Lesson 10: Student Activity Sheets

Unit Question:
Why don't antibiotics work like they used to?

NAME: _____

PERIOD: _____ DATE: _____

Lesson 10 **Student Activity Sheets**: How does the antibiotic interact with bacteria in a simulated infection?

INVESTIGATION 1: How does the antibiotic interact with the bacteria?

MODEL VARIATION: Investigation 1

In this next investigation, you will use a model that has many of the same mechanisms in it that it had before. One change to the simulation is the way that the individual bacteria can vary in the starting population. Bacteria don't just vary based on color; they also vary slightly in the structure of their cell membranes:

Notice that each of these four bacteria have a different number of pores (holes) in their cell membranes:

- The purple one shown on the left has three pores in its cell membrane.
- The second one is green and it has four pores in its cell membrane.
- The third one is brown and it has five pores in its cell membrane.
- The fourth one is red and it has six pores in its cell membrane.

PREDICT: Investigation 1

1. If antibiotic particles are released into the simulation, will those particles have the same chance of destroying each of these variations of bacteria when they reach them? Explain.

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These materials were developed with funding through grants from the National Science Foundation, the Gordon and Betty Moore Foundation, Denver Public Schools to Northwestern University and the University of Colorado Boulder.

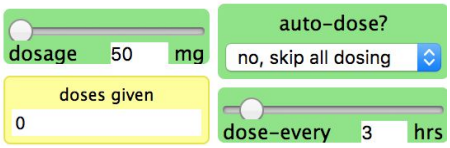
PROCEDURE: Investigation 1

In this next investigation, you will start the model with a population of bacteria in the body and administer only one small dose of antibiotic and record your observations.

A. Go to http://antibiotics.inquiry-hub.net/ to launch the simulation.

B. Set these sliders so that the patient starts with 10 of each individual variation (40 total bacteria):

C. Set these sliders so that the patient will get 50 mg of antibiotic with a single dose:

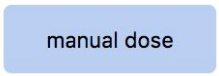


D. Turn the **REPRODUCE?** switch off to prevent bacteria from reproducing:

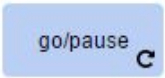
E. Press the ***SETUP/RESET*** to initialize the model.

F. Then press ***GO/PAUSE*** to run the model.

G. Press the ***MANUAL DOSE*** button. You should see antibiotic molecules at the top of the screen and see them start flowing downward.



H. Once all the antibiotic is gone from the environment, pause the model by pressing **GO/PAUSE** again.



I. Record the size of the population at the end of the simulation and the number of each variation in the simulation at this point in the table below.

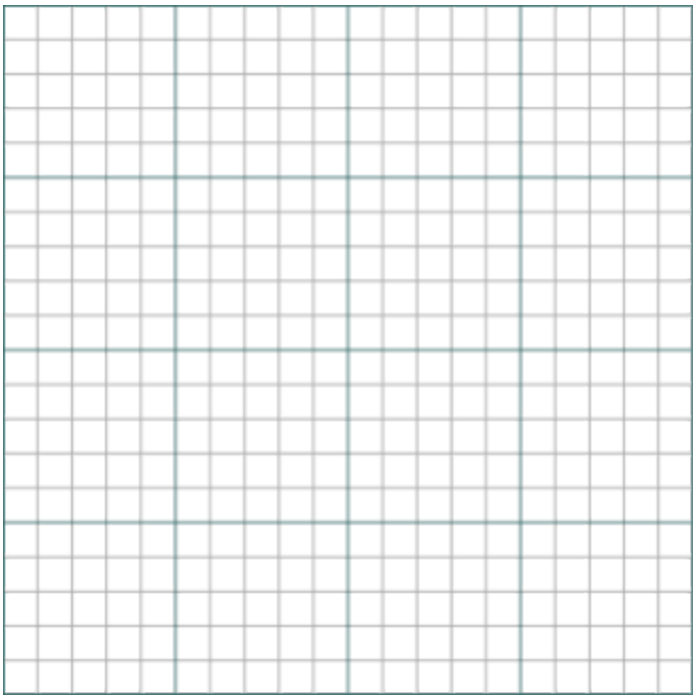
J. Rerun the model a second and third time by repeating the steps above.

