

Adaptations Over Time

Are today's cockroaches different from those that lived one million years ago? How have these and other organisms survived Earth's changing environments over time? What evidence exists for changes in a species? Theories about how species change over time and some of the evidence for these changes are presented in this chapter. You also will read about primate adaptations over time.

What do you think?

Science Journal Look at the picture below with a classmate. Discuss what might be happening. Here's a hint: *This is one of the reasons species change.* Write your answer or best guess in your Science Journal.

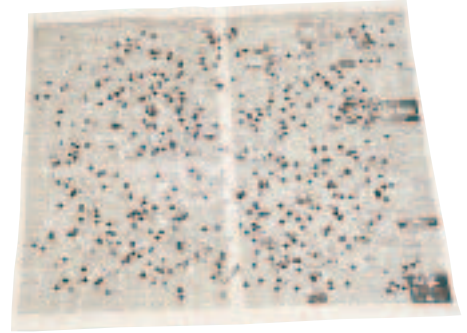


EXPLORE ACTIVITY

The cheetah is one of nature's speediest hunters, but it can run swiftly for only short distances. The cheetah's fur blends in with tall grass, making it almost invisible as it hides and waits for prey to wander close by. Then the cheetah pounces, capturing the prey before it can run away.

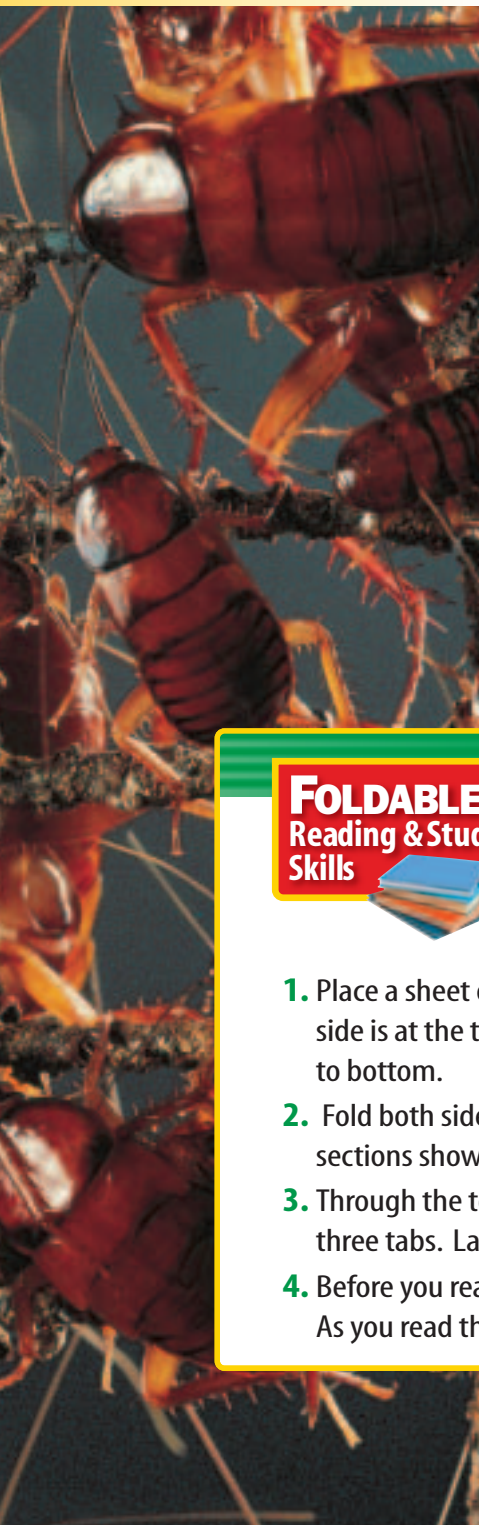
Model camouflage

1. Spread a sheet of newspaper classified ads on the floor.
2. Using a hole puncher, punch out 100 circles from each of the following types of paper: white paper, black paper, and classified ads.
3. Scatter all the circles on the newspaper on the floor. For 10 s, pick up as many circles as possible, one at a time. Have a partner time you.
4. Count the number of each kind of paper circle that you picked up. Record your results in your Science Journal.



Observe

Which paper circles were most difficult to find? What can you infer about a cheetah's coloring from this activity? Enter your responses to these questions in your Science Journal.



