyoidea. The dataset spans 149 taxa, including 41 fossil species, with 65 assigned to crown Heteromyidae. We additionally use a landmark-based geometric morphometrics approach to quantify shape change and test models of phenotypic evolution. By integrating body size, skull shape, and phylogeny, we assess how paleoclimate trends, biome transitions, and tectonic events structured trait evolution in one of North America's most distinctive rodent radiations.

Resistive Force Theory modelling of locomotion at the water-air interface

Zhaochen Xu, Laura Treers, Baxi Chong, Jianfeng Lin, Kelimar Diaz, Daniel Goldman

Laboratory experiments revealed that centipede L. forficatus (L = 2.3 ± 0.3 cm) propels itself on the water surface via self-deformations consisting of direct traveling waves of body bending. Limbs were not folded to the sides but remained arrayed outward from the body. A resistive force theory (RFT) approach, in which thrust and drag forces are integrated over the body and maintained in force balance, predicted the swimming direction (relative to the body undulation wave) and speed. This was surprising as RFT is traditionally applied to low Reynolds number swimmers. To gain insight into the potentially utility of RFT for water-interface locomotion, we developed a lightweight (46 g) undulatory surface-swimmer robophysical model actuated by a single motor with a passively elastic buoyant tail, varying length from 16–56 cm. A 3D-printed linkage generated linear oscillation at the base perpendicular to the direction of locomotion, producing emergent traveling waves. We varied tail length and temporal frequency and measured locomotor performance across body-length scales. Speed increased with increasing tail length, reaching a maximum and then plateaued to 5.5 ± 1.1 cm/s. To apply RFT, we measured drag anisotropy for small plates pulled at constant speeds varying angle of attack. RFT captured swimming speed at larger tail lengths, indicating that RFT applies to fluid-surface locomotion when "coasting" [Rieser/Chong et al, 2024] via inertia is small during cycles of self-deformation.

Elastomeric Hierarchical Interfaces for Underwater Attachment: Characterization and Performance

Jonathan Yaeger, Jason Nadler, Brooke Flammang

Many organisms have developed complex strategies to achieve reliable, reversible underwater suction adhesion to wide varieties of surface contours and conditions, including those with varying stiffness, roughness, and biofilms. Some of the most compelling structures occurring with these mechanisms are hierarchical while exploiting a secondary fluid phase to enhance suction-based attachment. For example, the functional morphologies of the attachment surfaces of tree frogs, clingfish and remora all utilize specialized tissue mechanics, mucus, and structural features such as micro- and nanofibular arrays to enhance attachment shear strength. To elucidate the role of structure and effective material properties on underwater attachment performance, laser-etched hierarchical elastomeric microstructures were fabricated and their shear attachment behavior under sub-ambient pressures were investigated. In this work, a series of parametric studies of both fabrication and surface conditions were investigated for their relationship to effective stiffness and shear attachment performance. In particular, relationships between structural hierarchy, compliance and attachment fidelity are discussed.

Social transitions are accompanied by differential patterns of neuroplasticity in an orchid bee

Denise Yamhure Ramirez, Santiago Ramirez

Females of the orchid bee Euglossa dilemma are characterized as being primitively eusocial: most transition from a solitary to a social lifestyle, except those that remain in their natal nest after emergence. This transition is accompanied by pronounced differences in the behavioural ecology and sensory biology of the individual, which could correlate with structural changes in different brain regions. Using micro-CT scanning, we tested for neuroplasticity patterns across brain regions with reported functions in insects. We found that throughout their solitary to social transition female bees show expansions and reductions of select brain regions that are dependent upon either age or experience. Mushroom bodies, a high-order brain centre for sensory integration, learning, and memory, were the only regions that showed age-dependent expansion, suggesting post-eclosion developmental processes independent of cognitive processing. The antennal lobes, the primary olfactory neuropils, only exhibited experience dependent expansion, indicating sensory input is required to trigger dendritic growth. The lamina and medulla, both visual neuropils of the optic lobe, show a volumetric reduction that correlates with the loss of active foraging and the habituation to dark environments, potentially indicating an energy-saving mechanism. Future studies may investigate whether the reported structural changes correspond to differences in sensory capacities as bees undergo behavioural transitions to fully measure the implications of this study.

The influence of diet on signal reliability in a weapon-bearing insect

Janice Yan, Christina Salerno, Noraly van Meer, Christine Miller

Animal weapons can often serve as signals, allowing individuals to convey information about their size, status, condition, or aggressive intent to rivals. By signalling with their weapons, animals can resolve contests before they escalate into dangerous physical altercations. Yet, the extent to which animal signals convey reliable information has remained an open question for decades. Ongoing research on leaf-footed cactus bugs (Narnia femorata) shows that variation in diet can alter the structural integrity and strength of their enlarged, spiny hind limb weapons, without compromising their external appearance. Therefore, variation in diet quality can potentially generate unreliable signals if individuals with low-quality weapons as a consequence of poor nutrition continue to signal during aggressive interactions. To test this hypothesis, we reared male leaf-footed cactus bugs on either low- or high-quality diets and assessed their subsequent behaviour in dyadic contests. We found that compared to high-quality diet males, poor-quality diet males performed more signals relative to attacks. These results therefore suggest that individuals with low-quality weapons may attempt to bluff their way to victory by adjusting their contest behaviour to include more signals. Overall, our findings

highlight how fluctuations in nutrient availability, a phenomenon relevant to most species, can play a major role in signal honesty, fighting strategies, and contest outcomes.

A low-cost modular passive integrated transponder (PIT) tag logger for monitoring bat activity

Angel Eunisse Yanga, DeeAnn Reeder, Ashlyn Sak, Thomas Mazzarulli, Luis Víquez-R, Ken Field

Passive Integrated Transponder (PIT) tags are a frequently used tool for tracking the roosting behavior of individual bats. Commercial PIT tag logging systems are expensive, proprietary, and often need customization to accurately track bat entrances and exits. The Bucknell University BatLab has created a modular system that is flexible, field-adaptable, and cost-effective and that utilizes open-source hardware and software. Each recording system was built for ~$180 USD. Data from FDX-B PIT tags (134.2 kHz) (i.e., Biomark HPT9) were read using a flexible antenna that surrounded the bat box opening; data were fed into an RFID module that connected to a Teensy 4.1 Development Board. The addition of an RTC module and a microSD card module facilitated the storage of timestamped data. Data on detections were saved in a CSV file for further processing in R. Systems were tested during our Ebola virus-like particle (eVLP) experimental infection trials in three captive colonies of bats: Brazilian free-tailed bats (Tadarida brasiliensis, at Bucknell University), Angolan free-tailed bats (Mops condylurus, at Muni University in Arua, Uganda), and Big Brown bats (Eptesicus fuscus, at Bucknell University). Additionally, bat body (skin) temperatures were monitored with modified iButton temperature loggers adhered to bats' backs. Collectively, we were able to monitor bat thermoregulatory decisions and responses, roostmate choices, and roost entry and exit timing.

Span efficiency in animal flight.

