NGSS Lesson Planning Template

Grade/ Grade Band: 8th	**Topic: Antibiotic Resistance** **(Lesson adapted from NGSS Classroom sample tasks http://www.nextgenscience.org/sites/default/files/MS-LS_%20Antibiotic%20Resistance_version2.pdf)**	**Lesson # _____ in a series of _____ lessons**

Brief Lesson Description: In this lesson, students will use their understanding of how natural selection leads to the predominance of certain traits in a population and the suppression of others to explain the frequencies of traits in a bacterial population and to consider the impact an antibiotic has on a bacterial population over many generations. Students calculate the frequencies of traits and use graphs to describe and interpret the changes in those frequencies. Students also consider the development of antibiotic resistance through natural selection and develop a list of criteria and constraints for solutions to combat antibiotic resistance in hospitals or other places that see large numbers of sick or elderly people.

Performance Expectation(s):

MS-LS4-4 **Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.** [Clarification Statement: Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, gene therapy); and, on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries.]

MS-LS4-6 **Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.** [Clarification Statement: Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time.]

Specific Learning Outcomes:

- **Students use data and graphs to describe and interpret the changes in frequencies.**
- **Students also consider the development of antibiotic resistance through natural selection**
- **Students develop a list of criteria and constraints for solutions to combat antibiotic resistance in hospitals or other places that see large numbers of sick or elderly people.**

Narrative / Background Information

Prior Student Knowledge:

Heredity
Natural Selection
Evolution
Antibiotics
angles
degrees
sector
graphing
frequencies
percent
circle graph
proportions

Science & Engineering Practices (SEPs)	Disciplinary Core Ideas (DCIs)	Crosscutting Concepts (CCs)
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.	**LS4.B: Natural Selection** ● Natural selection leads to the ● predominance of certain traits in a population, and the suppression of others. **LS4.C: Adaptation** ● Adaptation by natural selection acting over generations is one important process by which species change over	**Cause and Effect** ● Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

• Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena. **Using Mathematics and Computational Thinking** Mathematical and computational thinking in 6–8 builds on K–5 experiences and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. • Use mathematical representations to support scientific conclusions and design solutions.	time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.	

Possible Preconceptions/Misconceptions:

- antibiotics are used to treat any types of colds
- all bacteria are the same
- there is no fatality when antibiotics don't work
- natural selection works on animals only

LESSON PLAN – 5-E Model

ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions: (10 min)

- Teacher begins the lesson with the demonstration of the video:
  Antibiotics
- Students will be assigned into groups .
- Each group will collaboratively answer questions:

1. Why antibiotics are so important to us?
2. Why do we need to be concerned about bacteria becoming resistant to antibiotics?
3. What steps can be taken by humans to prepare for this big problem we are facing?

MS-LS- 4-4 SEP

- Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena. **(students will relate the increase in number of new traits in bacteria to higher chances of developing resistance to antibiotics)**

ML-LS-4-4 and ML-LS-4-6 CC

- **Cause and Effect**
  Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.
  (students will begin to form understanding that using antibiotics too often or using them improperly can lead to bacteria becoming resistant to them)

EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions: (35 min)

- ***Activity 1***
  Students will work in groups. Ask students to consider:
  - Samples of bacteria with different genetic traits are mixed together and added to one petri dish.
  - 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.
  - All these bacteria must compete for space and food within one petri dish in which they are growing.
  - Demonstrate the video (30 sec) Bacterial Growth
  - 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 will be measured and recorded in the Table 1.
- Between each time point many generations of bacteria were produced, and by Day 4, the entire petri dish was covered by bacteria.

- Students will be asked to make a statement of probability that predicts what the frequency of traits would be in the bacterial population on Day 4, if none of these traits provided a reproductive advantage to the bacteria over the other traits within the environment of the petri dish. (Students will be provided with template sentences for their answers such as :
  Bacteria1 will most likely/ least likely increase/decrease/ not change in frequency)
- Students will be directed to describe the reasoning behind their prediction.

- Using EV3 and *BACTERIAL GROWTH GYRO* program folder, collect the data for the Total % of Petri Dish covered for Days 2-4. Run these programs, following the instructions on the worksheet **and on the EV3**, in the following sequence:
  - Bacteria94
  - Bacteria230
  - Bacteria100

TABLE 1: Bacterial Traits

TRAITS DESCRIPTION	DAY1	DAY 2	DAY 2	DAY 3	DAY 3	DAY 4	DAY 4
	Percent of petri dish covered by bacteria	**Angle rotation**	**Percent of petri dish covered by bacteria**	**Angle rotation**	**Percent of petri dish covered by bacteria**	**Angle rotation**	**Percent of petri dish covered by bacteria**
Bacteria 1 Grow quickly	2						
Bacteria 2 Less cell death	2						
Bacteria 3 Can grow in toxic environment	2						
Bacteria 4 Can move around more easily	2						
TOTAL % of Petri dish covered by bacteria	8						

- Using the data students have collected, calculated and recorded in Table 1 (% of petri dish covered by bacteria), complete Table 2. Rewrite the percents for each bacteria strand on this table and calculate the frequency of the trait for each strand by calculating the actual frequency using proportions for each trait within the bacterial population on days 2-4.

