SECTION 2

Evolution

Organisms tend to be well suited to where they live and what they do. **Figure 7** shows a chameleon (kuh MEEL ee uhn) capturing an insect. Insects are not easy to catch, so how does the chameleon do it? Chameleons can change the color and pattern of their skin, and then blend into their backgrounds. Their eyes are raised on little, mobile turrets that enable the lizards to look around without moving. An insect is unlikely to notice such an animal sitting motionless on a branch. When the insect moves within range, the chameleon shoots out an amazingly long tongue to grab the insect, while the chameleon's big hind feet hold it securely to the branch.

Evolution by Natural Selection

How do organisms become so well suited to their environments? In 1859, English naturalist Charles Darwin proposed an answer. Darwin observed that organisms in a population differ slightly from each other in form, function, and behavior. Some of these differences are *hereditary* (huh RED i TER ee)—that is, passed from parent to offspring. Darwin proposed that the environment exerts a strong influence over which individuals survive to produce offspring. Some individuals, because of certain traits, are more likely to survive and reproduce than other individuals. Darwin used the term **natural selection** to describe the unequal survival and reproduction that results from the presence or absence of particular traits.

Darwin proposed that over many generations natural selection causes the characteristics of populations to change. A change in the genetic characteristics of a population from one generation to the next is known as **evolution.**

Objectives

- Explain the process of evolution by natural selection.
- Explain the concept of adaptation.
- Describe the steps by which a population of insects becomes resistant to a pesticide.

Key Terms

natural selection
evolution
adaptation
artificial selection
resistance

Connection to Geology

Darwin and Fossils In the 1800s, fossil hunting was a popular hobby. The many fossils that people found started arguments about where fossils came from. Darwin's theory of evolution proposed that fossils are the remains of extinct species from which modern species evolved. When his book on the theory of evolution was first published in 1859, it became an immediate bestseller.

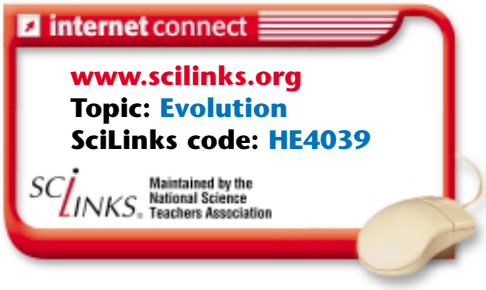


Figure 7 ▶ A chameleon catches an unsuspecting insect that has strayed within range of the lizard's long, fast-moving tongue.

Nature Selects Darwin thought that nature selects for certain traits, such as sharper claws or lighter feathers, because organisms with these traits are more likely to survive and reproduce. Over time, the population includes a greater and greater proportion of organisms with the beneficial trait. As the populations of a given species change, so does the species. **Table 1** summarizes Darwin's

Table 1 ▼

Evolution by Natural Selection	
1. Organisms produce more offspring than can survive.	In nature, organisms have the ability to produce more offspring than can survive to become adults.
2. The environment is hostile and contains limited resources.	The environment contains things and situations that kill organisms, and the resources needed to live, such as food and water, are limited.
3. Organisms differ in the traits they have.	The organisms in a population may differ in size, coloration, resistance to disease, and so on. Much of this variation is inherited.
4. Some inherited traits provide organisms with an advantage.	Some inherited traits give organisms an advantage in coping with environmental challenges. These organisms are more likely to survive longer and produce more offspring; they are "naturally selected for."
5. Each generation contains proportionately more organisms with advantageous traits.	Because organisms with more advantageous traits have more offspring, each generation contains a greater proportion of offspring with these traits than the previous generation did.

CASE STUDY

Darwin's Finches

Before Charles Darwin formulated his theory of evolution, he sailed around the coast of South America. The plants and animals he saw had a great effect on his thinking about how modern organisms had originated. He was surprised by the organisms he saw on islands because they were often unusual species found nowhere else.