Hiroki Yasuda, Hao Liu, Yosuke Yamamoto, Per Henningsson, Toshiyuki Nakata, Richard Bomphrey

Flying animals exhibit diverse wing shapes and kinematics that govern aerodynamic force generation. Here, we focus on one measure of performance, span efficiency (ei), which can be used to evaluate aerial locomotion in terms of induced drag, a key parameter for flight economy. Previously, it has been challenging to compare the flight efficiency of animals directly due to inconsistencies in measurement methods, although publication of suitable wake flow datasets for multiple species over the past two decades offers a resource for comparative analysis. We have systematically evaluated aspects of experimental methods and standardised ei estimates for all 30 species in the literature, comprising 22 insects, 5 birds and 3 bats. We applied phylogenetic comparative methods to investigate co-variation of ei with morphological and kinematic parameters, and contrasted empirical data with lifting-line and actuator disc theory to evaluate wake flows under steady gliding or flapping conditions. These comparisons show that, while wing planforms can have potentially high theoretical efficiencies (up to ei = 0.97 for the wings within our dataset), efficiencies measured by flow imaging while flapping are significantly lower and more variable (maximum ei = 0.73). The discrepancy suggests that high aerodynamic efficiencies - such as those achieved by propellers - are not demonstrated by extant flying animals in flapping flight, or that such a comparison is not valid.

Diel and seasonal variation in thermal tolerance of urban and rural green anoles

Shannan Yates, Joshua Beggs, Alex Gunderson

Urban centres are hotter than rural counterparts, leading to differences in thermal physiology. Habitats differ in temporal fluctuations, potentially selecting for variation in thermal plasticity, though this effect of urbanization is understudied. I tested thermal tolerance plasticity in urban and rural populations of green anole lizards in New Orleans. I focused on diel and seasonal plasticity and investigated: (a) does thermal tolerance differ between day and night, (b) does thermal tolerance differ between spring and summer, and (c) are there differences in diel and seasonal plasticity between urban and rural lizards. I predicted that (a) lizards would be more heat tolerant but less cold tolerance during the day compared to night, (b) lizards would be more cold tolerant but less heat tolerant in spring than summer and (c) urban lizards would show reduced plasticity in cold tolerance, but greater heat tolerance plasticity than rural lizards. We measured diel and seasonal heat and cold tolerances of 32 urban and rural lizards from 4 sites using dynamic assays and linear mixed models.

Lizards were more cold tolerant at night ($P < 0.01$). Urban and rural animals did not differ in diel cold tolerance plasticity. Animals were more heat tolerant during summer, with a significant seasonal × habitat interaction ($P < 0.01$); heat tolerance of rural animals changed more than urban animals. These results suggest diel plasticity is similar across habitats, but seasonal plasticity differs, potentially due to genetic factors or reduced environmental changes in urban habitats.

Costs of delayed hatching in the sand dollar Echinarachnius parma

Lydia Yeats, Jonathan Allen

Hatching plasticity, a behavior found across many phyla, occurs when environmental change alters the hatching time of an animal. In echinoderms, hatching plasticity is best known in the sand dollar, Echinarachnius parma. Sand dollar embryos typically hatch as either blastulae or gastrulae. However, when exposed to lowered salinities, E. parma embryos delay hatching and develop into pluteus larvae while remaining within the fertilization envelope, which physically inhibits postoral larval arm growth and access to food. We conducted experiments to test the costs of delayed hatching in the larval and juvenile stages of E. parma by culturing and comparing embryos that hatched at regular times with those that delayed hatching. First, we assessed competency rates in E. parma larvae by artificially inducing metamorphosis using potassium chloride (KCl) on two occasions. Additionally, to determine whether delayed hatching negatively impacts traits associated with predator avoidance and defense, we recorded juvenile size, spine number, and spine length for competent larvae that completed metamorphosis. Across two biological replicates, larvae became competent at approximately the same rate regardless of the treatment. Interestingly, we found mixed results regarding the impact of delayed hatching on juvenile quality. In the first trial, juvenile metrics did not differ between treatments. In the second trial, however, embryos that delayed hatching settled as smaller juveniles, with shorter and fewer spines than those that hatched at normal times.

Environmental drivers shape hydromedusae reproductive strategies in a productive coastal ecosystem

Farzana Yesmin, Robert Cowen, Su Sponaugle, Kelly Sutherland

Hydrozoans have complex life cycles that alternate between an asexual benthic polyp stage and a sexual pelagic medusa stage. The medusa form is widely distributed in marine ecosystems and is an important component of pelagic food webs. Reproductive strategies, such as size at maturity, and reproductive output, are critical in regulating hydromedusae population dynamics and are strongly influenced by environmental factors, particularly temperature and food availability. Despite their ecological importance, knowledge of hydromedusae reproductive strategies under varying environmental conditions remains limited. We collected hydromedusae Clytia gregaria and Eutonina indicans from the Northern California Current (NCC) during four cruises between 2022 and 2023. These cruises were strategically timed to capture seasonal variation, sampling during periods of low (winter) and high (summer) primary productivity and sea-surface temperature. Specimens were identified onboard and photographed with a DSLR camera, and morphological data, such as bell diameter and gonad area were extracted using ImageJ. To assess the effects of temperature and food availability more directly, we complemented these field observations with controlled laboratory experiments on live C. gregaria using a full factorial design with three temperature levels and two food concentrations. By integrating field observations with laboratory experiments, this study will provide deeper insight into how temperature and food availability shape hydromedusae reproductive strategies and population dynamics in the NCC, a productive eastern boundary current.

Heritable variation in morphology between lake populations of threespine stickleback fish

Alex Yeung, Daniel Bolnick

Understanding the extent of morphological variation among populations and whether these differences arise from environmental factors or are inherited is a key question in evolutionary biology. Threespine sticklebacks (Gasterosteus aculeatus) have emerged as a premier model for the study of evolutionary ecology and heritability. Previous studies used small sets of populations to discuss how morphological differences are seen between drastically different ecosystems. However, these studies lack broad geographic sampling and do not separate genetic inheritance from environmental influences. By creating a large-scale common garden experiment, heritability of different populations is gained. The question asked is to what extent are different morphological features present in different populations and are these differences due to their environment or genetics? We hypothesize that morphological variations occur in different lake populations in lab raised fish. Fish were sampled from 27 lakes in Vancouver Island; gametes were dissected, crossed, and brought into the lab. After a year, specimens were photographed and dissected for gill rakers and other morphological features. ImageJ is used to measure morphological features such as standard length, gill raker length, and others. All measured traits differed between populations, proving our hypothesis. During this academic year, measurements through ImageJ continue to be collected. Future work should compare the morphology between wild-caught fish and lab-raised fish.

Feeding performance across functional niche space in the ocellated clownfish

Sofia Yildirim, Robert Holmes, Katherine Corn

Functional diversity due to morphological differences in jaw structures can lend deeper insight into the patterns and processes of ecological diversification. To understand the full picture of a functional niche a clear understanding of the feeding performance of an organism is essential. This study examines how feeding performance changes across an array of prey types for the damselfish species, Amphiprion ocellaris. Five unique 3D printed prey types were modeled with varying complexity, and covered with a food paste. The weight of a structure was taken before and after a 20-minute feeding trial to measure the amount of food consumed by each fish, with replicates. The related starry blenny (Salarias ramosus) was also tested as an additional control. An ANOVA and LMM revealed significant differences in performance of prey removal among structures. Our results suggest that A. ocellaris is best suited for feeding on complex prey, where high levels of body mobility allow them to feed in nooks and crannies, but struggle with prey capture from crevices. While feeding best on highly complex coral-like structures, A. ocellaris can feed off of other structures but consistently less successfully. This provides some of the first evidence that variance in functional properties of prey, which range among damselfishes from algae to plankton, affects the total capacity of a substrate biting damselfish to utilize a given resource on the reef.

