

READING WARM-UP

Objectives

- List four sources of Charles Darwin's ideas about evolution.
- Describe the four parts of Darwin's theory of evolution by natural selection.
- Relate genetics to evolution.

Terms to Learn

trait
selective breeding
natural selection

READING STRATEGY

Brainstorming The key idea of this section is natural selection. Brainstorm words and phrases related to natural selection.

How Does Evolution Happen?

Imagine that you are a scientist in the 1800s. Fossils of some very strange animals have been found. And some familiar fossils have been found where you would least expect them. How did seashells end up on the tops of mountains?

In the 1800s, geologists began to realize that the Earth is much older than anyone had previously thought. Evidence showed that gradual processes had changed the 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. Like many young people just out of college, Darwin didn't know what he wanted to do with his life. His father wanted him to become a doctor, but seeing blood made Darwin sick. Although he eventually earned a degree in theology, Darwin was most interested in the study of plants and animals.

So, Darwin signed on for a five-year voyage around the world. He served as the *naturalist*—a scientist who studies nature—on the British ship the HMS *Beagle*, similar to the ship in **Figure 2**. 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.



Figure 2 Darwin sailed around the world on a ship similar to this one.

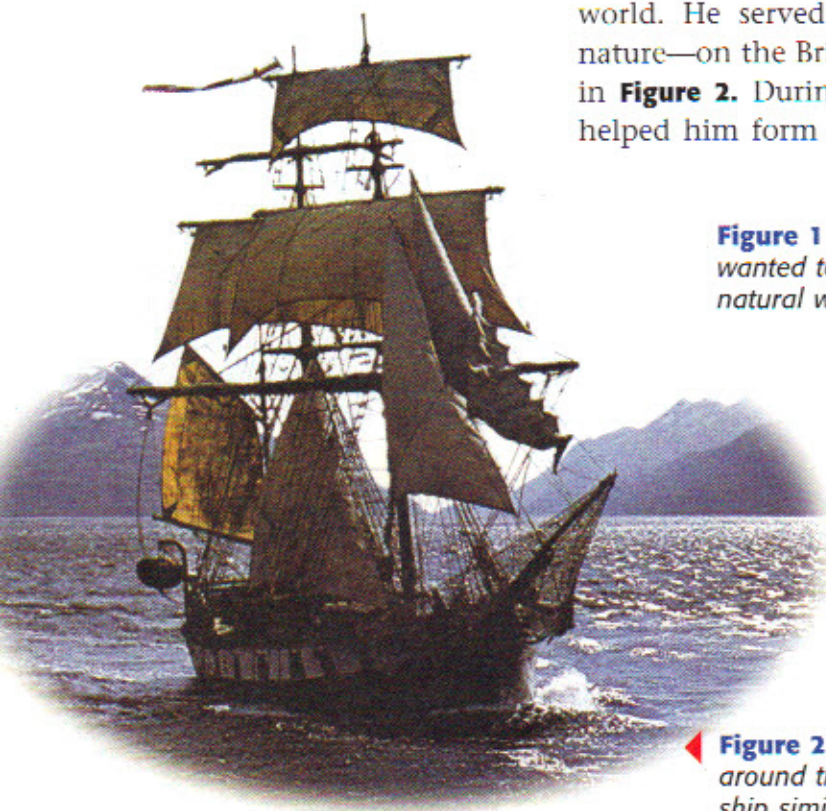




Figure 3 The course of the HMS Beagle is shown by the red line. The journey began and ended in England.

Darwin's Excellent Adventure

The *Beagle's* journey is charted in **Figure 3**. Along the way, Darwin collected thousands of plant and animal samples. He kept careful notes of his observations. One interesting place that the ship visited was the Galápagos Islands. These islands are found 965 km (600 mi) west of Ecuador, a country in South America.

✓ Reading Check Where are the Galápagos Islands? (See the Appendix for answers to Reading Checks.)

Darwin's Finches

Darwin noticed that the animals and plants on the Galápagos Islands were a lot like those in Ecuador. However, they were not exactly the same. The finches of the Galápagos Islands, for example, were a little different from the finches in Ecuador. And the finches on each island differed from the finches on the other islands. As **Figure 4** shows, the beak of each finch is adapted to the way the bird usually gets food.

Figure 4 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-nose 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

After returning to England, Darwin puzzled over the animals of the Galápagos Islands. He tried to explain why the animals seemed so similar to each other yet had so many different adaptations. For example, Darwin hypothesized that the island finches were descended from South American finches. The first finches on the islands may have been blown from South America by a storm. Over many generations, the finches may have adapted to different ways of life on the islands.

During the course of his travels, Darwin came up with many new ideas. Before sharing these ideas, he spent several years analyzing his evidence. He also gathered ideas from many other people.

Ideas About Breeding

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. **Traits** are specific characteristics that can be passed from parent to offspring through genes. The process in which humans select which plants or animals to reproduce based on certain desired traits is called **selective breeding**. Most pets, such as the dogs in **Figure 5**, have been bred for various desired traits.

You can see the results of selective breeding in many kinds of organisms. For example, people have bred horses that are particularly fast or strong. And farmers have bred crops that produce large fruit or that grow in specific climates.

trait a genetically determined characteristic

selective breeding the human practice of breeding animals or plants that have certain desired characteristics

Figure 5 Over the past 12,000 years, dogs have been selectively bred to produce more than 150 breeds.



