Category IV Notes for Natural Selection Examples

Representing Ideas Effectively

Material H, pp. 47-49s, 64-69t
Represents key idea that “Natural selection provides the following mechanism for evolution: Some variation in heritable characteristics exists within every species, some of these characteristics give individuals an advantage over others in surviving and reproducing, and the advantaged offspring, in turn, are more likely than others to survive and reproduce. The proportion of individuals that have advantageous characteristics will increase” (idea c).

Further Challenges

To create a real journalism article, take the summary of the highlights of your story and craft it into a smooth, informative article that answers for the reader all of the important questions about evolution.

MODELING NATURAL SELECTION

Elaborate

Darwin developed his theory of evolution, a theory that explains how organisms change across time, by analyzing his observations, including those from his voyage on the *HMS Beagle*, during a period of 20 years. In his theory, he proposed natural selection as the mechanism of evolution. You can model natural selection in the classroom in one or two days by limiting an investigation to just one of the many types of selective pressures, in this case the pressure imposed by predation. Predation is important to evolution because it places a limit on one of the key requirements of natural selection—the ability of organisms to survive long enough to reproduce.

In this activity you will model the effects of predation on a prey population. The prey consists of paper dots that represent a variation in the color of individuals in a species. You and your classmates will be the predators. By analyzing the selective effects of predation in this model, you will gain a better understanding of how natural selection can change the average characteristics of a population.

Materials (per team of 4)

3 petri dish halves
36-×-44-in piece of Fabric A or Fabric B
3 sheets of graph paper
6 colored pencils with colors similar to the dot colors
zip-type plastic sandwich bag containing 120 paper dots, 20 each of 6 colors (labeled *Starting Population*)
6 zip-type plastic sandwich bags, each containing 100 paper dots of a single color
watch or clock with a second hand
3 forceps (optional)

Process and Procedures

1. Decide which team member will be the game warden and which team members will be the predators.

   Three members of your team will play the role of predators of paper dots. As predators, each will hunt paper dots (the prey) in their habitat (the piece of fabric). The fourth member will be the game warden, who will keep track of the hunting.

2. Examine the paper dots in the bag labeled *Starting Population* and record the number of individuals (dots) of each color.

   The colored dots represent individuals of a particular species. The individuals of this species can be one of six colors.

The game warden should record the starting population in his or her journal and label this First Generation Starting Population.

3. Spread out the piece of fabric on a desk or table top.

   Half of the teams will have pieces of Fabric A, and half of the teams will have pieces of Fabric B.

4. Set up the model as follows:

   Predators: Obtain a petri dish half. Face away from the habitat.

   Game Warden: Spread the dots from the bag labeled *Starting Population* throughout the habitat.

   Spread the dots as uniformly as possible so that no dots are sticking together or covering other dots.

5. Begin to manipulate the model as follows:

   Game Warden: Direct the predators to face the habitat and begin picking up dots (prey); say "Stop" after 20 seconds.

   Predators: Pick up as many paper dots (prey) as possible until the game warden says "Stop."

   Use only your eyes to locate your prey; do not feel the fabric. Use only one hand (or one forceps). Pick up one dot at a time and put each dot in your petri dish half before taking another dot.

6. Finish Round 1 of predation in your model as follows:

   Predators: Collect the remaining paper dots from the fabric and sort them by color.

   Game Warden: Record the number of each color of the remaining paper dots.

   Label this First Generation Surviving Population.

7. Prepare for Round 2 of predation in your model as follows:

   Predators: Simulate reproduction among the paper dots by adding three paper dots for each remaining dot of the same color.

   The three paper dots of each color represent offspring. Obtain these offspring from the bags containing single colors of dots.

   Game Warden: Record the number of each color of paper dot in your journal as *Second Generation Starting Population.*

8. Repeat Steps 4–6 for Round 2 of predation.

9. Calculate the number of each color of paper dot, if each surviving paper dot were to produce three offspring. Record this information as *Third Generation Starting Population.*

   Each team member should record this information in his or her journal.

10. As a team use colored pencils and graph paper to prepare bar graphs that show the number of paper dots of each color in each of the three starting populations.

    Use colored pencils that correspond to the colors of paper dots. You should have three bar graphs when you are finished with this step. If you need information about how to make bar graphs, refer to Appendix B, Techniques.

11. Study the bar graphs of each generation. With your teammates consider the following questions and record your team's responses in your journal:
    a. Which, if any, colors of paper dots survived better than others in the second and third generation starting populations of paper dots?
    b. What might be the reason that predators did not select these colors as much as they did other colors?
    c. What effect did capturing a particular color dot have on the numbers of that color in the following generations?