Effects of coral restoration on fish abundance and diversity at Isabela Island, Galapagos Islands

Hailey Yoder, Daniel Velasco, Elizabeth Kroger, Nicolás Dávalos, Margarita Brandt

Coral bleaching and other events have continually diminished the health of coral reefs around the world's oceans. How these reefs benefit from restoration techniques is an important area of study to determine if coral health can be restored. This study assesses the impact of coral restoration on fish abundance and diversity by comparing fish community structure before and after restoration at Isabela Island with videos recorded with GoPro cameras. Preliminary analyses reveal a substantial increase in both total fish abundance and species richness following restoration. Prior to restoration, fish assemblages were sparse and dominated by a few species. After restoration, a significant rise in the abundance of several species was observed. Additionally, some species were recorded exclusively for post-restoration. These results suggest that coral restoration promotes the recovery of fish communities by enhancing structural complexity and ecological resilience. The observed changes underline the importance of coral restoration as a tool for restoring reef- associated biodiversity and highlight its potential to accelerate the return of ecologically valuable fish species.

Effects of mechanical loading on *Peromyscus* bone mechanoresponsiveness

Lindsey Young, Sandra Shefelbine

Stereotypic, repeated locomotor behavior such as burrowing can lead to a mechanoadaptive response in bone. We investigate whether burrowing species have bones that adapt more to mechanical loading than non-burrowing species. Here we compare the effects of mechanical loading on the tibia of two Peromyscus (deer mouse) species. Peromyscus polionotus creates complex burrows, while Peromyscus eremicus is a non-burrowing nesting mouse. By inducing an equivalent mechanoadaptive strain with a uniaxial tibial compression model, the mechanoresponsiveness of the two species can be compared.

Finite element models of representative laboratory-reared Peromyscus were used to determine in vivo loading profiles to design equivalent mechanoadaptive tibial strain profiles between species. The knee and ankle of burrowing and non-burrowing mice were placed in loading cups, and 100 cycles of 1 Hz compressive loads were applied to the tibia. Tibias were scanned using micro-computed tomography, and cortical bone structural properties were quantified and normalized for bone length.

Loaded P. polionotus tibias had a greater increase in cross-sectional area and normalized maximum and minimum second moment of area relative to the unloaded contralateral limb compared to P. eremicus. Results indicate that burrowing P. polionotus may adapt more to mechanical loading than non-burrowing P. eremicus. Greater mechanoresponsiveness may indicate an evolutionary adaptation for burrowing specimens to be more mechanically sensitive.

To flee or not to flee: The developmental response of Odonates to novel conditions at high elevation

Martha Young, Michael Moore

In response to warming temperatures, many animal populations are migrating to higher elevations. Current distribution data, however, suggests that upslope dispersal is not occurring fast enough to keep pace with increasing temperatures. One possible explanation for this mismatch is that species lack the phenotypic plasticity to develop traits needed to overcome high elevations' unusual physiological conditions, such as extreme temperature variability, low oxygen availability, and intense UV radiation. Here, we tested this idea by reciprocally transplanting dragonfly and damselfly larvae to low and high elevations in Colorado, USA and allowing them to develop to adulthood. Initial results indicate that low-elevation dragonfly species had slightly better hypoxia tolerance and cold tolerance when they developed at high elevations than when they developed at low elevations, but their tolerances were always much worse than high-elevation dragonfly species. By contrast, damselflies, which have a lower energetic demands than dragonflies, appear to be similarly tolerant to hypoxia and cold regardless of species or elevation of development. These results suggest that low-elevation dragonfly species may have an adaptive developmental plasticity response to these conditions, but it is likely insufficient to match the performance of species that are already adapted to those conditions. Insufficient plasticity may therefore offer one explanation for slower-than-expected upslope migration for some taxa, but this trend may vary even among closely related groups.

High-throughput machine learning resolves scaling kinematics of ultrafast snapping shrimp strikes

Melody Young, Shengwei Lei, Tarik Burlingham, Jackson Savage, Ben Schelling, Sophie Hanson, Christopher Ouifiero, Sarah Longo, Sheila Patek

Latch-mediated spring actuation (LaMSA) systems produce among the fastest movements in biology, yet resolving how their kinematics scale with body size has long been constrained by high-speed imaging challenges. Filming

at >10^5Hz yields sparse datasets, and manual digitization with inter-individual labeling errors propagates uncertainty, limiting biological inference. Here, we apply high-throughput machine-learning pose-estimation models, validated against manually-labeled strikes, to objectively track dactyl displacement in Alpheus heterochaelis snapping shrimp spanning a thermal gradient (12–33°C) and broad body mass range (0.15–1.3g) across 418 strikes from 54 individuals. Angular performance (peak angular velocity and acceleration) decreased as dactyl and claw length increased. Yet linear metrics revealed striking compensation – larger claws achieved comparable linear velocities (20–45ms-1) and accelerations (10^5–10^6ms-^{2}), consistently exceeding cavitation thresholds. Peak linear performance occurred at similar rotational angles across size, underscoring geometric regularity. Across the full thermal range, both angular and linear performance showed negligible variation, reinforcing the thermal resilience of the strike phase. These findings reveal how scaling in LaMSA systems is buffered: although larger structures rotate more slowly, their increased radius preserves linear performance and cavitation reliability. This raises new questions about the dynamics of spring unloading, energy transfer between propodus and dactyl, and how temperature may influence scaling. By pairing methodological advances with broad sampling, this work establishes a foundation for exploring cascading thermal effects in spring-powered systems.

Grasshopper diversity and phenology across elevations in the Cascade-Siskiyou National Monument

Jacob Youngblood, Joe Baures, Andrew Breeden, Jacob Florey, Avery Hernandez, Trevor Holt, Tayla Moore, Liora Solomon

Insect populations are declining globally, yet we lack basic knowledge of when and where many species occur. This gap is especially pronounced in mountains, where small changes in elevation yield large changes in the environment and associated communities. Understanding how montane insects respond to environmental change requires baseline surveys of diversity and phenology, yet such data are scarce for many groups, including grasshoppers. Here, we surveyed grasshopper communities along a 1300-meter elevation gradient in the Cascade-Siskiyou National Monument. From 2023–2025, we conducted repeated surveys at five sites between 700-2000 meters elevation, identifying 20 species and recording their relative abundances. We used generalized additive models to estimate changes in diversity and species phenology across space and time. Grasshopper diversity peaked at mid-elevation, where richness and Shannon's diversity were highest. NMDS ordination (stress = 0.13) showed distinct clustering of sites, indicating consistent differences in community composition. Phenology was more variable; across species and sites, adult activity typically began in early July and lasted about two months, but elevational trends in timing were weak and inconsistent. These findings demonstrate how environmental gradients shape montane insect communities and provide one of the first multi-year baselines of grasshopper diversity and phenology in this region. By filling a key spatial and taxonomic gap, this work creates a foundation for future monitoring and detection of climate change impacts.

Quantitative analysis of multivariate diet clarifies ecological diversity of mammalian herbivores

Julia Youssef, Selena Martinez, Anna Wisniewski, Jonathan Nations, Graham Slater

Herbivory in mammals encompasses a diverse range of non-animal-based diets, from small seed-eating mice to seagrass-feeding manatees. The diversity and abundance of mammalian herbivores demonstrate the importance of plant resources and the ecological opportunities they provide. Yet, quantifying herbivorous diets is limited by the disparate ways and resolutions in which they are described, complicating attempts to test large-scale hypotheses about the evolution of herbivory. Here, we expand upon a previously described approach for quantifying multivariate diet to determine whether ranked importance of plant food items yields novel insights into herbivore diet composition and whether these can be predicted from molar morphology.

Using primary literature-based rankings and standardized keywords, preliminary PCA and clustering analyses recover evidence of classical "grazer" and "browser"–based divisions, alongside consistent specialist guilds such as "frugivores." This scheme also reveals dietary subniches within the grazer/browser umbrellas by quantifying secondary and incidental dietary items, offering greater ecological resolution than categorical labels based on primary diet alone. We show how the incorporation of 3D scans of lower molars of extant herbivores can be used to develop Bayesian predictive frameworks, enabling probabilistic inference of diet in extinct herbivorous mammals from fossil molar morphology.

