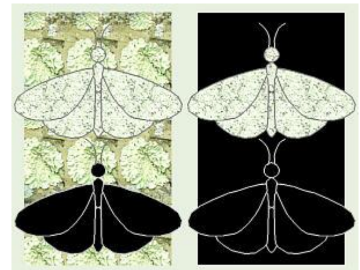
Name: ____

LAB: *Natural Selection and Antibiotic Resistance*

Background Information

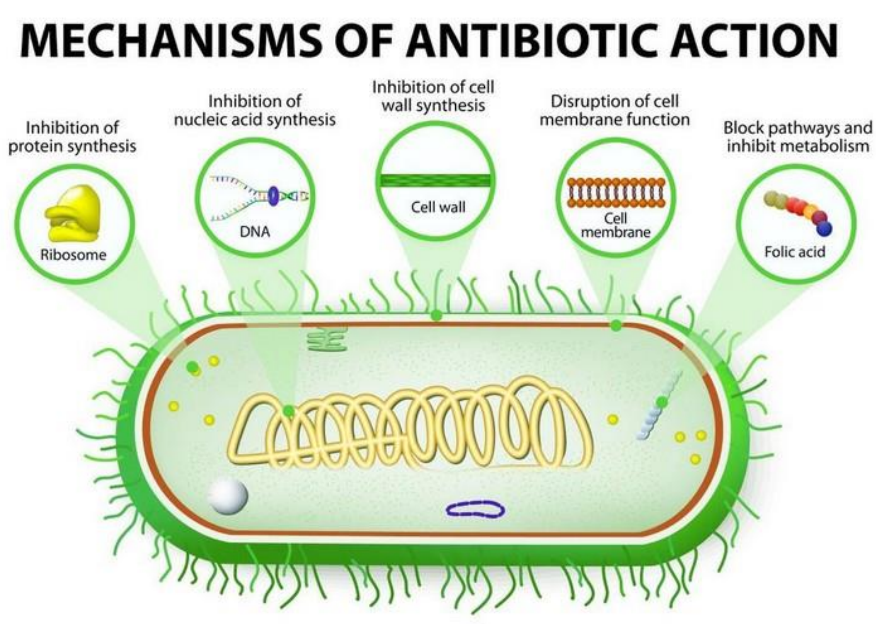


Prior to the Industrial Revolution in England, light colored peppered moths rested safely on the bark of light colored trees, unable to be seen by their predators, birds. In the mid-nineteenth century, however, trees that had light colored trunks became darkened by coal soot. Simultaneously, the number of light colored moths decreased, whereas the number of dark moths increased. Natural selection was favoring one form of the moth over another.

An increasing number of African elephants are now born tuskless because poachers have consistently targeted animals with the best ivory over decades, fundamentally altering the gene pool. In some areas, 98% of female elephants now have no tusks, researchers have said, compared to 2% – 6% born tuskless on average in the past. Almost a third of Africa's elephants have been illegally slaughtered by poachers in the past ten years to meet demand for ivory in Asia, where there is still a booming trade in the material, particularly in China. About 144,000 elephants were killed between 2007 and 2014, leaving the species at risk of extinction in some areas. Meanwhile those African elephant populations that do survive could become virtually tuskless, like their Asian cousins, researchers have warned. In this case, artificial selection has influenced which organisms have survived and reproduced to pass on their traits.

In 1943, penicillin was introduced as the "magic bullet" for curing many infectious diseases. By 1946, however, approximately 14 percent of *Staphylococcus aureus* strains isolated at a London hospital were resistant to penicillin. Today, scientists estimate that more than 95 percent of all *S. aureus* strains are penicillin-resistant. After the introduction of penicillin, additional antibiotics were rapidly isolated and developed, including streptomycin and tetracyclines. Today, there are more that 100 antibiotics available. Nevertheless, some strains of at least three bacterial species (*Enterococcus facecium, Mycobacteria tuberculosis, Pseudomonas aeruginosa)* are resistant to **all** of these antibiotics, and health care workers fear the time is rapidly approaching when more deadly organisms escape the effects of all known antibiotics.

The primary reason for the increase in antibiotic resistance is evolution. When mutant genes arise that make a bacterium less sensitive to an antibiotic, that bacterium survives and produces descendants in an environment rich in antibiotics. That is, the process of natural selection operates. Multiple mutations may be required to result in fully resistant bacteria. However, once resistant genes appear, bacteria have a variety of mechanisms for exchanging those genes both within and across species. This exchange allows for "accelerated evolution" of bacterial species because the random mutation that results in antibiotic resistance need not happen in every individual bacterium, but can simply be acquired from another bacterium (transformation).



