

Adaptations over Time

section 1 Ideas About Evolution

Before You Read

In what ways are you like your parents or other relatives?

What You'll Learn

- Lamarck's hypothesis of acquired characteristics
- Darwin's theory of natural selection
- variations in organisms
- the difference between gradualism and punctuated equilibrium

Read to Learn

Early Models of Evolution

There are millions of species of plants, animals, and other organisms living on Earth today. A **species** is a group of organisms that share similar characteristics and can reproduce among themselves to produce fertile offspring. The characteristics of a species that are passed from parent to offspring are called inherited characteristics. Change in these inherited characteristics over time is **evolution**.

What was Lamarck's hypothesis?

In 1809, Jean Baptiste de Lamarck proposed a hypothesis to explain how species change over time. He said that characteristics, or traits, that a parent organism develops during its lifetime are inherited by its offspring. Lamarck's hypothesis is called the inheritance of acquired characteristics. According to Lamarck's hypothesis, if a parent develops large muscles through exercise or hard work, the trait of large muscles would be passed on to the offspring. Scientists tested Lamarck's hypothesis by collecting data on traits that are passed from parent to offspring. The data did not support Lamarck's hypothesis.

Study Coach

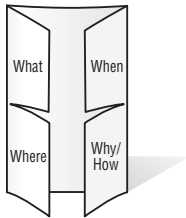
Ask Questions Read each question heading. Then work with a partner to write questions about the information related to the heading. Take turns asking and answering the questions. Use the questions as a study guide about evolution.



Think it Over

1. **Conclude** Do scientists today support Lamarck's hypothesis? Explain.

A Organize Make a four-door Foldable, as shown below, to organize information of how evolution occurs.



Picture This

2. **Describe** the location of the Galápagos Islands.

✓ Reading Check

3. **Identify** How did finches who ate seeds and nuts use their beaks?

Darwin's Model of Evolution

In 1831, Charles Darwin set out on a journey from England that took him to the Galápagos Islands. The Galápagos Islands, shown on the map below, are off the coast of Ecuador. Darwin was amazed by the variety of life he saw on these islands. He hypothesized that plants and animals living on the Galápagos Islands originally came from Central and South America. He noted that the species on the islands were similar in many ways to the species he had seen on the mainland. However, Darwin observed different traits in many species on the islands as well. Darwin studied several species and developed hypotheses to explain the differences in traits he observed.



What did Darwin observe?

Darwin observed 13 species of finches on the Galápagos Islands. He noticed that all 13 species were similar except for three characteristics—body size, beak shape, and eating habits. Darwin concluded that the different species of finches must have had to compete with each other for food. Finches that had beak shapes that allowed them to eat available food survived longer and had more offspring than finches without those kinds of beak shapes. After many generations, these groups of finches became separate species.

Darwin observed that the beak shape of each species of Galápagos finch is related to its eating habits. Darwin observed finches that ate nuts and seeds. Their beaks were short and strong for breaking hard shells. He observed finches that fed on insects. They had long, narrow beaks for finding the insects beneath tree bark. ✓

Natural Selection

In the mid-1800s, Darwin developed a theory of evolution that is accepted by most scientists today. He described his ideas in a book called *On the Origin of Species*.

What was Darwin's theory?

Darwin's theory became known as the theory of evolution by natural selection. **Natural selection** means that organisms with traits best suited to their environment are more likely to survive and reproduce. Their traits are passed to more offspring. The principles of natural selection are shown in the table below. ✓

The Principles of Natural Selection
1. Organisms produce more offspring than can survive.
2. Differences, or variations, occur among individuals of a species.
3. Some variations are passed to offspring.
4. Some variations are helpful. Individuals with helpful variations are better able to survive and reproduce.
5. Over time, the offspring of individuals with helpful variations increase and become a larger percentage of the population. Eventually, they may become a separate species.

