Genetic Variation and Survival

Science Grade-Level Expectations
This instructional task addresses content related to the following science grade-level expectations:

LS-M-A7 Identify and describe common communicable and non-communicable diseases and the methods by which they are transmitted, treated, and prevented (GLE 13)
LS-M-D2 Illustrate how variations in individual organisms within a population determine the success of the population (GLE 33)

	Objectives
Task	- Draw conclusions about antibiotic resistance using given data - Predict traits of sample bacteria using trends of survival and growth - Provide evidence to support scientific reasoning
Sample Student Exemplar Response	

Implementation Tips:

- This task is intended to be integrated into a larger unit that contains hands-on science opportunities, student-led investigations, non-fiction reading, and a variety of other instructional strategies.
- Teachers may choose to use or modify the task as part of an instructional lesson or as a formative or summative assessment.
- Strategic instructional decisions will need to be determined prior to implementation such as:
    - Should the provided text be read aloud to students or read independently by students?
    - Will students work collaboratively or individually to complete the task?
    - What content knowledge and skills will students need to have prior to attempting the task?
    - Does the task need to be modified based on the needs of the students at the time of implementation?

- View the video, *[The Science Behind Drug-Resistant Bacteria]*.

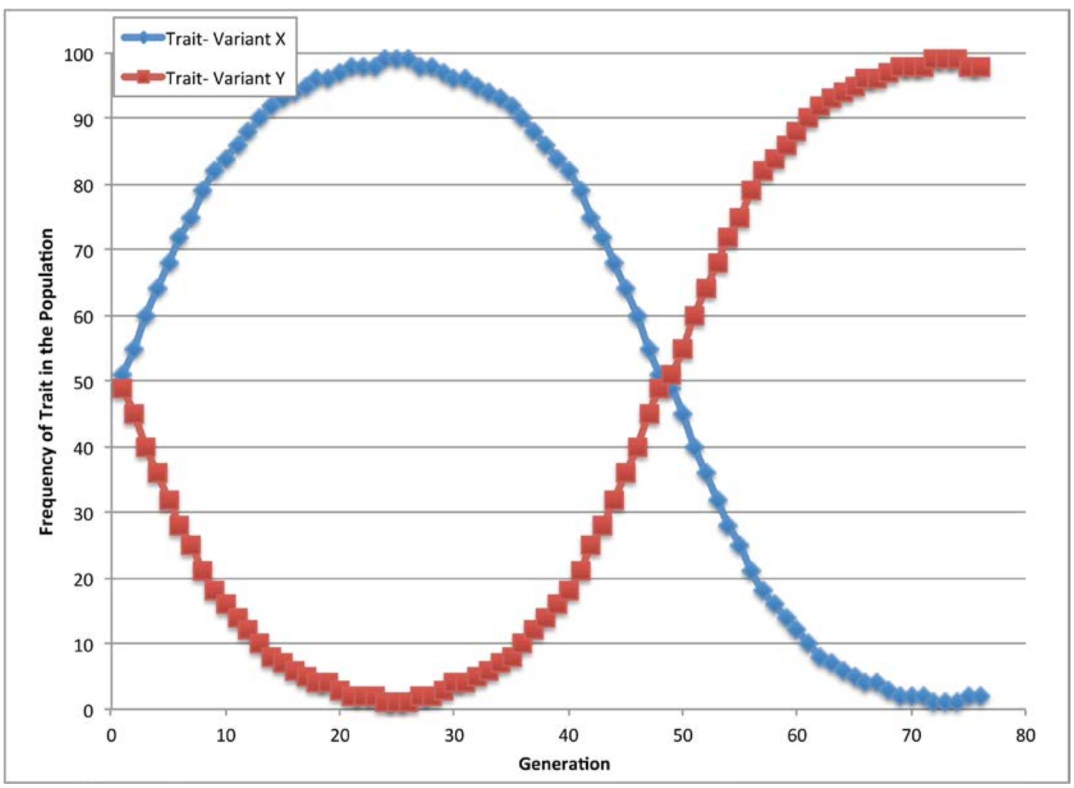
Bacterial genes are found on one circular chromosome containing a few thousand genes. Bacteria reproduce asexually. Reproduction involves only one parent rather than two parents. The single chromosome is copied and the cell divides into two daughter cells that are genetically identical to the original cell unless a mutation occurs. When a mutation does occur, it can cause a new genetic trait that could harm or help the bacteria depending on the environment in which it live.

