Environmental Science Institute
THE UNIVERSITY OF TEXAS AT AUSTIN

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Bacteria: Combatting Their Proliferation

Lesson Plan for Grades 9-12
Length of Lesson: 1 hr 30 min

Authored by: Mohammad Kamyab Javanmardi for UT Environmental Science Institute
Date created: 05/18/2015

Subject area/course: Biological Sciences/Biology

Materials:

- 1 computer (with internet access) per student or pair of students
- 1 worksheet (Elaboration and Exploration) per student
- Chalkboard or screen w/ projector (for Instructor's use)

Safety: Teacher should follow internet safety protocols to ensure a guided and effective use of online material during lesson activities. To do so, teachers may want to check the safe-search status for each online device.

TEKS/SEs

- §112.34. Biology, Grade 9^{th} – 12^{th} (4A, 7E, 7G)

Lesson objective(s): Students will be able to…

- Compare and contrast prokaryotic and eukaryotic cells.
- Analyze and evaluate the relationship of selection pressure to adaptation and to the development of diversity in and among species.
- Analyze and evaluate scientific explanations concerning the complexity of the cell.

Differentiation strategies to meet diverse learner needs:

- This lesson is designed to be delivered during the cell biology unit. Students are expected to have some understanding of fundamental cellular components. Additionally, students should be familiar with some of the differentiating characteristics between prokaryotes and eukaryotes.
- If students have difficulty with the engagement portion of the activity. The lesson can be divided into two separate days. The first day would consist of a "review" of cell components and prokaryotes vs eukaryotes. The second day would consist of the following lesson plan and its described activities.
- Students with specific learning disabilities can be accommodated with supplemental videos. - (see "Prokaryotes vs Eukaryotes video" and "Parts of the cell" in resources section)

ENGAGEMENT

- Instructor will create a large Venn-diagram to compare and contrast prokaryotic and eukaryotic cells. Students will use their previous knowledge from earlier in the unit to fill in the diagram - (see "Eukaryotic Cell vs. Prokaryotic Cell" in resources section)
- Instructor will address the common misconception that all single celled organisms are prokaryotic (yeast cells are eukaryotic and unicellular). Instructor will continue by explaining that vast numbers of eukaryotic cells (our body cells) and prokaryotic cells (different types of bacteria on and in our bodies) both compete and

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cooperate to survive/thrive. There are 10 times more bacterial cells in our bodies than somatic (eukaryotic) cells.

- Based off of the students' understanding of eukaryotes and prokaryotes, they will collectively analyze images of cells under microscope to determine whether they are eukaryotic or prokaryotic. – (see "Microscope images of cells" in resources section)
- Instructor will explain that illnesses can often be caused by the spreading and multiplication of certain bacteria in the body. Once the body becomes "infected" with bacteria, it can either fight off the bacteria and develop a natural immunity, or we can use various drugs and vaccinations to help prevent and fight off infection
- "Before we can dive into the details of how we can fight infections, let's explore a simulation which models infection in a small population."

EXPLORATION

- Instructor leads a discussion which addresses various mechanisms for infection: sneezing, coughing, sharing drinks, intermediate contacts (surface to hand to mouth), etc.
- Students work either individually or with a partner, on an internet capable device, to access the infection simulator. – (see "Interactive: Spread of Disease" in resources section)
- Students then follow the instructions on their worksheets to observe a possible infection scenario. It is important to note that this model focuses characterizing infection via contact and tracks the change in three different categories: susceptible individuals, infected individuals, and recovered/immune individuals.
- Students should be answering the questions on their worksheets as they complete the activity. Once complete, students may either await further instruction or continue by freely experimenting with the simulation.

