**Subject area/course**: Science/Life Science

**Grade level/band**: 7-8

**Task source**: Achieve

**Natural Selection and the Development of Antibiotic Resistance**

**TEACHER'S GUIDE**

1. **Task overview**:

In this task, 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 and scatterplots 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.

1. **Aligned standards:**
2. **Primary Common Core State Standards**

[CCSS.MATH.PRACTICE.MP2](http://www.corestandards.org/Math/Practice/MP2/) Reason abstractly and quantitatively.

[CCSS.MATH.PRACTICE.MP3](http://www.corestandards.org/Math/Practice/MP3/) Construct viable arguments and critique the reasoning of others.

[CCSS.MATH.PRACTICE.MP4](http://www.corestandards.org/Math/Practice/MP4/) Model with mathematics.

[CCSS.MATH.CONTENT.7.RP.A.2](mailto:http://www.corestandards.org/Math/Content/7/RP/A/2/) Recognize and represent proportional relationships between quantities.

[CCSS.MATH.CONTENT.8.F.B.5](mailto:http://www.corestandards.org/Math/Content/8/F/B/5/) Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally.

[CCSS.ELA-LITERACY.WHST.6-8.1](mailto:http://www.corestandards.org/ELA-Literacy/WHST/6-8/1/) Write arguments focused on *discipline-specific content*.

[CCSS.ELA-LITERACY.WHST.6-8.1.A](mailto:http://www.corestandards.org/ELA-Literacy/WHST/6-8/1/a/) Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s), and organize the reasons and evidence logically.

[CCSS.ELA-LITERACY.WHST.6-8.1.B](mailto:http://www.corestandards.org/ELA-Literacy/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.

[CCSS.ELA-LITERACY.WHST.6-8.1.C](mailto:http://www.corestandards.org/ELA-Literacy/WHST/6-8/1/c/) Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.

1. **Secondary Common Core State Standards (optional)**

[CCSS.MATH.CONTENT.7.SP.A.2](mailto:http://www.corestandards.org/Math/Content/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.

[CCSS.MATH.CONTENT.7.SP.C.7](mailto:http://www.corestandards.org/Math/Content/7/SP/C/7/) Develop a probability model and use it to find probabilities of events. Compare probabilities from a model to observed frequencies; if the agreement is not good, explain possible sources of the discrepancy.

[CCSS.MATH.CONTENT.7.SP.C.7.A](mailto:http://www.corestandards.org/Math/Content/7/SP/C/7/a/) Develop a uniform probability model by assigning equal probability to all outcomes, and use the model to determine probabilities of events.

[CCSS.MATH.CONTENT.8.F.A.1](mailto:http://www.corestandards.org/Math/Content/8/F/A/1/) Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.

1. **Critical abilities:**

*Research*: Conduct sustained research projects to answer a question (including a self-generated question) or solve a problem, narrow or broaden the inquiry when appropriate, and demonstrate understanding of the subject under investigation. Gather relevant information from multiple authoritative print and digital sources, use advanced searches effectively, and assess the strengths and limitations of each source in terms of the specific task, purpose, and audience.

*Analysis of information*: Integrate and synthesize multiple sources of information (e.g., texts, experiments, simulations) presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to address a question, make informed decisions, understand a process, phenomenon, or concept, and solve problems while evaluating the credibility and accuracy of each source and noting any discrepancies among the data.

*Modeling, designing, and problem solving*: Use quantitative reasoning to solve problems arising in everyday life, society, and the workplace, e.g., to plan a school event or analyze a problem in the community, to solve a design problem or to examine relationships among quantities of interest. Plan solution pathways, monitoring and evaluating progress and changing course if necessary, and find relevant external resources, such as experimental and modeling tools, to solve problems. Interpret and evaluate results in the context of the situation and improve the model or design as needed.

1. **Next Generation Science Standards (NGSS)**

MS-LS4-4 Construct an explanation based on evidence that describe how genetic variations of traits in a population increase some individuals’ probability of surviving and reproducing in a specific environment.