Quick Lab

Population Growth Versus Food Supply

1. Get an **egg carton** and a **bag of rice**. Use a **marker** to label one row of the carton "Food supply." Then, label the second row "Human population."
2. In the row labeled "Food supply," place one grain of rice in the first cup. Place two grains of rice in the second cup, and place three grains of rice in the third cup. In each subsequent cup, 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 row labeled "Human population," place one grain of rice in the first cup. Place two grains in the second cup, and place four grains in the third cup. In each subsequent cup, place twice as many grains as you placed in the previous cup. This rice represents people.
4. How many units of food are in the sixth cup? How many "people" are in the sixth cup? If this pattern continued, what would happen?
5. Describe how the patterns in the food supply and in the human population differ. Explain how the patterns relate to Malthus's hypothesis.

Ideas About Population

During Darwin's time, Thomas Malthus wrote a famous book entitled *An Essay on the Principle of Population*. Malthus noted that humans have the potential to reproduce rapidly. He warned that food supplies could not support unlimited population growth. **Figure 6** illustrates this relationship. However, Malthus pointed out that human populations are limited by choices that humans make or 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 survive to reproduce. Thus, there is something special about the survivors. Darwin reasoned that the offspring of the survivors inherit traits that help the offspring survive in their environment.

Ideas About Earth's History

Darwin had begun to think that species could evolve over time. But most geologists at the time did not think that Earth was old enough to allow for slow changes. Darwin learned new ideas from *Principles of Geology*, a book by Charles Lyell. This book presented evidence that Earth had formed by natural processes over a long period of time. It became clear to Darwin that Earth was much older than anyone had imagined.

✓ Reading Check What did Darwin learn from Charles Lyell?

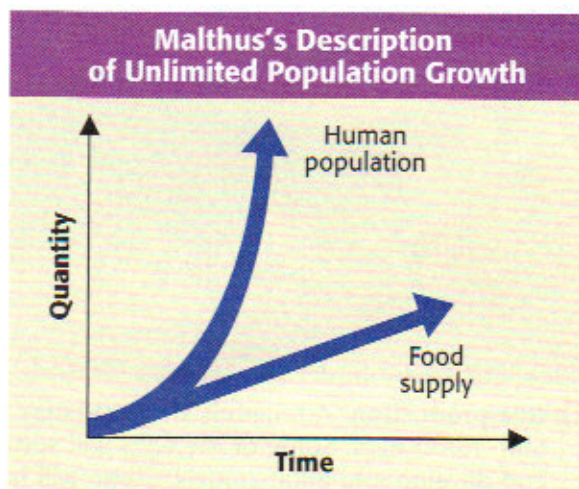


Figure 6 Malthus thought that the human population could increase more quickly than the food supply, with the result that there would not be enough food for everyone.

Darwin's Theory of Natural Selection

natural selection 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 he returned from 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 fellow naturalist named Alfred Russel Wallace. Wallace had arrived at the same ideas about evolution that Darwin had. Darwin grew more and more motivated to present his ideas. 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 through a process that he called **natural selection**. This process, explained in **Figure 7**, has four parts.


 **Reading Check** What is the title of Darwin's famous book?

Figure 7 Four Parts of Natural Selection



1 Overproduction A tarantula's egg sac may hold 500–1,000 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 to, 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 lacked evidence for parts of his theory. For example, he knew that organisms inherit traits, but not *how* they inherit traits. He knew that there is great variation among organisms, but not *how* that variation occurs. Today, scientists have found most of the evidence that Darwin lacked. They know that variation happens as a result of differences in genes. Changes in genes may happen whenever organisms produce offspring. Some genes make an organism more likely to survive to reproduce. The process called *selection* happens when only organisms that carry these genes can survive to reproduce. New fossil discoveries and new information about genes add to scientists' understanding of natural selection and evolution.



SECTION Review

Summary

- Darwin explained that evolution occurs through natural selection. His theory has four parts:
 1. Each species produces more offspring than will survive to reproduce.
 2. Individuals within a population have slightly different traits.
 3. Individuals within a population compete with each other for limited resources.
 4. Individuals that are better equipped to live in an environment are more likely to survive to reproduce.
- Modern genetics helps explain the theory of natural selection.

Using Key Terms

1. In your own words, write a definition for the term *trait*.
2. Use the following terms in the same sentence: *selective breeding* and *natural selection*.

Understanding Key Ideas

3. Modern scientific explanations of evolution
 - a. have replaced Darwin's theory.
 - b. rely on genetics instead of natural selection.
 - c. fail to explain how traits are inherited.
 - d. combine the principles of natural selection and genetic inheritance.
4. Describe the observations that Darwin made about the species on the Galápagos Islands.
5. Summarize the ideas that Darwin developed from books by Malthus and Lyell.
6. Describe the four parts of Darwin's theory of evolution by natural selection.
7. What knowledge did Darwin lack that modern scientists now use to explain evolution?

Math Skills

8. In a sample of 80 beetles, 50 beetles had 4 spots each, and the rest had 6 spots each. What was the average number of spots per beetle?

Critical Thinking

9. **Making Comparisons** In selective breeding, humans influence the course of evolution. What determines the course of evolution in natural selection?
10. **Predicting Consequences** Suppose that an island in the Pacific Ocean was just formed by a volcano. Over the next million years, how might species evolve on this island?

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Topic: Galápagos Islands;
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