EXPLANATION

- Once the class has completed the activity, the instructor will gather the class and initiate a discussion about the simulation by asking questions such as:
    - What were the possible "states" an individual could be in at any point in the simulation?
    - What did the ratios of these individuals look like over time (the time dependent graph)?
    - What were some basic variables that this simulation did not account for? – ex. deaths, population growth, various methods of spreading infection (other than direct contact).
    - Why is it that the entire population does not become permanently immune to the infection?
- The instructor will then lead a discussion about antibiotics by highlighting that drugs are chemicals that often target particular cellular components and structures. How can drugs harm prokaryotic (bacterial) cells without causing harm to eukaryotic (somatic) cells? The answer is that these drugs often target cell components that are unique to prokaryotic cells and not eukaryotic cells (such as the ribosome). – (see "How Antibiotics Work" in resources section)
- "Just as humans can develop a resistance to specific strains of bacteria, bacteria can also mutate and evolve to develop resistance to antibacterial drugs."

ELABORATION

- Instructor will explain that antibiotics work in different ways to get a similar end result, to stop the proliferation of that bacteria. There are two main approaches: One is to actively kill the bacteria by harming

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one or several of its key cellular components (this is a bactericide), the other is to prevent the growth and multiplication of the bacteria (this is a bacteriostatic). – (see "Stopping Bacteria" in resources section)

- Students will get into groups of 4 and access their internet capable devices. Next, they will access the specified website on their worksheets to help them devise both a bactericidal drug and a bacteriostatic drug. – (see "Guide to Prokaryotes and Eukaryotes" in resources section)
- To design the antibiotic drugs, students will focus on targeting components unique to prokaryotes that would essentially stop growth or kill the bacteria directly. It is important to note that this activity is not intended for students to learn and study the complicated biology and chemistry underlying specific antibiotics. Rather, it is more important that they use creativity and critical thinking to develop ideas for potential drug targets within the cell and justify why they would work to kill bacteria or inhibit their growth.
- Students will use their worksheets as a template to help guide the activity.

EVALUATION

- Each group will present their plans for their bactericidal and bacteriostatic drugs to the class. This will give other groups an opportunity to see how their ideas compare to those of other groups. Once again, it is important to emphasize that these antibiotic designs don't necessarily have to be realistic. They just need to be logical and well explained.
- Students will also have an opportunity to comment on other groups' ideas. It is the instructor's job to help keep the discussion/comments focused but open (minimal input from instructor).
- The instructor will wrap up the lesson by explaining that bacteria can often rapidly evolve to counteract the mechanisms by which certain antibiotic drugs work. For example, if a drug targets specific molecules in the bacteria's ribosome, the bacteria can alter the ribosome's molecular composition such that the drug could no longer have an effect. Thus there is a constant battle between prokaryotes and eukaryotes to keep each other in check.

SOURCES AND RESOURCES

- Dr. Contreras Hot Science – Cool Talks Lecture #96
- Eukaryotic Cell vs. Prokaryotic Cell - http://www.diffen.com/difference/Eukaryotic_Cell_vs_Prokaryotic_Cell
- Microscope images of cells - http://emp.byui.edu/wellerg/The%20Cell%20Lab/Prokaryotic%20Cells/The%20Prokaryotic%20Cell.html
- Parts of the cell - https://quizlet.com/7884205/7-cell-parts-and-their-functions-flash-cards/
- Prokaryotes vs Eukaryotes video - https://www.youtube.com/watch?v=WRO-DPyB9Bk
- Interactive: Spread of Disease - http://www.shodor.org/interactivate/activities/SpreadofDisease/
- How Antibiotics Work - http://health.howstuffworks.com/medicine/medication/question881.htm
- Stopping Bacteria - http://study.com/academy/lesson/types-of-antibiotics-bacteriocidal-vsbacteriostatic-narrow-spectrum-vs-broad-spectrum.html
- Guide to Prokaryotes and Eukaryotes - http://www.ck12.org/biology/Prokaryotic-and-Eukaryotic-Cells/lesson/Prokaryotic-and-Eukaryotic-Cells/

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EXPLORATION ACTIVITY or ACTIVITIES

Purpose: The first activity is designed to provide students with an understanding how of an "infection" can spread throughout a population of humans. There are various mechanism by which bacteria can be spread from individual to individual. This simulation tracks the number of individuals who are either susceptible, infected or recovered/immune. With an understanding of the overall population, the second activity is designed to stimulate students' creativity and critical thinking be asking them to devise methods by which drugs could control a bacterial population.

