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Evolution

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Introduction:

The design of my unit plan is to remodel and restructure the traditional instruction of the evolution unit, designed for most biology classes, to be more relevant and more current to our students' perspectives.

Science has been difficult for most of our students to comprehend and the expected level they should be. According to the *2023 School Accountability Report Card*, out of the 90% of students who have taken the California Assessment of Student Performance and Progress test, only 14% either have met or exceeded the science standard. However, looking at the report closely shows that the majority of the students who did not meet the science standards, showed they were "nearly met" with 70% of 11 grade students and 85% of 12 grade students who took the test in 2022-23. When focused on my subject matter (biology), only 4% of all 11 grade students met the standards. This data informs us that between 9th and 11th grade, our students are not retaining the content that is specific to biology. And although both physical and earth science was higher than biology (5.03% and 5.02%, respectively), [science] content is not being retained. My understanding of this is that the content does not relate to our students. A conversation I have had with some previous students is that they do not understand how biology is relevant to them, despite biology [loosely] meaning: the study of life. I want my unit to have a relevant story for my students to understand. Evolution is a difficult subject to discuss and present to a younger audience, due to no current notice of evidence of evolution.

I have been teaching for 3 years now, and I think my intentions as a teacher are as follows: I want to teach these students content material that I believe today's adults should have learned. I am also a firm believer of showing empathy to all organisms that are not humans. Some of my students who do well, have a basic understanding of organisms and their purpose on this planet. However, those who struggle, have a harder time to connect the contents that I teach and how that relates to their world/community. Because of this, apathy increases in learning and understanding the material. In turn, this affects understanding how ALL living organisms have a purpose in the biome. My evolution unit will try to highlight a potential problem that my students will have to face in the biomedical field by showing evidence of how bacterial diseases continue to evolve and become more resistant to antibiotic drugs. Since minor to severe bacterial diseases affect humans, I am hoping I can stress the importance of innovating and evolving modern medicine to keep up with the evolution of infectious diseases. In doing so, this is how we can have a personal connection. My intention is for my students to understand the importance of evolution, but also to realize that we need to problem solve

what we need to do to advance modern medicine.

Before continuing this unit, I feel like it is important to note that this is purely to focus on the concept and evidence of Evolution in a biology class. Although the unit does involve content specific information about genetics and cells (both of which have their own unit structures and content that also needs to be taught to a high school audience), evolution is the main highlight of the unit. Therefore vocabulary, labs, and activities are to reflect the content and evidence of evolution.

Rationale:

The purpose of this unit is to help improve the classic curriculum of evolution. Normally, the curriculum includes the formation of the Earth, the Cambrian explosion, cells forming into organisms, dinosaurs and fossils, human evolution, and natural selection. Although all important information, it does not have an appreciation among our younger generations in high school. It has been my job to make sure that I make what I teach relatable and understandable biological content to my students.

Therefore, I want my unit to have something that the students would care about, such as a case study involving a kid with an antibiotic resistant bacterial infection that is considered as life threatening. This would change the focus on human evolution to a more medical focus. Because this is something that they will likely have to face in the future about the overuse of antibiotics, they will learn about its severe consequences. Introducing them to Addie Rerecich, who, in 2011, contracted a life threatening antibiotic resistant bacterial infection. This will invoke an empathic response that I want them to have where they will care about what is going on with the future of modern medicine.

I plan on using this unit at the start of the academic school year. I want to start biology from a “Macro” perspective on the content, and end the year with a “Micro” perspective. However, I know it would take a while for the students to understand the theory of evolution, I do believe that teaching in this method could help with engagement.

Content Objective:

The unit will have students’ focus on the following:

Case study:

In 2013, Addie Rerecich was an active 11-year-old girl in Tucson, Arizona.[7] One night, she mentioned to her mom, Tanya Rerecich, that she was feeling pain in her hip. Her mom figured that she must have injured herself a bit while doing one of her activities. Tanya only gave Addie ibuprofen, in hopes that this would help her with her pain. Later that night, the pain got worse and they had to take her to the emergency room. That is when they found out she had a methicillin-resistant *Staphylococcus aureus* (MRSA) bacterial infection in her body. At this point, the bacteria had already spread to Addie’s bloodstream. The doctors would give her a

series of antibiotics to fight the bacteria. The treatment would leave Addie in a state of recovery-relapse scenario, where she would be fine for a series of days, but then fall back ill until the doctors gave her a different set of antibiotics. Afterwards, the doctors had exhausted all their options and had the idea of administering an Extracorporeal Membrane Oxygenation (ECMO) procedure. ECMO is an invasive procedure where a machine oxygenates blood for the patient, then returns it back to their body. There are many risks to this "last-resort" procedure, as medical equipment may not be clean enough for such an invasive treatment. Unfortunately, this was the case for Addie who contracted a new antibiotic resistant bug, *Stenotrophomonas maltophilia*. *S. maltophilia* is commonly found in healthcare facilities and is a serious threat to human health because of antibiotic resistance as well. Tanya had to beg and fight for a lung transplant for her daughter, as it was possibly the remaining option for her daughter to live. Which ended up working! However, not without consequences. Addie has to take a treatment mixture of different medications to ensure her health after her fight with the superbug, and has gone through a lung transplant at a very young age.

Evolution Terminology:

Evolution terminology will be taught first to the students, to make sure they have a handle on the relevant definitions. The terms include natural selection, genetic variation, mutations, phylogenetics, etc. Beyond making sure that students have an understanding of known terminology expected during this unit, additionally these terms will be used when focused on the medical information of antibiotic resistant bacteria.

1. Natural Selection-Differential survival or reproduction of different genotypes in a population leading to changes in the gene frequencies of a population. The conditions required for the operation of evolution by natural selection include variation, a system of heredity, differential reproduction, and time.[17] Students need to know that bacteria that are antibiotic resistant can be favored for fitness relative to other variants, and thus can replicate and proliferate in antibiotic environments.
2. Artificial Selection-the method where particular traits are changed in populations by humans choosing which individuals are allowed to breed, thus designing traits according to human preferences. This is seen in domestication. Students need to know the difference between Natural Selection and Artificial Selection, with examples of how to identify a species that evolved via one or the other process.
3. Adaptation-A trait that evolved because it fosters better survival or reproduction in the environment. This term is to help students understand how a population of organisms can react to changes in an environment, if it is selected to better survive and reproduce.
4. Genetic Variation-the presence of differences in sequences of genes between individual organisms of a species. It enables natural selection, one of the primary forces driving the evolution of life.[12] Students need to understand how genetic variation is "created" in an organism with examples of what that looks like
5. Mutations: Random events in DNA/RNA that can occur during mitosis/meiosis/Cell division. There are different types of mutations, such as:
    a. Silent Mutation: A mutation where a nucleotide substitution that codes for the same amino acid; therefore, there is no change in the amino acid sequence or protein function.[11]
    b. Nonsense Mutation: A mutation where protein production has stopped prematurely. Could have serious consequences, where the protein is not functioning properly.
    c. Frameshift Mutation: A mutation where an extra nucleotide (either insertion or deletion) shifts the original mRNA, could lead to a Nonsense mutation or an overproduction of amino acids for a protein that will not work properly. VERY SEVERE
6. Phylogenetics or Phylogeny: A method of analyzing how organisms can be related, on a genomic level. A phylogenetic tree is used often when explaining how species share common ancestry shown by a

branching pattern. This term is for students to understand about bacteria (or multicellular organisms) being able to evolve from an earlier ancestor or form and what it currently is today.

7. DNA/RNA (Deoxyribose Nucleic Acids/Ribose Nucleic Acids): Genetic Code for all living organisms. Students should know that evolution is focused on an organism's genetic code. **DISCLAIMER**: You can mention what DNA/RNA is, however be careful not to go full in detail. We will discuss DNA/RNA during the genetics unit.

Students need to know this term and the subcategories to know when a mutation occurs. Mutations in any species is a sign of potential evolutionary change, if it is favorable to survive[7] .

