Advanced Placement Correlation

Big Idea 1: The process of evolution drives the diversity and unity of life.

Essential knowledge	*Pages*	*Illustrative examples covered*
1.A.1 Natural selection is a major mechanism of evolution.	2–6, 396–414, 418–434, 443	• Graphical analysis of allele frequencies in a population, 397 • Application of Hardy-Weinberg equilibrium equation, 399–401
1.A.2 Natural selection acts on phenotypic variations in populations.	404, 406–408, 418–434, 491–495, 499–500, 554, 834, 1257–1261	• Peppered moth, 420–421 • Sickle cell anemia, 408 • Artificial selection, 422 • Overuse of antibiotics, 404
1.A.3 Evolutionary change is also driven by random processes.	401–405, 441–445	
1.A.4 Biological evolution is supported by scientific evidence from many disciplines, including mathematics.	360–363, 397, 398, 418–434, 458–460, 473–476, 509–511	• Graphical analyses of allele frequencies in a population, 397 • Analysis of sequence data sets , 398 • Analysis of phylogenetic trees, 427 • Construction of phylogenetic trees based on sequence data, 427
1.B.1 Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.	65, 73–75, 123–125, 188, 189–190, 278–284, 460–470, 473–482, 485–486	• Cytoskeleton (is a network of structural proteins that facilitate cell movement, morphological integrity and organelle transport), 75 • Membrane-bound organelles (mitochondria and/or chloroplasts), 73–75 • Linear chromosomes, 188 • Endomembrane systems, including the nuclear envelope, 65
1.B.2 Phylogenetic trees and cladograms are graphical representations (models) of evolutionary history that can be tested.	446–450, 455–470, 720, 1023–1025	• Number of heart chambers in animals, 1023–1025 • Opposable thumbs, 720 • Absence of legs in some sea mammals, 720
1.C.1 Speciation and extinction have occurred throughout the Earth's history.	446–453, 469, 1257–1261, 1264–1275	• Human impact on ecosystems and species extinction rates, 469, 1257–1261, 1264–1275
1.C.2 Speciation may occur when two populations become reproductively isolated from each other.	437–451	
1.C.3 Populations of organisms continue to evolve.	404–407, 418–419, 424–427, 534–536	• Chemical resistance (mutations for resistance to antibiotics, pesticides, herbicides or chemotherapy drugs occur in the absence of the chemical), 404 • Emergent diseases, 535 • Observed directional phenotypic change in a population (Grants' observations of Darwin's finches in the Galapagos), 419
1.D.1 There are several hypotheses about the natural origin of life on Earth, each with supporting scientific evidence.	511–513	
1.D.2 Scientific evidence from many different disciplines supports models of the origin of life.	34, 142–143, 282–283, 418–434, 509–513, 517–520	

Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.

Essential knowledge	*Pages*	*Illustrative examples covered*
2.A.1 All living systems require constant input of free energy.	107–121, 124–144, 160–162, 771, 783, 830–834, 857–858, 875–884, 1214–1222	• Krebs cycle, 125–138 • Glycolysis, 125–134, 136–138, 140–144, 161–162 • Calvin cycle, 160–161, 783 • Fermentation, 129 • Endothermy (the use of thermal energy generated by metabolism to maintain homeostatic body temperatures), 880 • Ectothermy (the use of external thermal energy to help regulate and maintain body temperature), 879 • Life–history strategy (biennial plants, reproductive diapause), 771 • Change in the producer level can affect the number and size of other trophic levels, 1214 • Change in energy resources levels such as sunlight can affect the number and size of the trophic levels, 1214
2A.2 Organisms capture and store free energy for use in biological processes.	122–132, 134–142, 147–167, 515–516, 554, 563–564, 881	• $NADP^+$ in photosynthesis, 148 • Oxygen in cellular respiration, 134
2.A.3 Organisms must exchange matter with the environment to grow, reproduce and maintain organization.	18–32, 37, 59–62, 736, 740–744, 987, 1007, 1208–1213	• Cohesion, 26 • Adhesion, 27 • High specific heat capacity, 28 • Universal solvent supports reactions, 28 • Heat of vaporization, 28 • Heat of fusion, 28 • Water's thermal conductivity, 28 • Root hairs, 736 • Cells of the alveoli, 1007 • Cells of the villi, 987 • Microvilli, 987
2.B.1 Cell membranes are selectively permeable due to their structure.	79–81, 88–98, 540–543	
2.B.2 Growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes.	96–106	• Glucose transport, 97 • Na^+/K^+ transport, 101
2.B.3 Eukaryotic cells maintain internal membranes that partition the cell into specialized regions.	59–78	• Endoplasmic reticulum, 69 • Mitochondria, 74 • Chloroplasts, 74 • Golgi, 70 • Nuclear envelope, 62