Materials:

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- 1 worksheet (Elaboration and Exploration) per student
- Chalkboard or screen w/ projector (for Instructor's use)

Safety Information: Teacher should follow internet safety protocols to ensure a guided and effective use of online material during lesson activities. To do so, teachers may want to check the safe-search status for each online device.

Procedure:

Exploration:

- Instructor leads a discussion which addresses various mechanisms for infection: sneezing, coughing, sharing drinks, intermediate contacts (surface to hand to mouth), etc.
- Students work either individually or with a partner, on an internet capable device, to access the infection simulator. – (see "Interactive: Spread of Disease" in resources section)
- Students then follow the instructions on their worksheets to observe a possible infection scenario. It is important to note that this model focuses characterizing infection via contact and tracks the change in three different categories: susceptible individuals, infected individuals, and recovered/immune individuals.
- Students should be answering the questions on their worksheets as they complete the activity. Once complete, students may either await further instruction or continue by freely experimenting with the simulation.

Elaboration:

- Instructor will explain that antibiotics work in different ways to get a similar end result, to stop the proliferation of that bacteria. There are two main approaches: One is to actively kill the bacteria by harming one or several of its key cellular components (this is a bactericide), the other is to prevent the growth and multiplication of the bacteria (this is a bacteriostatic). – (see "Stopping Bacteria" in resources section)
- Students will get into groups of 4 and access their internet capable devices. Next, they will access the specified website on their worksheets to help them devise both a bactericidal drug and a bacteriostatic drug. – (see "Guide to Prokaryotes and Eukaryotes" in resources section)
- To design the antibiotic drugs, students will focus on targeting components unique to prokaryotes that would essentially stop growth or kill the bacteria directly. It is important to note that this activity is not intended for students to learn and study the complicated biology and chemistry underlying specific antibiotics. Rather, it is more important that they use creativity and critical thinking to develop ideas for potential drug targets within the cell and justify why they would work to kill bacteria or inhibit their growth.
- Students will use their worksheets as a template to help guide the activity.

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TEACHER PAGE(S)

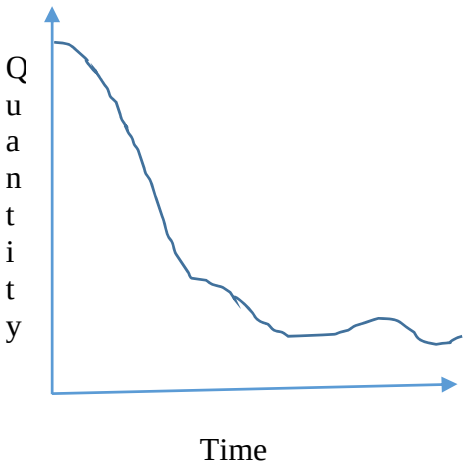
EXPLORATION: Find a partner and obtain an internet capable device (computer or tablet). When instructed to do so, go to: http://www.shodor.org/interactivate/activities/SpreadofDisease/ . You should notice a large grid filled with yellow neutral faces and one sad face. You will also notice that there are various controls and options surrounding the grid window. Follow the instructions below and answer to following questions.

- To begin the simulation, click on "Start Simulation." You will notice the number faces (representing individuals) will spontaneously move around and might even change in color. This simulation tracks how a single sick individual can spread infection throughout a small population of individuals who were originally healthy.