Microorganism Biodiversity:

For this content, it is important for students to understand that although we do get sick from bacteria, most bacteria are not relevant for human health. I would not worry so much about the different types of bacteria that exist, but to focus on the observation that bacteria exist everywhere and that some are "bad", whereas most are "good" bacteria in terms of Earth's ecosystems and for interactions with other organisms, such as our beneficial microbiome. The Bacteria Lab will help with this understanding for the students that bacteria are everywhere (more under the activity section). That being said, the following information should be taught to your students when focused on bacteria:

- Gram Positive vs. Gram Negative Bacteria-Gram-Positive versus Gram-Negative bacteria details a key difference in the cell wall structure of the two major bacteria groups. The outer membrane of the cell wall of the bacteria is present in one (Gram Negative) versus the other (Gram Positive). This plays a part in human health because one group of bacteria can trigger the immune response and can evolve resistance to antibiotics (Gram Negative). And although Gram Positive bacteria can still trigger diseases, they can be more often treated successfully using antibiotics because of the lack of the protective outer membrane. Students need to understand that the outer membrane layer of the cell wall structure is the reason why antibiotic resistant bacteria (Gram Negative) are more favored for fitness in disease, thus the issue of dealing with them can be difficult[10] .
- Bacteria vs. Viruses-Bacteria are living, single-celled organisms that can survive and reproduce on their own. They have similarities to other cellular species, such as the ability to maintain homeostasis, use nutrients to survive, and reproduce. Bacteria can often be treated with antibiotics. In contrast, viruses are not made of cells; they are composed of genetic material (RNA or DNA) surrounded by a protein coat called a capsid. Unlike bacteria, viruses cannot function or reproduce without infecting a host cell. This fundamental difference makes viruses more challenging to treat, as they require a host to multiply, and most treatments focus on supporting the immune system rather than directly targeting the virus.[1,4]

DO NOT talk about the total structure or morphology of the bacteria, as that is all for the cell unit. Focus more on the evolution of bacteria and less about the functionality of bacteria.

Medical Information:

Students will be getting a lot of medical terminology and information that would need to be broken down/scaffolded for them to understand better:

1. Antibiotics-medication prescribed to treat bacterial infection. Explain to students what they are, the history of antibiotics, the advancement of modern life and human existence, and their current problem about overusing or underuse of antibiotics.

2. Superbug-A bacteria that is Multi-drug resistant. Elaborate on what a “superbug” is, why it got its name, and how come they are our current issue.
3. MRSA (Methicillin-resistant Staphylococcus aureus)-A “superbug” strain of S. aureus that is resistant to methicillin and typically other antibiotics as well. This is necessary when focused on the case study.
4. ECMO (Extracorporeal Membrane Oxygenation)-A medical procedure where a machine filters and oxygenates a patient's blood. This is necessary when focused on the case study
5. The rate of bacterial growth-The speed of proliferation for any bacteria. The students need to understand how quickly bacteria can grow in a matter of hours. A graph detailing the rate of growth would be ideal. I would get examples of different types of cells and bacteria species that have different rates of growth.

Evolutionary Medicine:

The content and focus of the unit is on Evolutionary Medicine. Evolutionary Medicine is defined as the use of modern evolutionary approaches to better understand human health and improve disease treatment. A central question in evolutionary medicine is this: Why has natural selection left our bodies vulnerable to disease?[16] For this, you must use the concepts of traditional evolution content normally taught at a high school level, and combine with the information of how bacteria are organisms who are currently evolving to build a resistance towards .

Last Resort:

I plan on having my students do a research project involving different types of superbugs. The final thing I want them to consider, is a patient’s last resort option. You may need to have a list of options for them to consider. Last Resort options could be the following:

1. Organ Transplant-Organ transplants can have a series of risks including the body rejecting the organ or the organ giving the patient cancer, if the donated organ was from someone who either has a history of cancer or a family history of cancer[7]
2. Invasive Procedure-Procedures that may have high risk include general surgery in a highly infected area or a method, like ECMO, where risk of sepsis exists (Sepsis is a life-threatening condition that arises when the body's response to an infection causes widespread inflammation.) Essentially, it's the body's extreme reaction to an infection. or other “superbug” infections can occur. Added risk may include if the patient is immunocompromised or if the patient is an older patient.
3. Experimental Medication-The high risks of experimental medication can result in a medication not working or a medication with extremely volatile results such as other organs or cells being targeted versus the actual pathogen causing the problem. Chemotherapy is a prime example of this, but other drugs can also have this effect.
4. Amputation-This option is considered when the infection is located on and spreading to the extremities of the human body. However, amputation may not always resolve the issue, so regular reexaminations are crucial for ongoing care. It’s important to note that the patient will lose a limb permanently.[8]
5. Death-This is if there are no other options and up to the patient to decide. It is the job of the medical professionals to make sure the patient is comfortable during “end of care” treatment.