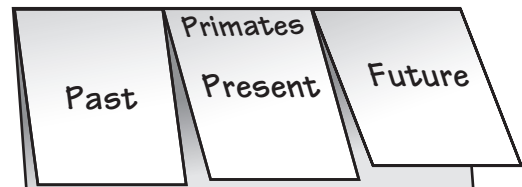
FOLDABLES Reading & Study Skills



Before You Read

Making a Sequence Study Fold Make the following Foldable to help you predict what might occur next in primate adaptations over time.

1. Place a sheet of paper in front of you so the long side is at the top. Fold the paper in half from top to bottom.
2. Fold both sides in. Unfold the paper so three sections show.
3. Through the top thickness of paper, cut along each of the fold lines to the top fold, forming three tabs. Label the tabs *Past*, *Present*, and *Future* as shown. Title the middle tab *Primates*.
4. Before you read the chapter, write what primates have in common under the *Present* tab. As you read the chapter, write what primates were like in the past under the *Past* tab.



Ideas About Evolution

As You Read

What You'll Learn

- **Describe** Lamarck's hypothesis of acquired characteristics and Darwin's theory of evolution.
- **Identify** why variations in organisms are important.
- **Compare and contrast** gradualism and punctuated equilibrium.

Vocabulary

species
 evolution
 natural selection
 variation
 adaptation
 gradualism
 punctuated equilibrium

Why It's Important

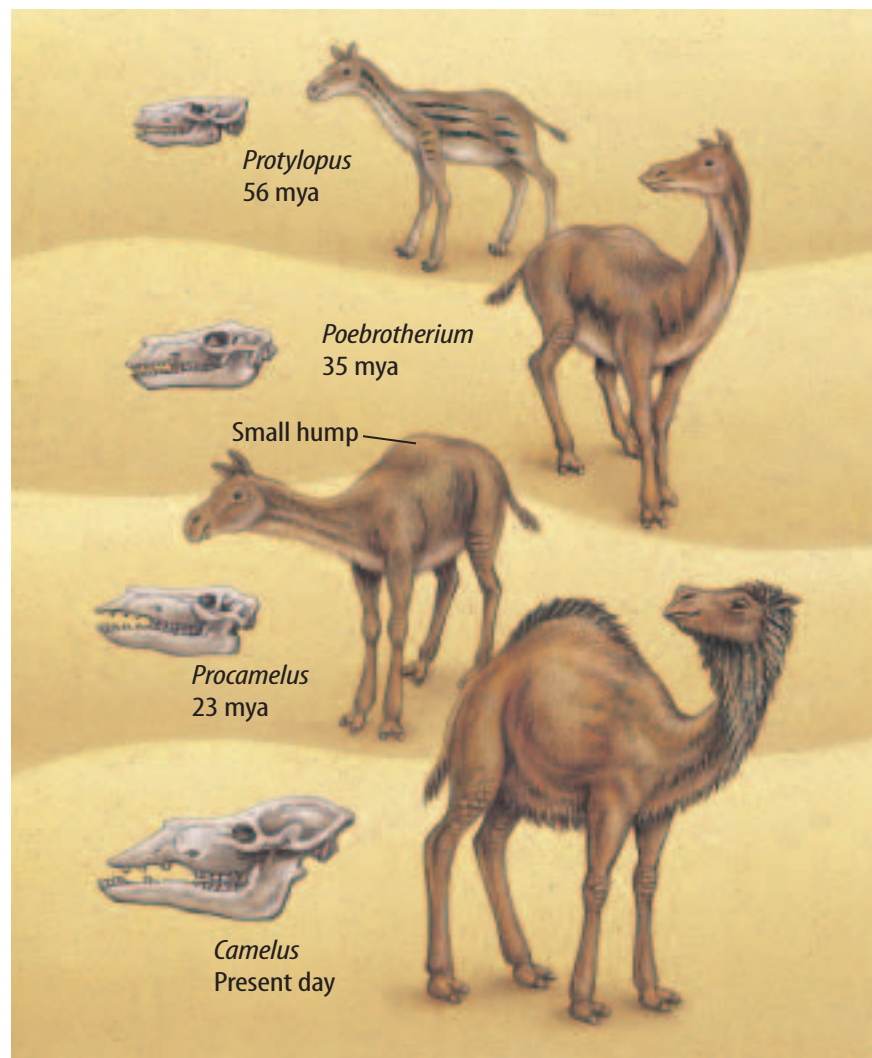
The theory of evolution suggests why there are differences among living things.

Figure 1

By studying fossils, scientists have traced the evolution of the camel. About 56 million years ago (mya), camels had a small body. Some 33 million years later, species of camels had grown larger and had a small hump. Present-day species are even larger and have a bigger hump.

Early Models of Evolution

Millions of species of plants, animals, and other organisms live on Earth today. Do you suppose they are exactly the same as they were when they first appeared—or have any of them changed? 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 are inherited when they pass from parent to offspring. Change in these inherited characteristics over time is **evolution**. **Figure 1** shows how the characteristics of the camel have changed over time.





Hypothesis of Acquired Characteristics In 1809, Jean Baptiste de Lamarck proposed a hypothesis to explain how species change over time. He suggested that characteristics, or traits, developed during a parent organism's lifetime are inherited by its offspring. His hypothesis is called the inheritance of acquired characteristics. Scientists collected data on traits that are passed from parents to children. The data showed that traits developed during a parent's lifetime, such as large muscles built by hard work or exercise, are not passed on to offspring. The evidence did not support Lamarck's hypothesis.

✓ Reading Check What was Lamarck's explanation of evolution?

Figure 2 This map shows the route of Darwin's voyage on the HMS *Beagle*. Darwin noticed many species on the Galápagos Islands that he had not seen along the coast of South America, including the marine iguana. This species is the only lizard in the world known to enter the ocean and feed on seaweed.

Darwin's Model of Evolution

In December 1831, the HMS *Beagle* sailed from England on a journey to explore the South American coast. On board was a young naturalist named Charles Darwin. During the journey, Darwin recorded observations about the plants and animals he saw. He was amazed by the variety of life on the Galápagos Islands, which are about 1,000 km from the coast of Ecuador. Darwin hypothesized that the plants and animals on the Galápagos Islands originally must have come from Central and South America. But the islands were home to many species he had not seen in South America, including giant cactus trees, huge land tortoises, and the iguana shown in **Figure 2**.

Figure 3

Darwin observed that the beak shape of each species of Galápagos finch is related to its eating habits.

A Finches that eat nuts and seeds have short, strong beaks for breaking hard shells.



B Finches that feed on insects have long, slender beaks for probing beneath tree bark.



C Finches with medium-sized beaks eat a variety of foods including seeds and insects.



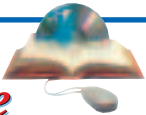
Darwin's Observations Darwin observed 13 species of finches on the Galápagos Islands. He noticed that all 13 species looked similar, except for differences in body size, beak shape, and eating habits, as shown in **Figure 3**. He also noticed that all the Galápagos finches looked similar to a finch species he had seen on the South American coast. Darwin hypothesized that all 13 Galápagos species evolved from South American species.

Competition and Survival All living organisms produce more offspring than survive. Galápagos finches lay several eggs every few months. Darwin realized that in just a few years, several pairs of finches could produce a large population. A population is made up of all the individuals of a species living in the same area. Members of a large population compete for living space, food, and other resources. Those that are best able to survive are more likely to reproduce and pass on their traits to the next generation.

Darwin reasoned that the Galápagos finches must have had to compete for food. Finches with beak shapes that allowed them to eat available food survived longer and produced more offspring than finches without those beak shapes. After many generations, these groups of finches became separate species.

✓ Reading Check *How did Darwin explain the evolution of the different species of Galápagos finches?*

SCIENCE Online



Research Visit the Glencoe Science Web site at science.glencoe.com for more information about the finches Darwin observed. In your Science Journal, describe the similarities and differences of any two species of Galápagos finches.



Natural Selection

After the voyage, Charles Darwin returned to England and continued to think about his observations. He collected more evidence on inherited traits by breeding racing pigeons. He also studied breeds of dogs and varieties of flowers. In the mid 1800s, Darwin developed the theory of evolution that is accepted by most scientists today. He described his ideas in a book called *On the Origin of Species*, which was published in 1859.

Darwin's observations led many other scientists to conduct experiments on inherited characteristics. After many years, Darwin's hypothesis 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 that describe how natural selection works are listed in **Table 1**.

Over time, as new data have been gathered and reported, some changes have been made to Darwin's original ideas about evolution by natural selection. His theory remains one of the most important ideas in the study of life science.

Table 1 The Principles of Natural Selection

1. Organisms produce more offspring than can survive.
2. Differences, or variations, occur among individuals of a species.
3. Variations are passed to offspring.
4. Some variations are helpful. Individuals with helpful variations survive and reproduce better than those without these variations.
5. Over time, the offspring of individuals with helpful variations make up more of a population and eventually become a separate species.

Problem-Solving Activity

Does natural selection take place in a fish tank?

Alejandro raises tropical fish as a hobby. Could the observations that he makes over several weeks illustrate the principles of natural selection?

Identifying the Problem

Alejandro keeps a detailed journal of his observations, some of which are given in the table to the right.

Solving the Problem

Refer to **Table 1** and match each of Alejandro's journal entries with the principle(s) it demonstrates. Here's a hint: *Some entries may not match any of the principles of natural selection. Some entries may match more than one principle.*

Fish Tank Observations

Date	Observation
June 6	6 fish are placed in aquarium tank.
July 22	16 new young appear.
July 24	3 young have short or missing tail fins. 13 young have normal tail fins.
July 28	Young with short or missing tail fins die.
August 1	2 normal fish die—from overcrowding?
August 12	30 new young appear.
August 15	5 young have short or missing tail fins. 25 have normal tail fins.
August 18	Young with short or missing tail fins die.
August 20	Tank is overcrowded. Fish are divided equally into two tanks.

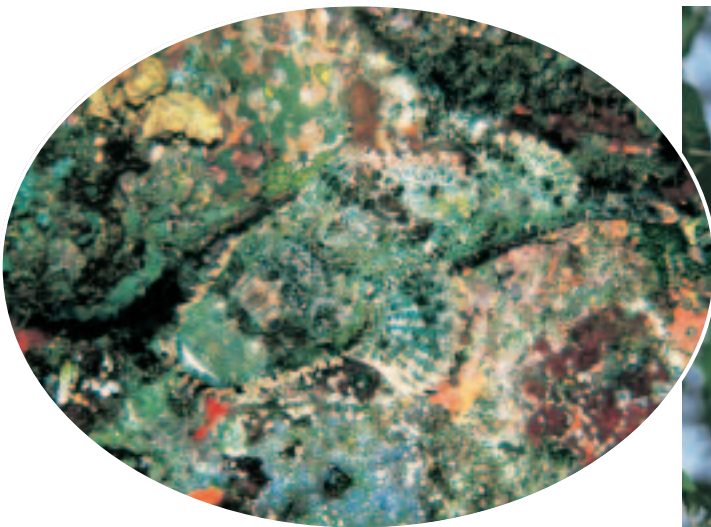
Variation and Adaptation

Darwin's theory of natural selection emphasizes the differences among individuals of a species. These differences are called variations. A **variation** is an inherited trait that makes an individual different from other members of its species. Variations result from permanent changes, or mutations, in an organism's genes. Some gene changes produce small variations, such as differences in the shape of human hairlines. Other gene changes produce large variations, such as an albino squirrel in a population of gray squirrels or fruit without seeds. Over time, more and more individuals of the species might inherit these variations. If individuals with these variations continue to survive and reproduce over many generations, a new species can evolve. It might take hundreds, thousands, or millions of generations for a new species to evolve.

Some variations are more helpful than others. An **adaptation** is any variation that makes an organism better suited to its environment. The variations that result in an adaptation can involve an organism's color, shape, behavior, or chemical makeup. Camouflage (KA muh flahj) is an adaptation. A camouflaged organism, like the one shown in **Figure 4A**, blends into its environment and is more likely to survive and reproduce.

Figure 4

Variations that provide an advantage tend to increase in a population over time. Variations that result in a disadvantage tend to decrease in a population over time.



A Camouflage allows organisms to blend into their environment. *How does its coloration give this scorpion fish a survival advantage?*

B Albinism can prevent an organism from blending into its environment. *What might happen to an albino lemur in its natural environment?*





A European rabbits feed during the day and are fairly large.



B Canary Island rabbits feed during the night. *Why might large eyes be considered a helpful adaptation in Canary Island rabbits?*

Figure 5

About 600 years ago, European rabbits were introduced to the Canary Islands from a visiting Portuguese ship. The Canary Islands are in the Atlantic Ocean off the northwest coast of Africa. Over time, the Canary Island rabbits became a separate species.

Changes in the Sources of Genes Over time, the genetic makeup of a species might change its appearance. For example, as the genetic makeup of a species of seed-eating Galápagos finch changed, so did the size and shape of its beak. Many kinds of environmental factors help bring about changes. When individuals of the same species move into or out of an area, they might bring in or remove genes and variations. Suppose a family from another country moves to your neighborhood. They might bring different foods, customs, and ways of speaking with them. In a similar way, when new individuals enter an existing population, they can bring in different genes and variations.

Geographic Isolation Sometimes mountains, lakes, or other geologic features isolate a small number of individuals from the rest of a population. Over several generations, variations that do not exist in the larger population might begin to be more common in the isolated population. Also, gene mutations can occur that add variations to populations. Over time, the two populations can become so different that they no longer can breed with each other. The two populations of rabbits shown in **Figure 5** have been geographically isolated from each other for thousands of generations.

Mini LAB

Relating Evolution to Species

Procedure

1. On a piece of lined paper, print the alphabet in lower-case letters.
2. Organize the letters into three groups. Put all of the vowels in the first group. Place all of the letters that drop below the line into the second group. Place all of the remaining letters in the third group.

Analysis

1. How are the three groups of letters similar to each other?
2. If the letters were organisms, what traits would indicate to scientists how closely related the letters were to each other?

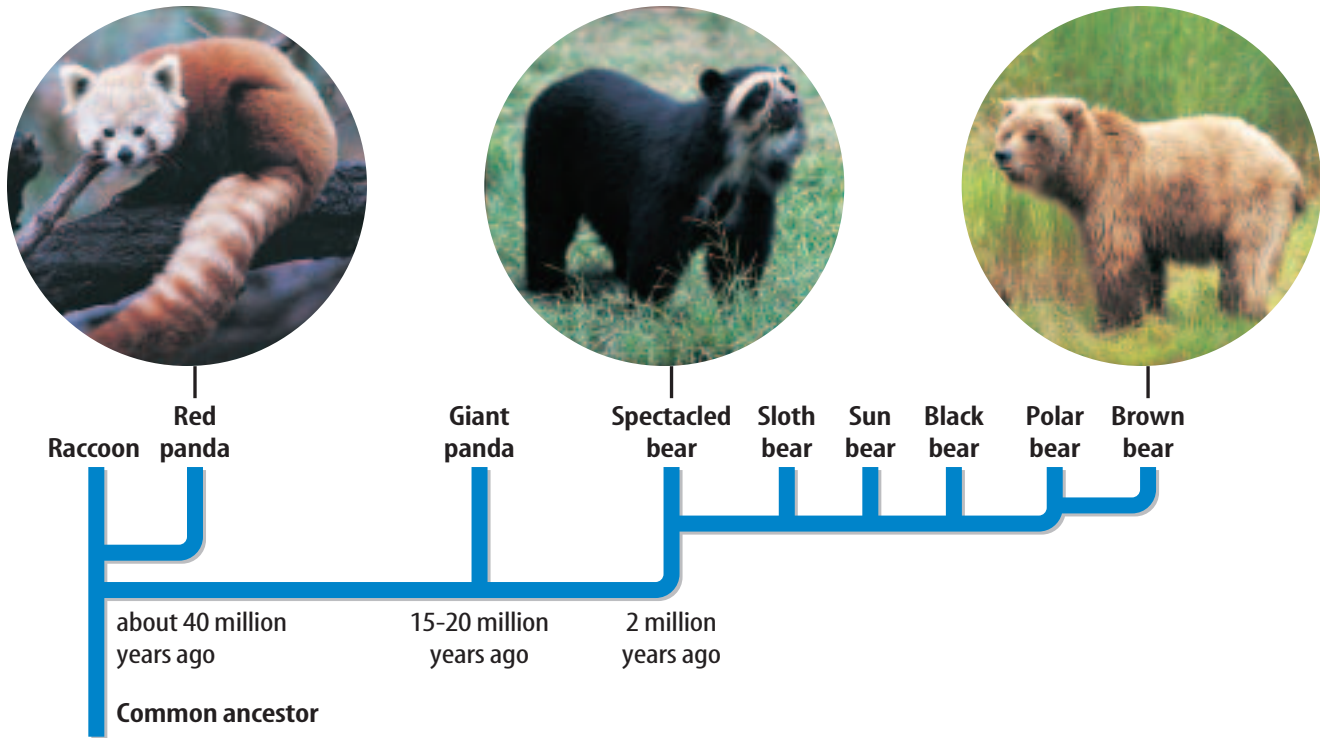


Figure 6
The evolution of bears illustrates the **punctuated equilibrium** model of evolution. Six distinct bear species evolved over two million years. The same series of changes would have taken many times longer according to the **gradualism** model of evolution.

The Speed of Evolution

Scientists do not agree on how quickly evolution occurs. Many scientists hypothesize that evolution occurs slowly, perhaps over tens or hundreds of millions of years. Other scientists hypothesize that evolution can occur quickly. Some scientists propose that evidence supports both of these models.

Gradualism Darwin hypothesized that evolution takes place slowly. The model that describes evolution as a slow, ongoing process by which one species changes to a new species is known as **gradualism**. According to the gradualism model, a continuing series of mutations and variations over time will result in a new species. Look back at **Figure 1**, which shows the evolution of the camel over tens of millions of years. Fossil evidence shows a series of intermediate forms that indicate a gradual change from the earliest camel species to today’s species.

Punctuated Equilibrium Gradualism doesn’t explain the evolution of all species. For some species, the fossil record shows few intermediate forms—one species suddenly changes to another. According to the **punctuated equilibrium** model, 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. The fossil record gives examples of this type of evolution, as you can see in **Figure 6**.

Punctuated Equilibrium Today Evolution by the punctuated equilibrium model can occur over a few thousand or million years, and sometimes even faster. For example, many bacteria have changed in a few decades. The antibiotic penicillin originally came from the fungus shown in **Figure 7**. But many bacteria species that were once easily killed by penicillin no longer are harmed by it. These bacteria have developed resistance to the drug. Penicillin has been in use since 1943. Just four years later, in 1947, a species of bacteria that causes pneumonia and other infections already had developed resistance to the drug. By the 1990s, several disease-producing bacteria had become resistant to penicillin and many other antibiotics.

How did penicillin-resistant bacteria evolve so quickly? As in any population, some organisms have variations that allow them to survive unfavorable living conditions when other organisms cannot. When penicillin was used to kill bacteria, those with the penicillin-resistant variation survived, reproduced, and passed this trait to their offspring. Over a period of time, this bacteria population became penicillin-resistant.



Health

INTEGRATION

When a doctor prescribes antibiotics, the patient is told to take the medicine every few hours for a week or more. A patient who feels better after two or three days might stop taking the medicine. But, if any of the disease-causing bacteria remain in the body, the patient could become ill again. In your Science Journal, explain why it is important to take all of the antibiotics the doctor prescribes.

Figure 7

The fungus growing in this petri dish is *Penicillium*, the original source of penicillin. It produces an antibiotic substance that prevents the growth of certain bacteria.

Section 1 Assessment

1. Compare Lamarck's and Darwin's ideas about how evolution takes place.
2. Explain why variations are important to the survival of a population.
3. Explain how the gradualism model of evolution differs from the punctuated equilibrium model of evolution.
4. How does geographic isolation contribute to evolution?
5. **Think Critically** What adaptations would be helpful for an animal species that was moved to the arctic?

Skill Builder Activities

6. **Concept Mapping** Use information given in **Figure 6** to make a concept map that shows how raccoons, red pandas, giant pandas, polar bears, and black bears are related to a common ancestor. **For more help, refer to the Science Skill Handbook.**
7. **Using Percentages** The evolution of the camel can be traced back at least 56 million years. Use **Figure 1** to estimate the percent of this time that the modern camel has existed. **For more help, refer to the Math Skill Handbook.**

Activity

Hidden Frogs

Through natural selection, animals become adapted for survival in their environment. Adaptations include shapes, colors, and even textures that help an animal blend into its surroundings. These adaptations are called camouflage. The red-eyed tree frog's mint green body blends in with tropical forest vegetation as shown in the photo on the right. Could you design camouflage for a desert frog? A temperate forest frog?

What You'll Investigate

What type of camouflage would best suit a frog living in a particular habitat?

Materials (for each group)

cardboard form of a frog	glue
colored markers	beads
crayons	sequins
colored pencils	modeling clay

Goals

- **Create** a frog model camouflaged to blend in with its surroundings.

