# Disease-ology: Transforming the teaching of biology using a disease model: Evolution

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**Abstract**:

Student engagement is one of the most important factors in determining a student's success in the classroom By increasing engagement, I believe that students' achievement on teacher-made assessments will increase. Working with a group of teachers, we are transforming the state Biology I course so that every unit is taught through a disease model. I have focused my efforts on updating my current unit on evolution, based around drug resistant *Staphylococcus aureus*. I am adding two lessons, both on Ebola virus, to the unit to add more molecular biology into the evolution curriculum. We will each give a student interest inventory, a science attitudes survey, and a pre-, midpoint, and post-assessment for all aspects of biology to assess the effectiveness of our action proposal.

**The rationale:**

I teach at Rockledge High School in Brevard County, Florida. I have just completed my sixth year of teaching and Rockledge has been the only place I have taught in my career. During this time, I have taught a wide range of students of varying abilities, as well as many of our science courses, including biology, integrated science, and marine science. This past year, I taught three sections of Cambridge International A-Level marine science, a college-level course, two sections of zoology, and one section of experimental science, an independent science research course. In general, students in our Cambridge International Examinations program are student who are high academic performers, though we open up any of our classes to students who are willing to challenge themselves with the content. Zoology typically has students from across the spectrum. Experimental science is populated by students who are very interested in the sciences, and it gives them a chance to explore their interests.

Previously, I have taught the biology and integrated science 3 courses. Each of these courses takes the state Biology End of Course Assessment. In the next school year, I will be

teaching two sections of standard level integrated science 3. This course is typically taken by 11th and 12th grade students who have not performed well in their science and math courses, and typically do not have a particular interest in science. They are tracked in this sequence of courses (integrated science 1, 2, and 3) when they start science in 9th grade. It is this course that I am going to focus my action proposal on.

It has been shown that engagement is one of the most important things that influences a student's achievement in any academic endeavor. Student engagement is at the heart of any good teacher's pedagogical philosophy. Keeping students interested in content consistently shows an increase in achievement across social and economic situations. There is no single way to define what engagement actually is, but Finn and Zimmer (2012) have identified characteristics of engagement, including intrinsic student motivation to respond to requirements, class activities and it is shown by the student with a sense of valuing what they are doing in school as well as a feeling of belonging in the school environment. It is therefore imperative that we as educators do everything that we can to improve student engagement.

Anecdotally, through my personal experience, when you can gross out a student, or when you can tie the curriculum to something related to their own personal health, they become engaged. This is why myself, with a group of other teachers from CATALySES and my own school, are going to develop a curriculum to teach the Biology I course through the lens of disease, whether the disease originates with emerging pathogens (Ebola virus, Zika virus, drug resistant pathogens, etc.), established infectious disease (influenza, HIV, etc.), or other, non-infectious disease (diabetes, heart disease, etc.). Each of us has decided to write a unit of the major themes of biology using a pathogens lens: chemistry of water, macromolecules, cell anatomy and physiology, cell reproduction, genetics, ecology, and evolution. For this action

proposal, I am going to focus on my particular topic, evolution.

**The intervention, data collection, and connection to CATALySES:**

Currently I teach a unit on evolution using the lens of drug resistant *Staphylococcus aureus*, based on Cook (2009). This unit has been my workhorse for the evolution subject, and I have been happy with it. However, there is a failing in this. It focuses on the action of natural selection on an organism's phenotype, which is the principal mechanism of action (Brown University, n.d.) What I would like to do with this updated version of the unit is to incorporate more genotypic information using what I learned from the CATALySES workshop this year.

In terms of what I would change, I would move the focus away from drug resistant *S. aureus*, and use multiple models of drug resistance and evidence of evolution of pathogens throughout the unit, using the examples of influenza, HIV and Ebola. For lessons, I will leave the unit basically intact, but I will add two activities that we did during our Ebola sessions with Dr. Bokor. First, I will add the map activity, titled "The Ebola Epidemic", where students must act as epidemiologists and determine where the particular outbreak of Ebola virus began in western Africa. This connects back to the ecology unit, which would have been delivered before this unit. I would also add the second lesson in the sequence from CATALySES, from Howard Hughes Medical Institute (HHMI) Biointeractive, called "Ebola: Disease Detectives". During this lesson, students are presented with a variety of shortened Ebola virus genomes, and a reference Ebola genome, and they are to infer the relatedness of the different strains of the virus using this information. This connects perfectly to my goal of incorporating more molecular biology into the evolution unit.

As this unit is part of a much larger collaboration, we are going to use a variety of data

collection tools, given at various times throughout the school year when appropriate. At the beginning of the school year we are going to give our students two surveys: one is a survey about students' current attitudes about science, including current self-perceived levels of engagement with previous science content, the other a general interest inventory, covering topics from science to their personal interests and goals. Then, we will give students a pre-assessment gauging their current mastery of the biology course standards, to give us a baseline score. We will also collect baseline standards mastery data based on our own units, and I will do the same with my evolution unit as well. We will give the same survey and assessments at the end of the first semester, and one more time at the end of the second semester, giving us multiple data points with which we can see what, if any, trends appear. We will then use appropriate statistical analysis to determine significance, taking into account the small number of data points per class.