Research and Note taking:

A unit assessment that I will perform with my students is to do a research project about a “superbug”, the antibiotic that is failing to treat the bacteria infection, the moment the bacteria become resistant to the

antibiotic, and possible last resort ideas. I mainly have incoming 9th graders in a high school class, who likely have not done a research project before. So, it is best to talk about doing proper research.

I would collaborate with the school librarian when talking with students about their research. I would invite the librarian as a guest speaker and come up with an exercise with the students to practice how to do proper research. For example, they could do an activity where they research a personal interest to them that is culturally relevant [2,3] .

Note taking should also be taught when doing research. Teach the students on different methods of note taking and practice.[19] It is important to talk about linear note taking (i.e. outlines or transcribing) versus non-linear (i.e. mind maps or Cornell notes) and have your students self-assess what works best for them[3] . Talk to the librarian, or an English or History teacher about how they prepare their students to do research for their classes, if you need more assistance.

Graphing:

Rate of growth is important to understand the speed of how all cells can proliferate. According to Next Generation Science Standards (NGSS) HS-LS3-3, HS-LS4-1, HS-LS4–2, and HS-LS4-3, these standards focus on a student's ability to use statistical data, analyze the data, and communicate the explanation of growth of an organism. This requires students to understand and interpret scientific models, such as graphs and images. For students to understand this, they must understand how to read a graph. Teach students the difference between an independent and dependent variable, how to properly label a graph, the different types of graphs that they overall may see in the class or in society (such as bar, line, and pie charts), and practice how to make a graph using an example dataset (more during the activities section). Later, give them an exercise on how to communicate on the graphs. All of this will prepare them to understand the rate of growth of different types of bacteria species.

Claim, Evidence, Reasoning (CER)-CER is an argumentative style of writing. In science classes, CERs help students practice their writing to support their scientific claims using evidence that they have found, and why they are using this particular evidence. I do this almost every opportunity in my lessons, but for this unit, it helps you execute NGSS standard HS-LS3-2, HS-LS4-2, HS-LS4-4, And HS-LS4-5.

Teaching Strategies:

Gallery Walk:

I plan on exercising my students' note taking skills by having them analyze random graphs. The graphs will not have any significance to the case study or unit in general, but will exercise their understanding of "how to read a graph". The gallery walk will have students look at their peers' analysis and give feedback on their peer's note taking ability. This will also help students learn what a scientific model is, what is the importance of a graph, and how one can analyze a graphical representation of data.

Exit Tickets:

Exit Tickets will be given at the end of each week to check in on student's understanding of the lessons of the

week, any terminology, or their comprehension of reading that was given. If I see there was a lack of understanding in a subtopic, then I will review the topic starting the following week of each lesson. This will make sure that students are reviewing information or fixing any mistakes they may have made, but can correct themselves.

Inquiry-Based Learning:

Students will watch portions of the "When Antibiotics Don't Work" documentary[5] focused on the case study. And a series of open-ended questions will be asked to spark discussions about what are ideas or possible scenarios that can occur during Addie's stories. And slowly I will reveal new information about Addie's case during a lesson. This will have my students practice their critical thinking ability and see if they are thinking both logically and creatively.

Group Presentation:

Groups and cooperative learning will be a key part of a summative unit project. Students will research a superbid, exploring its origin, history, the antibiotic initially developed to combat it, how the bacteria developed resistance, and the current status of the bacteria, determining whether it is common or rare for humans to contract the disease. This project will allow students to practice their argumentative skills (using the CER framework) and enhance their ability to work collaboratively. Finally, students will review all last resort treatment options and decide on the final action a patient might take if all other treatments fail.

Activities:

Activity #1-Sit Spot

Sit Spot is an activity that focuses on a student's observation and note taking skills but doing scientific illustrations. To perform this activity, you need the following materials:

- Flowers and plants
    - You can either use your schools landscape if there are plants and flowers around, or you may need to purchase or harvest samples to be used
- Color Pencils, Markers, Crayons
- Notebook paper

This activity should be done after going over the note taking lecture. Students will spend 30-45 minutes to sketch a chosen sample and to write notes about what they observe. Emphasize the importance of using the human senses (specifically touch, sight, and smell) to give the best description. It is important to note that the point of the exercise is not to be the best drawer, but to see how accurate and precise the student is with being detailed in both their illustration and note taking. REMIND THEM TO TAKE THEIR TIME AND DO NOT RUSH! This activity can be graded or not graded. If graded, we are assessing if the student is accurate with their scientific illustrations and if there are detailed notes.