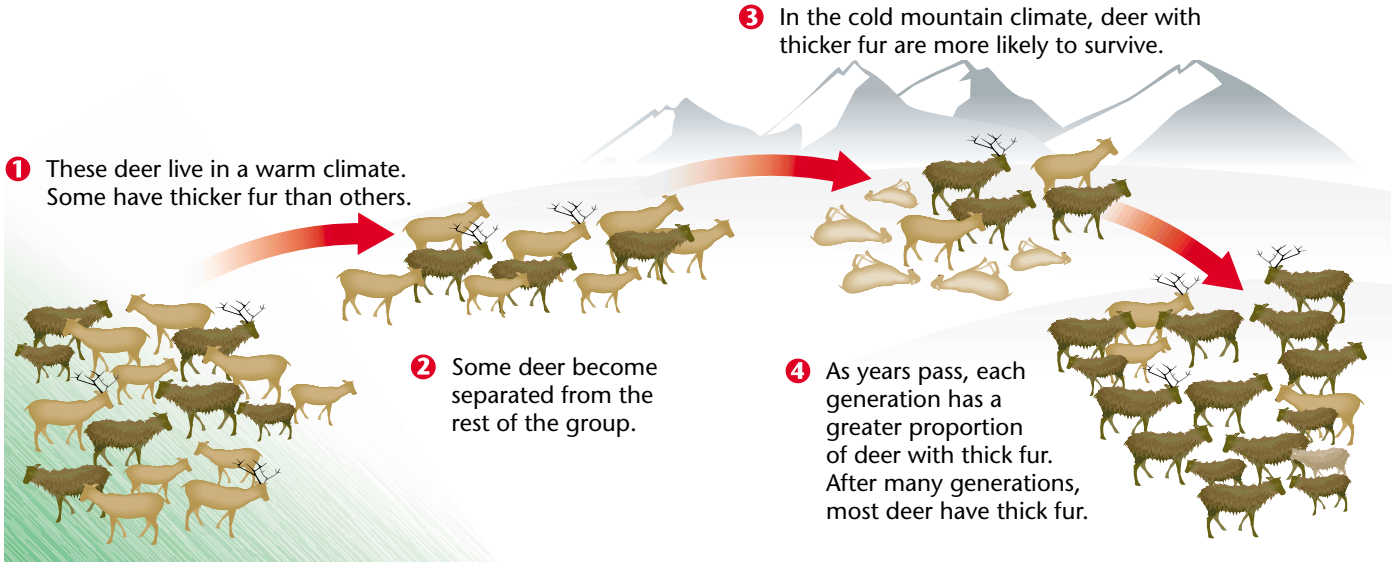
He was particularly impressed by the organisms in the Galápagos Islands, an isolated group of volcanic islands in the Pacific Ocean west of Ecuador. The islands contain 13 unique species of birds, which have become known as Darwin's finches. All the species look generally similar, but each species has a specialized bill adapted to eating a different type of food. Some species have large, parrotlike bills adapted to cracking big seeds, some species have slim bills that are used to sip nectar from flowers, and some species have even become insect eaters. Darwin speculated that all the Galápagos finches had evolved from a single species of seed-eating finch that found its way to the islands from the South American mainland. Populations of the finches became established on the various islands, and those finches that survived were able to eat what they found on their island.

▶ Notice the beaks in the two species of Darwin's finches. What do you think the finches eat?

Princeton University biologists Peter and Rosemary Grant have spent 25 years studying Darwin's finches on Daphne Major, one of the Galápagos Islands. Here, one

theory of evolution by natural selection. An example of evolution is shown in **Figure 8**, in which a population of deer became isolated in a cold area. Many died, but some had genes for thicker, warmer fur. These deer were more likely to survive, and their young with thick fur were also more likely to survive to reproduce. The deer's thick fur is an **adaptation,** an inherited trait that increases an organism's chance of survival and reproduction in a certain environment.

Figure 8 ▶ These steps show the evolution of thicker fur in a population of deer.



species, the medium ground finch, has a short, stubby beak and eats seeds as well as a few insects. The ground finches have few predators. The Grants found that the main factor that determined whether a finch lived or died was how much food was available. During a long drought in 1977, many plants died and the small seeds that the finches eat became scarce. Only finches that had large beaks survived. Large beaks allowed them to eat larger seeds from the larger plants that had survived the drought.

