16.2 Ideas That Shaped Darwin's Thinking

Key Questions

- *What did Hutton and Lyell conclude about Earth's history?*
- *How did Lamarck propose that species evolve?*
- *What was Malthus's view of population growth?*
- *How is inherited variation used in artificial selection?*

Vocabulary

artificial selection

Taking Notes

Outline Make an outline of this lesson using the green headings as main topics and the blue headings as subtopics. As you read, fill in details under each heading.

THINK ABOUT IT All scientists are influenced by the work of other scientists, and Darwin was no exception. The *Beagle*'s voyage came during one of the most exciting periods in the history of science. Geologists, studying the structure and history of Earth, were making new observations about the forces that shape our planet. Naturalists were investigating connections between organisms and their environments. These and other new ways of thinking about the natural world provided the foundation on which Darwin built his ideas.

An Ancient, Changing Earth

What did Hutton and Lyell conclude about Earth's history?

Many Europeans in Darwin's day believed Earth was only a few thousand years old, and that it hadn't changed much. By Darwin's time, however, the relatively new science of geology was providing evidence to support different ideas about Earth's history. Most famously, geologists James Hutton and Charles Lyell formed important hypotheses based on the work of other researchers and on evidence they uncovered themselves. **Hutton and Lyell concluded that Earth is extremely old and that the processes that changed Earth in the past are the same processes that operate in the present.** In 1785, Hutton presented his hypotheses about how geological processes have shaped the Earth. Lyell, who built on the work of Hutton and others, published the first volume of his great work, *Principles of Geology*, in 1830.

FIGURE 16–4 Ancient Rocks These rock layers in the Grand Canyon were laid down over millions of years and were then slowly washed away by the river, forming a channel.

Hutton and Geological Change Hutton recognized the connections between a number of geological processes and geological features, like mountains, valleys, and layers of rock that seemed to be bent or folded. Hutton realized, for example, that certain kinds of rocks are formed from molten lava. He also realized that some other kinds of rocks, like those shown in **Figure 16–4,** form very slowly, as sediments build up and are squeezed into layers.

Hutton also proposed that forces beneath Earth's surface can push rock layers upward, tilting or twisting them in the process. Over long periods, those forces can build mountain ranges. Mountains, in turn, can be worn down by rain, wind, heat, and cold. Most of these processes operate very slowly. For these processes to have produced Earth as we know it, Hutton concluded that our planet must be much older than a few thousand years. He introduced a concept called *deep time*—the idea that our planet's history stretches back over a period of time so long that it is difficult for the human mind to imagine—to explain his reasoning.

Lyell's *Principles of Geology* Lyell argued that laws of nature are constant over time and that scientists must explain past events in terms of processes they can observe in the present. This way of thinking, called *uniformitarianism,* holds that the geological processes we see in action today must be the same ones that shaped Earth millions of years ago. Ancient volcanoes released lava and gases, just as volcanoes do now. Ancient rivers slowly dug channels, like the one in **Figure 16–5,** and carved canyons in the past, just as they do today. Lyell's theories, like those of Hutton before him, relied on there being enough time in Earth's history for these changes to take place. Like Hutton, Lyell argued that Earth was much, much older than a few thousand years. Otherwise, how would a river have enough time to carve out a valley?

Darwin had begun to read Lyell's books during the voyage of the *Beagle,* which was lucky. Lyell's work helped Darwin appreciate the significance of an earthquake he witnessed in South America. The quake was so strong that it threw Darwin onto the ground. It also lifted a stretch of rocky shoreline more than 3 meters out of the sea—with mussels and other sea animals clinging to it. Sometime later, Darwin observed fossils of marine animals in mountains thousands of feet above sea level.

Those experiences amazed Darwin and his companions. But only Darwin turned them into a startling scientific insight. He realized that he had seen evidence that Lyell was correct! Geological events like the earthquake, repeated many times over many years, could build South America's Andes Mountains—a few feet at a time. Rocks that had once been beneath the sea could be pushed up into mountains. Darwin asked himself, If Earth can change over time, could life change too?

BUILD Vocabulary

ACADEMIC WORDS The noun **process** means "a series of actions or changes that take place in a definite manner." The processes that shape Earth are the series of geological actions that do things such as build mountains and carve valleys.

178 LAVA EXCAVATED BY THE SIMETO.

Recent Excavation of the Simeto.—The power of running water to hollow out compact rock is exhibited, on a larger scale, at the western base of Etna, where a great current of lava (A A, diagram 3), descending from near the summit

No. 3.