Variation and Adaptation

Darwin's theory of evolution by natural selection focuses on the variations of species' members. A **variation** is an inherited trait that makes an individual organism different from other members of its species. Variations happen when there are permanent changes, or mutations, in an organism's genes. Some mutations produce small variations, such as differences in the shape of human hairlines. Other mutations produce large variations, such as fruit without seeds. Over time, more and more members of a species might inherit these variations. If individuals with these variations continue to survive and reproduce over time, a new species can evolve.

Some variations are more helpful than others. An **adaptation** is any variation that makes an organism better suited to its environment. Adaptations can include an organism's color, shape, behavior, or chemical makeup. Camouflage (KA muh flahj) is an adaptation. An organism that is camouflaged can blend into its environment. Camouflage makes it easier for the organism to hide, increasing the chances that it will survive and reproduce. ✓

✓ Reading Check

4. Explain According to the theory of evolution by natural selection, which organisms are most likely to survive and reproduce?

✓ Reading Check

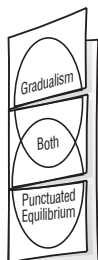
5. Determine How does camouflage help an organism survive?

Reading Check

6. **Infer** What two factors affected the development of new species?
-

FOLDABLES™


B Compare Make a three-tab Foldable, as shown below, to compare gradualism and punctuated equilibrium.



How do changes in genes affect species?

Over time, changes in the genes of a species might change the appearance of the species. As the inherited traits of a species of seed-eating Galápagos finch changed, so did the size and shape of its beak. Environmental conditions can help bring about these changes. When individuals of the same species move into an area, they bring genes and variations. When they move out of an area, they remove their genes and variations. Suppose a family from a different country moves to your neighborhood. They might bring different foods, customs, and ways of speaking. In a similar way, when new individuals enter an existing population, they can bring different genes and variations.

Does geographic isolation affect evolution?

Sometimes geologic features such as mountains or lakes can separate a group of individuals from all the other members of the population. Over time, variations that are not found in the larger population might become common in the smaller, separate population. Also, gene mutations could add variations to the smaller population. After many generations, the two populations can become so different that they can no longer breed with each other. They become two different species. For example, during the last ice age, Virginia white-tailed deer moved south ahead of an advancing ice sheet. When ice sheets melted worldwide about 4,000–10,000 years ago, ocean levels rose. Some deer were isolated on a chain of islands. They evolved into a new subspecies, the Key deer. Key deer live only on approximately 30 islands in the subtropical lower keys of Florida. 

The Speed of Evolution

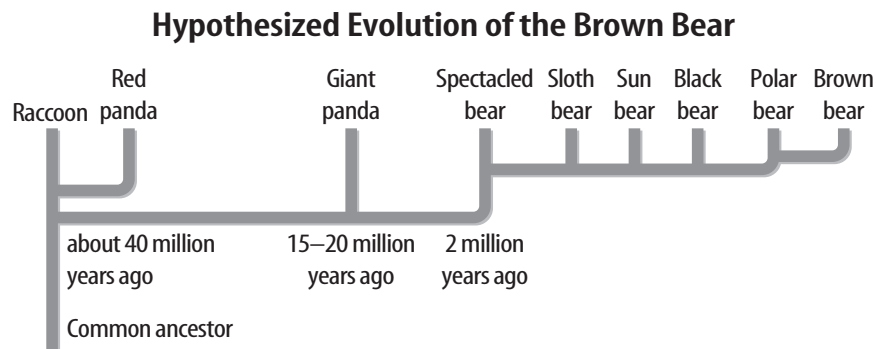
Scientists do not agree on how quickly evolution happens. Some hypothesize that it happens slowly, over hundreds of millions of years. Others hypothesize that it can happen quickly. Most scientists agree that there is evidence to support both hypotheses.

What is gradualism?

Darwin hypothesized that evolution happens slowly. His hypothesis is called gradualism. **Gradualism** is a hypothesis that describes evolution as a slow, continuing process in which one species changes to a new species over millions or hundreds of millions of years.

What is punctuated equilibrium?