The finches that survived the drought passed their genes for large beaks to their offspring. Two years later, the Grants found that the beaks of medium ground finches on Daphne Major were nearly 4 percent larger, on average, than they were before the drought. The Grants had observed evolution occurring in birds over a short period of time, something that had seldom been seen before.

The Galápagos Islands are well suited for research on evolution because the islands are strongly influenced by El Niño and La Niña weather patterns.

These weather patterns produce alternating periods of very wet and dry weather in a relatively short period of time. The weather determines which plants live and which plants die. Then, this effect exerts selective pressure on the animals that depend on particular plants for food or for places to reproduce.

CRITICAL THINKING

1. Making Inferences What is the shortest period in which a population of Darwin's finches can evolve?

2. Analyzing Relationships Would you expect that the finches that evolved bigger beaks in this study might one day evolve smaller beaks?

Figure 9 ▶ This Hawaiian honeycreeper is using its curved beak to sip nectar from a lobelia flower.

Coevolution Organisms evolve adaptations to other organisms as well as to their physical environment. The process of two species evolving in response to long-term interactions with each other is called *coevolution* (koh EV uh LOO shuhn). One example is shown in **Figure 9.** The honeycreeper's beak is long and curved, which lets it reach the nectar at the base of the long, curved flower. The flower has evolved structures that ensure that the bird gets pollen from the flower on its head as it sips nectar. When the bird moves to another flower, some of the pollen will rub off. In this way, the bird helps lobelia plants reproduce. The honeycreeper's adaptation is a long, curved beak. The plant has two adaptations. One is sweet nectar, which attracts the birds. The other is a flower structure that forces pollen onto a bird's head when the bird sips nectar.

Evolution by Artificial Selection

Many populations of plants and animals do not live in the wild but instead are cared for by humans. People control how these plants and animals reproduce and therefore how they evolve. The wolf and the Chihuahua in **Figure 10** are closely related species. Over thousands of years, humans bred the ancestors of today's wolves to produce the variety of dog breeds we now have. The selective breeding of organisms by humans for specific characteristics is called **artificial selection.**

The fruits, grains, and vegetables we eat were also produced by artificial selection. Humans saved the seeds from the largest, sweetest fruits and most nutritious grains. By selecting for these traits, farmers directed the evolution of crop plants. As a result, crops produce fruits, grains, and roots that are larger, sweeter, and often more nutritious than their wild relatives do. Native Americans cultivated the ancestor of today's corn from a grasslike plant in the mountains of Mexico. Modern corn is very different from the wild plant that was its ancestor.

MATHPRACTICE

Plumper Pumpkins
Each year a farmer saves and plants only the seeds from his largest pumpkins. If he starts with pumpkins that average 5 kg and each year grows pumpkins 3 percent more massive, on average, than those he grew the year before, what will be the average mass of his pumpkins after 10 years?

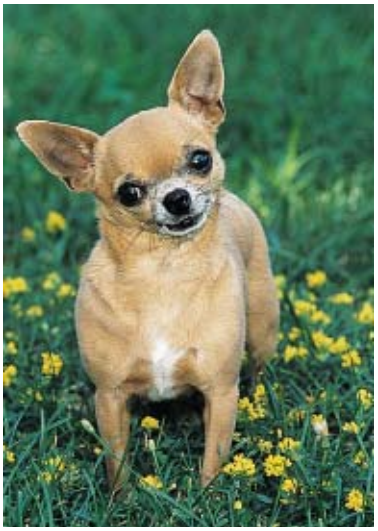


Figure 10 ▶ As a result of artificial selection, the Chihuahua on the right looks very different from its wolf ancestor on the left.