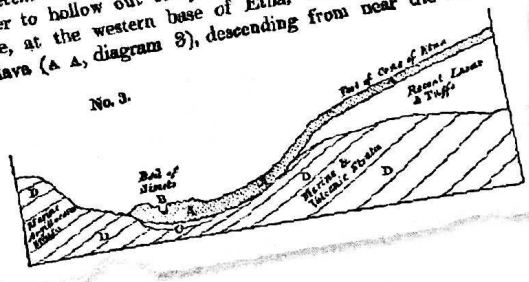

FIGURE 16–5 A woodcut from Lyell's *Principles of Geology* shows geological features near Italy's Mount Etna. Among them is a deep channel, labeled "B," carved into a bed of lava. The channel, shown in the photo, was formed gradually by the movement of water in the Simeto River.

Lamarck's Evolutionary Hypotheses

How did Lamarck propose that species evolve?

Darwin wasn't the first scientist to suggest that characteristics of species could change over time. Throughout the eighteenth century, a growing fossil record supported the idea that life somehow evolved. Ideas differed, however, about just *how* life evolved. The French naturalist Jean-Baptiste Lamarck proposed two of the first hypotheses. **Lamarck suggested that organisms could change during their lifetimes by selectively using or not using various parts of their bodies. He also suggested that individuals could pass these acquired traits on to their offspring, enabling species to change over time.** Lamarck published his ideas in 1809, the year Darwin was born.

FIGURE 16–6 Acquired Characteristics? According to Lamarck, this black-winged stilt's long legs were the result of the bird's innate tendency toward perfection. He claimed that if a water bird needs long legs to wade in deep water, it can acquire them by making an effort to stretch and use its legs in new ways. He also claimed that the bird can then pass the trait on to its offspring.

Lamarck's Ideas Lamarck proposed that all organisms have an inborn urge to become more complex and perfect. As a result, organisms change and acquire features that help them live more successfully in their environments. He thought that organisms could change the size or shape of their organs by using their bodies in new ways. According to Lamarck, for example, a water bird could have acquired long legs because it began to wade in deeper water looking for food. As the bird tried to stay above the water's surface, its legs would grow a little longer. Structures of individual organisms could also change if they were not used. If a bird stopped using its wings to fly, for example, its wings would become smaller. Traits altered by an individual organism during its life are called *acquired characteristics.*

Lamarck also suggested that a bird that acquired a trait, like longer legs, during its lifetime could pass that trait on to its offspring, a principle referred to as *inheritance of acquired characteristics.* Thus, over a few generations, birds such as the one in **Figure 16–6** could evolve longer and longer legs.

Evaluating Lamarck's Hypotheses Today, we know that Lamarck's hypotheses were incorrect in several ways. For one thing, organisms don't have an inborn drive to become more perfect. Evolution does not mean that over time a species becomes "better" somehow, and evolution does not progress in a predetermined direction. We now also know that traits acquired by individuals during their lifetime cannot be passed on to offspring. However, Lamarck was one of the first naturalists to suggest that species are not fixed. He was among the first to try to explain evolution scientifically using natural processes. He also recognized that there is a link between an organism's environment and its body structures. So, although Lamarck's explanation of evolutionary change was wrong, his work paved the way for later biologists, including Darwin.

In Your Notebook *Why are Lamarck's ideas called scientific hypotheses and not scientific theories?*

Population Growth

What was Malthus's view of population growth?

In 1798, English economist Thomas Malthus noted that humans were being born faster than people were dying, causing overcrowding, as shown in Figure 16–7. **Malthus reasoned that if the human population grew unchecked, there wouldn't be enough living space and food for everyone.** The forces that work against population growth, Malthus suggested, include war, famine, and disease.

Darwin realized that Malthus's reasoning applied even more to other organisms than it did to humans. A maple tree can produce thousands of seeds each summer. One oyster can produce millions of eggs each year. If all the descendants of almost any species survived for several generations, they would overrun the world. Obviously, this doesn't happen. Most offspring die before reaching maturity, and only a few of those that survive manage to reproduce.

Why was this realization so important? Darwin had become convinced that species evolved. But he needed a mechanism—a scientific explanation based on a natural process—to explain how and why evolution occurred. When Darwin realized that most organisms don't survive and reproduce, he wondered which individuals survive … and why.