Cross-correlations link sea star tube feet's contact events to body motion

Zitao Yu, Matthew McHenry, William Bialek, Eva Kanso

Sea stars form low-speed crawling gait and high-speed bouncing gait by the coordination between hundreds of tube feet without the modulation of central brain. Although biomechanical models havened predict that local sensory-feedback control strategies are enough for synchronization of tube feet and collective transportation, the causal relationship between feet gait and locomotion of seastar body remains elusive. Here, we recorded the location, speed of seastar (Protoreaster nodosus) body and their feet activity simultaneously. The high-throughput data containing all the "spike" event where tube feet touches floor enables us to study the correlation between individual feet contact and body locomotion. We then compute event-triggered cross-correlations between body motion and contact events, enabling unbiased measurement of lead–lag structure across locomotor conditions. The analysis reveals a robust, general time-lag pattern: the attachment rate peaks prior to positive acceleration, the detachment rate peaks near zero lag at maximal speed, and the contact count is anti-phased with velocity—minimal at or just before the velocity peak and recovering during deceleration as attachment rate rises. Moreover, when we compare these empirical correlation signatures to predictions from existing decentralized models that reproduce crawling and bouncing, the models fail to recover the observed lead–lag structure. Our results identify gait-specific temporal coordination rules between local contacts and global motion, motivating new mechanistic assumptions for decentralized control in echinoderms and other decentralized systems.

Surprising bite force variation among non-venomous snakes

Koun Yun, David Penning, Kyle Dixson, Johnathan Evenson, Gavin Payne, Madison Kalter, Julia Molnar

Striking, constriction, and swallowing have been studied extensively in snakes, but bite force has only been reported in one species, Lampropeltis getula. However, biting likely plays an important role in the feeding of most non-venomous snakes, which use their jaws to grasp prey before prey handling and ingestion. In this study, we present the largest collection and comparison on snake bite force to date with measurements from four snake species (Pantherophis guttatus, Lampropeltis abnorma, L. getula, and Drymarchon melanurus). Our findings reveal statistically significant differences in bite force between species, after accounting for head size. The snakes fell into two distinct groups: "hard biters" (L. getula and D. melanurus) with bite forces ranging from 1.6-5.2 Newtons, and "soft biters" (P. guttatus and L. abnorma) with bite forces ranging from 0.4-0.8 Newtons. Even the "hard biting" snakes still produced much lower bite forces than lizards of similar size. The differences between snake species likely reflect adaptations for different feeding strategies and mating behaviors. Kingsnakes (L. getula) rely on biting during mating, and indigo snakes (D. melanurus) are known to strike their prey against objects and significantly lacerate their prey to subdue it. We did not observe any skeletal differences that could explain these results, suggesting that differences in musculature, or behavior, may form the basis for variation in bite force among snake species.

Environmental impact on forelimb trabecular bone architecture of the common raccoon (Procyon lotor)

Hartrich Zack, Tristan Reinecke, Stephanie Smith, Zewdi Tsegai, Kenneth Angielczyk

Spongy trabecular bone is found within most vertebrate joints and throughout some skeletal elements. As it remodels based on the mechanical loading experienced throughout an animal's lifetime, it can hold a signal of locomotor

behavior and ecology. The relationship between trabecular bone architecture (TBA) and force regimes is relatively well established, so intraspecific variation in force regimes could lead to variation in TBA among populations. The common raccoon (Procyon lotor) is a medium-sized, generalist carnivoran found throughout North America in forests, deserts, mountains, prairies, and coastal regions. Because raccoons occupy such a large range and behave so plastically, their home range size, behavior, and habitat use vary substantially among populations and across regions. When combined with their availability in museum collections, raccoons are ideal for examining intraspecific variation in TBA. We compare TBA of the humerus, radius, and ulna of raccoons from five North American ecoregions. The forelimb is variably loaded across the spectrum of raccoon behavior, making it suitable for examining variation in TBA. Preliminary results do not show differences between the mean TBA metrics between ecoregions, but the ranges of all TBA metrics are smaller for ecoregions in the northwestern US than ecoregions in the southeast. Further examination will allow us to quantify intraspecific variation and analyze how different aspects of TBA are impacted by environment.

Anti-predator behavior of captive finches in response to a model house cat

Dorothy Zahor, Jamie Cornelius

Free-ranging house cats (Felis catus) are abundant in urban spaces and pose a considerable threat to wildlife populations. Potential prey, such as songbirds, often engage in anti-predator behaviors (e.g. increased vigilance) which reduce the risk of immediate mortality but may increase negative fitness consequences (i.e. reduced body condition, reproductive failure). However, the degree to which some avian species may respond, especially to unfamiliar predators, remains unclear. In this study, we asked how species that differ in urban habitat preference and foraging height may vary in their response to house cat exposure during a captive experiment. We exposed wild-caught house finches (Carpodacus mexicanus; low foraging, urban), pine siskins (Spinus pinus; moderate in foraging height and urban preference), and red crossbills (Loxia curvirostra; high foraging, rural) to model cats, model rabbits, and controls (no model present) and took body condition scores (fat and muscle). We found that house finches were the slowest to approach and ate the least amount of seeds in the presence of the cat model. This may reflect their familiarity with cats that could contribute to their success in urban environments. Here we discuss these species-specific results in addition to body condition (fat and muscle stores) in relation to risky-foraging behavior.

Comparing 3D models created using photogrammetry vs. CT-scanning via Orientation Patch Count (OPCr)

Zariel Zamudio, Priyank Kapur, Megan Vandenberg, Brenlee Shipps

Orientation Patch Count (OPC) is used to quantify the complexity of a 3D surface. Previous studies using OPC have correlated high feeding surface complexity with herbivory in a variety of amniotes. To employ OPC, specimens are digitized into 3D models. One common method of digitization is computed tomography (CT) scanning, which produces high-quality renderings of both internal and external anatomy. However, despite its popularity, CT scanning is still relatively costly and inaccessible for many researchers. In cases where only the external anatomy is of interest, researchers may opt for the comparatively cheaper method of photogrammetry. Though both methods produce high resolution 3D models, there is little research analyzing how models made using these techniques vary in terms of surface complexity. This study addresses this gap in knowledge by exploring variation between OPC values of 3D models depending on the digitization technique used. Nineteen turtle skulls previously digitized using photogrammetry were CT-scanned to create a parallel set of 3D models. The skulls ranged in size from a 1.5 cm Terrapene carolina to 11 cm Macrochelys temminckii. Differences in OPC between parallel models depend on several factors, including color, reflectiveness, and width of the specimens. Photogrammetric models exaggerated morphology in very white specimens and those under 2.5 cm. We found no significant difference on average, suggesting datasets could be combined provided specimens are selected carefully.

Character displacement in Spiny-tailed Iguana (Ctenosaura) head coloration

Peter Zani

Reproductive character displacement can be symmetrical or asymmetrical, meaning displacement can occur in one or both lineages, and has been suggested to lead to differences in sympatric species and enhanced prezygotic isolation. Yet among reptiles, there are few examples of reproductive character displacement in nature. Herein, I leveraged community-science observations from iNaturalist.org of two species of Spiny-tailed Iguanas (Ctenosaura pectinata, C. similis) from Central America that have overlapping ranges in southern Mexico (Oaxaca and Chiapas) to show that head coloration changes when these species are in contact compared to when they are not. Specifically, more area of the heads of C. similis are light colored compared to C. pectinata when they occur in sympatry. Contact-zone changes in absolute color and color contrast of the head do not rise to the level of significance despite between-species differences in head coloration. These results suggest Ctenosaura head coloration is experiencing ongoing reinforcement of speciation by asymmetric reproductive character displacement when these species occur in sympatry.

