Activity 3

Natural Selection

GOALS
In this activity you will:

• Investigate the process of natural selection.
• Describe the major factors causing evolutionary change.
• Distinguish between the accommodation of an individual to its environment and gradual adaptation of a species.
• Read about the meaning of a theory in science.

What Do You Think?
One hundred rabbits were trapped and introduced to an island with a huge diversity of plants. The rabbits had several noticeable variations. Thirty years later scientists returned to the island. They were amazed that although the number of rabbits was still around 100, the later generations did not vary as much as the earlier rabbits had.

• What happened to the variations that were evident in the original species?
• How would you explain why the variations seemed to have disappeared?

Write your answer to these questions in your Active Biology log. Be prepared to discuss your ideas with your small group and other members of your class.

For You To Do
In this part of the activity you will study the process of natural selection. You will work with a hypothetical population of organisms in a hypothetical environment.
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You will use a sheet of newspaper as the environment. You will use paper squares to represent individual prey. You will be given a chance to capture five prey individuals. The remaining prey will reproduce. You will then have another chance to capture the prey.

Part A: Predator and Prey

1. Work in groups of four. One student (the keeper) sets up the environment before each round (generation). The other three in the group act as “predators.” They remove prey from the environment.

2. Lay a sheet of newspaper flat on a table or floor.

3. Take at least 50 each of newspaper, white, and red paper squares (150 squares). Keep the three types separate, as each represents a different type of the same prey species. Some are brightly colored. The others are not. An example of such different populations is the species *Canis familiaris*, the common dog. Although dogs come in many different colors and sizes, they all belong to the same species. The paper squares represent individuals of different colors, but of the same species.

4. The keeper collects 10 squares from each of the three prey populations. The keeper then mixes them and scatters them on the environment while the predators are not looking. Each predator may look at the environment only when it is her or his turn. When it is not your turn, simply close your eyes or turn your back until the keeper indicates that it is your turn. When it is your turn, remove five prey individuals as quickly as you can. Continue in order until each predator has removed five prey individuals.

5. Shake off the individuals left on the environment and count these survivors according to their type. They represent generation 1.

   a) Enter the data for your group in a table similar to the one shown.

   b) Place the data on the chalkboard also, so a class total can be reached.

<table>
<thead>
<tr>
<th>Generation</th>
<th>Paper-Prey Species</th>
<th>Newspaper Individuals</th>
<th>White-Paper Individuals</th>
<th>Red-Paper Individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Team</td>
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<td>Class</td>
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<td>Class</td>
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</tbody>
</table>
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6. Analyze your data for the first generation. Record answers to the following questions in your *Active Biology* log:
   
a) Does any population have more survivors than the others?

b) Write a hypothesis that might explain this difference.

c) Consider your hypothesis. If it is valid, what do you predict will happen to the number of newspaper individuals by the end of the fourth generation? to the red-paper individuals? to the white-paper individuals?

7. The survivors will be allowed to “reproduce” before the next round begins. For each survivor, the keeper adds one individual of that same type. The next generation will then include survivors and offspring. This should bring the total prey number back up to 30.

8. The keeper scatters these 30 individuals on the habitat. Repeat the predation and reproduction procedures for three more generations.
   
a) Calculate the change in the number of all three populations after each round.

9. Look at your data and analyze your findings.
   
a) Does it take you a longer or shorter period of time to find one prey individual as you proceed through the generations? Give an explanation for this.

b) How does the appearance of the surviving individuals compare with the environment?

c) Is your hypothesis and your prediction in question supported, or do they need to be revised?

d) Were the red-paper individuals suited or unsuited for this environment? Explain.

e) Would you say this species *as a whole* is better adapted to its environment after several generations of selection by the predators? Explain.

10. Now think of the “real” world.
   
a) Is appearance the only characteristic that determines whether an individual plant or animal is suited to its environment? If so, explain. If not, give several other characteristics.

b) In your own words, what is natural selection? What role does reproduction play in your definition?

11. Now you may test some of your own ideas about natural selection.
   
   • What would happen if there was a change in the environment, such as a change in color of the habitat?

