

Relating Natural Selection and Frequency of Traits

Throughout the oceans, small volcanic islands form when undersea volcanoes erupt and send materials above the surface of the water. When these islands first form, they are barren rock. Yet many of these islands become inhabited by a rich variety of plant and animal species.

How does such a transformation come about? Species from a mainland or other islands travel to the new island and colonize the new habitat. Bacteria, fungi, algae, mosses, and lichens are examples of early inhabitants that can thrive in harsh, barren environments. Some organisms, such as lichens and mosses, are transported to a new habitat as spores in the wind. Green plants usually arrive as seeds and fruits carried great distances by the wind and waves. Birds may have landed during stopovers on migration routes, while other land animals may simply have been carried to the shores by accident.

Some species are not as well suited to an island environment as to their original homes. To have survived on these islands, organisms must have adapted to different conditions. This provides a new environment for evolution—a place where humans can learn a great deal about the processes of natural selection.

Imagine that you are a naturalist studying a population of plants on an isolated volcanic island in the Pacific. A simple physical characteristic, such as seed color, could affect a plant's chances of survival in a particular habitat. Plants with a favorable genetic variation tend to survive and pass that trait to their offspring, while those with unfavorable variations could become extinct. In this lab, you will investigate the inheritance of a single trait, and explore how natural selection changes the frequency of this trait in the surviving plant population.

OBJECTIVES

Hypothesize how color variations in a population are affected by environmental factors.

Graph and compute the percentages of seed colors in three generations of offspring.

Explain how natural selection affects the inheritance of traits in succeeding generations.

MATERIALS

- construction paper or poster board (optional)
- containers, such as empty margarine tubs (6)
- glue stick (optional)
- graph paper
- imaginary island habitat (on school lawn or a field)
- meter stick (1)
- brown pinto bean seeds (100)
- white pinto bean seeds (100)
- white pinto bean seeds, colored red, green, and blue (300 total)



Relating Natural Selection and Frequency of Traits *continued*

Procedure

1. On the mainland, where the pinto bean plants originated, the original seed colors were brown and white. Mutations may have produced additional seed color variations such as the red, blue, and green seeds found on your island. It is reasonable to conclude that these colors are advantageous to the bean plants' survival. Write a hypothesis to explain how you think such color variations might affect the survival of a population.

2. Select a 1-meter square area to simulate the island habitat of your population. Your teacher will decide whether you should work outdoors or indoors. If working outdoors, find and mark off a small area with soil or sand and some vegetation, such as green grass. If working indoors, use a large sheet of posterboard or construction paper as your habitat. Select colors that you think would best model your island habit. Draw in the outline and physical terrain. Glue some green paper to the background to simulate plants. Write a brief description of your island habitat below.

3. Start with 100 seeds of each color in five plastic containers. Mix 20 seeds of each color together in the sixth container, and shake well. Have one team member scatter the seeds randomly over the 1-meter square island habitat. This person will act as the reporter.

4. Have the other three team members act as "birds" feeding on the seeds. Each person quickly picks up 25 of the scattered seeds and brings the results of the "hunt" to the reporter, who counts and returns them to the plastic containers by color. Record data on the number and type of each color of seed "eaten." Calculate and record the number of surviving seeds of each color left in the habitat for the first generation in Table 1.

5. Assume that each surviving seed produces three offspring with the same seed color and continues to live throughout the season. For each surviving seed, scatter three seeds of the same color randomly in the habitat. There should now be 100 seeds in your island habitat that represent the surviving parent generation and their offspring.