Increasing tendon fatigue resistance with genipin

Arjun Zaveri, Miles Valencia, Manny Azizi

The accumulation of microdamage from mechanical fatigue increases the risk of tendon rupture and the development of tendinopathy. Age- and disease-related increases in collagen cross-linking are known to alter tendon mechanical properties, but these changes are often accompanied by other phenotypic shifts, making it difficult to isolate the specific effects of cross-linking. In this study, we used genipin - a naturally derived, biocompatible cross-linking agent - to investigate the direct impact of cross-linking on tendon fatigue resistance. Isolated rat tail tendon fascicles were treated with genipin and subjected to one of two stress relaxation protocols: static loading at 4% strain for 5 minutes or cyclic loading at 4% strain for 5 minutes at 1 Hz. Following either a 2-minute or 30-minute rest period, fascicles underwent ramp-to-failure testing to assess ultimate failure stress. Preliminary results suggest that genipin treatment enhances both the mechanical strength and fatigue resistance of tendon fascicles. Treated samples showed reduced force loss during stress relaxation and exhibited higher failure stress and toughness after loading, regardless of rest duration. Notably, static loading resulted in greater force loss than cyclic loading but produced higher toughness. These findings suggest that genipin-induced cross-linking promotes more elastic behavior and improves fatigue resistance in tendons. Supported by NSF DBI 2319710.

Emergence of personality during the post-fledging period in red-winged blackbirds

Angela Zbaracki, Shelby Lawson, David Kikuchi

Behavioral responses are critical for animals to adapt to changing environments, affecting survival, social interactions, and resource acquisition. In birds, the post-fledging period is a vital stage for developing exploratory behavior, aggression, and responses to novelty that are key to dispersal, territory establishment, and predator avoidance. Using a suite of behavioral assays (neophobia, open arena, novel object recognition, and mirror tests), we examined whether fledgling red-winged blackbirds (Agelaius phoeniceus) show consistent individual differences across contexts and time. Physical interactions with objects were scored by hand, while DeepLabCut, a deep learning tool for automated pose estimation, was used to quantify continuous measures of movement and space use, providing finer resolution into how behavioral syndromes develop during this critical life stage. We found that fledglings became more exploratory and aggressive as they aged, aligning with the increasing demands of independence in the wild. We also found that birds differed in some traits based on sex, and that siblings often displayed similar behavioral syndromes to each other than compared to unrelated birds. Together, these findings suggest that fledgling red-winged blackbirds develop behavioral strategies shaped by both intrinsic and social factors, highlighting the ecological importance of early personality variation during the transition to independence.

Ultra-fast flipping of ballistic tongues in salamanders: from biomechanics to evolution

Yu Zeng, Stephen Deban

The lungless salamanders (Plethodontidae) repeatedly evolved ballistic tongues that can be projected at 2 – 4 m/s and reach prey within 10 milliseconds. However, how they reorient a dorsally oriented tongue pad remains unclear. Here, we examine the mechanism of tongue flipping by integrating high-speed videography, biomechanical models, and evolutionary patterns. In ballistic tongues, we found two major mechanisms for powering rapid rotations of a distally located tongue pad without direct muscle attachment. In some species, the linear impulse from ballistic projection is transferred to a tapered tongue pad as a traveling wave, thus flipping via a whip-like unrolling. In other species, a mushroom-shaped tongue pad is first accelerated by the ballistic impulse, and subsequently rotated by the deceleration force from the tongue retractor system. Both single- and dual-impulse flipping mechanisms achieve a high angular speed, ranging 50000 – 270000 deg/s (870 – 4700 round/s), which are among the fastest rotations observed in animals. Comparing the rapid tongue flipping mechanisms with the evolutionary precursors with protrusive tongues, we further reveal that these highly specialized flipping mechanisms are derived from a pulley-like actuation. The remote actuation of tongue pads, with a variety of musculoskeletal reconfigurations, is evolutionarily coupled with the emergence of ballistic projection yet subject to different biomechanical constraints. Our research demonstrates extraordinary rotational power amplification achieved with unremarkable vertebrate tissues.

Gliding insects and the transitional origins of flapping flight

Yu Zeng, Robert Dudley

The evolutionary transition from wingless to winged insects remains unresolved due to the absence of intermediate forms in the fossil record. A critical gap lies in understanding how partially winged stages (i.e., as in protopterygotes) could aerodynamically utilize wing motions. Here, we examine the gliding origins of insect flight by describing functionality of low-amplitude flapping and a subsequent gain of powered flight. First, we demonstrate a gliding-to-flight spectrum in extant stick insects (Phasmatodea), such that flight capability (from parachuting to powered flight), wing size (from wingless to fully winged), and wing aerodynamic performance (from passive drag generation to propulsive flapping) are coevolved features that can result in fully powered flight. Second, we use aerodynamic models of gliding for protopterygote morphologies to show how stability constraints limit the size and longitudinal location of static winglets, thereby favoring retention of wing pairs on the meso- and meta-thoracic segments. Finally, we show that gliding stick insects can engage in transient flapping during descent at high advance ratio, illustrating the kinematic and aerodynamic transition between static wings and propulsive flapping. In aggregate, these results suggest that a protopterygote body plan under aerodynamic constraint can undergo a functional and morphological transition from a serial-winged to a dual-wing pair, and that further selection for vertical force production can promote stepwise acquisition of powered flapping through wing/free-stream flow interactions during controlled gliding.

Evaluating the role of downsampling in quantitative morphological analysis using Malaclemys terrapin

Jenny Zhan, Alexandria Lardent, Brenlee Shipps

Over the past quarter-century, the use of CT scans for quantitative morphological analysis has become ubiquitous among biologists. CT scans typically produce high resolution 3D models that are too computationally intensive for most devices to analyze, thus most 3D models produced by CT scans are downsampled for analysis. An important assumption behind using downsampled data is that downsampling impacts all specimens more or less equally, assuming other variables have been controlled for. In this study, we tested this assumption by analyzing the occlusal surface complexity of 21 female and 13 male Malaclemys terrapin skulls using orientation patch count rotated (OPCR). All of these specimens were scanned at the same facility using the same scanning parameters, and all were downsampled to the same resolution using Quadric Edge Collapse Decimation (QECD) at target resolutions of 5,000, 10,000, and 15,000 faces. At 5,000 faces, no significant difference in OPCR was found between male and female specimens. However, higher resolution models yielded significantly lower occlusal complexity for female specimens than males. The occlusal surface complexity of male specimens did not vary significantly with resolution. This suggests that not only can downsampling impact some models more than others, but that higher resolution does not inherently result in increased surface complexity.

Testing the island rule using an introduced population of muskrats in the Gulf of Maine

Ariel Zhang, Max Zeltsar, Alexis Mychajliw

Biogeographic theory predicts that small mammals respond to the evolutionary pressures of island life by growing larger ("gigantism"). This pattern is typically studied on macroevolutionary timescales but has also been described for rodent populations evolving over centuries. We test the expectations of the island rule using an insular population of muskrats (Ondatra zibethicus) that was historically introduced in the early 20th century to the Isles of Shoals archipelago in the Gulf of Maine. Previous research suggests that these muskrats may display differences in diet, predation, and habitat use as compared with their mainland counterparts. We predict that the Shoals muskrats are larger in body size and may also show changes in cranial and limb features in response to shifts in herbivory and digging behaviors. We collected skeletal elements from >100 unique individuals, including 47 skulls and 92 specimens with at least one limb bone. We took 23 cranial measurements (e.g., lower molar length) and 20 additional osteological measurements on postcrania (e.g., humerus length), as well as estimated overall body mass using the skeletal measurements of 10 salvaged whole muskrats. We compare the skeletal and body mass measurements of our insular muskrats with those from mainland North American populations using natural history collections and interpret our findings within the specific ecological context of the Isles of Shoals.