TABLE 2: Bacterial Traits

TRAITS DESCRIPTION	DAY1	DAY 2	DAY 2	DAY 3	DAY 3	DAY 4	DAY 4
	Frequency of the trait in the bacterial population	***Percent of Petri Dish Covered by Bacteria***	**Frequency of the trait in the bacterial population**	***Percent of Petri Dish Covered by Bacteria***	**Frequency of the trait in the bacterial population**	***Percent of Petri Dish Covered by Bacteria***	**Frequency of the trait in the bacterial population**
Bacteria 1 Grow quickly	25%						
Bacteria 2 Less cell death	25%						
Bacteria 3 Can grow in toxic environment	25%						
Bacteria 4 Can move around more easily	25%						

MS-LS4-6 SEP

- Use mathematical representations to support scientific conclusions and design solutions.
  (students will create mathematical representation by calculating frequencies to demonstrate how the size of the populations have changed)

MS-LS4-4 DCI

- Natural selection leads to the predominance of certain traits in a population, and the suppression of others

(students will observe that while bacteria with certain traits have increased in numbers, the others have decreased)

CC

Cause and Effect

- Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

(by asking to predict probability students are led to the understanding that the presence or absence of certain traits leads to better survival rates for bacteria)

Math Standards:

7.RP.A.2 Recognize and represent proportional relationships between quantities.(students calculate frequency using ratios)

7.SP.A.2 Use data from a random sample to draw inferences about a population with an unknown characteristic of interest. Generate multiple samples (or simulated samples) of the same size to gauge the variation in estimates or predictions. (using given data set for Day1 students predict what the data would look like on Day4)

EXPLAIN: Concepts Explained and Vocabulary Defined: (20 min)

- Students will be asked to compare the probabilities based on their prediction to actual measured frequencies. (Students identify and describe, as evidence, the pattern from the plots that over time the bacterial populations with traits of "grows quickly" and "less cell death" increase in frequency relative to the frequency of the other two traits.)
- Students will construct an explanation for why the measured frequencies either match or do not match your prediction. Use your graphical representations and the calculated frequencies to support your explanation. (Students identify and describe, as evidence, the pattern from the plots that over time the bacterial populations with traits of "grows quickly" and "less cell death" increase in frequency relative to the frequency of the other two traits.)
- Discuss the role natural selection may have played when explaining why the frequencies of traits in the bacterial population may have changed over many generations within the environment of the petri dish. (The traits of "grows quickly" and "less cell death" provided an advantage to the bacteria with those traits because those traits helped those bacterial populations increase in number faster, using more food and space. o Because the bacteria with traits for "grows quickly" and "less cell death" increased in number faster than the other bacteria, the frequency of the traits for "grows quickly" and "less cell death" in the population increased (greater than 25%) and the frequency of the other traits decreased (less than 25%)).

DCI

LS4.B: Natural Selection

- Natural selection leads to the predominance of certain traits in a population, and the suppression of others.

(students will conclude that while bacteria with certain traits have increased in numbers, the others have decreased)

LS4.C: Adaptation

- Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.

(students will observe and that while bacteria with certain traits have increased in numbers, the others have decreased due to certain traits providing a better advantage for the survival)

SEP

- Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena.
- Use mathematical representations to support scientific conclusions and design solutions.

(Students will use data collected to support their conclusions and will be describing natural selection)

CC

Cause and Effect

- Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

(by asking students to answer questions students are led to the understanding that the presence or absence of certain traits leads to better survival rates for bacteria)

