Teacher Guide: Natural Selection

Learning Objectives

Students will…

- Predict the color of moth that will survive better on various colors of tree trunks.
- Understand how camouflage can promote survival.
- Explain the process of natural selection.

Vocabulary

biological evolution, camouflage, Industrial Revolution, lichen, morph, natural selection, peppered moth

Lesson Overview

In the *Natural Selection* Gizmo™, you play the role of a bird hunting for moths resting on tree trunks. The moths are found in light (speckled) and dark varieties, and tree trunks can be either light or dark in color. Students can track the populations of light and dark moths over a five-year period.

The Student Exploration sheet contains two activities:

- Activity A – Students hunt moths on trees with light bark.
- Activity B – Students hunt moths on trees with dark bark.

Three speckled moths and three dark moths on a dark tree trunk

Suggested Lesson Sequence

1. **Pre-Gizmo activity: Hidden moths** (variable)
   Pass out paper, colored pencils/crayons/markers, scissors, and tape. Have each student create his or her own camouflaged moth. They can design their moth to be camouflaged anywhere in the classroom (or hallway), as long as it is in plain view (no taping moths underneath the desks).

   Once all the moths have been placed in the room, invite visitors to the classroom to hunt for moths. Give each visitor 60 seconds to find as many moths as he or she can. Keep track of how many moths each visitor catches, and how many times each hidden moth was found. At the end of the project, discuss which visitors and moths would be most likely to survive in the wild.

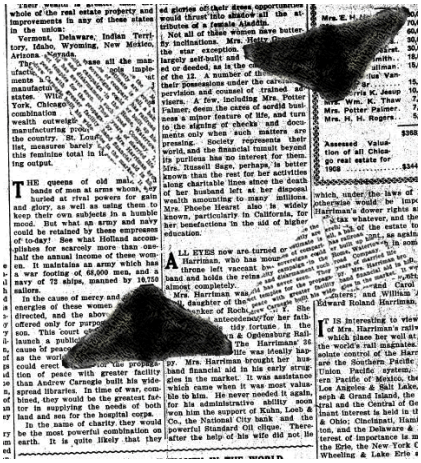
2. **Prior to using the Gizmo** (10 – 15 minutes)
   Before students are at the computers, pass out the Student Exploration sheets and ask students to complete the Prior Knowledge Questions. Discuss student answers as a class, but do not provide correct answers at this point. Afterwards, if possible, use a projector to introduce the Gizmo and demonstrate its basic operations. Demonstrate how to take a screenshot and paste the image into a blank document.

3. **Gizmo activities** (15 – 20 minutes per activity)
   Assign students to computers. Students can work individually or in small groups. Ask students to work through the activities in the Student Exploration using the Gizmo. Alternatively, you can use a projector and do the Exploration as a teacher-led activity.

4. **Discussion questions** (15 – 30 minutes)
   As students are working or just after they are done, discuss the following questions:
   - Which type of moth is hardest to catch on the light trees? Dark trees?
   - What strategies did you use to hunt for moths? Did you carefully examine each tree, or did you flip through trees rapidly and pick off the most obvious moths?
   - Did your hunting strategy change as the simulation went on? If so, how?
   - In what ways is the *Natural Selection* Gizmo realistic? Unrealistic?

5. **Follow-up activity** (30 – 45 minutes)
   Create your own peppered moth simulation using newspaper and black construction paper. Have students work in pairs. The first step is to cut out 10-20 "moth" shapes from newspaper and from black or brown construction paper. Use a newspaper and a sheet of black construction paper as backgrounds.

   For each pair, designate a "hunter" and an "arranger." The hunter turns her back while the arranger scatters a random number of each kind of moth on the newspaper background. When this is done, the hunter turns around and counts how many light and dark moths she sees. Repeat this test several times, and then switch to the dark background. Switch roles so that each partner has a chance to be the hunter.



Can you spot *all* the moths?

When all the data has been collected, discuss the class results. Which moths were easiest to spot? Hardest to spot? Which hunters were the best at finding hidden moths?

Scientific Background

The story of the peppered moth, *Biston betularia*, is one of the best-known examples of natural selection in action. The peppered moth is common in Europe, North America, and Asia. It shelters on trees during the day and is eaten by birds. Peppered moths are found in three forms, or *morphs*:

- *Biston betularia* morpha *typica* is light gray in color and speckled.
- *Biston betularia* morpha *carbonaria* is dark gray in color.
- *Biston betularia* morpha *insularia* is intermediate in color. (This morph is *not* shown in the *Natural Selection* Gizmo.)

Prior to 1800, the *typica* morph was much more common than the darker *carbonaria* morph in the English countryside. The speckled-gray moths blended in well with light-colored tree bark and lichens. The dark *carbonaria* form contrasted with the tree bark, making it easier to spot.

During the 1800s, the Industrial Revolution changed the landscape of England. New coal-powered factories spewed tons of dirty smoke into the air, blanketing the forests with soot. The lichens on tree trunks died, and tree trunks were darkened. When this happened, the *typica* form was easier to spot than the *carbonaria* form, and as a result more were eaten. By 1895, dark moths accounted for nearly 100% of the total population in some forests. The pattern of darkening is described by the term *industrial melanism*.

Throughout the 20th century, air quality improved, trees became lighter in color, and the proportion of *typica* moths increased. Today, *carbonaria* is almost as rare as it was before the Industrial Revolution.

Historical connection: Peppered-moth controversy

In the 1950's, Bernard Kettlewell conducted a series of experiments to test the hypothesis that natural selection, and more specifically bird predation, was the cause of industrial melanism in the peppered moth. Kettlewell released marked moths into polluted and unpolluted forests. In the polluted forests, dark moths were recaptured at a higher frequency, indicating that light moths were predated upon more by birds. The opposite was true in the unpolluted forests.

In the past two decades, some controversy has erupted over the validity of Kettlewell's methods and conclusions. For example, Kettlewell released moths during the day, a time when they are normally at rest and less likely to select an ideal hiding place. Other scientists have claimed that the moths normally rest on the undersides of branches, rather than on the exposed trunks. If this is the case, their coloration may be less of a factor.

Starting in 2000, lepidopterist Michael Majerus began an experiment that was designed to address many of the criticisms of Kettlewell's results. Every night Majerus released both light and dark moths into his garden, which contained trees that were covered in lichen and therefore favorable to the light moths. The next morning, he noted the resting place of each moth, and then checked again four hours later to see which moths had survived the morning. As Majerus expected, dark moths were eaten at significantly higher frequencies than light moths.

Selected Web Resources

Peppered moth simulation: http://www.biologycorner.com/worksheets/peppermoth_paper.html
Peppered moth animation: http://www.techapps.net/interactives/pepperMoths.swf
Moth history and controversy: http://www.millerandlevine.com/km/evol/Moths/moths.html, http://scienceandevolution.blogspot.com/2007/12/creationism-evolution-and-peppered-moth.html, http://bsgran.people.wm.edu/melanism.pdf

Related Gizmos:
Evolution: Mutation and Selection: http://www.explorelearning.com/gizmo/id?554
Evolution: Natural and Artificial Selection: http://www.explorelearning.com/gizmo/id?575
Microevolution: http://www.explorelearning.com/gizmo/id?521
Rainfall and Bird Beaks: http://www.explorelearning.com/gizmo/id?404