Relating Natural Selection and Frequency of Traits *continued*

TABLE 1: SEED COLOR CHANGE OVER GENERATIONS

Seed Color	Generation 1			Generation 2			Generation 3		
	Start	Eaten	Survive	Start	Eaten	Survive	Start	Eaten	Survive
white	20								
brown	20								
red	20								
green	20								
blue	20								
Totals	100	75	25	100	75	25	100	75	25

- The reporter records the number of seeds of each color at the start of Generation 2 in the chart. The “birds” again collect and “eat” 25 seeds each and bring them to the reporter for tallying as before. Record data for the number of each color “eaten” and compute and record the number of each color surviving in Generation 2.
- Add three more seeds of the same color to the habitat for each survivor. Repeat the procedure and record your data for Generation 3 in Table 1. Collect all the seeds and return them to the plastic containers. If you are working outdoors, return to the classroom to analyze your data.

Analysis

- Organizing Data** Calculate the percentage of each surviving bean color in the three generations. Divide the number of survivors of each color by the total number of survivors and multiply this number by 100 to get your percentages. Record the your results in Table 2.

TABLE 2: SEED SURVIVAL

Seed Color	Survivors in Gen. 1	% Gen. 1 Population	Survivors in Gen. 2	% Gen. 2 Population	Survivors in Gen. 3	% Gen. 3 Population
white						
brown						
red						
green						
blue						

- Organizing Data** On a separate piece of graph paper, make a bar graph or histogram to illustrate your results. Plot the surviving seeds in each of the three generations on the horizontal, or x-axis, and indicate the number of each color of surviving seeds on the vertical, or y-axis.

Relating Natural Selection and Frequency of Traits *continued*

3. Examining Data Study your survivor populations for each generation. What changes occurred in the frequencies of colors among the three generations?

4. Examining Data Compare the original and the survivor populations. Are any seed color(s) from the original population not represented in the survivor population?

5. Identifying Patterns How do the colors of the survivors appear to relate to their habitat?

Conclusions

6. Making Predictions What do you predict would happen to the plant population if the seeds continued to be collected by the bird population for several more generations?

7. Interpreting Information Explain how natural selection changes the frequency of genes over many generations.

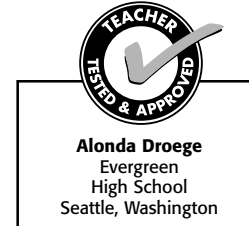
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Teacher Notes

TIME REQUIRED Two 45-minute periods

SKILLS ACQUIRED

Communicating
Collecting data
Organizing and analyzing data
Interpreting results



RATING

Easy ← 1 2 3 4 → Hard

Teacher Prep–2
Student Set-Up–2
Concept Level–2
Clean Up–2

THE SCIENTIFIC METHOD

Formulate a Hypothesis Procedure step 1 asks students to formulate a hypothesis about how color variations might affect a plant population.

Make Observations In Procedure steps 2–7, students prepare a model and collect data on the effects of natural selection on color variations in a plant population.

Analyze the Result In Analysis questions 1–5, students calculate the percentages of different seed colors in three generations of bean plants, graph their results, and examine their data.

Draw Conclusions In Conclusions questions 6 and 7, students interpret data, make predictions, and explain how natural selection affects the inheritance of traits.

MATERIALS

Materials for this Lab Activity can be purchased from WARD's. See the *Master Materials List* for ordering instructions.

Purchase four pounds of white and one pound of brown Pinto bean seeds. Before introducing the activity, use fast-drying enamel spray paint to color one pound each of the white pinto bean seeds to obtain blue, green, and red seeds (or whatever other colors you select). Place about 100 seeds of each color in separate containers such as empty 8-ounce plastic margarine tubs. Each team should have its own set of colored seeds.

SAFETY CAUTIONS

Allow beans to dry completely overnight before presenting the simulation activity. Be sure to check for any known student allergies to pinto beans.

DISPOSAL

Discard used papers in trash bins. Store beans used in this activity in separate containers. They have a shelf life of up to eight months after opening. As beans age they tend to lose their oils, resist water absorption and won't swell. Beans used in this activity should not be used as food, but those not treated with enamel paints could be used in plant growth experiments at a later time.

MISCONCEPTION ALERT

Explain to students that only the traits which enhance an organism's ability to survive get passed on to future generations. A species does not adapt in order to survive; the species survives because it happened to have adapted.