Activity #2-Research Exercise

This will need to be in collaboration with the school librarian, or if you would like to execute on your knowledge. Research is important because students (and adults) need to learn to actually investigate to see if a claim is true or not. This should be done after the research lecture. Emphasize on the importance of primary and secondary sources and how to take proper notes. A graphic organizer of “Who? What? Where? Why? And How?” would be useful for students with their reading comprehension of articles, news stories, and YouTube videos.

The activity is focused on student interest. Encourage the students to use a personal interest (such as pop culture or cultural practice or something they have been curious about) and expand their learning on said subject. The starting question should be: “What Can We Learn About Our Interest?” To scaffold this, you may need to have a prepared slide of your personal interest to showcase. Make sure you are using good research techniques, such as acknowledging the source where you got the information, the length of your information (if you decided to write a paragraph or have a 2-3 slide presentation), and having a work cited page/slide. This activity can be graded or not graded. If graded, we are assessing the students' usage of citations and acknowledgments, if they actually got it from a primary or secondary source (not Google), and if they can communicate their research in a nice and concise presentation or paragraph essay.

Activity #3-Natural Selection Lab

This activity should be executed after students have learned about graphs, as well as the concepts of Natural Selection and Survival of the Fittest from the relevant lectures. The activity will use the Natural Selection Simulation from the University of Colorado-Boulder PhET Interactive Simulations Website. You can either create your own lab activity focused on the simulation or use the preset activity provided by PhET. In this activity, students will explore how the fur color of rabbits and their environment impact the survivability of specific traits. They will analyze how the independent variables (fur color and environment type) correlate with the dependent variable (the number of rabbits remaining after a wolf pack feeding). After completing the simulation, students will create a graph to visualize the data and defend their conclusions (using the CER framework) on the importance of fur color and environment in natural selection and survival. This lab will be graded, and we will assess whether students correctly plot the exponential graph of the rabbit population, input the data into a data table, and interpret and analyze the collected data.

Activity #4-Bacteria Lab

This activity is designed to demonstrate to students that bacteria are everywhere and provide them with a hands-on application to observe this. It aims to engage students by showing how bacteria can be easily sampled from everyday objects and grown without the use of a microscope. Although bacteria are ubiquitous, our bodies have defense mechanisms that protect us, though some bacteria can still be harmful. In this exercise, students will touch various objects with their cleaned hands or use a sterile tool to collect samples. They will then gently apply the samples to the surface of an agar plate. After closing the agar plate and wrapping it in Parafilm (or tape), they will give the plate to their instructor to incubate for at least 24 hours. This will allow bacterial growth (colony formation) to occur on the agar surface, which the students can then observe and analyze. The following materials are needed:

- Agar Plates
- A form of sterilization (hand sanitizer or loop and fire)
- An incubator or a warm dark area

- Parafilm or tape
- Sharpies
- Gloves

It is important to have some questions for them to hypothesize versus having them come up with their own questions. Example questions can be:

- "Who Has the Cleanest Phones?"
    - Zone out the Agar Plates into 4 Zones, with one zone being a control. Have students test their phone and 2 other students' phone
- "Are Bacteria Growing in My Backpack?"
    - Zone out the Agar Plates into 4 Zones, with one zone being a control. Have students pick 3 items they use all the time in their backpack and swab to see if bacteria is growing. Which item do they believe will have the cleanest sample.
- "Where At School Is the Cleanest?"
    - Zone out the Agar Plates into 4 Zones, with one zone being a control. Make sure you let your school know that your students will be out collecting samples. Have your students think of 3 places on campus they believe are the cleanest.

Remind your students that to reduce contamination, they need to sterilize their hands or their loop tool every time, before they collect more samples. This can be graded or not graded. If graded, we are assessing if the student can read instructions, identify the independent variable, generate a hypothesis, and discuss their results.