Essential knowledge	Pages	Illustrative examples covered
2.C.1 Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes.	286, 812, 814, 875–884, 942–958, 1091, 1128	• Operons in gene regulation, 286 • Temperature regulation in animals, 875 • Plant responses to water limitations, 812 • Lactation in mammals, 1128 • Onset of labor in childbirth, 1128 • Ripening of fruit, 814 • Diabetes mellitus in response to decreased insulin, 954 • Dehydration in response to decreased antidiuretic hormone ADH, 947 • Graves' disease (hyperthyroidism), 948 • Blood clotting, 1091
2.C.2 Organisms respond to changes in their external environments.	721, 803, 832–837, 880, 882, 887, 1133–1137, 1144–1154	• Photoperiodism and phototropism in plants, 803 • Hibernation and migration in animals, 882 • Nocturnal and diurnal activity: circadian rhythms, 721 • Shivering and sweating in humans, 880, 887
2.D.1 All biological systems from cells and organisms to populations, communities and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy.	6, 541–558, 570, 581–584, 766–767, 773–776, 1162–1175, 1178, 1186–1197, 1202–1205, 1208, 1209, 1213, 1215, 1230–1237, 1260	• Biofilms, 541, 555 • Temperature, 1208 • Water availability, 1208 • Sunlight, 1208 • Symbiosis (mutualism, commensalism, parasitism), 1196–1197 • Predator–prey relationships, 1192 • Water and nutrient availability, temperature, salinity, pH, 1209 • Water and nutrient availability, 1209 • Food chains and food webs, 1215 • Species diversity, 1203 • Population density, 1175, 1178, 1189, 1260 • Algal blooms, 570, 1213
2.D.2 Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments.	545–548, 567, 647–654, 660–664, 672, 677, 686–689, 700–710, 717, 750–754, 765–770, 877–884, 982–990, 1002–1012, 1018–1029, 1038–1053, 1192–1201	• Gas exchange in aquatic and terrestrial plants, 1002 • Digestive mechanisms in animals such as food vacuoles, gastrovascular cavities, one-way digestive systems, 677, 982–990 • Respiratory systems of aquatic and terrestrial animals, 1002–1012 • Nitrogenous waste production and elimination in aquatic and terrestrial animals, 1038–1053 • Excretory systems in flatworms, earthworms and vertebrates, 672, 1038–1053 • Osmoregulation in bacteria, fish and protists, 567, 1038–1053 • Osmoregulation in aquatic and terrestrial plants, 1038–1053 • Circulatory systems in fish, amphibians and mammals, 717, 1018–1029 • Thermoregulation in aquatic and terrestrial animals (countercurrent exchange mechanisms), 881