Mudskipper-Inspired bi-locomotion vehicle for efficient dual-mode propulsion

Kenny Zhang, Ian Bergerson, Daehyun Choi, Kai Lauren Yung, Saad Bhamla

Current aquatic vehicles, such as submarines, torpedoes, and boats, are limited to a single mode of locomotion, which restricts their adaptability across environments. Our study aims to design and test a bi-locomotion underwater vehicle inspired by the mudskipper, capable of both underwater propulsion and surface 'skipping' locomotion. The prototype features a 65 mm finspan, 80 mm body length, and 24 mm depth, powered by a 5 × 10 mm motor driven at 15 V in 200 ms on/50 ms off cycles. Hydrodynamic scaling indicates a Reynolds number of ~20,000 in water and ~2,000 in air, with a Weber number of ~286, validating the dominance of inertial forces over viscous and surface tension effects in the tested regime. A custom 3D-printed housing (PLA, resin) emphasizes waterproofing, weight distribution, and structural stability, while a launch system and pool test setup enable trajectory and efficiency analysis. Results show that increased fin surface area and optimized fin placement enhance stability, while hybrid locomotion achieves lower energy consumption compared to underwater propulsion alone. These findings highlight the potential of biomimetic, dual-mode vehicles to outperform traditional aquatic platforms in adaptability, energy efficiency, and stability, offering applications in environmental monitoring, search and rescue, and future aquatic robotics.

Escaping with a click: the multifunctional survival mechanism of click beetles

Liyuan Zhang, Teagan Mathur, Aimy Wissa, Justin Yim, Marianne Alleyne

Click beetles (Coleoptera: Elateridae) are remarkable for their ability to jump without using their legs. This ability is enabled by a specialized hinge structure between the prothorax and mesothorax. This mechanism is a form of latch-mediated spring actuation (LaMSA), which produces high power output through the rapid release of stored elastic energy. Despite extensive study, it remains unclear why this mechanism evolved exclusively within Elateridae

and how it contributes to their survival. Previous work from our group demonstrated that clicking can cause beetles to wiggle and slide free from constraints, suggesting that it functions as an effective escape strategy when, for example, a beetle is restrained by a predator or trapped under debris.

To investigate the broader potential and limitations of this mechanism, we employed high-speed videography, force sensing, and sound recognition to examine click responses under confinement. Our results show that when the reaction force generated by a click exceeds static friction, sliding occurs, which may lead to a successful escape. These findings indicate that the clicking mechanism is not limited to short-distance locomotion or self-righting but also provides a versatile strategy for escape. In this way, clicking emerges as a multifunctional mechanism that plays a crucial role in the survival of click beetles.

Evaluating the role of multi-articular tendons in overall tail stiffness

Margaret Zhang, Charlotte Andreasen, Juri Miyamae, William Olenich, Amelia Wu, Talia Moore

Musculoskeletal models, like those developed in OpenSim, are composed of muscle–tendon units that combine established muscle mechanics with the elastic properties of tendons. Most modeled systems are muscle-dominated, so small inaccuracies in tendon properties exert minimal influence on model predictions. In contrast, mammalian tails are actuated by extrinsic muscles connected to long tendons that span multiple joints. For tendon-dominated systems, precisely characterizing tendon properties is critical for accurate biomechanical modeling.

We experimentally tested individual jerboa (Jaculus jaculus) tail tendons to determine variation in material properties. Tendons were dissected, grouped by insertion site, and tested within 24 hours. Each underwent cyclic loading in a dynamic mechanical analyzer at 5 Hz with a logarithmic strain sweep until failure. Storage and loss moduli were calculated to evaluate elastic energy storage and dissipation.

All tendons had low loss to storage modulus ratios, indicating a predominantly elastic and mechanically similar behavior. Despite tendon similarity, differences in number of joints spanned suggest that together, tendons confer localized differences in tail stiffness. We therefore developed complementary testing of individual tail joint stiffness. To isolate tendon contributions to local tail stiffness, intact tails were compared with experimental manipulations in which tendons were severed proximally.

Future work will use the tail musculoskeletal anatomy, individual tendon mechanics, and overall tail stiffness data to validate predictions as we construct a jerboa OpenSim tail model.

Beyond fish in formations: a two-tier approach to studying kinematic modulation in schooling fish

Yangfan Zhang, Divya Ramesh, George Lauder

Despite much of the literature perceiving fish schooling as an organized system and focusing on specific formations for theoretical analyses, experimental observations demonstrate that fish frequently rearrange their positions. However, previous studies demonstrated that fish schools result in energetic savings relative to individuals swimming alone. This introduces an intriguing dichotomy. How can individual fish within schools exhibit dynamic interactions while at the same time saving energy? We hypothesize that dynamic individual interactions are the result of positional and kinematic modulation of individuals in response to fluid dynamic stimuli from the movement of neighbouring individuals. We propose a new two-tier approach to studying kinematic modulation within fish schools. First, quantifying the overall variation of individual movement in a school relative to that of a solitary individual using an artificial-intelligence-based computer vision analytical pipeline. Second, using a small enclosure to control the positions of fish, coupled with a robotic flapping mechanism to dissect kinematic modulation in response to changing hydrodynamic stimuli. We discovered that individual fish in schools have higher levels of positional and kinematic modulation than solitary individuals. Live fish in enclosures can robustly respond to fluid stimuli from either a simple robotic fish or other live fish located in proximity. These two-tier approaches allow high-resolution analysis of positional and kinematic modulation within fish schools and their impacts on the energy conservation resulting from collective movement.

Stuck as a juvenile: the dual role of a leg-gap gene in regulating beetle metamorphosis

Yuke Zhang, Yuichiro Suzuki

The regulation of developmental timing has important implications for both the survival and reproductive fitness of individuals and their ecological interactions with other organisms. Metamorphosis, characterized by a dramatic transformation from a larva to an adult, results from a complex interaction between various genes and hormones, with juvenile hormone (JH) as an established key regulator. Previous research has suggested the appendage-patterning gene, Distal-less (Dll), to be an influencing factor in this process, where the knockdown of its expression in the red flour beetle, Tribolium castaneum, resulted in appendage malformities and supernumerary molts. Here, we continued the examination of Dll in a separate beetle species, the yellow mealworm Tenebrio molitor, to better understand the process by which the leg development gene could regulate metamorphic timing. Dll knockdown in T. molitor resulted in supernumerary molts of the larva. However, the molts were not accompanied by any observable appendage abnormalities, which were previously present in T. castaneum. The results indicate a potential neuroendocrine role of Dll beyond appendage patterning, which is indeed supported by our tissue-specific qPCR results. In addition, RNA-seq of T. castaneum head shows farnesol dehydrogenase and CYP15A1 as potential targets of Dll. These findings suggest that, like Dlx genes in mammals, which have both limb patterning and neuronal functions, Dll in insects may also have a dual role in development processes.