One example of a genetic trait that can provide an advantage to bacteria is the development of antibiotic resistance. Bacteria can die or their growth can be inhibited when they are exposed to an antibiotic. If a mutation causes a trait to develop in a bacterium that blocks an antibiotic, then the bacterium is protected from the harming effects of that antibiotic and is more likely to survive to reproduce– passing this antibiotic-resistant trait onto its offspring. There are many different types of antibiotics, so the development of resistance to one type does not guarantee resistance to other types.

Task Part 1:

Graph A compares the frequency of two genetic variations of a gene over a period of time. Variant X represents bacteria with the X form of the gene, and Variant Y represents bacteria with the Y form of the same gene. The data in the graph were collected from a study examining the effect of different antibiotics on bacterial populations over a span of time. Both populations were treated with only streptomycin for a period of time then they were treated with only tetracycline, a different antibiotic, for a period of time. Using the scatterplot as evidence, describe how each antibiotic affected the genetic variations.

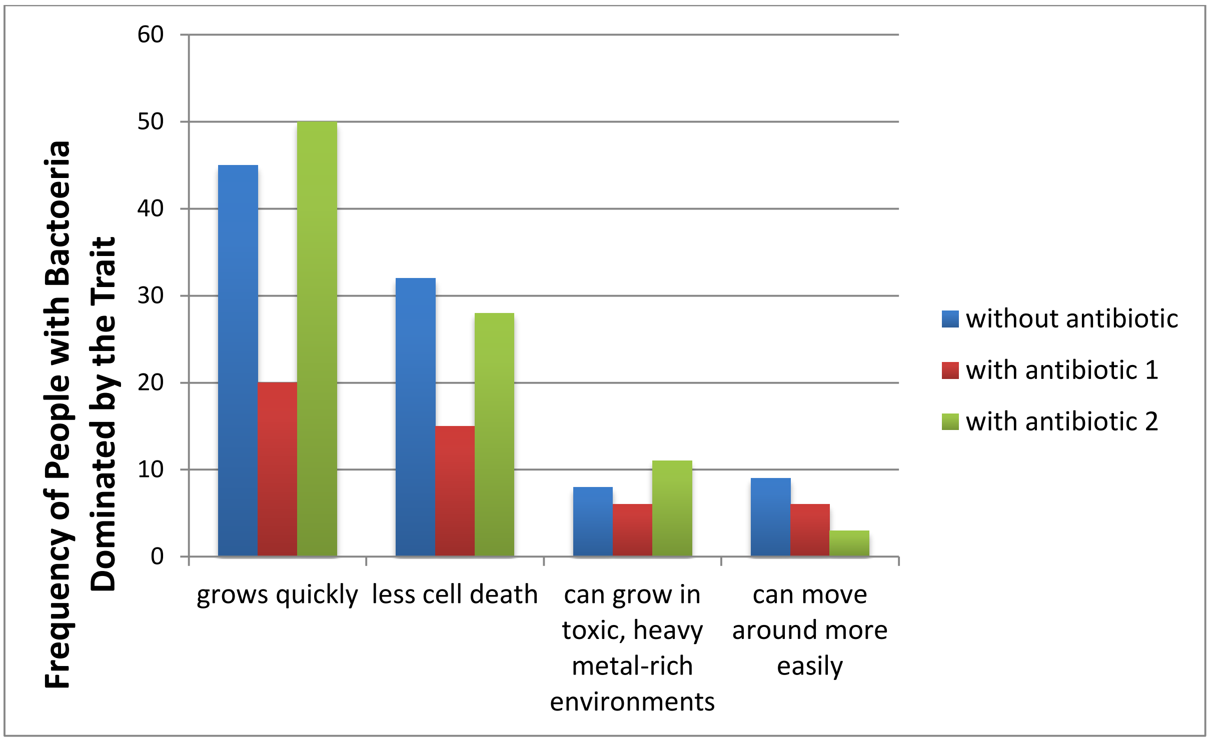
Graph A



Task Part 2:

Graph B shows the number of people who each developed a bacterial infection from four different populations of bacteria. Some bacteria have a trait that helps them to grow and divide quickly. Some bacteria have a trait that slows down the cell death process. Other bacteria have a trait that helps them to survive in toxic environments rich in heavy metals. The rest of the bacteria have a trait that helps them to move around more easily. For the sake of this assignment, each bacterial population is dominated exclusively by only one trait.

Graph B



Samples of the same bacteria were added to a petri dish. All of these bacteria must compete with each other for space and food within the petri dish in which they are growing. Because it is difficult to count the number of individual bacteria cells present, the percent of the petri dish covered by the bacteria is used instead. The bacteria mixture starts out taking up a total of 8% of the surface area of the petri dish, equivalent to about 2% coverage for bacteria with each trait. The proportion of the petri dish that each bacteria type covers at the start and at three other points in time was measured and recorded in Table C. Many generations of bacteria were produced between each time point and by Time 4, bacteria covered the entire petri dish.

Use the data in Graph B to predict the type of genetic variation in samples 1-4. Explain your reasoning for each predication.

Table C

Trait (Variation)	Day 1 – Start		Day 2		Day 3		Day 4	
	% Of Petri Dish Covered	Frequency of Trait	% Of Petri Dish Covered	Frequency of Trait	% Of Petri Dish Covered	Frequency of Trait	% Of Petri Dish Covered	Frequency of Trait
Sample A	**2**	**25**	**4**	**15**	**9**	**14**	**13**	**13**
Sample B	**2**	**25**	**5**	**19**	**8**	**13**	**11**	**11**
Sample C	**2**	**25**	**8**	**31**	**21**	**33**	**33**	**33**
Sample D	**2**	**25**	**9**	**35**	**26**	**41**	**43**	**43**
Total % of Dish Covered	**8**		**26**		**62**		**100**	

Sample Student Exemplar Responses

Part 1:
Variant X is the streptomycin resistant form of this gene. The graph shows that the population steadily increases while the bacteria are subjected to the antibiotic streptomycin. The population increases from about 51% of the population to almost 100% of the population. Variant Y is not resistant to the antibiotic, as evidenced by the decrease in the frequency of trait over the first 25 generations. The population for Variant Y decreases from about 51% of the population to about 1% of the population.

The introduction of a new antibiotic, tetracycline occurs around generation 25. At that point, the frequency of trait numbers change for Variant X and Y. The data collected after generation 25 indicates a shift in antibiotic resistance. Variant X shows a steady decline in population, which indicates that X is not resistant to tetracycline. However, the increase in population for Y indicates this form of the gene is resistant to the new antibiotic tetracycline.

Part 2:
Sample A and B could both correspond to “moves around quickly” and “can grow in toxic, heavy metal environment” because both have the lowest frequencies in the group without the antibiotic and they have the lowest frequency in Table A. Because the numbers are almost equal, it is reasonable to predict that the two samples have equal chances of being either of the two traits.

Sample C and D could both correspond to “grows quickly” or “less cell death”. The numbers in Table 1 support this prediction because by Day 4 (Table 1) both of these traits have the highest frequencies. The number of frequencies for these two traits is also high in Graph B (both without antibiotic and with an antibiotic). However, Sample D is more likely to represent the trait “grows quickly” since the frequencies are higher by Day 4 in Table 1 (43% versus 33% for Sample C) and higher than “less cell death” in Graph B.