Materials

Bingo chips – red, green, blue

Beads – various colors

one die

Pre-Lab Questions

Read through the background information and then answer the following questions before doing the lab. This is due at the beginning of the lab period.

1. In your own words, explain why the number of light colored peppered moths decreased from one generation to the next:

Struggle for Existence: ____

____

Survival of the Fittest: ____

____

Descent with Modification: ____

____

2. In this lab, we will be observing the change in the frequency of a particular strain/variant of bacteria compared to the whole population of bacteria. A bacterial strain is a genetic variant of one species. For example, the bacterial species *E. coli* is found in 45 different known strains. They are all *E. coli*, but have slightly different DNA sequences that can cause one strain to be deadly and another to be completely harmless.

The frequency is calculated by dividing the number of bacteria of one strain by the number of total bacteria. It is similar to a percentage, but rather than having numbers add up to a total of 100%, we use decimals that add up to a total of 1.

What is the frequency of strain A in the population if there are 20 strain A and 40 strain B?
Show your work.

What is the frequency of strain B in this population?
Show your work.

Procedure

1. Place 14 green bingo chips and 6 blue chips on the work surface in front of you and your partner. These chips represent harmful bacteria in a patient's body before beginning antibiotic treatment. Set aside the remaining bingo chips and the beads.

2. It is time to take the first dose of antibiotics. Roll the die and follow the key below.

Number tossed	**Event**	**Results**
2,3,4	Antibiotic was taken at appropriate time – bacteria are killed	Remove 5 disks in the following order: remove green chips first, then blue chips when no more green are left.
5,6	Antibiotic was not taken at the appropriate time	Do not remove any bingo chips.
1	Mutation!	Add a red chip. The red strain is completely resistant to the antibiotic. If a 2nd 1 is tossed, add a colored bead, a different color for each 1 tossed.

3. Record the number of each remaining type of bacteria in the table on the next page.

4. Bacteria are constantly reproducing in the patient's body. If one or more bacteria of a particular strain are still present after the first dose, add one chip of that color to the population. *Example*: If the patient still has blue and green bacteria present, add one blue and one green chip to the population. If you have a red chip, add another. If you have a bead, add another bead also.

5. Repeat steps 2-4 for 14 doses, or until all bacteria have been eliminated.

6. Using the data from the table, construct a graph displaying the number of each strain of bacteria versus the number of doses. Use different colored pencils to plot the following data: total number of bacteria, least resistant strain, medium resistant strain, highly resistant strains. Connect each set of data points by drawing a colored line.

Data Table
Simulated bacterial population changes with antibiotic treatment.

		Bacterial Population			
Dose #	**# rolled**	**Low Resistance (green)**	**Medium Resistance (blue)**	**Highly resistant (red + beads)**	**TOTAL**
INITIAL	**N/A**	**14**	**6**	**0**	**20**
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					

Calculate frequencies:

After dose #	**Frequency of low resistance (green) strain**	**Frequency of medium resistance (blue) strain**	**Frequency of highly resistant (red & bead) strains**
1			
7			
14			

Analysis of Results

Construct a graph below to show the changes in population of the bacterial strains over the course of antibiotic treatment:

Conclusion Questions

1. CLAIM: Which strain represented the fit bacterial strain with “favorable” characteristics? Which represent the unfit bacterial strain with characteristics considered “harmful” (to the bacteria)?

2. EVIDENCE: What was the original *frequency* of low resistance strain to highly resistant strain? What was the *frequency* of each after dose 14?

3. EVIDENCE: Based on your data, was one strain of bacteria killed more frequently than the others? If so, which strain?

4. <u>REASONING</u>: How did the *frequency* of low resistance strain in the population change over treatment period? What was the overall pattern? Refer to your data.

5. <u>REASONING</u>: How did the *frequency* of the highly resistant strain change over the treatment period? What was the overall pattern? Refer to your data.

6. <u>PREDICTION</u>: What do you think will happen to the strain(s) with the "favorable" characteristic over time?

7. <u>GOING FURTHER</u>: Based on your prediction above, does this mean that the antibiotic caused the bacteria to "mutate" and become resistant? Explain.

If you were infected with the resistant strain of this bacteria, what would the results of this lab mean to your health? How would the doctors need to treat your illness?

People often start feeling better after 3-5 days and stop taking their antibiotics. Predict what would happen in your experiment if you had stopped taking the antibiotics after day 5? ____________________

8. Explain the results of the lab in terms of Darwin's 4 principles of natural selection: