**Natural Selection and the Development of Antibiotic Resistance - Middle School Sample Classroom Task**

**Classroom Task**

**Context**

When Alexander Fleming discovered penicillin in the 1920s, the field of medicine was revolutionized. Antibiotics like penicillin are chemicals that inhibit the growth of bacteria or cause them to die. While your body naturally contains many different types of helpful bacteria that protect the body and aid digestion, some bacteria are harmful to us; for example, E.coli can cause food poisoning, and Staphylococcus aureus can cause skin and respiratory infections. Antibiotics are a way to help our immune system fight off bacterial infections that in the past may have resulted in death.

Over time, however, the wide spread use of antibiotics has led to the development of resistant strains of bacteria. Infectious diseases such as staphylococcal infection are becoming increasingly difficult to treat because the bacteria that cause them are becoming resistant, through mutations and natural selection, to the antibiotics used to treat them. New types of antibiotics are being developed, but bacteria continue to develop resistance to these new medicines. This antibiotic resistance makes it difficult to eliminate infections because existing medicines are becoming less effective. Thus, diseases that were once highly treatable are now becoming a problem once again.

People who are infected with antibiotic-resistant bacteria require longer hospital stays and may require more expensive and complicated treatments. The National Institutes of Health estimate that 5-10% of all hospital patients develop some type of infection while in the hospital. In 1992, an estimated 13,300 people died from infections that they developed in the hospital, compared to an estimated 90,000 patients who died for the same reason in 2011. The Centers for Disease Control and Prevention estimate that antibiotic resistance in the United States costs $20 billion each year for additional health care and $35 billion in lost productivity (NIH website-

http://www.niaid.nih.gov/topics/antimicrobialResistance/understanding/Pages/quickFacts.aspx- accessed April 2014).

In this task, you will explore how natural selection affects the frequency of traits in a bacterial population, including what conditions cause the increase in frequency of the trait for antibiotic resistance in bacterial populations. You will also consider the criteria and constraints to evaluate solutions for the problem of antibiotic resistance in hospitals, where this problem is compounded by the presence of vulnerable patient populations (elderly and sick individuals) and a contained environment where bacteria can easily spread among patients.

**Task Components**

A. Consider: Samples of bacteria with different genetic traits are mixed together and added to a 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 of these bacteria mustcompete 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 the table in Attachment 1. Between each time point many generations of bacteria were produced, and by Time 4, the entire petri dish was covered by bacteria.

I. Make a statement of probability that predicts what the frequency of traits would be in the bacterial population at Time 4, if none of these traits provided a reproductive advantage to the bacteria over the other traits within the environment of the petri dish. Describe the reasoning behind your prediction.

II. Complete the table by calculating the actual frequency of each trait within the bacterial population at Time 2, Time 3, and Time 4, using the data in Attachment 1. Create a graphical representation(s) to show the trait frequency of the bacterial population at the different points in time. The representation(s) should include a title, scale, axis labels, unit labels, and legend where appropriate. Representations such as bar graphs, line plots, pie charts, or other data displays should be considered.