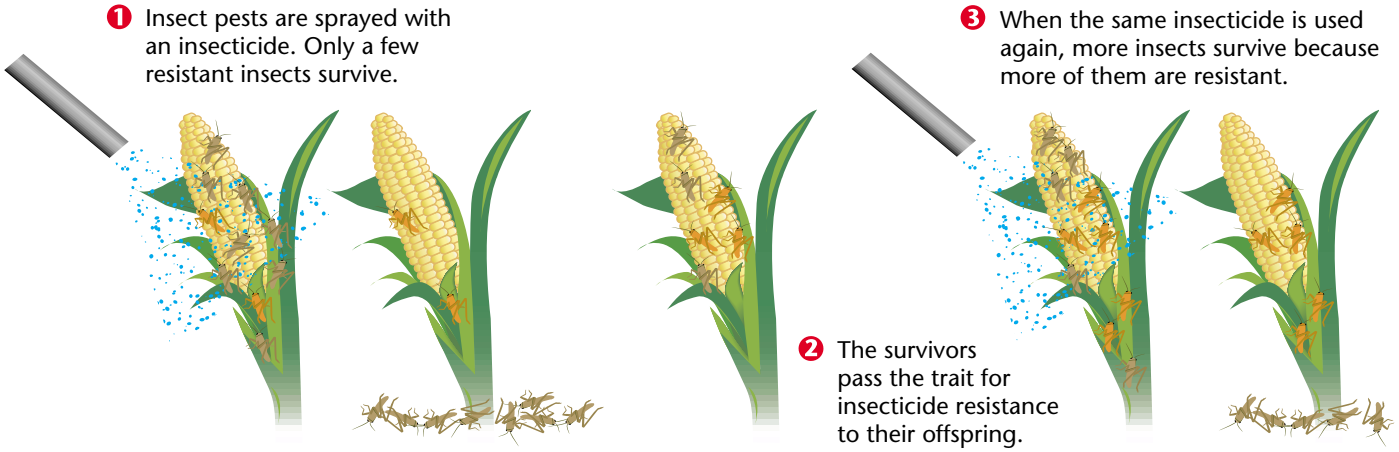


Figure 11 ▶ The evolution of resistance to a pesticide starts when the pesticide is sprayed on the corn. Most of the insects are killed, but a few resistant ones survive. After each spraying, the insect population contains a larger proportion of resistant organisms.

Evolution of Resistance

Sometimes humans cause populations of organisms to evolve unwanted adaptations. You may have heard about insect pests that are resistant to pesticides and about bacteria that are resistant to antibiotics. What is resistance, and what does it have to do with evolution?

Resistance is the ability of one or more organisms to tolerate a particular chemical designed to kill it. An organism may be resistant to a chemical when it contains a gene that allows it to break the chemical down into harmless substances. By trying to control pests and bacteria with chemicals, humans promote the evolution of resistant populations.

Pesticide Resistance Consider the evolution of pesticide resistance among corn pests, as shown in **Figure 11.** A pesticide is sprayed on corn to kill grasshoppers. Most of the grasshoppers die, but a few survive. The survivors happen to have a gene that protects them from the pesticide. The surviving insects pass on the gene to their offspring. Each time the corn is sprayed, the insect population changes to include more and more resistant members. After many sprayings, the entire population may be resistant, making the pesticide useless. The faster an organism reproduces, the faster its populations can evolve.

FIELD ACTIVITY

Artificial Selection Look around your school grounds and the area around your home for possible examples of artificial selection. Observe and report on any examples you can find.

Dogs are one example of artificial selction mentioned in this chapter, but you will probably find many more plant examples. Record your observations in your ***EcoLog.***

SECTION 2 Review

1. **Explain** what an adaptation is, and provide three examples.
2. **Explain** the process of evolution by natural selection.
3. **Describe** one way in which artificial selection can benefit humans.
4. **Explain** how a population of insects could become resistant to a pesticide.

CRITICAL THINKING

5. **Understanding Concepts** Read the description of evolution by natural selection in this section and describe the role that the environment plays in the theory. READING SKILLS
6. **Identifying Relationships** A population of rabbits evolves thicker fur in response to a colder climate. Is this an example of coevolution? Explain your answer.