Teaching Genetics and Evolution in the midst of a pandemic: how a real-world example helps students learn better

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Background

• Freshman (1st semester) course in Biology
  • Mostly science majors but also 25% general education students
  • Many first-generation students
  • Conservative school systems in much of Ohio (some do not teach evolution at all, or teach a very biased view)
  • Students have a hard time connecting with some topics (why am I learning this?)
  • Many students arrive at their freshman year with poor learning/study habits
Background

• Freshman (1st semester) course in Biology
  • Follow typical pattern of topics
    • Processes of science
    • Basic biochemistry
    • Cells and their parts
    • Basic genetics
    • Evolution basics
  • Have used the MATE assessment tool for past 5 years
    • Significant gains due to low starting point overall
  • Use case studies when teaching genetics and evolution
    • NCCSTS  https://sciencecases.lib.buffalo.edu/
      • Create real-world examples with the case studies (relevance)
  • Project-based learning in lab sections
Background

• Genetics course (sophomore) for majors
  • Pick up on first-year course and go deeper
  • RELEVANCE
    • It’s not just about the MCAT
    • What do students need to know in today’s society
  • Current topics / applications are the most relevant to students
  • Use case studies
  • Use current events
  • Project-based and problem-based learning in lab sections
Pandemic Year

• Connecting learning to their daily lives
  • Relevance of COVID 19 *(once in a lifetime)*
  • Opportunities to make genetics and evolution “come alive”
    • Real-time learning (daily updates)
    • Students are concerned / afraid
    • Students are being subjected to misinformation
      • Family, friends, social media

• Day 1 (both courses) – survey
  • What do they know about the coronavirus and viruses in general?
  • What do they know about COVID?
  • What do they know about the development of immunizations?
  • What are the concerns they have?
Pandemic Year

• Topics in first-year course – GENETICS
  • Most of these topics were learned to some extent in high school biology classes
  • Go over basics, but with a tie to the pandemic
  • DNA vs. RNA
    • Two types of viruses
    • Coronavirus is which type?
    • Interactions with human cells / DNA
    • mRNA (leading to mRNA vaccines)
    • Reverse transcription
Pandemic Year

• Topics in first-year course – GENETICS
  • Transcription and Translation
    • Production of proteins
    • What proteins are part of the virus?
    • How is the virus producing those proteins?
    • What changes are made in our cells by the virus?
  • Dominant, recessive, co-dominant
    • Human blood types
    • Case study
    • Students scrambled to find out what blood type they are
Pandemic Year

• Topics in first-year course - GENETICS
  • Mutations
    • What causes viruses to mutate?
    • “Variants” (another name for mutations)
    • Speed of mutations – comparing humans to viruses
    • Role of the environment
  • Epigenetics
    • Are changes passed on?
    • Will we ever get the virus ‘under control’?
    • Will viral proteins be passed on to our children?
Pandemic Year

• Topics in sophomore course - GENETICS
  • Many of the same topics – more in-depth
    • Students assigned to find the relevant information
    • Original articles and reviews assigned for reading and understanding
    • Students teach each other in groups
      • Think, pair, share and other models
    • Case studies
Pandemic Year

• Topics in **sophomore** course - **GENETICS**
  
  • Additional Topics
    • Genomics and proteomics
      • How did they find the viral genome so quickly?
      • What is the technology for doing that?
    • Estimating mutation rates
      • Case study
      • Forward and backward mutation
Pandemic Year

• Topics in sophomore course - GENETICS
  • Additional Topics
    • Using NCBI Blast to find genome sequences
      • Case study
    • Understanding the role of the CDC
    • Public health and genetics
    • Personalized medicine based on genomics
Pandemic Year

• Topics in sophomore course - GENETICS
  • Additional Topics
    • Biotechnology – expanded
      • Tracing genome across species
      • Contact tracing in human populations
      • Developing new tests for coronavirus mutations
  • Viruses and cancer
    • Can the coronavirus cause cancer?
    • What is cancer?
    • Will a vaccine stop cancers?
Pandemic Year

• Topics in first-year course - **EVOLUTION**
  • How does our definition of species hold up with viruses?
    • Are they alive?
    • Do they fit the definition (reproduction, viable offspring, etc)?
  • **Why did Darwin not mention viruses?**
  • What does “survival of the fittest” mean in a pandemic?
    • Viral mutations = survival
    • Human (host) genetics versus ability to fight coronavirus
    • Over-riding factors of socioeconomics
    • Herd immunity concepts
      • Problems with social media and family ideas
Pandemic Year

• Topics in first-year course - **EVOLUTION**
  
  • **Speed of evolution**
    • Does it really take millions of years?
    • Can we watch it happening?
    • How many mutations does it take?
  
  • **Drop in the average age of the US population**
    • Evolution, fitness, selection pressure?
    • Loss of elderly, but also decline in birth rate
  
  • **What happens to the species (humans) when we remove more people of color or more people with diabetes or ....**
    • Questions that overlap socioeconomics with biology
    • Mechanisms for evolution seen in human populations
      • Very small percentages, but ....
Pandemic Year

• Topics in first-year course - **EVOLUTION**
  • Change of hosts as a mechanism of evolution
    • How did it get to humans?
    • Other species likely involved
    • Mutations allow new hosts
      • How many mutations does it take?
    • Increase in species survival (virus)
Assessment

- First-year course
  - Students have always rated the case studies well
    - Rated case studies as extremely helpful in learning concepts
    - Noted the relevance of the case studies
      - Thanks to NCCSTS for publishing several quickly
  - Students noted .....  
    - They were able to teach their family and friends (or at least have dialog with them)
    - They felt confident about coronavirus biology and the dangers of COVID
    - They were looking forward to a vaccine and to being vaccinated
    - They saw evolution in a broader way than what they had learned in high school
    - They saw humans as interconnected with the environment
Assessment

• Second-year Genetics course
  • Students rated the case studies highly
    • Relevance to their lives
    • Better understanding of clinical and technological issues
  • Students noted ..... 
    • They enjoyed reading primary literature and sharing in groups
    • They were able to share better with family and friends
    • They felt better informed
    • Many commented about the lack of connections (to coronavirus and the pandemic) in other courses they were taking
Assessment

• Grades and attendance?
  • Because both of these classes were completely online (Zoom) we were unable to compare attendance rates or grades with previous semesters
    • Comparing apples and oranges
    • No basis for rates of attendance in online science classes
      • May be literature cases, but not with our particular population of students
Bottom Line

• Regardless of whether we are teaching high school or undergraduate, our curriculum needs to be relevant for the times we are in and the students we have in our classrooms
  • When the pandemic hit it gave us an opportunity to teach the same subjects in a new and more relevant way
  • Students tend to learn better (as a whole) when they can see the relevance in what they are learning
  • Students are better ambassadors for science (to family, friends, and community) when they understand more completely
BUT.....

• We as faculty have to be willing to step out of our comfort zone and our ‘traditional’ way of teaching
  • “just in time” changes in the curriculum
• We need to always be looking for relevant new ways to teach the same topics
  • Daily updates and conversations
• We need to understand where our students are coming from in any given generation
Thank You

• QUESTIONS?

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