**Permissions:**

For this action research, I will get the permission of my principal, and notify her of what I intend to do. Since this research does not involve anything outside of the normal process of teaching, parents do not need to be notified. However, our district requires us to notify the Office of Accountability, Testing, and Evaluation. They will require a copy of this document and will make a decision on approval.

Works Cited

Brown University. (n.d.). Phenotype and Genotype. Retrieved June 29, 2017, from https://biomed.brown.edu/Courses/BIO48/5.Geno.Pheno.HTML

Cook, K. (2009). A Suggested Project-Based Evolution Unit for High School: Teaching Content Through Application. *The American Biology Teacher*, 95-98.

Finn, J. D., & Zimmer, K. S. (2012). Student Engagement: What is it? Why Does It Matter? In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of Research on Student Engagement*

## Appendix 1: Lesson plan

**LESSON PLAN FORMAT (Example)**

**TITLE:** Ebola: Disease Detectives

**KEY QUESTION(S):** How is genotype related to phenotype? How has Ebola virus changed through the most recent outbreak? How does molecular biology relate to evolution?

**SCIENCE SUBJECT**: Evolution, molecular biology, epidemiology

**GRADE AND ABILITY LEVEL**: Integrated science 3 standard level

**SCIENCE CONCEPTS**: Evolution, molecular biology, epidemiology, genetics, genotype and phenotype.

**OVERALL TIME ESTIMATE:** One 47 minute class period, with a bellringer question for the next day.

**LEARNING STYLES**: Visual, auditory, and kinesthetic.

**VOCABULARY:** Ebola, virus, genotype, phenotype, epidemiology, nitrogenous bases, mutation

**LESSON SUMMARY:** Provide a 1-2 sentence summary of WHAT the lesson will cover and HOW this content will be covered (Lab? Discussion? Role play? Simulation? Lecture and demonstration? etc.)

**STUDENT LEARNING OBJECTIVES WITH STANDARDS:**

The student will be able to...

1. Compare genotype and phenotype
2. Explain how genotype influences phenotype in Ebola virus
3. Describe how Ebola virus has changed over time

**MATERIALS:**

ESSENTIAL: Ebola genome strips (one set per pair), student work sheet (one per person), printer (one total, to print genome strips)

SUPPLEMENTAL: Color printer (one total), computer access (one per pair)

**BACKGROUND INFORMATION**: In this lesson, students are to investigate the genetics of the most recent Ebola outbreak (2013-2016) in west Africa. **Ebola** is an RNA virus that causes Ebola hemorrhagic fever, a disease that is easily spread through body fluids and causes pain, fever, diarrhea, vomiting, weakness, and fatigue, and can lead to hemorrhage. Symptoms can appear anywhere from 2-21 days after exposure. A **virus** is an infective agent that typically consists of a nucleic acid molecule in a protein coat, is too small to be seen by light microscopy, and is able to multiply only within the living cells of a host. The virus' **genotype**, the actual makeup of its genetic code, determines the virus' **phenotype**, the physical characteristics of the agent. The virus' genetic code is made up of smaller units called **nitrogenous bases**. When one or more of these bases is changed, due to improper copying, or from other external environmental source, that is called a **mutation**. **Epidemiology** is the study of the spread of disease in the environment.

**ADVANCE PREPARATION**: Print each pair a set of genome strips, ideally in color. Print out a worksheet for each student in the class.

**PROCEDURE AND DISCUSSION QUESTIONS WITH TIME ESTIMATES:**

1. Have students read the background information provided with the lesson and give them time to read it.
2. Have students watch the YouTube video clip listed on the worksheet. If only the teacher has computer access, wait until all students have finished reading the background information and watch as a class.
3. Give each pair of students a set of DNA sequences that includes the reference sample from Guinea and 15 Ebola DNA sequences from samples of patients in Sierra Leone. Explain that although Ebola is an RNA virus, scientists studying Ebola and other RNA viruses can use reverse transcription to copy the RNA to DNA prior to sequencing, so the data that students analyze is DNA, but the actual genetic material inside the virus particles is RNA.
4. The shaded nucleotide sequences, labeled 1-15 represent mutations that occurred in these different viruses compared to the reference sequence. (Keep in mind that the reference sequence is from a virus that was present at the start of the outbreak.) Move the Ebola sequences 1–15 around to identify patterns in the mutations.
5. Students should then group sequences according to any patterns they see.
6. Remind students that every sequence should be in a group, even if they are not identical. They should use their groupings to answer the analysis questions.
7. Begin a discussion with the group about Ebola and evolution, using the questions from the student's worksheets and questions from the teacher materials as a guide for discussion.

**ASSESSMENT SUGGESTIONS**: To assess each objective, give the following short quiz as an exit slip or bellringer for the next class meeting:
1. Compare genotype and phenotype.
2. Explain how genotype influences phenotype in Ebola virus and in living things.
3. How has the Ebola virus changed over time? How does that relate to evolution?

**EXTENSIONS:**

LITERATURE: There are quite a few other Ebola-related exercises listed in the teacher materials from the HHMI activity.

**RESOURCES/REFERENCES:**

https://www.hhmi.org/biointeractive/ebola-disease-detectives- This site contains all the parts of the lesson, including student worksheets and printable genetic strips.