12. Now that your manipulations are complete, clean up by sorting the colored dots into their respective plastic bags as you found them, and then return the bags to the materials station.

Analysis

At the location that your teacher indicates, post your team's bar graph for the third starting population beside the fabric that you used. Compare the bar graphs of teams who used Fabric A with the bar graphs of teams who used Fabric B. Complete the following tasks as a team. Record your team's responses in your journal.

1. How well do the class data support your team's conclusions in Step 11?

2. Imagine a real-life predator/prey relationship and write a paragraph that describes how one or more characteristics of the predator population or the prey population might change as a result of natural selection.

   Base your proposition on what you have learned in this model of natural selection by predation.

3. Write one paragraph that describes how the process of natural selection adds to the collection of evidence and inference that your team examined in the activity *Evidence for Change across Time.* Write a second paragraph that summarizes your understanding of biological evolution.

A COLD HARD LOOK AT CULTURE

Elaborate

Seahorses that look like marine plants, bacteria that live in hot springs, and giant pandas that feed almost exclusively on bamboo. Through biological evolution, all of these organisms have changed and passed their

recognize these links, so accept other answers that are logical and based on their experiences and knowledge base.

A question like this one is likely to spark the evolution/creationism debate in your classroom. You can defuse this debate quickly if you get the students to focus on the nature of scientific explanations as being different from the nature of religious (or other) explanations.

2. **Choose one member of your team to offer the rebuttal orally to your editor (your teacher). Although one person should present the team's response, both of you should be prepared to answer further questions about the issue if your editor is not convinced by your initial comments.**

   You may consider this question optional or offer it for extra credit. If you have taken advantage of all of the class presentation options in this chapter, consider having students give their rebuttal to you at your desk while other students work on something else. Or students could rebut in writing and turn in their journals to you.

ELABORATE — Modeling Natural Selection

Major Concepts: Natural selection; adaptation

Overview

Students have examined multiple lines of evidence for biological change across time and the nature of the theory of evolution. In this activity the students experience the mechanism for evolution through a simulation game that models the principles of natural selection and helps answer the question, How might biological change have occurred and been reinforced over time?

Materials (per class of 30, teams of 4)

24 petri dish halves
8 36-x-44-in pieces of fabric, 4 each of two different patterns
24 sheets of graph paper
8 sets of colored pencils with colors similar to the paper dot colors (see *Preparations*)
48 zip-type plastic sandwich bags, each containing 120 paper dots, 20 each of 6 colors, labeled *Starting Population*
48 zip-type plastic sandwich bags of spare paper dots (see *Preparations*)
watch or clock with second hand
computer with spreadsheet software program (optional)
24 forceps (optional)

To create the paper dots
24 8½-x-11-in sheets of construction paper, 4 each of 6 different colors
3-hole or regular paper punch

Preparations

Obtain fabric from a local fabric supply store or from the home economics teacher. Choose fabric patterns that simulate natural environments, such as floral, leaf, or fruit prints. The patterns should have several colors and be of intricate design; small prints work better than large blocky prints. Select two designs, each with a different predominant color. Label one design *Fabric A* and the other *Fabric B*. The use of two designs enables the students to demonstrate the evolution of different color types from the same starting population.

Use the paper punch to punch out 1/4-in paper dots from construction paper, 1000 each of six different colors. Punch out all four sheets of a color at once or fold each sheet into four thicknesses. Use a wide variety of colors, such as red, orange, purple, green, blue, yellow, brown, grey, black, or white. Select two light colors (including white) and two dark colors so that they will compete against each other. Include at least two colors that blend well with the fabrics. For each color, put 100 dots into each of eight zip-type plastic sandwich bags. Put 20 dots of each color (for a total of 120 dots of six colors) into each of eight additional bags. Label these bags *Starting Population*. Save any extra dots for replacement dots or additional supplies. Enlist student aides or ask for student volunteers to punch dots or stuff bags at home or after school.

Note: As an alternative to paper dots, you might try colored aquarium gravel or colored rice. Both are heavier than paper dots and are less likely to blow around the room. You could color the rice grains with food dyes according to the criteria that we specified above for the dots. You also might use gift-wrapping paper instead of the pieces of fabric.

Outcomes and Indicators of Success

The following indicators allow you to assess the students' level of success with the activity and their process of learning.

By the end of this activity, the learners should

1. better understand predator/prey relationships.