Essential knowledge	Pages	Illustrative examples covered
2.D.3 Biological systems are affected by disruptions to their dynamic homeostasis.	774–776, 780, 789, 795, 812, 1051, 1057, 1202–1204, 1209, 1245–1254, 1260, 1263, 1269	• Physiologial responses to toxic substances, 1248 • Dehydration, 812, 1051 • Immunological responses to pathogens, toxins and allergens, 1057 • Invasive and/or eruptive species, 1269 • Human impact, 1250–1254, 1260 • Hurricanes, floods, earthquakes, volcanoes, fires, 1248, 1252, 1263 • Water limitation, 780, 1209 • Salination, 775
2.D.4 Plants and animals have a variety of chemical defenses against infections that affect dynamic homeostasis.	791–796, 799–801, 875, 1055–1082	• Plant defenses against pathogens include molecular recognition systems with systemic responses; infection triggers chemical responses that destroy infected and adjacent cells, thus localizing the effects, 799–801 • Vertebrate immune systems have nonspecific and nonheritable defense mechanisms against pathogens, 875
2.E.1 Timing and coordination of specific events are necessary for the normal development of an organism, and these events are regulated by a variety of mechanisms.	287–288, 317–321, 373, 375–381, 383–393, 610–616, 832–837, 839–841, 1067, 1106–1107, 1110–1112, 1116–1117, 1126–1127	• Morphogenesis of fingers and toes, 390, 1126–1127 • C. *elegans* development, 391–392 • Flower development, 839–841
2.E.2 Timing and coordination of physiological events are regulated by multiple mechanisms.	177, 437–441, 581–584, 806, 818, 829–837, 882, 904, 938–959, 1142–1143, 1145, 1149	• Circadian rhythms, or the physiological cycle of about 24 hours that is present in all eukaryotes and persists even in the absence of external cues, 806, 818 • Diurnal/nocturnal and sleep/awake cycles, 806, 904 • Seasonal responses, such as hibernation, estivation and migration, 882 • Release and reaction to pheromones, 177, 938, 1145 • Visual displays in the reproductive cycle, 439, 1149 • Fruiting body formation in fungi, slime molds and certain types of bacteria, 581
2.E.3 Timing and coordination of behavior are regulated by various mechanisms and are important in natural selection.	581, 610, 630–632, 803, 815–818, 832–837, 841–843, 882, 934, 1106, 1133–1138, 1142–1143, 1150–1152, 1187–1192, 1196	• Hibernation, 882 • Estivation, 882 • Migration, 934, 1142–1143 • Courtship, 1106, 1134–1136, 1150–1152 • Availability of resources leading to fruiting body formation in fungi and certain types of bacteria, 581 • Niche and resource partitioning, 1189 • Mutualistic relationships (lichens; bacteria in digestive tracts of animals; mycorrhizae), 1196 • Biology of pollination, 610

Big Idea 3: Living systems store, retrieve, transmit and respond to information essential to life processes.

Essential knowledge	*Pages*	*Illustrative examples covered*
3.A.1 DNA, and in some cases RNA, is the primary source of heritable information.	41–44, 187–191, 256–276, 278–302, 318–320, 328, 329, 330, 332–333, 334, 338, 339–343, 345, 348–350, 362–363, 380–381, 524–527, 540–544, 548–552	• Addition of a poly-A tail, 288–289 • Addition of a GTP cap, 288–289 • Excision of introns, 289–290 • Electrophoresis , 329 • Plasmid–based transformation, 330, 334 • Restriction enzyme analysis of DNA, 328 • Polymerase Chain Reaction (PCR), 332 • Genetically-modified foods, 342–343 • Transgenic animals, 345 • Knockout mice, 338 • Cloned animals, 380–381 • Pharmaceuticals, such as human insulin or factor X, 342
3.A.2 In eukaryotes, heritable information is passed to the next generation via processes that include the cell cycle and mitosis, or meiosis plus fertilization.	186–220, 373–374	• Mitosis-promoting factor (MPF), 198 • Action of platelet–derived growth factor (PDGF), 202 • Cancer results from disruptions in cell cycle control, 202–204
3.A.3 The chromosomal basis of inheritance provides an understanding of the pattern of passage (transmission) of genes from parent to offspring.	221–226, 228–231, 244–246, 249, 250–251, 1091–1092, 1096	• Sickle cell anemia, 249 • Tay-Sachs disease, 249 • Huntington's disease, 249 • X-linked color blindness, 229 • Trisomy 21/Down syndrome, 250–251 • Klinefelter's syndrome, 251
3.A.4 The inheritance pattern of many traits cannot be explained by simple Mendelian genetics.	232–235, 240–247, 249–255	• Sex-linked genes reside on sex chromosomes (X in humans), 241 • In mammals and flies, the Y chromosome is very small and carries very few genes, 241 • In mammals and flies, females are XX and males are XY; as such, X-linked recessive traits are always expressed in males, 241 • Some traits are sex limited, and expression depends on the sex of the individual, such as milk production in female mammals and pattern baldness in males, 243
3.B.1 Gene regulation results in differential gene expression, leading to cell specialization.	285, 304–305, 308–313, 316–319, 322–325	• Promoters, 285 • Terminators, 285 • Enhancers, 313
3.B.2 A variety of intercellular and intracellular signal transmissions mediate gene expression.	168–180, 197–199, 203–204, 242, 310, 375–376, 379–386, 388, 581, 622, 814, 1086	• Cytokines regulate gene expression to allow for cell replication and division, 197–199 • Mating pheromones in yeast trigger mating gene expression, 581, 622 • Levels of cAMP regulate metabolic gene expression in bacteria, 310 • Expression of the SRY gene triggers the male sexual development pathway in animals, 242, 1086 • Ethylene levels cause changes in the production of different enzymes, allowing fruits to ripen, 814 • Seed germination and gibberellin, 814 • Morphogens stimulate cell differentiation and development, 386 • Changes in p53 activity can result in cancer, 203–204 • HOX genes play a role in development, 388