Gradualism does not explain the evolution of all species. For some species, fossil records show that one species suddenly changes into another. **Punctuated equilibrium** is a hypothesis that describes evolution as a rapid process in which one species changes suddenly to a new species. Rapid evolution happens when the mutation of a few genes results in a new species over a fairly short period of time. The figure below shows how punctuated equilibrium describes the evolution of the brown bear.



Is punctuated equilibrium happening today?

Evolution by punctuated equilibrium can happen over a few thousand or hundreds of thousands of years. Sometimes, evolution can happen even faster than that. For example, many species of bacteria have changed into new species in only a few decades. Many disease-causing bacteria species were once easily killed by the antibiotic penicillin. Some of these species are no longer harmed by penicillin. These bacteria have become resistant to penicillin.

These penicillin-resistant bacteria evolved quickly. The bacteria changed because some individuals had variations that allowed them to survive even when exposed to penicillin. Other individuals could not survive. The bacteria that had the penicillin-resistant variation survived to reproduce and pass this trait to their offspring. Over a period of time, all of the bacteria in the population had the variation for penicillin resistance.

Picture This

- 7. Identify** Circle the name of the common ancestor of the giant panda and the brown bear.



Think it Over

- 8. Analyze** What allowed some bacteria to survive while other bacteria were killed by penicillin?

● After You Read

Mini Glossary

adaptation: any variation that makes an organism better suited to its environment

evolution: change in inherited characteristics over time

gradualism: hypothesis that describes evolution as a slow, ongoing process by which one species changes to a new species

natural selection: theory that states that organisms with traits best suited to their environment are more likely to survive and reproduce

punctuated equilibrium: hypothesis that says rapid evolution comes about when the mutation of a few genes results in the appearance of a new species over a relatively short period of time

species: group of organisms that share similar characteristics and can reproduce among themselves to produce fertile offspring

variation: inherited trait that makes an individual different from other members of its species

1. Review the terms and their definitions in the Mini Glossary. Write a sentence that describes a variation that helps an organism survive.

2. Complete the chart below to explain the models of evolution listed in the chart.

Theory or Model	Description
Hypothesis of acquired characteristics	
Theory of evolution by natural selection	
Gradualism	
Punctuated equilibrium	



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Adaptations over Time

section 2 Clues About Evolution

Before You Read

Have you ever seen a fossil? On the lines below, tell what kind of fossil it was and where you saw it.

What You'll Learn

- why fossils provide evidence of evolution
- how relative and radiometric dating are used to estimate the age of fossils
- five types of evidence for evolution


Read to Learn

Clues from Fossils

Paleontologists are scientists who study the past by collecting and examining fossils. A fossil is the remains of an ancient organism or an imprint left behind by the organism.

The Green River Formation is one of the richest fossil deposits in the world. It covers parts of Wyoming, Utah, and Colorado. About 50 million years ago, during the Eocene Epoch, this area was covered by lakes. By studying fossils from the Green River Formation, paleontologists have learned that fish, crocodiles, and lizards lived in the lakes. After the animals died, they were covered with silt and mud. Over millions of years, they became fossils.

Types of Fossils

Most of the evidence for evolution comes from fossils. Most fossils are found in sedimentary rock. **Sedimentary rock** is formed when layers of sand, silt, clay, or mud are pressed and cemented together or when minerals are deposited from a solution. Fossils are most often found in a sedimentary rock called limestone. 

Mark the Text

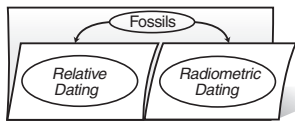
Identify Unfamiliar Words

Skim the reading and underline any word that you do not know. At the end of each paragraph review the words you have underlined and see if you can define them. If you cannot, look up the word and write its definition in the margin.

Reading Check

1. **Explain** What is the main source of evidence for evolution?

Describe Make a two-tab concept map Foldable, as shown below, to describe the two methods scientists use to date fossils—relative dating and radiometric dating.