TIPS AND TRICKS

This activity works well with groups of three or four students. The model works well indoors or outdoors depending on weather conditions. In an outdoor setting, the effects of camouflage on the results are more pronounced. Seed colors that blend well with their surroundings are less likely to be retrieved during the collection stage. This effect can be modeled by using colored construction paper to simulate vegetation.

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Relating Natural Selection and Frequency of Traits *continued***Procedure**

1. On the mainland, where the pinto bean plants originated, the original seed colors were brown and white. Mutations may have produced additional seed color variations such as the red, blue, and green seeds found on your island. It is reasonable to conclude that these colors are advantageous to the bean plants' survival. Write a hypothesis to explain how you think such color variations might affect the survival of a population.

Answers may vary. Sample answer: Having a color that blends in with the surrounding environment might prevent the seed from being eaten and allow it to germinate and thus produce more offspring with the same color variation.

2. Select a 1-meter square area to simulate the island habitat of your population. Your teacher will decide whether you should work outdoors or indoors. If working outdoors, find and mark off a small area with soil or sand and some vegetation, such as green grass. If working indoors, use a large sheet of posterboard or construction paper as your habitat. Select colors that you think would best model your island habit. Draw in the outline and physical terrain. Glue some green paper to the background to simulate plants. Write a brief description of your island habitat below.

Answers may vary. Sample answer: There is tall a volcanic cone in the center of our island, a small stream, and some low hills. Most of the vegetation is located near the stream and on the low hills.

3. Start with 100 seeds of each color in five plastic containers. Mix 20 seeds of each color together in the sixth container, and shake well. Have one team member scatter the seeds randomly over the 1-meter square island habitat. This person will act as the reporter.
4. Have the other three team members act as "birds" feeding on the seeds. Each person quickly picks up 25 of the scattered seeds and brings the results of the "hunt" to the reporter, who counts and returns them to the plastic containers by color. Record data on the number and type of each color of seed "eaten." Calculate and record the number of surviving seeds of each color left in the habitat for the first generation in Table 1.
5. Assume that each surviving seed produces three offspring with the same seed color and continues to live throughout the season. For each surviving seed, scatter three seeds of the same color randomly in the habitat. There should now be 100 seeds in your island habitat that represent the surviving parent generation and their offspring.

Name _____ Class _____ Date _____

Relating Natural Selection and Frequency of Traits *continued*

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Name _____ Class _____ Date _____

Relating Natural Selection and Frequency of Traits *continued*

- 3. Examining Data** Study your survivor populations for each generation. What changes occurred in the frequencies of colors among the three generations?

Answers may vary. Variations will depend on which seeds were collected by the “birds” throughout the three generations, which in turn depends on the characteristics of habitats on which seeds were dispersed.

- 4. Examining Data** Compare the original and the survivor populations. Are any seed color(s) from the original population not represented in the survivor population?

Any conspicuous or bright seed color such as red, blue, or white seeds that stand out might be eliminated, leaving only the brown or green seeds in the habitat.

- 5. Identifying Patterns** How do the colors of the survivors appear to relate to their habitat?

Answers may vary. Sample answer: Surviving seeds tend to have colors similar to the habitat; brown seeds among dry vegetation and green seeds on a green lawn.

Conclusions

- 6. Making Predictions** What do you predict would happen to the plant population if the seeds continued to be collected by the bird population for several more generations?

Answers may vary. Seed colors that resemble the surrounding environment would be favored. Surviving conspicuous seed colors (red, blue and white) would probably tend to be eliminated from the population.

- 7. Interpreting Information** Explain how natural selection changes the frequency of genes over many generations.

Answers may vary. Student responses should relate the main ideas of natural selection to this simulation. For example, populations tend to produce more offspring than can survive so there is competition for resources. Genetic variations that are advantageous to the organism, such as seed colors that remain hidden in the surrounding vegetation, tend to be transmitted to future generations and increase in frequency in the population.