   • What would be the result if one type of paper square “reproduced” at a faster rate than the others?

Part B: Hypothetical Model

1. Examine the story shown in the pictures on the next two pages. It is purely a hypothetical model and not an actual situation that occurred.
2. Discuss the following questions in your small group. Then answer them in your Active Biology log.

a) What change took place in the environment of the original moth population?

b) What change was produced in the moth population as a result of this environmental change?

c) Provide evidence that indicates that the change in the moth population is not simply an
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Effect of the environment, but is really a hereditary population change.

D) Do you think that the change was a result of a change in reproductive capacity of the two kinds of moths? Do you think the change was a result of the survival of the moth best fit for the environment (selection pressure)?

E) What has happened to the frequency of the gene for speckled white color in the moth population now living in the pine woods?

F) What has happened to the frequency of the gene for speckled white color in the moth population living in the birch woods?

G) If environments change over a period of time, what must happen to populations if they are to survive?

H) If natural selection is responsible for the changes in frequency of black and of speckled-white moths in the two types of woods, what comparison can you make between the color of the favored type of moth and the color of the bark of the trees in each woods?

I) Assume there is benefit in protective coloration on the part of moths. What type of predators would you suspect to prey on moths?

J) What special abilities would these predators have to possess if they are really the agents of selection here?

K) Devise an experiment that would test this hypothesis.
Theories in Science

The popular use and scientific use of the term “theory” are very different. Scientific theories attempt to provide explanations. Scientists make observations and then try to explain them. In popular terms you often hear the expression, “it’s just a theory.” That usually means that it is a guess. In scientific terms, a **theory** implies that an idea has been strongly supported by observations.

When scientists use the scientific method they often begin with questions from curious observations. They then develop hypotheses that can be tested experimentally. A **hypothesis** is a prediction between an independent (cause) variable and a dependent (result) variable. Hypotheses can either be supported or not, depending on the data collection. A hypothesis is not a guess. You developed and tested hypotheses in this activity. The hypothesis is then tested by further observations and experiments. Over time, if the observations and experiments satisfy the hypothesis, it becomes accepted as a scientific theory.

However, a theory is not the absolute truth. It only provides an explanation. The acceptance of a theory is often measured by its ability to enable scientists to make predictions or answer questions. A good theory provides an explanation that scientists can use to explain other observed events. Theories can be modified as new information becomes available or ideas change. Scientists continually “tinker” with a theory to make it more elegant and concise, or to make it more all encompassing.

Darwin’s Hypothesis of Natural Selection

The theory of **evolution** owes much to the work of Charles Darwin. He presented his research in the mid-19th century. However, Darwin never labeled his hypotheses as “evolution.” He was interested in how species change and how new species come about. His many years of work led to explanations that have proved to be valid. But Darwin was not the first to think that existing species might evolve into new ones. However, Darwin was a most believable scientist for two reasons. First, he amassed a great deal of evidence. He verified its accuracy and presented it in a convincing way. Second, his hypothesis stated how change in organisms might take place, a contribution no one else had made.
On November 24, 1859, the first edition of Darwin’s *On the Origin of Species* was published. The book was so popular that its first printing was sold out in one day. There were, of course, many who disagreed with him.

The theory of evolution has undergone many changes since Darwin’s time. However, Darwin’s original thinking still serves as a convenient introduction to the subject.

Here is his analysis:

- **First**, there are many differences among the individuals of every species. In a population, or group, of these individuals, variations occur. Usually it is safe to say that no two individuals are exactly alike. Darwin knew or suspected that many of the individual differences could be inherited.

- **Second**, the population size of all species tends to increase because of reproduction. One amoeba, for example, divides and produces two. These two divide, and the next generation numbers four. Then there will be 8, 16, 32, and so on.

- **Third**, this increase in the size of populations cannot go unchecked. If it did, the number of individuals of any species would outgrow the food supply and the available living space.