Determining a Fossil's Age

Paleontologists study the rock layers that fossils are found in. The rocks provide clues about the age of the fossils. Some of these clues include information about the geologic time period in which it was formed. Information may include weather, geology, and other organisms that were alive. Paleontologists have two ways of estimating the age of rocks and fossils—relative dating and radiometric dating.

What is relative dating?

Relative dating is based on the fact that younger rock layers usually lie on top of older rock layers. Relative dating gives only an estimate of a fossil's age. Scientists compare the ages of rock layers found above and below the fossil layer. For example, if a 50-million-year-old rock layer lies below a fossil and a 35-million-year-old rock layer is above the fossil, then the fossil is probably between 35 million and 50 million years old.

What is radiometric dating?

Radiometric dating gives an estimate of the age of a rock layer that is more exact. This method of dating fossils uses radioactive elements. A **radioactive element** gives off a steady amount of radiation as it slowly changes to a nonradioactive element. Each radioactive element gives off radiation at a different rate. Scientists estimate the age of the rock by comparing the amount of radioactive element with the amount of nonradioactive element in the rock.

Fossils and Evolution

Fossils provide a record of organisms that lived in the past. However, the fossil record has gaps, much like missing pages in a book. The gaps exist because most organisms do not become fossils. Even though there are gaps, scientists have still been able to draw conclusions from the fossil records. For instance, they have learned that simple organisms were the first forms of life to appear on Earth. More complex forms of life appeared later.

Fossil discoveries are made all over the world. When scientists find fossils, they make models that show what the organisms might have looked like when they were alive. Scientists can use fossils to find out whether organisms lived in family groups or alone, what they ate, and what kind of environment they lived in. Most fossils are from extinct organisms.

Reading Check

- 2. Identify** Name two things scientists can learn about organisms from fossils.

More Clues About Evolution

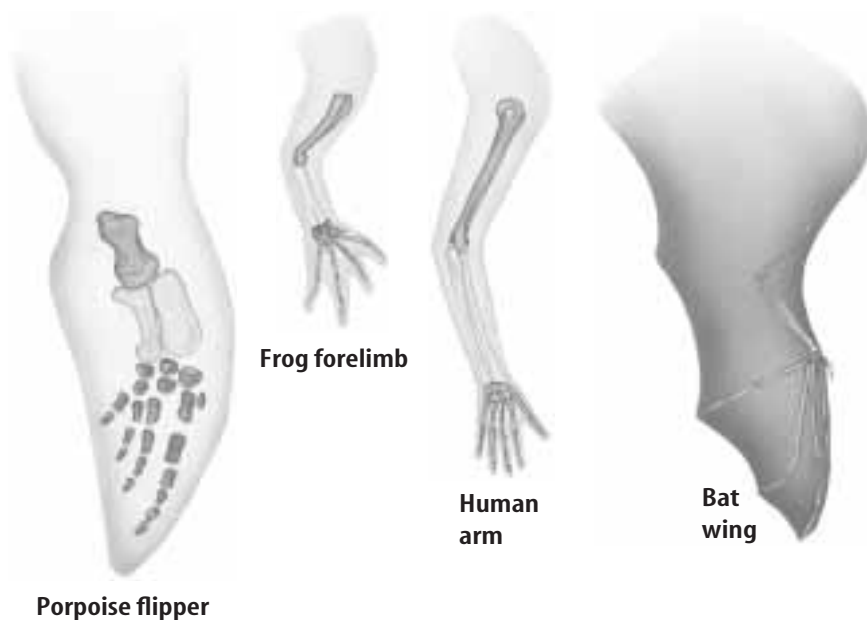
Besides fossils, there are other clues about evolution. Some kinds of evolution can be observed today. The development of penicillin-resistant bacteria is a direct observation of evolution. Another direct observation of evolution is the development of insect species that are resistant to pesticides.

What is embryology?