OBSERVATIONS: Investigation 1

Variation		At the start of the simulation		At the end of the simulation		
				Trial 1	Trial 2	Trial 3
# of pores in the cell membrane	Color visualization for this variation	# of bacteria	the % of the population that is made up of this variation	# of bacteria	# of bacteria	# of bacteria
3	Purple	10	25%			
4	Green	10	25%			
5	Brown	10	25%			
6	Red	10	25%			
Total bacteria		40	100%			

DATA ANALYSIS AND RESULTS: Investigation 1

2. Compare your results to your other group members and decide how to best pool all of your trials together to determine any trends in distribution of trait variations in the population at end of one dose of antibiotic. Use the space below for any calculations and use the graph for any data visualization you decide to create.



3. At the start of this lesson, you predicted whether releasing antibiotic particles into the simulation would result in the same chance of destroying each of these variations of bacteria. What claim can you now make?

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CONCLUSIONS: Investigation 1

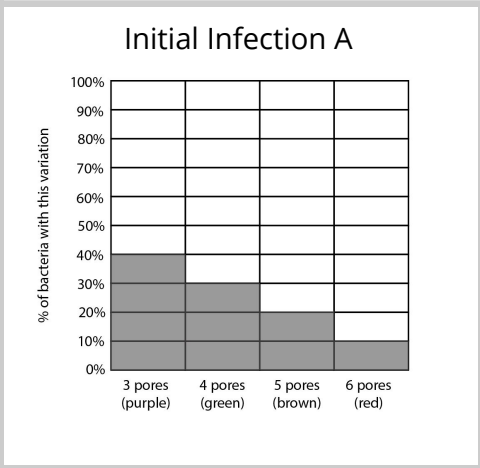
4. In the space below draw a model that helps show why bacteria in this simulation with certain trait variations tend to have a better chance of surviving a single dose of antibiotic compared to other bacteria. Label and annotate your model.

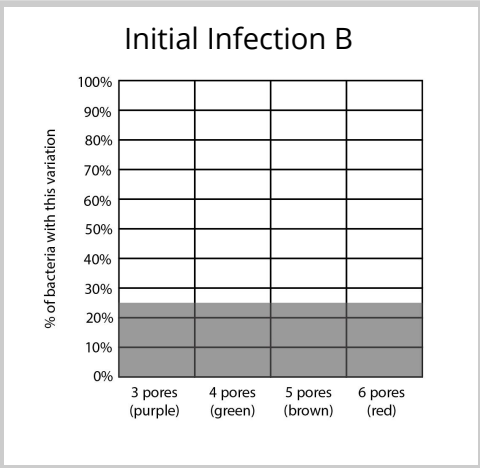
<u>INVESTIGATION 2:</u> How will the combination of both reproduction and antibiotic application affect the bacteria population?

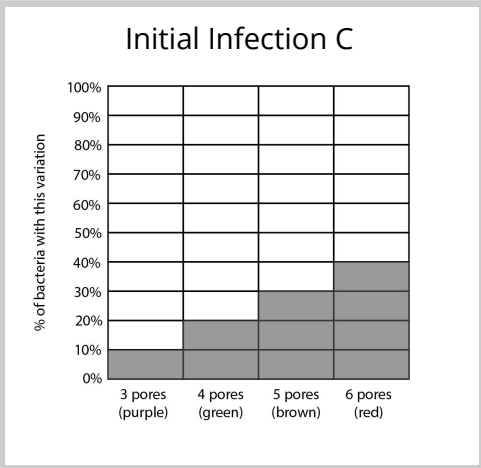
In this investigation, note the following items:

- Bacteria will reproduce every hour (simulated time).
- You will start with 40 total bacteria in the infection.
- In all cases you test, you will add a dose of 150 mg of antibiotics every two hours (simulated time).
- You will test three different cases of infection. In one case, you will start with an equal number of each variation of bacteria in the population. In the two other cases, you will start with unequal distributions of antibiotics. These three cases are shown in the graphs below:

Distribution of trait variations in each infection







PREDICT: Investigation 2

5. Do you think it will take the same number of doses of antibiotic to wipe out all the bacteria each time you run the simulation?