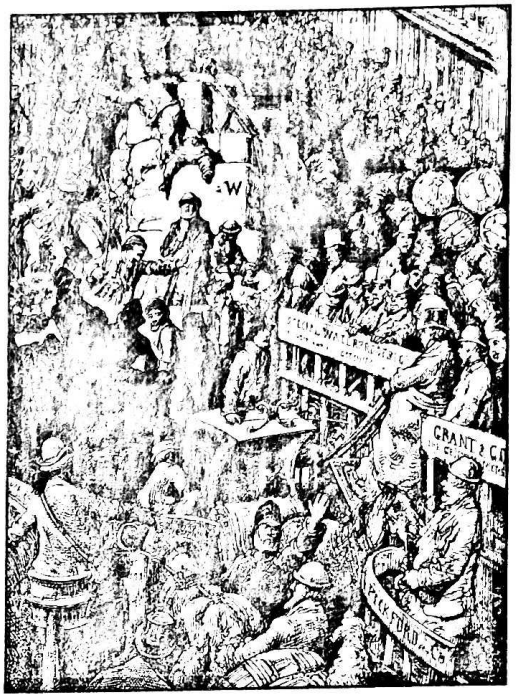

FIGURE 16–7 Overcrowding in London A nineteenth-century engraving shows the crowded conditions in London during Darwin's time. **Relate Cause and Effect** ***According to Malthus, what would happen if the population of London continued to grow?***

Artificial Selection

How is inherited variation used in artificial selection?

To find an explanation for change in nature, Darwin studied change produced by plant and animal breeders. Those breeders knew that individual organisms vary—that some plants bear larger or smaller fruit than average for their species, that some cows give more or less milk than others in their herd. They told Darwin that some of this variation could be passed from parents to offspring and used to improve crops and livestock.

Quick Lab
GUIDED INQUIRY

Variation in Peppers

1. Obtain a green, yellow, red, or purple bell pepper.
2. Slice open the pepper and count the number of seeds it contains.
3. Compare your data with the data of other students who have peppers of a different color.

Analyze and Conclude

1. Calculate Find the average (mean) number of seeds in your class's peppers. Then determine by how much the number of seeds in each pepper differs from the mean number. MATH

2. Pose Questions Think of the kinds of variations among organisms that Darwin observed. If Darwin had seen your data, what questions might he have asked?

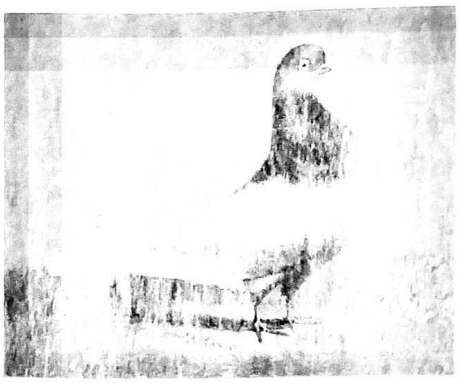

FIGURE 16–8 Artificial Selection Darwin used artificial selection in breeding fancy pigeons at his home outside London.

Farmers would select for breeding only trees that produced the largest fruit or cows that produced the most milk. Over time, this selective breeding would produce more trees with even bigger fruit and cows that gave even more milk. Darwin called this process **artificial selection. In artificial selection, nature provides the variations, and humans select those they find useful.** Darwin put artificial selection to the test by raising and breeding plants and fancy pigeon varieties, like those in **Figure 16–8.**

Darwin had no idea how heredity worked or what caused heritable variation. But he did know that variation occurs in wild species as well as in domesticated plants and animals. Before Darwin, scientists thought variations among individuals in nature were simply minor defects. Darwin's breakthrough was in recognizing that natural variation was very important because it provided the raw material for evolution. Darwin had all the information he needed. His scientific explanation for evolution was now formed—and when it was published, it would change the way people understood the living world.

16.2 Assessment

Review Key Concepts

1. a. Review What were Hutton's and Lyell's ideas about the age of Earth and the processes that shape the planet?

b. Apply Concepts How would Hutton and Lyell explain the formation of the Grand Canyon?

2. a. Review What is an acquired characteristic? What role did Lamarck think acquired characteristics played in evolution?

b. Evaluate What parts of Lamarck's hypotheses have been proved wrong? What did Lamarck get right?

3. a. Review According to Malthus, what factors limit human population growth?

b. Draw Conclusions How did Malthus influence Darwin?

4. a. Review What is artificial selection?

b. Infer Could artificial selection occur without inherited variation? Explain your answer.

WRITE ABOUT SCIENCE

Creative Writing

5. Imagine you are Thomas Malthus and the year is 1798. Write a newspaper article that explains your ideas about the impact of a growing population on society and the environment.