The study of embryos and their development is called **embryology** (em bree AH luh jee). An embryo is the earliest growth stage of an organism. The embryos of many different species are similar. The embryos of fish, birds, reptiles, and mammals have tails. As the organisms grow, the fish, birds, and reptiles keep their tails, but many mammals do not. Because the embryos of vertebrates are similar, scientists hypothesize that vertebrates come from a common ancestor.

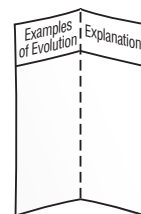
What are homologous structures?

Body parts that are similar in origin and structure are called **homologous** (hoh MAH luh gus). Some homologous structures have the same function, but others do not. If two or more species have homologous structures, they probably have common ancestors. The figure below shows several homologous structures.



FOLDABLES™

D List Make a half-book Foldable, as shown below, to list examples of evolution and explanations of how the examples show evidence of evolution.



Picture This

3. Describe Above each structure, list one way the organism uses that structure.


Reading Check

4. **Identify** Name a vestigial structure that humans have?

Reading Check

5. **Explain** What clues does DNA provide about evolution?

What are vestigial structures?


The bodies of some organisms have structures known as vestigial (veh STIH jee ul) structures. Vestigial structures do not seem to have any use, or function. Vestigial structures provide evidence for evolution. Scientists hypothesize that vestigial structures are body parts that were useful in an ancestor. Humans have three small muscles around each ear that are vestigial. The figure below shows the location of these muscles. In some mammals, such as horses, these muscles are large. They allow a horse to turn its ears toward the source of a sound. 



Doug Martin

How does DNA provide clues about evolution?

If you enjoy science fiction, you probably have read books or seen movies in which scientists recreate dinosaurs from DNA taken from fossils. DNA is the molecule that controls heredity. It directs the development of every organism. DNA is found in the genes of all organisms. Scientists can compare the DNA of living organisms to find similarities among species. Scientists also can study the DNA of extinct species. They can learn how some species evolved from their extinct ancestors.

Studying DNA helps scientists see how closely related the organisms are. For example, DNA studies show that dogs are the closest relatives of bears. 

If organisms from two species have DNA that is similar, the two species may share one or more common ancestors. For example, DNA evidence suggests that all primates have a common ancestor. Primates include chimpanzees, gorillas, orangutans, and humans.

● After You Read

Mini Glossary

embryology (em bree AH luh jee): the study of embryos and their development

homologous (hoh MAH luh gus): body parts that are similar in origin and structure

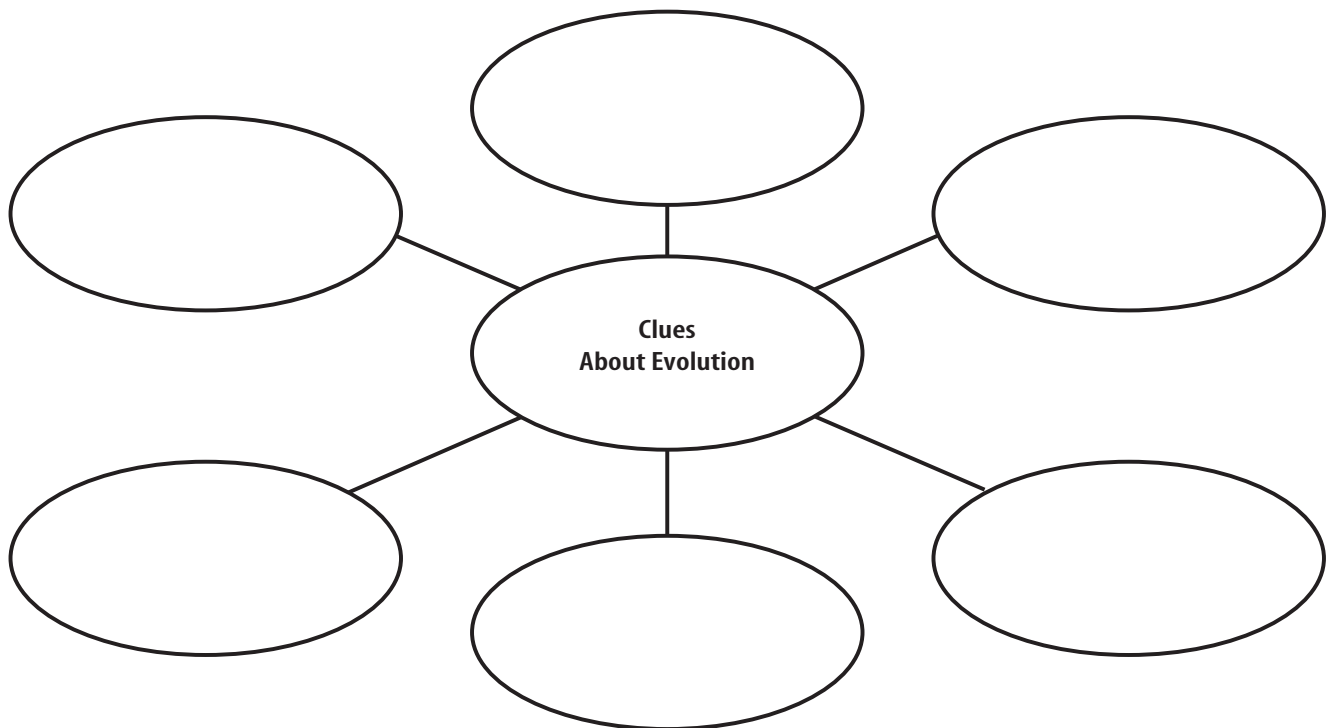
radioactive element: an element that gives off a steady amount of radiation as it slowly changes to a nonradioactive element

sedimentary rock: rock in which most fossils are found, formed when layers of sand, silt, clay, or mud are pressed and cemented together, or when minerals are deposited from a solution

vestigial (veh STIH jee ul) structures: structures that do not seem to have a function

1. Review the terms and their definitions in the Mini Glossary. Choose one of the terms and write a sentence that explains how it provides a clue to evolution.

2. In the web diagram below, list the clues that scientists have as evidence of evolution.



Adaptations over Time

section ③ The Evolution of Primates

What You'll Learn

- the differences among living primates
- the adaptations of primates
- the evolutionary history of modern primates

● Before You Read

Describe the appearance and behavior of a primate such as monkeys and gorillas.

Mark the Text

Identify Main Points

Underline the main idea of each paragraph. Then circle one supporting detail.

● Read to Learn

Primates

Humans, monkeys, and apes belong to a group of mammals known as primates. Primates have several characteristics that show they have evolved from a common ancestor. These characteristics include opposable thumbs, binocular vision, and flexible shoulders.

An opposable thumb can cross over the palm and touch the fingers. You have an opposable thumb that lets you grasp and hold things with your hand. Binocular vision means that you have two eyes that look in the same direction. Binocular vision lets you judge distance with your eyes. It allows primates that live in trees to judge distances as they move between branches. Flexible shoulders allow primates to use their arms to swing from branch to branch. Flexible shoulders allow humans to do such moves as the backstroke in swimming.

What are some characteristics of hominids?


Hominids are humanlike primates that are the ancestors of modern humans. Hominids are different from all the other primates. They first appeared on Earth about 4 million to 6 million years ago. They ate both meat and plants and they walked upright on two legs.



Think it Over

1. **Explain** What are two similarities between hominids and humans?

Where have fossils of hominids been found?

In the 1920s, scientists discovered a fossil skull in South Africa. The skull had a small space for the brain, but it had a humanlike jaw and teeth. The fossil was named *Australopithecus*. It was one of the oldest hominids that had ever been discovered. In 1974, scientists found an almost-complete skeleton of *Australopithecus* in northern Africa. It had a small brain and may have walked upright. This fossil shows that modern hominids might have evolved from a common ancestor. 

Who were the ancestors of early humans?

In the 1960s, scientists discovered a hominid fossil named *Homo habilis* that was estimated to be 1.5 million to 2 million years old. Scientists hypothesize that *Homo habilis* changed into another species, called *Homo erectus*, about 1.6 million years ago. These two hominids are thought to be ancestors of humans because they had larger brains and more humanlike features than *Australopithecus*.