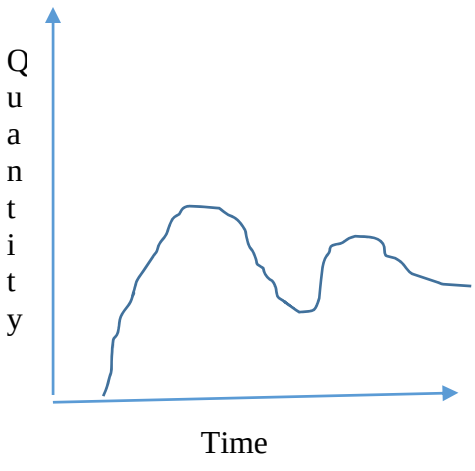
How many different types of faces do you see over time? 3
What does each different face type represent in terms of the simulation? The yellow faces represent healthy but susceptible individuals. The green faces represent sick/infected individuals. The blue faces represent recovered/immune individuals.
How do the faces change from one type to another? What does this mean in terms of the simulation?
It seems that the susceptible faces become infected when they come into close proximity with another infected individual. Over time, the infected (green) faces spontaneously become recovered (blue). This allows the simulation to show how individuals in a population can become sick and then become immune to an infection.

- Pause the Simulation and then Reset the Simulation. Next, locate the speed dial and slide the black block all the way to the left to slow down the speed of the simulation. This will make it easier for you to keep track of what happens over time.
- Start the simulation again try to keep track of the relative number of each type of individual you see over time.

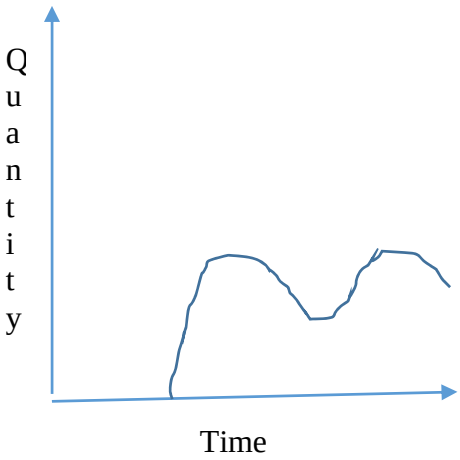
Graph each of the 3 types of individuals separately on the plots below. It is not important to get exact values for the x and y axes, but rather to get a general idea of how the populations of these individuals changes over time.



Face Type: _Susceptible__



Face Type: _Sick__



Face Type: _Recovered__

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- Click on "View Population Graph" to get an idea of what has happened to your populations over time.

Do the results displayed on the graph correlate with the trends you drew earlier? If not, what do you think you missed/didn't understand? It is possible that students failed to comprehend the relative number of individuals in each category over time.

What are some variables/factors that this simulation does not readily account for? This simulation did not account for various mechanisms of infection, it only accounted for infection via direct contact. The simulation also did not include a category for individuals that could have died from the infection. The timeframe of the simulation is not well explained.

- By clicking on "View/Modify Parameters" you can adjust some of the settings on the simulation.

How can you alter the settings to potentially demonstrate how different types of bacteria could infect a population?
If a particular strain of bacteria is more or less infections than others, you could adjust the % Sick Rate. If an infection is hard to recover from, you could also increase the number of Days to Recovery.

Do you notice any changes in the window when you modify one or more of the variables? If so, what do you see and what did you change?
After I decreased the % Sick Rate, I immediately noticed the number of susceptible individuals increased.

ELABORATION: Get into a group of 4 people and obtain access to a couple of internet capable devices (computers or tablets). Using your previous knowledge about cell biology and the following website as a guide, you will be tasked with creating two different types of antibacterial drugs. The first type must be a bactericide which will actively kill the bacteria. The second type must be a bacteriostatic drug which will prevent the bacteria from dividing and/or growing.

Guide: http://www.ck12.org/biology/Prokaryotic-and-Eukaryotic-Cells/lesson/Prokaryotic-and-Eukaryotic-Cells/

***HINT**: A good antibacterial drug will specifically target things that are more unique to bacteria (prokaryotes), so that harm won't be dealt to human somatic cells (eukaryotes).*

Bactericidal drug:
What cellular components does your drug target? Targets the cell membrane specific to bacteria (has different membrane proteins than most eukaryotic cells and even other bacteria).
How will this drug act as a bactericide (kill the bacteria)? Be as detailed as possible. This drug will cause the cell membrane to fall apart and cause the bacterial cell to rupture and die off. Since the cellular membrane is key to keeping the intercellular contents packed together, it is an ideal target for a bactericidal drug.