PLAN: Investigation 2

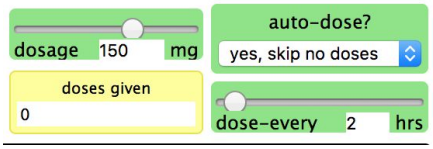
6. Assign each person in your group one case to test. Decide how many times you should test each of the three cases to know what a typical result would be for each.

PROCEDURE: Investigation 2

A. Circle the case that you are testing in the table below. Then set these sliders so that the initial population has the corresponding distribution of trait variations in it.

Initial Infection A	
Initial Infection B	
Initial Infection C	

B. Set the **DOSAGE**, **AUTO-DOSE?,** and **DOSE-EVERY** values to the ones shown here. ---------->



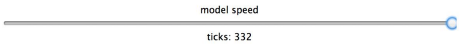
C. Set the **REPRODUCE-EVERY** and **REPREDUCE?** values to the ones shown here. ---------->

D. Press the **SETUP/RESET** to initialize the model.

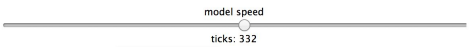
E. Press ***GO/PAUSE*** to run the model.

F. Press the ***GO/PAUSE*** button where there are no bacteria left. Record your observations on the next page.

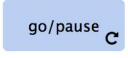
G. One way to speed up the model results is to slide the speed slider to the right.



H. If you do that, the graphs and monitors will update very fast, because the computer will skip drawing the image of the bacteria and antibiotics on the screen. To see the image again, return the speed slider back to the middle.



I. Press the **GO/PAUSE** button when it reaches 750 minutes. Record your observations on the next page.



J. Rerun the simulation as many times as your group decided by repeating the previous steps.

OBSERVATIONS: Investigation 2

Which condition did you start with? (A B C)			
Trial #	Was the infection wiped out?	If yes, how many doses did it take?	When the simulation stopped, which variation of bacteria was the most numerous?

MAKING SENSE: Investigation 2

7. Compare the results among group members. Did it take the same number of antibiotic doses to wipe out all the bacteria each time you ran the simulation?

8. What, if any, outliers did you find?

CONCLUSIONS: Investigation 2

9. We discovered that under certain environmental conditions, bacteria with one kind of variation tended to become more common in the population over time. Which kind(s) of bacteria was this?_____

10. If a patient was infected by a population made up of 40 of this kind of bacteria, would they be as easy, as hard, or harder to eliminate with antibiotics as a population of the 40 bacteria you started with in Investigation 2, Trial B?_____

11. Individual Stop and Jot: How is it possible that applying antibiotics can lead to a population of bacteria developing over time that are more resistant to antibiotics than they were initially?

12: Imagine you want to add a single, antibiotic-resistant bacterium to our simulation that was even more resistant to antibiotics than any of the variations that were in the population to start with. Draw a picture of what its cell membrane would look like. **Why would this structure give it a competitive advantage for survival over the other variations of bacteria from the simulation?**

13: Sketch a graph showing how the introduction of a single bacterium of that type into the environment might affect the proportions of different kinds of bacteria in the population over time:

Incremental Modeling Tracker (IMT):

Document your major discoveries from this activity in the second column of your *IMT*. Highlight which discoveries may help us with our model. In the third column, propose ideas for how you might reflect the discoveries in your model.