Essential knowledge	*Pages*	*Illustrative examples covered*
3.C.1 Changes in genotype can result in changes in phenotype.	249–255, 273–276, 299–301, 373–375, 405, 408–410, 418–420, 477–480, 549–553, 571–574	• Antibiotic resistance mutations, 405 • Pesticide resistance mutations, 405, 571 • Sickle cell disorder and heterozygote advantage, 250
3.C.2 Biological systems have multiple processes that increase genetic variation.	210–214, 218, 273–275, 373–375, 548–553	
3.C.3 Viral replication results in genetic variation, and viral infection can introduce genetic variation into the hosts.	357, 524–536, 548, 549–553	• Transduction in bacteria, 548 • Transposons present in incoming DNA, 357
3.D.1 Cell communication processes share common features that reflect a shared evolutionary history.	168–180, 203, 622, 899, 938, 1086	• Use of pheromones to trigger reproduction and developmental pathways, 177, 622, 938 • Epinephrine stimulation of glycogen breakdown in mammals, 899 • Temperature determination of sex in some vertebrate organisms, 1086 • DNA repair mechanisms, 203
3.D.2 Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling.	82–87, 168–180, 384, 798–799, 809–810, 942–958, 1055–1076, 1184	• Immune cells interact by cell-cell contact, antigen-presenting-cells (APCs), helper T-cells and killer T-cells, 1062–1063 • Plasmodesmata between plant cells that allow material to be transported from cell to cell, 83 • Neurotransmitters, 1184 • Plant immune response, 809–810 • Morphogens in embryonic development, 384 • Insulin, 954–955 • Human growth hormone, 950 • Thyroid hormones, 951–952 • Testosterone, 956 • Estrogen, 957
3.D.3 Signal transduction pathways link signal reception with cellular response.	173, 174–180, 182, 316–317, 891	• G-protein linked receptors, 178–179 • Ligand-gated ion channels, 891 • Receptor tyrosine kinases, 182 • Second messengers, such as: cyclic GMP, cyclic AMP calcium ions (Ca^{2+}), and inositol triphosphate (IP_3), 173
3.D.4. Changes in signal transduction pathways can alter cellular response.	179–180, 202–204, 1101	• Diabetes, heart disease, neurological disease, autoimmune disease, cancer, cholera, 202–204, 1101

Essential knowledge	Pages	Illustrative examples covered
3.E.1 Individuals can act on information and communicate it to others.	797, 842–843, 888, 898, 953–954, 1135–1136, 1140, 1142, 1144–1154, 1158, 1159, 1194, 1195, 1222	• Fight or flight response, 888, 898, 953–954 • Protection of young, 1159 • Predator avoidance, 1148 • Plant-plant interactions due to herbivory, 797, 1222 • Avoidance responses, 1158 • Territorial marking in mammals, 1149 • Bee dances , 1146 • Birds songs, 1140 • Herd, flock, and schooling behavior in animals, 1158 • Colony and swarming behavior in insects, 1158 • Coloration, 1194 • Parent and offspring interactions, 1150 • Migration patterns, 1142 • Courtship and mating behaviors, 1135–1136 • Foraging in bees and other animals, 1148 • Avoidance behavior to electric fences, poisons, or traps, 1158, 1195
3.E.2 Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses.	886–901, 905, 908, 909–910, 914–918, 919, 927, 946, 1141	• Acetylcholine , 896–900 • Epinephrine, 908 • Norepinephrine, 908 • Dopamine, 908 • Serotonin, 908 • GABA, 908 • Vision , 927 • Hearing, 919 • Abstract thought and emotions, 1141 • Neuro-hormone production, 946 • Forebrain (cerebrum), midbrain (brainstem) and hindbrain (cerebellum), 900–901 • Right and left cerebral hemispheres in humans , 905

Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.