MS-LS4-6 Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in a population over time.

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.

1. **Time/schedule requirements:**

The entire task could take from 5-­11 class periods (45-50 minutes each) spread out over the course of an instructional unit, with the divisions listed below:

* Task Component A: 2-3 periods
* Task Component B: 2-4 periods
* Task Component C: 1-2 period(s)
* Task Component D: Up to 2 periods, depending on whether parts of this component are done outside of the classroom

1. **Materials/resources:**

* If the teacher asks students to graph variant frequency data using graphing calculators and/or a computer plotting or spreadsheet program, then the students will need access to these resources.
* Access to the Internet and/or a set of articles is necessary for students to research solutions to antibiotic resistance in bacteria.
* Information from the CDC and the NIH on antibiotic resistance:
  + <http://www.cdc.gov/drugresistance/threat-report-2013/pdf/ar-threats-2013-508.pdf>
  + <http://www.niaid.nih.gov/topics/antimicrobialresistance/documents/arstrategicplan2014.pdf>
  + <http://www.niaid.nih.gov/topics/antimicrobialresistance/Pages/default.aspx>
* Instructors may also find it useful to provide graphic organizers, word banks, translator tools, apps that reproduce verbal language into written language, and opportunities for collaborative group work to aid students as necessary. Worldwide or local information about the prevalence and effects of antibiotic resistance may provide further relevance and context for students.
* Data tables – see attachments within task materials.

1. **Prior knowledge:**

Students experiencing this task will have already studied concepts related to heredity, natural selection, and evolution; have prior experience with the characteristics of creating and interpreting graphs (linear/nonlinear, increasing/decreasing, etc.); and have experience with calculating and understanding the frequency of a component within a population. It is assumed that students have mastered the 6th grade CCSS-M standards, specifically 6.SP.B.4 and 6.RP.A.3.c**.**

1. **Connection to curriculum:**

This task would fit following an instructional unit(s) on percent, frequency, and proportions, and within an instructional unit on natural selection and evolution. This task is ideally used within a math and science integrated course or in a science course that includes coordination with the mathematics teacher to ensure students are able to apply their math learning in the science classroom.

1. **Teacher instructions:**
2. Task A: Students begin by predicting how five different bacterial traits will compete with one another in the same environment. Students will use percentage calculations (teacher should review this skill) to find trait frequencies in the bacterial population over time. Students will analyze and interpret the percentages to compare their prediction to the experimental values. Using their background knowledge of natural selection, students will write explanations of the results. Students may work in groups to do calculations and check each other’s work, as well as peer review their writing.
3. Task B: Students construct a scatterplot of gene frequencies over time and apply their mathematics knowledge to interpret the data and make sense of the patterns they see. Students then apply their knowledge of natural selection to propose an explanation of the results and predict how gene frequencies would be different in a new environment.
4. Task C: Students synthesize what they learned from Task A (survival values of different bacterial traits) and Task B (effects of antibiotics on natural selection in bacterial populations) to make sense of gene frequency data in human bacterial infections under different conditions. It may help students make sense of the data if a class discussion about the graphs precedes the writing tasks.
5. Task D: Students conduct internet research about antibiotic resistance and how this challenge affects patients in hospitals. Based on their findings, students come up with guidelines to consider in the design of a solution to the problem of antibiotic resistance. It will be helpful here to provide graphic organizers for use during research and writing scaffolds for the final writing task.
6. **Student support:**

* Graphic organizers (during internet research or Task C class discussion) will help students keep track of information that they gather
* Writing scaffolds such as sentence starters and paragraph frames will enable students with language challenges to engage in writing tasks.
* Students may work in pairs or groups to support one another where skills and knowledge are varied. In particular, students can use a jigsaw format for the internet research in Task D.

1. **Extensions or variations:**

Not provided.

1. **Scoring:**

Student work can be scored using a rubric of your choosing/creation, using the provided evidence statements as a scoring guide, in order to formulate an appropriate rubric for each task component.