Humans

Fossil records show that *Homo sapiens* evolved about 400,000 years ago. By 125,000 years ago, two early human groups probably lived in parts of Africa and Europe. These two groups were the Neanderthals (nee AN dur tawlz) and Cro-Magnon humans.

Who were the Neanderthals?

Neanderthals had short, heavy bodies with thick bones, small chins, and heavy browridges. They lived in caves in family groups. They used stone tools to hunt large animals. Neanderthals are probably not direct ancestors of modern humans.

Who were the Cro-Magnon humans?

The fossils of Cro-Magnon humans have been found in Europe, Asia, and Australia. They are between 10,000 and about 40,000 years old. Cro-Magnon humans looked very much like modern humans. They lived in caves, made stone carvings, and buried their dead. Cro-Magnon humans are thought to be direct ancestors of early humans. Early humans are called *Homo sapiens*. Modern humans are called *Homo sapiens sapiens*. Fossil evidence shows that modern humans evolved from *Homo sapiens*.

Reading Check

2. **Identify** two characteristics of *Australopithecus*.



Think it Over

3. **Compare** Name two ways that Neanderthals and Cro-Magnon humans were similar.

● After You Read

Mini Glossary

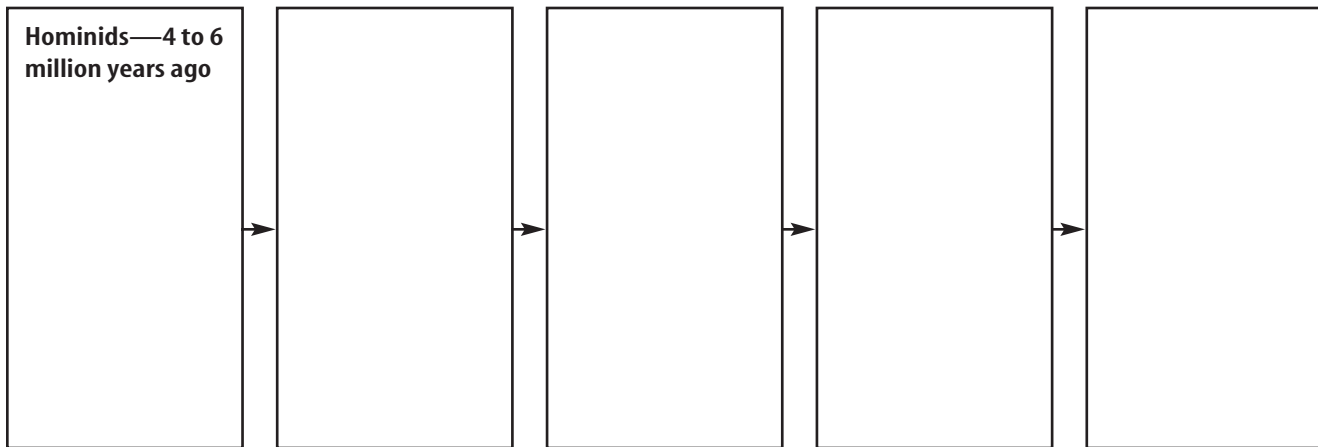
hominids: humanlike primates that lived about 4 million to 6 million years ago and were different from the other primates

***Homo sapiens*:** direct ancestors of humans

primate: group of mammals to which humans, monkeys, and apes belong

1. Review the terms and their definitions in the Mini Glossary. Choose one term and write a sentence that describes how it is related to modern humans.

2. In the boxes below, show the sequence of the evolution of the ancestors of modern humans. Write down how long ago scientists believe each of the following human ancestors first appeared: hominids, *Homo habilis*, *Homo erectus*, *Homo sapiens*, Neanderthals and Cro-Magnon humans. The first box has been completed for you.



3. How did you benefit from underlining main ideas in paragraphs?



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