Essential knowledge	Pages	Illustrative examples covered
4.A.1 The subcomponents of biological molecules and their sequence determine the properties of that molecule.	34–58, 259–262, 271–272	
4.A.2 The structure and function of subcellular components, and their interactions, provide essential cellular processes.	59–87, 148–149, 151–153, 292–293	
4.A.3 Interactions between external stimuli and regulated gene expression result in specialization of cells, tissues and organs.	308–311, 375–376, 379–386, 388, 390–391, 494–499	

Essential knowledge	*Pages*	*Illustrative examples covered*
4.A.4 Organisms exhibit complex properties due to interactions between their constituent parts.	730–772, 970–974, 985–988, 1008, 1010, 1045–1050	• Stomach and small intestines, 985–988 • Kidney and bladder, 1045–1050 • Respiratory and circulatory, 1008, 1010 • Nervous and muscular, 972
4.A.5 Communities are composed of populations of organisms that interact in complex ways.	1174–1182, 1186–1205, 1223–1226, 1250, 1269–1270	• Symbiotic relationship, 1196–1200 • Introduction of species, 1269–1270 • Global climate change models, 1250
4.A.6 Interactions among living systems and with their environment result in the movement of matter and energy.	556–558, 1162–1164, 1175–1177, 1181, 1214–1222, 1230–1254	
4.B.1 Interactions between molecules affect their structure and function.	48–49, 113–116, 118–119, 138	
4.B.2 Cooperative interactions within organisms promote efficiency in the use of energy and matter.	59–68, 554, 557–558, 647–654, 660–667, 672, 677, 686–689, 700–725, 872–875, 985, 991, 1002–1003, 1004–1005, 1018, 1043–1045	• Exchange of gases, 664–667, 1002–1003, 1004–1005 • Circulation of fluids, 1018 • Digestion of food, 677, 985 • Excretion of wastes, 672, 1043–1045 • Bacterial community in the rumen of animals, 991
4.B.3 Interactions between and within populations influence patterns of species distribution and abundance.	626, 1186–1201, 1220–1222, 1224	• Loss of keystone species, 1201, 1224 • Dutch elm disease, 626
4.B.4 Distribution of local and global ecosystems changes over time.	451–453, 575, 626, 1213, 1243, 1245–1273, 1275–1278	• Logging, slash and burn agriculture, urbanization, monocropping, infrastructure development (dams, transmission lines, roads), and global climate change threaten ecosystems and life on Earth, 1213, 1246 • An introduced species can exploit a new niche free of predators or competitors, thus exploiting new resource, 1270 • Dutch elm disease, 626 • Potato blight, 575 • El Niño, 1243
4.C.1 Variation in molecular units provides cells with a wider range of functions.	92–93, 152, 406, 481–484, 1064–1066, 1068–1069	• Different types of phospholipids in cell membranes, 92–93 • MHC Proteins, 1064–1066 • Chlorophylls, 152 • Molecular diversity of antibodies in response to an antigen, 1068–1069 • The antifreeze gene in fish, 483
4.C.2 Environmental factors influence the expression of the genotype in an organism.	224–226, 232–235, 308–311, 624–627, 735–736, 834	• Height and weight in humans, 233 • Seasonal fur color in arctic animals, 232–233 • Darker fur in cooler regions of the body in certain mammal species, 232–233
4.C.3 The level of variation in a population affects population dynamics.	398–400, 488, 573–577, 625, 1162–1164, 1264–1273, 1275–1278	• California condors, 1276 • Potato blight causing the potato famine, 575 • Corn rust affects on agricultural crops, 625 • Tasmanian devils and infectious cancer, 488
4.C.4 The diversity of species within an ecosystem may influence the stability of the ecosystem.	1201, 1256–1275	