The scaling of mammalian claws for vertical ascent

Arthur Zhao, Cassie Shriver, Young-Hui Chang, David Hu

Climbing is a demanding form of locomotion that requires an animal to ascend vertical surfaces, with clawed animals relying on surface asperities for necessary grip. Heavier climbers face scaling constraints because their mass scales with the cube of body length, whereas appendage surface area scales with the square of length. We hypothesize that larger climbers compensate for these scaling limitations through morphological adaptations in claw shape, exhibiting bigger claws relative to isometric growth. We calculated contact loading, the stress on the climbing appendage by collecting claws from animal carcasses provided by Zoo Atlanta and gathering appendage sizes from literature. Our findings confirm that the contact area used to climb in larger animals scales faster than expected under isometry, but this increase is insufficient to offset the rising shear stress with body mass. Consequently, larger climbers experience a lower safety factor, and may help explain why there are fewer large climbers compared to those on the scale of insects and lizards.

Short-term social isolation acts on hypothalamic neurons to promote social behavior in female mice

Xin Zhao

Humans and other social animals are strongly motivated to seek social connections. Short-term isolation is potent driver of social behaviors, but how short-term social isolation alters the brain to promote social behavior remains poorly understood. To address this gap, we first found that three days of isolation has pronounced effects on female B6 mice: single-housed females spend more time investigating same-sex partners, begin mounting, and produce higher rates of social ultrasonic vocalizations (USVs) than group-housed females. To identify neural circuits underlying these changes, we compared Fos expression after social interactions in group- and single-housed females. We found a subset of preoptic hypothalamic neurons (POAsocial neurons) with increased Fos activity in single-housed females, correlating with social investigation and mounting. Using TRAP2-based activity-dependent labeling, we tested their function. Chemogenetic silencing and caspase-mediated ablation of POAsocial neurons reduced mounting in single-housed females, though effects on investigation and USVs varied. Conversely, optogenetic activation of POAsocial neurons in group-housed females triggered investigation, USV

production, and mounting. We further revealed that the effects of short-term social isolation on the POA activity and social behaviors are sex- and context-dependent. Together, these findings reveal how short-term isolation recruits hypothalamic circuits to shape female social behavior and lay the groundwork for understanding sex-specific mechanisms through which social isolation alters social motivation and behavior.

Long-range actin-driven endosymbiont mobility in an animal-algal symbiosis

Grace Zhong, Gaëlle Toullec, Pierre-Henri Jouneau, Johan Decelle, Manu Prakash

In animal-microbe symbioses, established symbionts are often thought to be confined to a niche and generally lose their motile appendages such as flagella. Whether this loss implies immobility within the animal host remains an open conundrum. We discover long-range, host-mediated symbiont mobility in a dinoflagellate-acoel worm symbiosis. Using long-term tracking, fluorescence, and electron microscopy, we find that hundreds of dinoflagellate symbionts (Amphidinium sp., 10-20 µm in size) travel across the entire body of an acoel worm host (Waminoa sp.) at high velocities (around 1 µm/s) while under high confinement inside a network of ultra-thin host parenchymal cells (200 nm thin). We unveil the molecular mechanism of this mobility to be host actin machinery. We further reveal spatiotemporal regulation of symbiont distribution associated with diel rhythms and during regeneration. We establish the presence of host-mediated mobility in animal-microbe symbioses, which suggests the existence of previously overlooked regulatory processes in holobionts' maintenance of dynamic homeostasis.

An open source flow-physics informed agent-based model of fish schooling

Ji Zhou, Jung-Hee Seo, Ashley Peterson, Matthew McHenry, Rajat Mittal

Fish schools arise from the interplay between social interactions and the surrounding fluid, yet most behavioral models reduce individuals to self-propelled particles and overlook flow-mediated effects. Growing evidence shows that hydrodynamics—and particularly the vortex wakes shed by swimming fish—strongly shape school topology, stability, and efficiency, in ways that simplified models cannot capture.

We present a physics-informed agent-based model that incorporates wake dynamics parameterized by high-fidelity three-dimensional numerical simulations. The framework integrates established social rules with hydrodynamic interactions, representing both the potential flow around the body and the persistent vortex wakes generated by the tailbeat. Simulations reveal that wakes reorganize schools into ordered structures, such as oblique and diamond-like formations, and markedly shift nearest-neighbor distributions compared to wake-free models. These results show that hydrodynamic coupling is not a secondary effect but a central determinant of collective organization.

This physics-informed model is available to the wider community as an open-source app with a straightforward interface. Users can adjust biological and physical parameters to explore their influence on the schooling dynamics—all with a single click.

Gene expression and chromatin accessibility across the development of 'living fossil' fishes

Zehua Zhou, Ingo Braasch, Andrew Thompson, Treyton Grigg, Brett Racicot

Holostean fishes, comprised of bowfins (Amiiformes) and gars (Lepisosteiformes), occupy a crucial phylogenetic position as the sister clade to teleost fishes. Holosteans diverged from teleosts before the teleost genome duplication (TGD). The uniquely slow rates of molecular sequence evolution make the unduplicated genomes of the holostean 'living fossils' excellent references when making comparisons between ray-finned and lobe-finned fishes including tetrapods. Previous studies have provided gene expression and chromatin accessibility from multiple developmental timepoints of teleosts such as zebrafish and medaka. Here, we present profiles of spotted gar (Lepisosteus oculatus) whole-embryo gene expression and chromatin accessibility through development in comparison to the emerald bowfin (Amia ocellicauda) and teleosts. Analyzing the gene regulation dynamics of holosteans provides insights into both regulatory conservation from the ancestral ray-finned state and lineage-specific variations. With this dataset, we 1) build gene co-expression networks and cluster genes by their expression patterns across development; 2) investigate the correlation of accessible promoter-transcription start sites and the corresponding genes; and 3) describe the genomic regulatory landscape of T-box transcription factor (tbx) genes. The tbx18 gene is of particular interest because its expression tracks the development of vertebrate body appendages, i.e., fins and limbs. Since fins and limbs are shared across most jawed vertebrates, we expect to uncover conserved developmental regulatory elements across gnathostomes.

Uncovering the neuroethology of bumblebee undertaking behaviors

Stephanie Zhu, Micaela Romero, Sophia Burns, Z Yan Wang

Group-living animals, from social insects to mammals, are among the most successful on earth, but they also face unique challenges such as frequent encounters with dead conspecifics that pose pathogen and predation risks. Animals across taxa mitigate these threats through undertaking behaviors, including corpse removal, burial, cannibalism, and avoidance, that are critical for fitness and survival. While undertaking behaviors have been studied extensively in advanced eusocial insects such as ants and termites, much less is known in species with other forms of sociality, and almost nothing is known about the environmental contexts or neurobiological mechanisms shaping them. Here, we investigate undertaking behaviors using the annually eusocial bumblebee, Bombus impatiens. We characterize worker bees' responses toward dead larvae and adult conspecifics, identifying major behavioral motifs such as corpse carrying, and test for task specialization based on age and body size. In addition, we explore sensory and molecular mechanisms underlying undertaking. By linking behavior, worker bee identity, and mechanism, our study helps elucidate how undertaking evolves and contributes to group living. More broadly, this research advances our understanding of how the social environment acts on the nervous system to shape behavior.

Sniffing out adaptation: comparative genomics of olfactory receptors in turtles

Paul Zimmerman, Lindsay Roberts, Laurel Yohe

Olfactory receptor (OR) genes form the largest multigene family in vertebrates and mediate the detection of both airborne and water-soluble odorants. While OR evolution is well studied in mammals, non-model clades such as turtles (Testudines) remain underexplored despite their repeated transitions among terrestrial, freshwater, and marine habitats. These transitions provide an opportunity to test how ecological pressures shape sensory gene repertoires.

