Teacher Guide: Evolution: Mutation and Selection

Learning Objectives

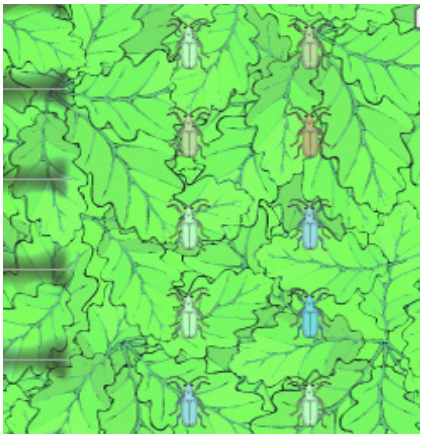
Students will …

- Understand what contributes to an organism's fitness.
- Explain how mutation and sexual reproduction produce variation in a population.
- Determine that, in general, fit individuals have a better chance of surviving and reproducing than less fit individuals (survival of the fittest).
- Predict how a population will evolve when its environment changes.
- Describe how mutation and natural selection allow a population to become adapted to its environment.

Vocabulary

adaptation, allele, chromosome, evolution, fitness, gene, genotype, mutation, natural selection, phenotype, trait

Lesson Overview



All species have evolved from ancient common ancestors. In the process, life has become greatly diversified. According to the theory of evolution by natural selection, life diversified as different species developed specialized adaptations for particular environments. The *Evolution: Mutation and Selection* Gizmo™ simulates how this process takes place.

Using the Gizmo, students can change an environment by altering its background color. Students then observe how insects in that environment evolve in response to the change.

The Student Exploration sheet contains three activities:

- Activity A – Students identify the processes that cause a population to have variation.
- Activity B – Students determine how fitness affects an organism's chances of survival.
- Activity C – Students observe how evolution can occur through natural selection

Suggested Lesson Sequence

1. **Pre-Gizmo activity: Modeling natural selection** (15 – 25 minutes)
   Have students work in pairs. Students should count out 20 regular raisins and 20 yogurt-covered raisins. Instruct students to mix the raisins together in a cup and then sprinkle them randomly on a white plate or paper towel.

   Tell students that the raisins represent prey and the plate represents an environment. One student in the pair will act as the "hunter," and the other student will be the recorder. The hunter should turn his or her back on the plate of raisins. When signaled by the recorder, the hunter should turn around and grab the first raisin he or she sees before turning away again. The recorder should note which type of raisin the hunter selected.

Have students continue “hunting” for raisins for 2 minutes. Afterwards, ask the pairs to determine which type of raisin the “hunter” selected most often. Ask students to explain why one kind of raisin was selected more often than the other kind. [The regular raisins might have been selected more often because they stood out against the white background. Alternatively, the yogurt-covered raisins might have been selected more often because of their taste.] Then have students switch roles and repeat the activity.

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:
   - Do you think the fittest individuals always survive and reproduce? Why might some of the fittest individuals not survive?
   - How do you think changing the mutation rate would change how quickly a population evolved? [If time allows, have students use the Gizmo to test their predictions.]
   - How could mutations affect the fitness of an organism?
   - Do populations evolve on purpose?

5. **Follow-up activity: Allele frequency** (30 – 45 minutes)
   In the field of genetics, evolution is defined as a change in the frequency of alleles in a population’s gene pool. Have students explore this concept with the Gizmo by recording allele frequency every 10 generations. Students can construct graphs showing how the allele frequency changed as natural selection acted on the population.

   After students finish exploring this Gizmo, consider trying the *Evolution: Natural and Artificial Selection* lesson, which uses a similar simulation but allows students to create their own strains of bugs by selecting breeding pairs.

Scientific Background

Environments have finite resources. There is only so much space and energy to support a population. Because more individuals are produced than are able to survive, the individuals in a population must compete with one another to survive and reproduce.

So, which individuals will end up winning the competition? To address this question, it is important to first recognize that the individuals in a population are rarely identical. They each have small variations. Variations that are beneficial to an organism are called *adaptations*.

Adaptations may be physical, such as a fawn's camouflage. Other adaptations may involve behavior, such as the instinct many birds have to migrate. Organisms with an adaptation have a greater level of fitness than organisms in the same population that lack that adaptation. The adaptation gives the organism a competitive edge in its environment, making it more likely that the organism will survive and reproduce. This concept is known as *survival of the fittest*.

The principle of natural selection states that the fittest organisms in each generation are the ones most likely to survive and produce offspring. Offspring are likely to inherit their parents' adaptations. In this way, adaptations can gradually spread throughout a population, resulting in evolution.

It should be noted that adaptations do not guarantee survival and reproduction. Often, chance alone determines whether an organism survives. For example, a beetle, no matter how well-adapted it is, can just as easily be crushed under a hiker's boot as a poorly-adapted beetle. In the beetle's case, it is simply a matter of being in the wrong place at the wrong time.

Despite the vagaries of chance, it is always slightly more probable that a well-adapted individual will outcompete less well-adapted individuals. Because of this, natural selection is one of the main driving forces of evolution. However, natural selection is not the only way that evolution can take place. Other processes, including non-random mating (sexual selection) and genetic drift, also provide mechanisms for evolution.

Health Connection: Antibiotic resistance

Antibiotics are drugs used to treat bacterial infections. This class of drug was first developed in the 1920s. At that time, infectious diseases were the leading cause of death worldwide. Within two decades of the introduction of antibiotics, almost every major bacterial disease could be effectively cured with an antibiotic. In the late 1960s, Surgeon General William Stewart reported to Congress that infectious diseases would soon be a thing of the past. Little did he know that the process of natural selection would soon prove his words false.

As antibiotics were dispensed for practically every ailment, some bacteria developed mutations that allowed them to become resistant to specific antibiotics. Through natural selection, these bacteria rapidly multiplied and spread, effectively neutralizing the effectiveness of one antibiotic after another. Today, strains of bacteria that cause tuberculosis, staph infections, and other infectious diseases are almost completely untreatable with antibiotics. Experts predict that the problem will continue to grow and can only be held in check by the discovery of new drugs.

Selected Web Resources

Understanding evolution: http://evolution.berkeley.edu/evolibrary/article/0_0_0/evo_toc_01
Examples of evolution: http://www.nature.com/nature/newspdf/evolutiongems.pdf
Natural selection: http://www.actionbioscience.org/evolution/futuyma.html
Resistance to antibiotics: http://evolution.berkeley.edu/evosite/relevance/IA1antibiotics.shtml

Related Gizmos:
Evolution: Natural and Artificial Selection: http://www.explorelearning.com/gizmo/id?575
Natural Selection: http://www.explorelearning.com/gizmo/id?447
Microevolution: http://www.explorelearning.com/gizmo/id?521
Rainfall and Bird Beaks: http://www.explorelearning.com/gizmo/id?404
Human Evolution - Skull Analysis: http://www.explorelearning.com/gizmo/id?576