   They will demonstrate their understanding by
   a. appropriately completing an assigned task,
   b. recording data from the predator/prey simulation, and
   c. creating a graphic representation of the activity.

2. recognize that various factors are involved in the survival and reproductive success of individual members of a species.

   They will show their recognition by developing their own explanations for the reproductive success of certain colors of paper dots after several rounds of hunting.

3. be able to use the idea of natural selection to explain the reproductive success of certain members of a hunted species.

   They will demonstrate their ability by
   a. describing the details of the mechanism at work in the simulation. These details should include variation, reproductive potential, and differential survival,

b. listing two ways that Darwin's explanation of evolution helps explain the results of the simulation, and
c. explaining why change would proceed very slowly if there were little variation within a population.

4. understand that the process of natural selection helps explain the body of evidence that their team collected in the activity *Evidence for Change across Time*.

   They will demonstrate their understanding by writing a paragraph that describes this connection.

Strategies for Guiding Learners

Process and Procedures

This activity requires that students work in teams of four. If your class does not divide evenly, use teams of five. The activity calls for a jigsaw strategy with half of the teams using Fabric A and half of the teams using Fabric B.

Before the students begin the activity, review the procedure with them. Also make sure your students are familiar with the concept of predator/prey relationships.

Step 1
Tell the students to decide who will be the game warden and who will be the predators. (Be sure everyone understands that the dots are the prey.)

Step 2
Make sure the game warden records the number of individuals of each color in the starting population.

Step 3
Make certain that half of the teams use Fabric A and half use Fabric B. The procedures remain the same for both groups.

Steps 4-5
The predators must turn away from the habitats until the game wardens tell them to turn around, and then they must stop hunting when the game warden says: "Stop." If the predators have difficulty picking up the paper dots, provide forceps.

Step 6
Make sure the predators carefully collect all of the dots that remain on the fabric and that they sort them by color. Remind the game wardens that they are responsible for recording these data.

Step 7
Explain to the students that as they complete this step, they are simulating reproduction in the surviving population.

Step 8
As the students repeat the predation, make sure that they now are using the second generation.

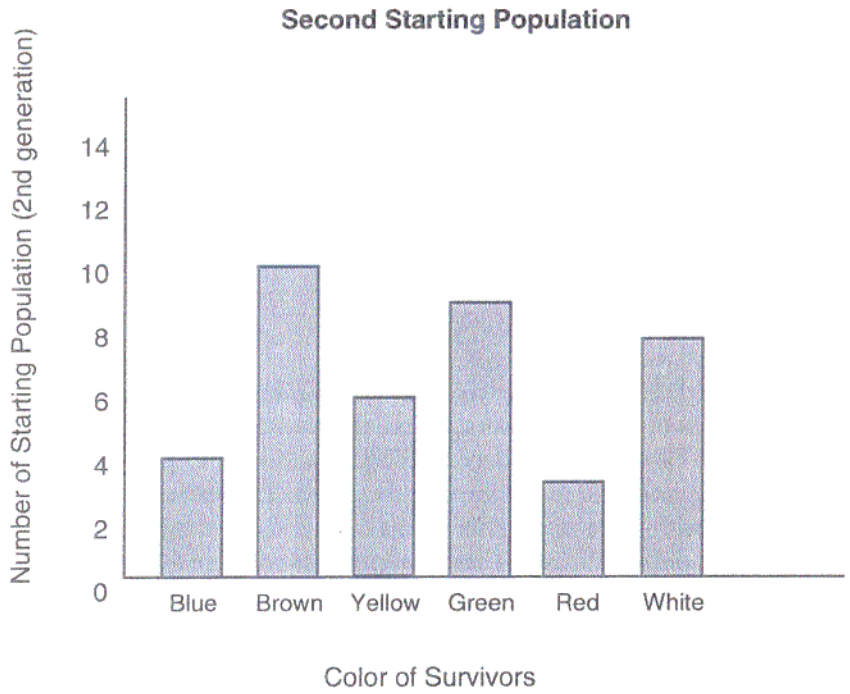
Step 9

Explain to the students that they do not have to simulate reproduction as they did before, but rather calculate the number of individuals that would be in the third generation starting population.

Step 10

The construction and analysis of the bar graphs is a critical and time-consuming part of this activity. If your students need help making bar graphs, refer them to *Techniques, Appendix B*, in the student book. The bar graph in Figure T2.2 is an example of what to expect from the students. If you have ready access to computers and spreadsheet programs, you could incorporate the use of a spreadsheet during this step.