Name your drug: Ruptenex

Bacteriostatic drug:
What cellular components does your drug target? Passages through cell membrane (specific to prokaryotes)
How will this drug act as a bacteriostatic (stop bacterial growth/multiplication)? Be as detailed as possible.

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This drug is designed to target channels and protein facilitators that allow for nutrients to come into the cell. With these passages being blocked and disabled, the cell will be unable to grow sufficiently to successfully divide. The cell will also eventually starve to death. This mechanism makes this drug an ideal bacteriostatic antibiotic.

Name your drug: Starvanex

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STUDENT PAGE(S)

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How many different types of faces do you see over time? _____
What does each different face type represent in terms of the simulation?

_____
_____

How do the faces change from one type to another? What does this mean in terms of the simulation?

_____
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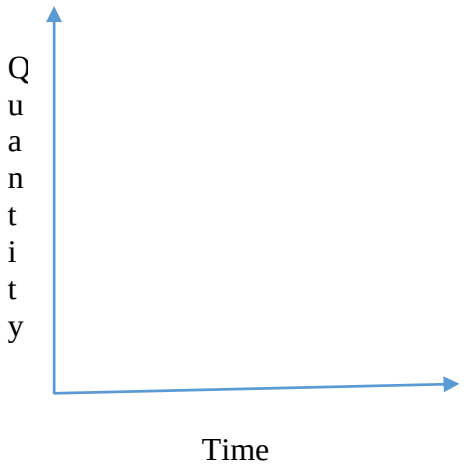
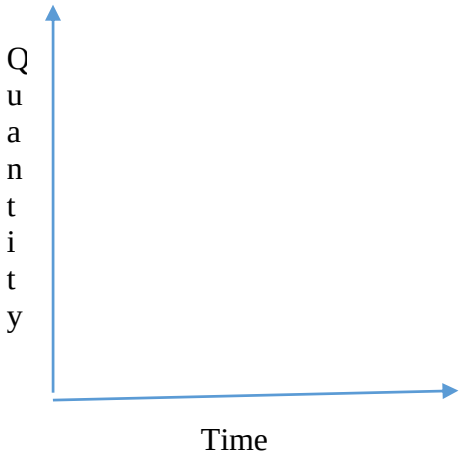
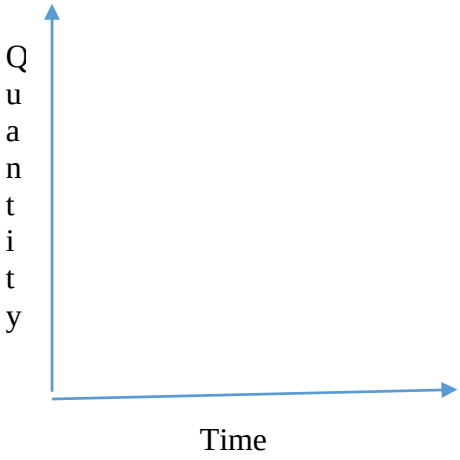


Face Type: _____



Face Type: _____



Face Type: _____

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***HINT**: A good antibacterial drug will specifically target things that are more unique to bacteria (prokaryotes), so that harm won't be dealt to human somatic cells (eukaryotes).*

Bactericidal drug:
What cellular components does your drug target? _____
How will this drug act as a bactericide (kill the bacteria)? Be as detailed as possible.

_____
_____
_____
_____
_____

Name your drug: _____

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Bacteriostatic drug:
What cellular components does your drug target? _____
How will this drug act as a bacteriostatic (stop bacterial growth/multiplication)? Be as detailed as possible.
_____
_____
_____
_____
_____

Name your drug: _____