From 1831 to 1836 Charles Darwin, a British naturalist, served aboard the H.M.S. Beagle on a science expedition around the world. The expedition visited places around the world, and Darwin studied plants and animals everywhere he went, collecting specimens for further study. In South America Darwin found fossils of extinct animals that were similar to modern species. On the Galapagos Islands in the Pacific Ocean he noticed many variations among plants and animals of the same general type as those in South America.
Fourth, it is obvious that this huge increase seldom occurs in nature. The number of organisms in a species does not continue to increase over long periods of time. In fact, the sizes of many populations seem to remain nearly the same over time. How can this be explained? Observations of natural populations show that many individuals die before they are able to reproduce.

Why do some individuals die early, but not others? Darwin thought there must be a sort of “struggle for survival.” The individuals of a species “compete” for food, light, water, places to live, and other things important for their survival. The “struggle” or “competition” may be either active or passive. That is, sometimes animals actually fight for food or the opportunity to mate. In other cases, there is no direct fight or competition. The first animal that happens to find a suitable living area may settle there. This prevents the area from being used by others. In either case, individuals with certain characteristics, or traits, will survive and produce offspring more often than individuals without them.

Consider, for example, how the African cheetah came to be such a fast runner. Cheetahs are hunters. They capture their food; mostly antelopes, gazelles, and birds, by first stalking near their prey. Then they run the prey down with a terrific burst of speed over a short distance. In any population of cheetahs, some can run faster than others. Those that run fastest are most successful in getting food. Those that are better at getting food also are more likely to survive.

While chasing prey, cheetahs often reach speeds of 70 miles per hour. Unfortunately, their great speed may not be enough for this species to survive. Scientists have found that wild cheetahs have virtually no genetic variation. Cheetahs suffer from inbreeding. This lowers their resistance to diseases and also causes infertility and high cub-death rates.
But survival is not the whole story. The characteristics that make an organism better able to survive in its environment are inherited. Therefore, those who survive are likely to pass on those characteristics to their offspring. For example, the surviving cheetah is likely to produce offspring with long, thin necks and powerful leg muscles, capable of great speed. Over many generations, one could expect an increase in the number of individuals that have these traits. The number with less beneficial characteristics would decrease. The organisms with the beneficial characteristics are likely to live longer and produce more offspring. Darwin called this process of survival and reproduction **natural selection**. Darwin thought that several factors were involved in natural selection:

1. The presence of variation among individuals in a population.
2. The hereditary basis of such variable characteristics.
3. The tendency of the size of populations to increase.
4. The “struggle for survival” (or competition for the needs of life).
5. A difference in the inherited characteristics that individuals pass on to succeeding generations.

**Bio Words**

natural selection: the differences in survival and reproduction among members of a population

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**Reflecting on the Activity and the Challenge**

A change in the environment can have a large impact on the natural selection process. In this activity you investigated two situations. In the first, the “animals” that were best adapted to the environment were the ones to survive. In the second part you saw how a change in an environment could affect the natural selection process. Animals more suited to the changed environment would survive. You will need to explain the process of natural selection as part of your Chapter Challenge.

At one time some scientists believed that the necks of giraffes became long as a result of continually stretching to reach high foliage. Using what you know about natural selection, how would you explain the long necks?
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1. What evidence supports the following idea: hereditary differences are important in determining whether or not an individual survives and leaves offspring?

2. What is the difference between natural selection and evolution?

3. What did Darwin emphasize as the major factors in causing evolutionary changes?

4. What did Darwin mean by natural selection?

5. Write a short paragraph expressing your ideas now of what happened to the rabbit population on the island in the What Do You Think? section.

6. Comment on the validity of the following statement: Breeders of domestic stock abandon natural selection. Only artificial selection plays an important role in animal-breeding programs.

### Inquiring Further

1. **Animal-breeding programs**
   What are the advantages and disadvantages to animal-breeding programs? Research and report on the pros and cons of human intervention in genetic processes.

2. **Captive breeding**
   Captive breeding is one strategy used by governments and non-government organizations to preserve rare and endangered species. What are the advantages and disadvantages of captive breeding?