SECTION 2

How Does Evolution Happen?

Key Concept After making observations and analyzing evidence, Charles Darwin concluded that natural selection is the mechanism of evolution.

What You Will Learn

- Darwin made many observations and was influenced by ideas from other fields.
- The four parts of natural selection are overproduction, inherited variation, struggle to survive, and successful reproduction.

Why It Matters

Natural selection causes populations to change to become better adapted to their environment.

Vocabulary

- trait
- selective breeding
- natural selection

READING STRATEGY

Graphic Organizer In your **Science Journal,** create a Process Chart that shows how Darwin arrived at his conclusions about evolution and natural selection.

Imagine that you are a scientist in the 1800s. Fossils of some very strange animals have been found. How would you explain the existence of these fossils?

In the 1800s, geologists began to realize that Earth was much older than anyone had previously thought. Evidence showed that gradual processes had changed Earth's surface over millions of years. Some scientists saw evidence of evolution in the fossil record. However, no one had been able to explain *how* evolution happens—until Charles Darwin.

Charles Darwin

In 1831, 21-year-old Charles Darwin, shown in **Figure 1,** graduated from college. Darwin didn't know what he wanted to do with his life. Although he eventually earned a degree in theology, Darwin was most interested in the study of plants and animals. So, he signed on for a five-year voyage around the world. He served as the *naturalist*—a scientist who studies nature—on the HMS *Beagle,* a British ship similar to the ship in **Figure 1.** During the trip, Darwin made observations that helped him form a theory about how evolution happens.

Figure 1 *Charles Darwin wanted to understand the natural world. He sailed around the world on a ship similar to the one shown here.*

7.3.b Students know the reasoning used by Charles Darwin in reaching his conclusion that natural selection is the mechanism of evolution.

Figure 2 *The course of the HMS* Beagle *is shown by the red line. The journey began and ended in England.*

Darwin's Journey

The *Beagle*'s journey is shown in **Figure 2.** Darwin observed plants and animals from places such as the Galápagos Islands. These islands are found 965 km (600 mi) west of Ecuador, a country in South America.

Darwin's Finches

Darwin noticed that the animals and plants on the Galápagos Islands were like those in Ecuador. But the plants and animals were not identical. For example, the finches on the Galápagos Islands differed slightly from the finches in Ecuador. And the finches on each island differed from the finches on the other islands. One difference between the finches was the shape of their beaks. As **Figure 3** shows, the beak of each finch is adapted to the way the bird usually gets food.

Standards Check **What did Darwin notice about the finches of Ecuador and the Galápagos Islands?** 7.3.b

Figure 3 **Some Finches of the Galápagos Islands**

The **large ground finch** has a wide, strong beak that it uses to crack open big, hard seeds. This beak works like a nutcracker.

The **cactus finch** has a tough beak that it uses for eating cactus parts and insects. This beak works like a pair of needle-nosed pliers.

The **warbler finch** has a small, narrow beak that it uses to catch small insects. This beak works like a pair of tweezers.

Darwin's Thinking

Darwin puzzled over the animals that he had seen on his journey. He tried to explain why some of the animals, such as the Galápagos finches, were very similar yet had unique adaptations. Darwin hypothesized that the island finches descended from South American finches. He proposed that the first finches on the islands were blown there from South America by a storm. He suggested that the finches evolved adaptations for the various island environments over many generations. For example, Darwin noticed that the shape of the beak was directly related to the finch's food. Darwin's hypothesis about the Galápagos finches explained his observations.

Standards Check **What structural change helped the Galápagos finches adapt to their environment?** 7.3.b

Ideas About Breeding

trait (TRAYT) a genetically determined characteristic

selective breeding (suh LEK tiv BREED ing) the human practice of breeding animals or plants that have certain desired traits

In Darwin's time, farmers and breeders had produced many kinds of farm animals and plants. These plants and animals had traits that were desired by the farmers and breeders. A **trait** is a form of an inherited characteristic. For example, redness is a trait, and fruit color is the corresponding characteristic. The practice by which humans select plants or animals for breeding based on desired traits is **selective breeding.** Most pets, such as the dogs in **Figure 4,** have been bred for various desired traits. Selective breeding shows that the traits of organisms can change and that certain traits can spread through populations.

Figure 4 *Over the past 12,000 years, dogs have been selectively bred to produce more than 150 breeds.*

Quick Lab

Population Growth Vs. Food Supply

7.3.b

1. Use a **marker** to label the first row of an **egg carton** "Food supply" and the second row "Human population."
2. In the "Food supply" row, place one grain of **uncooked rice** in the first cup. Place two grains in the second cup and three grains in the third cup. In each subsequent cup in the row, place one more grain than you placed in the previous cup. Imagine that each grain represents enough food for one person's lifetime.
3. In the "Human population" row, place one grain in the first cup, two in the second cup, and four in the third cup. In each subsequent cup, place twice as many grains as you placed in the previous cup. Each grain represents one person.
4. How many "lifetimes" of food are in the sixth cup? How many "people" are in the sixth cup? If this pattern continued, what would happen?
5. How did the change in the food supply differ from the change in the human population? How do these patterns relate to Malthus's hypothesis?

15 min

Ideas About Population

During Darwin's time, Thomas Malthus wrote *An Essay on the Principle of Population*. Malthus noted that the human population can grow more rapidly than food supplies can grow. **Figure 5** shows this relationship. Malthus also pointed out that the size of human populations is limited by problems such as starvation and disease.

After reading Malthus's work, Darwin realized that any species can produce many offspring. He also knew that the populations of all species are limited by starvation, disease, competition, and predation. Only a limited number of individuals live long enough to reproduce. Darwin reasoned that the survivors had traits that helped them survive in their environment. He also thought that some of these traits would be inherited by the offspring of the survivors.

Standards Check **How did Thomas Malthus's ideas about population influence Darwin?** 7.3.b

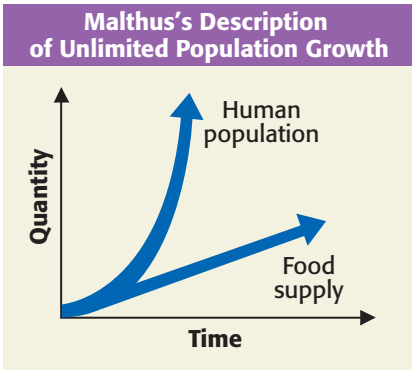

Figure 5 *Malthus thought that the human population could increase more quickly than the food supply. Such an increase would result in a worldwide food shortage.*

Ideas About Earth's History

During Darwin's time, most geologists thought that Earth was very young. But important books, such as *Principles of Geology* by Charles Lyell, were changing ideas about Earth. Lyell's book presented evidence that Earth had formed by natural processes over a long period of time. Darwin reasoned that if Earth were very old, then there would be enough time for organisms to slowly change.

Darwin's Theory of Natural Selection

natural selection (NACH uhr uhl suh LEK shuhn) the process by which individuals that are better adapted to their environment survive and reproduce more successfully than less well adapted individuals do; a theory to explain the mechanism of evolution

After his voyage on the HMS *Beagle*, Darwin privately struggled with his ideas for about 20 years. Then, in 1858, Darwin received a letter from a naturalist named Alfred Russel Wallace. Wallace had arrived at the same ideas about evolution that Darwin had. In 1859, Darwin published a famous book called *On the Origin of Species by Means of Natural Selection*. In his book, Darwin proposed the theory that evolution happens by natural selection. **Natural selection** is the mechanism, or process by which organisms that are better adapted to their environment survive and reproduce more successfully than less well adapted organisms do. The process has four steps and is explained in **Figure 6.**

Standards Check What is natural selection? 7.3.b

Figure 6 **Four Parts of Natural Selection**

1 Overproduction A tarantula's egg sac may hold 500 to 1,000 eggs. Some of the eggs will survive and develop into adult spiders. Some will not.

2 Inherited Variation Every individual has its own combination of traits. Each tarantula is similar but not identical to its parents.

3 Struggle to Survive Some tarantulas may be caught by predators, such as this wasp. Other tarantulas may starve or get a disease. Only some of the tarantulas will survive to adulthood.

4 Successful Reproduction The tarantulas that are best adapted to their environment are likely to have many offspring that survive.

Genetics and Evolution

Darwin knew that organisms inherit traits, but not *how* they inherit traits. He also knew that there is great variation among organisms, but not *how* that variation occurs. Today, scientists know that variation happens as genetic information is passed from parent to offspring in sexual reproduction. Some genes make an organism more likely to survive to reproduce. Natural selection happens when organisms that carry these genes survive and reproduce more than organisms that do not carry these genes. New fossil discoveries and new information about genes add to scientists' understanding of natural selection and evolution.

SECTION Review

7.3.b

Summary

- Finch species of the Galápagos Islands evolved adaptations in response to their environment.
- Natural selection is the process by which organisms that are better adapted to their environment are more likely to survive and reproduce than less well adapted organisms do.
- The four steps of Darwin's theory of evolution by natural selection include overproduction, inherited variation, struggle to survive, and successful reproduction.
- Variation in each species is due to the exchange of genetic information as it is passed from parent to offspring.

Using Vocabulary

1. Write an original definition for *trait*.

Understanding Concepts

2. **Describing** Describe Darwin's observations about the finches on the Galápagos Islands.
3. **Describing** Describe the four parts of Darwin's theory of evolution by natural selection.
4. **Identifying** What ideas from geology influenced Darwin?

Critical Thinking

5. **Identifying Relationships** Summarize Malthus's ideas about population. How did Darwin relate Malthus's ideas to evolution by natural selection?
6. **Evaluating Assumptions** Explain overproduction in natural selection. Can a species that reproduces at a slow rate, such as a whale that produces one offspring every six years, still overproduce?
7. **Analyzing Processes** How did Darwin use scientific methods, such as making observations, analyzing data, and drawing conclusions, before presenting his ideas on the theory of evolution by natural selection?
8. **Making Comparisons** How are selective breeding and natural selection similar? How are they different?

Challenge

9. **Identifying Relationships** Although both Charles Darwin and Gregor Mendel lived during the same time period, Darwin was unaware of Mendel's work. How do Mendel's ideas about the inheritance of traits relate to Darwin's theory of evolution by natural selection?

Internet Resources

For a variety of links related to this chapter, go to www.scilinks.org

Topic: Galápagos Islands; Darwin and Natural Selection

SciLinks code: HY70631; HY70378