Activity #5- "Superbug" Research Project (Unit Assessment)

This is the Unit Assessment where we will see the student's research skills, argumentative skills, use of graphical representations or other scientific models, and critical thinking ability. Can be done in groups or individually (I will do groups for the cooperative learning teaching strategy). Have a list of "superbugs" from which they choose. They are to do the following:

1. A history of origin of their superbug. Where was the first case that observed the bacteria?
2. A common antibiotic that was used to treat the bacteria.
3. When did we start to see resistance towards the medication?
4. A possible "Last Resort" option that patients may try to use.

Rubric will be used for students to see what criteria they will be graded on.

Philosophy:

Since I have started teaching, my goal has always been to teach my students content that I want adults to know. Through my own personal observations on most adults, especially those in political power, there has been very little to no understanding of science knowledge. These are the same people in power who have made incorrect comments about simple science information such as the following U.S. politicians: former President Donald Trump, Marjorie Taylor Greene, Robert F. Kennedy, Jr., Rand Paul, Ron DeSantis, and many

others. Although some of the comments made by these figures can be seen as “outlandish” and “ridiculous”, they still have decision power when it comes to scientific understanding and policy. Which in turn can be harmful and dangerous for the U.S. constituents that these people represent. Although there are some elected officials with a science background, those numbers are in the minority. And we need more figures in political power, with at least a strong basic knowledge of science information.

This is why I believe it is important to teach kids how science affects their everyday life. Now, science is normally a “hard” subject for most students to understand. However, I feel that they view science as “hard” because it is difficult for students to understand how science relates to them personally. This is the motivation for my unit; I want to design a unit where they can have information and knowledge on a topic of relevance to their lives. Maybe not a current problem, but one that they may face in their future. It is the same approach I have with teaching about plants and deforestation. Just as I emphasize the importance of scientific literacy in understanding how deforestation impacts ecosystems and the planet, I aim to equip my students with the knowledge they need to critically evaluate environmental issues and policies. By making these connections, I hope to foster a deeper understanding of how science affects real-world decisions, both in environmental contexts and beyond.This generation, and future generations, need to have a better grasp of basic science knowledge. This is why I am passionate about being a teacher today.

Appendix of Implementing District Standards:

Following Standards come from the Next Generation Science Standards:

- HS-LS2-7: Design, Evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity ***“This standard is used to understand how humans have an impact and how our actions directly affect the evolution of these microorganisms. Students will have to understand the problem with overusing antibiotics and how climate change can also affect the potency of bacterial diseases”*** [11]
- HS-LS3-1: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. ***“Normally, this standard does focus on humans and how traits are passed. However, bacteria are able to reproduce asexually. So, if rapidly reproducing bacteria are immune to antibiotics, they can reach a very large population size that causes serious damage to the human body”*** [4]
- HS-LS3-2: Make and defend a claim based on evidence that inheritance genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. ***“This standard can demonstrate how if an organism is a variant that can better survive an environmental effect (such as bacteria genotypes that survive an antibiotic treatment or insect genotypes that survive a chemical pesticide), then the variants and their beneficial traits will increase through future generations.”***
- HS-LS3-3: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. ***“We will practice reading data focused on the effectiveness of antibiotics and the resistance of bacteria.”***
- HS-LS4-1: Communicate scientific information that common ancestry and biological evolution and

supported by multiple lines of empirical evidence. ***"This standard reflects the student's understanding of phylogeny."***

- HS-LS4-2: Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increases in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. ***"This standard reflects on the student's understanding of how natural selection can affect the population increase of bacterial diseases that are antibiotic resistant. Since we are examining how bacteria evolve to develop traits that favor survival against antibiotics, particularly in the context of human health, it's crucial to understand the implications for treatment and prevention. They should also be able to realize that humans need to come up with a solution to this problem."***
- HS-LS4-3: Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait ***"This standard reflects on student's interpretation of graphical representations of growth rate. Additionally, the inferring and predicting of what could potentially happen with the bacteria are still in conditions of survivability"***
- HS-LS4-4: Construct an explanation based on evidence for how natural selection leads to adaptation of populations ***"This is useful when explaining how bacteria can survive after an antibiotic treatment and continue to attack the human body."***
- HS-LS4-5: Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species ***"This is the prediction portion of standard HS-LS4-3"***
- HS-LS4-6: Create and revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity ***"This is the prediction portion of standard HS-LS4-3"***

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