Vocabulary:

population frequency

antibiotic resistance
adaptations
natural selection
evolution

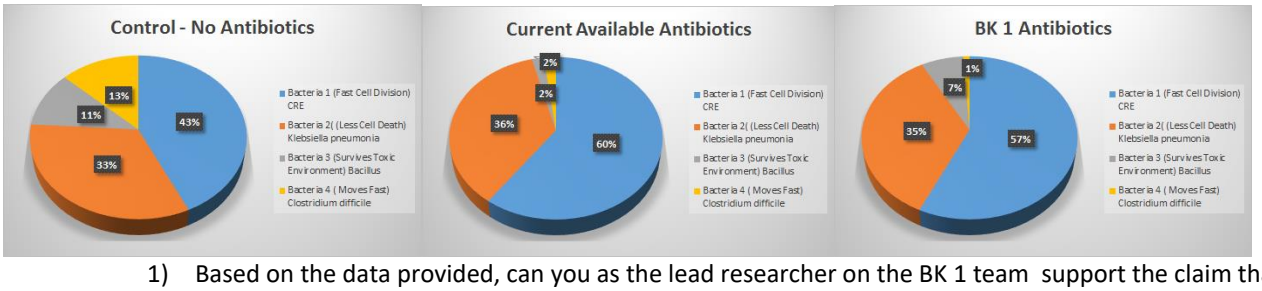
ELABORATE: Applications and Extensions:

Activity 2 (20 min)

You are the leader of a developing pharmaceutical company (BK 1). Your team of researchers have developed an antibiotic that your company believes has been effective in treating CRE (a superbug found in the stomach that cause life threatening blood infections) and other common bacterial infections. Your team is presenting your findings to the FDA for drug approval. Below is a snapshot of the efficacy of BK 1 Antibiotics on treating CRE and other common bacterial infection.

	Control (No Antibiotics)	Treated with Current Antibiotics on the market	Treated with BK 1 Antibiotics
Bacteria 1 (Fast Cell Division) **CRE**	43%	60%	57%
Bacteria 2((Less Cell Death) **Klebsiella pneumonia**	33%	36%	35%
Bacteria 3 (Survives Toxic Environment) **Bacillus**	11%	2%	7%
Bacteria 4 (Moves Fast) **Clostridium difficile**	13%	2%	1%

Below is a graphical representation of the data from the chart above:



1) Based on the data provided, can you as the lead researcher on the BK 1 team support the claim that BK 1 Antibiotics is effective in treating CRE? Use evidence to support or dispute this claim.
2) How does natural selection lead to bacteria becoming resistant to antibiotics?
3) When antibiotics are used, why is there a decline in one or more strains of bacteria while other strains seem to be thriving? How does the graph capture these changes?
4) Are there any benefits to a patient who may be infected with the 4 strains of bacteria mentioned in the chart in deciding against taking antibiotics? Explain.
5) As part of the BK 1 team, how would you market your antibiotic so that it can be approved by the FDA? (Can be done as an extension to the lesson)

DCI

LS4.B: Natural Selection

- Natural selection leads to the predominance of certain traits in a population, and the suppression of others.

LS4.C: Adaptation

- Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new

environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes

(students will be guided to connect natural selection to acquiring the trait for antibiotic resistance

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SEP

- Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena.
- Use mathematical representations to support scientific conclusions and design solutions.

(Students will analyze data provided to support their claims and will be describing natural selection)

CC

Cause and Effect

- Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

(by asking students to come up with a claim they are led to the understanding that the presence or absence of certain traits leads to better survival rates for bacteria)

EVALUATE:

Formative Monitoring (Questioning / Discussion): Exit ticket (5min)

Question: Explain how the overuse of antibiotics can increase bacterial resistance

SEP

Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena.

(in order to answer the question students will have to consider quantitative relationships between the numbers of

Summative Assessment (Quiz / Project / Report): see below

Elaborate Further / Reflect: Enrichment: (90 min)

If bacteria become resistant to the antibiotics we have, then there may be no antibiotics left for people to take that will work to fight bacterial infections. For this reason antibiotic resistance in bacteria is a major concern for hospitals, nursing homes, and other people and places that provide care to large numbers of sick or elderly people.

- **Consider the different solutions, found through your research on the topic, that others have proposed for combating antibiotic resistance.**
- **Using what you learned about how antibiotic-resistant strains develop and become dominant, make a list of criteria and constraints that you think must be considered when people design a tool, process, or system to reduce or prevent bacterial antibiotic resistance in hospitals and nursing homes**
- **. Consider criteria and constraints on long and short time scales that address economic considerations, environmental concerns, issues related to resource availability, societal or cultural concerns and impacts, and technological requirements.**

Suggested websites for resource :
https://www.niaid.nih.gov/research/antimicrobial-resistance
https://www.cdc.gov/drugresistance/threat-report-2013/pdf/ar-threats-2013-508.pdf

MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions

ELA

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

WHST.6-8.1.b Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.

Materials Required for This Lesson/Activity

Quantity	Description	Potential Supplier (item #)	Estimated Price
8	EV3		
8 sheets	Poster Paper		
8 sets	Hand outs		
	Graph paper		
	Access to Internet		