We analyzed 49 turtle genomes spanning all major lineages, with outgroups. Using a custom-made chemoreceptor pipeline, we identified intact and pseudogenized ORs and classified them into Class I (aquatic-associated), Class II (airborne-associated). In addition, coding sequences were aligned under their best-fit codon substitution models, placed on phylogenetic trees, and clustered into orthogroups, providing finer insight into the evolutionary history of each OR subfamily.

Our results reveal ecological signatures of OR evolution: aquatic taxa show elevated counts of Class I receptors, while terrestrial clades exhibit expansions of Class II subfamilies. Several OR gene subfamilies, such as OR11G, show clade-specific expansions in terrestrial lineages. This suggests potential neofunctionalization within the subfamilies dependent on habitat.

These findings highlight the dynamic birth–death evolution of OR gene families in turtles and support a link between habitat and chemosensory diversification.

Utilizing sponge community structure as a bio-indicator of coral reef health in the Florida Keys

Annabel Zlatich, Heather Bracken-Grissom, Mary Williams

Over the past few decades, coral reefs in the Florida Keys have been exposed to anthropogenic threats, eutrophication, and climate change resulting in mass bleaching events and high mortality. As the future of coral reef health remains uncertain, understanding reef dynamics is imperative. Recent ecological shifts from coral domination to sponge and macroalgae have revealed possible links between sponge presence and coral abundance. Sponges are powerful filter feeders with some species filtering up to 50,000 times their volume in seawater a day, contributing to clean waters, nutrient recycling and benthopelagic coupling. The functional role sponges play on reef ecosystems leads to the question, can sponges be used as regional bioindicators of reef health? Data was collected over three-years spanning eight reefs in the upper Florida Keys using quadrat photos processed with a focus on morphotype, species, and functional group compared against coral and algae percent coverage. To assess sponges as bio-indicators, a principal component analysis will be performed in addition to PERMANOVA and SIMPER test to further confirm results. Preliminary findings suggest that certain sponge species like Scopalina ruetzeleri are present on reefs with higher coral coverage, whereas reefs with high algal coverage will have little to no sponges present. We hope our results can help inform reef status with the presence of highly resilient species providing structure and diverse community compositions.

Muscle architecture and biomechanics of macrostomy in *Nerodia fasciata pictiventris*

Christopher Zobek, Bruce Jayne, Casey Holliday

Macrostomatan gape is a hallmark of the snake feeding system and is integral to the feeding behaviors of most snakes. The skeletal features that permit extreme gape, such as elongated quadrates and unfused mandibular symphyses, have been characterized across the group. However, the adaptations of muscles and other soft tissues underlying macrostomy are less understood, with only a handful of studies examining the effects of enlarged gape on soft tissues. The effects of macrostomatan gape on whole-muscle architecture and biomechanics have not been quantified. Here, we used DiceCT data of Nerodia fasciata pictiventris to visualize and quantify the effects of macrostomatan gape on the architecture and biomechanics of the cranial musculature. We DiceCT scanned 3 Florida watersnakes held in closed mouth, 50% maximal gape, and 100% maximal gape positions. We measured muscle architecture using Xfiber for Avizo 3D to quantify muscle fiber lengths, orientations, and pennation angles. Force orientations were calculated using the segmented attachment sites for each muscle. With these data, we characterize the changes in muscle architecture and biomechanics across a selection of muscles that control movement of the palate and jaws. We see a lateral shift in orientation in many of the jaw muscles, and an over 100% increase in fiber length in the pterygoideus muscle at maximum gape. Interestingly, fiber lengths shortened in at least one muscle, the mRPT.

Comparison of Avizo Xfiber and Goodfibes R package DiceCT muscle fascicle tracing results

Christopher Zobek, Kevin Middleton, Casey Holliday

DiceCT has created a proliferation of 3D soft tissue data, resulting in the development of methods for quantifying and studying it. One quantifiable aspect of soft tissue morphology is muscle architecture, which describes the morphology of a muscle via parameters including fiber lengths, orientation, and curvature. Several software packages have been developed for studying muscle architecture from DiceCT data, but two prominent examples are Xfiber for Avizo 3D and the Goodfibes R Package. Xfiber is an extension for Avizo/Amira image analysis software, and Goodfibes is a package for the R software environment, which is commonly used in biological sciences. Direct comparisons between these packages have been limited to a small number of datasets that cannot fully capture the range of read-world muscle architecture or data quality. Here we compare the muscle architecture measurements for Avizo Xfiber and Goodfibes on 9 datasets covering a variety of muscle morphologies and data quality. Our datasets varied in the number of fibers, fiber curvature, pennation, noise levels, and resolution. For each dataset, we compared data on fiber lengths and orientations measured using both software packages. Both Goodfibes and Xfiber showed similar performance on most high-quality datasets when reconstructing fiber length and orientation. However, results diverged when analyzing noisy datasets and muscles with strongly curving fibers, with Xfiber visually appearing more reliable in these cases.

Phenotypic plasticity of thermoregulatory traits in the zebra finch (*Taeniopygia castanotis*)

Juan Zuluaga, Elizabeth Derryberry

Organisms adjust their traits in response to environmental change through phenotypic plasticity, yet behavioral and physiological responses are often studied in isolation. Current models of thermoregulation typically focus on single metrics, limiting our ability to integrate behavioral and physiological thermoregulation. Moreover, the plasticity of non-metabolic traits—particularly behavioral responses—remains poorly understood. We hypothesize that thermoregulation is optimized via behavioral adjustments in concert with physiological changes. To test this hypothesis, we combined empirical measurements of behavior and heat fluctuation at a range of temperatures (32 to 45°C), collected before and after 4 weeks of heat acclimatization in a within subjects' design, to develop a mechanistic model of thermoregulatory phenotypic plasticity in the Zebra Finch (Taeniopygia castanotis). We found that behavior plays a central role in heat fluctuation dynamics: as temperatures rise, birds shift from cost-effective postural changes that increase dry heat loss to more costly behaviors that increase evaporative cooling (panting). Post-acclimatization, birds deferred panting until higher ambient temperatures, reducing the costs of evaporative cooling—potentially mediated by changes in heat tolerance and dry heat loss. These findings underscore the interdependence of behavioral and physiological processes, highlighting the importance of measuring both in studies of heat stress. Accounting for these integrated plastic responses will be critical for predicting the resilience of birds in a rapidly changing climate.

Transcriptomic signatures of sperm competition across species and morphs

Maximiliano Zuluaga Forero, Ehren Bentz, Ben Sandkam

When females mate with multiple males, sperm competition exerts intense post-copulatory selection that rapidly shapes male reproductive traits such as sperm production and morphology. Understanding the genetic basis of these traits is critical for explaining how selection maintains diversity in male strategies. We study three closely related livebearing fishes (Poecilia reticulata, P. picta, and P. parae), which show striking variation in how sperm competition shapes male mating behavior both across and within species. While males of P. reticulata and P. picta use both display and forced mating tactics, P. parae males occur as three main discrete morphs that specialize in aggressive, displaying, or sneaking tactics. These morphs are strictly Y-linked, differ categorically in morphology, behavior, and sperm traits, and thus provide a rare opportunity to dissect the genetic basis of reproductive polymorphism within a single species. We generated RNA-seq data from gonads of all three species and all P. parae morphs. Expression analyses revealed consistent divergence among morphs of P. parae, with 17–72 genes differentially expressed in pairwise comparisons. These findings indicate a strong response to selection on sperm specialization. Identifying enriched functions within these gene sets reveals candidate genetic drivers of sperm competition. This integrative approach provides a framework for understanding how sperm competition shapes reproductive diversity and drives the rapid evolution of alternative male traits.