Figure T2.2 This bar graph is an example of what to expect from the students. It represents the starting population in the second generation.



Step 11

Use the questions in this step for the class discussion. Also, ask the students what physical or behavioral characteristics (besides camouflage) might be the basis of evolution by natural selection. This will help students generalize from the example of camouflage to other factors that contribute to reproductive success (for example, better night vision, ability to move quickly, ability to survive with little water). Some students may advance alternative explanations for the unity and diversity of life that are based on other ways of knowing. Acknowledge the obvious wide range of opinions that students might hold, but help the students make a distinction between explanations that are scientifically derived (that is, those based on observation and testable hypotheses) and those based in whole or in part on other criteria.

Look for responses such as the following:

11a. Which, if any, colors of paper dots survived better than others in the second and third generation starting populations of paper dots?

Answers will vary depending on the color of the fabric that the students used. The starting populations for the second and third generations should include more dots that are of colors similar to the fabric and fewer dots that are of colors that stand out against the fabric. The change between the first and third generations should be more dramatic than the change between the first and second generations.

11b. **What might be the reason that predators did not select these colors as much as they did other colors?**

Some colors were better camouflaged than others—they blended into the environment.

11c. **What effect did capturing a particular color dot have on the numbers of that color in the following generations?**

When an individual is removed from a population and dies, in this case through predation, that individual no longer reproduces. The students should realize that heavy predation leads to a decrease in the size of the population and in the size of the gene pool.

Step 12

Allow the students enough time to re-sort the colored dots into the appropriate bags. The dots tend to stick to clothing and fly away easily. *Be sure the students re-count the dots in each bag and replace missing dots.* Have a three-hole punch and construction paper on hand to replace lost dots.

Analysis

This *Analysis* provides you with an opportunity to assess the learners' understanding of evolution and the mechanisms by which it occurs. Before the students begin to work on these tasks, display a piece of Fabric A and a piece of Fabric B and ask the learners to post their third generation bar graphs beside the fabric that they used. The learners now will benefit by comparing their own results with those from other teams that used the same fabric as well as with those from teams that used a different fabric. These comparisons will give them more data with which to construct explanations for the results that they see.

1. **How well do the class data support your team's conclusions in Step 11?**

Students need to be able to analyze the relationship between their response in Step 11 and the cumulative data. The specific response is not important as long as it addresses the relationship between the team data and the class data.

2. **Imagine a real-life predator/prey relationship and write a paragraph that describes how one or more characteristics of the predator population or the prey population might change as a result of natural selection.**

The students should explain that variation exists in populations. Individuals with certain characteristics are better adapted than other individuals to their environment, and consequently survive to produce offspring; less well adapted individuals do not. The offspring, in turn, possess characteristics similar to those of their parents, and that makes them better adapted to the environment as well. These two concepts are the basis of natural selection, and they explain how populations evolve.

Little variation in a population of organisms would mean that fewer differences would be expressed in the offspring. Fewer differences would mean that individuals would have similar advantages and disadvantages in the prevailing environmental conditions. This similarity, in turn, would mean that their survival and reproductive rates would be similar, so few heritable differences then would be passed on to the next generation.

3. **Write one paragraph that describes how the process of natural selection adds to the collection of evidence and inference that your team examined in the activity *Evidence for Change across Time*. Write a second paragraph that summarizes your understanding of biological evolution.**

   In the first paragraph, expect that students will describe that in a population of organisms, variation exists among characteristics that parents pass on to their offspring. Individuals with certain characteristics may have a slight advantage over other individuals and thus live longer and reproduce more. If this advantage remains, the difference would be more noticeable across time. These changes could eventually lead to new species. This process of natural selection, then, provides an explanation both for the relatedness of organisms and for biological change across time.

ELABORATE — A Cold Hard Look at Culture

Major Concepts: Cultural and biological evidence for evolution; inference

Overview

In this activity the students examine information about the well-preserved remains of a man who was found in 1991 in the Italian Alps. The students review a table that describes the artifacts that were recovered with this "Iceman." They then consider the evidence and make inferences about the Iceman's life and culture. The students also have the opportunity to consider the differences between biological and cultural evolution.

Materials (per class of 30, teams of 4)

Videodisc Side 1
videodisc player and monitor
VCR and monitor (optional)

Preparations

You may find it useful to read some of the reports of the discovery and scientific study of this 1991 archeological find (for example, *National Geographic*, June 1993, pp. 36-67). There is also a NOVA videotape that chronicles the discovery and the research on the Iceman (*Iceman*, 1993). Your school district may have this video available.