Safety Precautions

Procedure

1. Choose one of the following habitats for your frog model: muddy shore of a pond, orchid flowers in a tropical rain forest, multicolored clay in a desert, or the leaves and branches of trees in a temperate forest.
2. **List** the features of your chosen habitat that will determine the camouflage your frog model will need.
3. **Brainstorm** with your group the body shape, coloring, and skin texture that would make the best camouflage for your model. Record your ideas in your Science Journal.



4. **Draw** samples of colors, patterns, texture, and other features your frog model might have in your Science Journal.
5. Show your design ideas to your teacher and ask for further input.
6. **Construct** your frog model.

Conclude and Apply

1. **Explain** how the characteristics of the habitat helped you decide on the specific frog features you chose.
2. **Infer** how the color patterns and other physical features of real frogs develop in nature.
3. **Explain** why it might be harmful to release a frog into a habitat for which it is not adapted.

Communicating

Your Data

Create a poster or other visual display that represents the habitat you chose for this activity. Use your display to show classmates how your design helps camouflage your frog model. **For more help, refer to the Science Skill Handbook.**

Clues About Evolution

Clues from Fossils

Imagine going on a fossil hunt in Wyoming. Your companions are paleontologists—scientists who study the past by collecting and examining fossils. As you climb a low hill, you notice a curved piece of stone jutting out of the sandy soil. One of the paleontologists carefully brushes the soil away and congratulates you on your find. You’ve discovered part of the fossilized shell of a turtle like the one shown in **Figure 8**.

The Green River Formation covers parts of Wyoming, Utah, and Colorado. On your fossil hunt, you learn that about 50 million years ago, during the Eocene Epoch, this region was covered by lakes. The water was home to fish, crocodiles, lizards, and turtles. Palms, fig trees, willows, and cattails grew on the lakeshores. Insects and birds flew through the air. How do scientists know all this? After many of the plants and animals of that time died, they were covered with silt and mud. Over millions of years, they became the fossils that have made the Green River Formation one of the richest fossil deposits in the world.

As You Read

What You’ll Learn

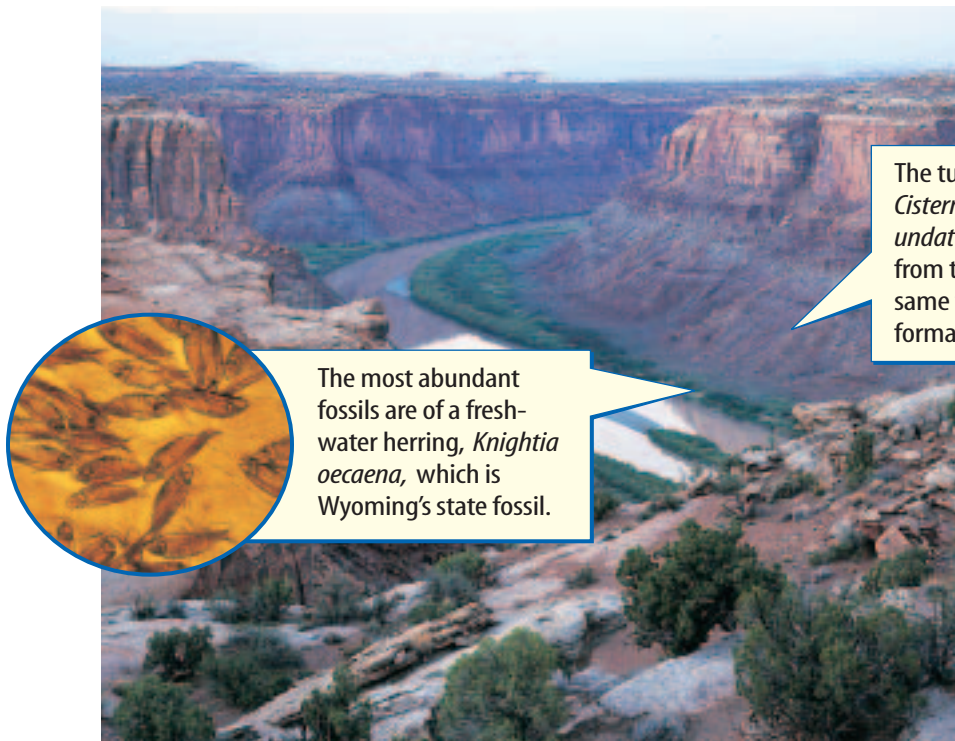
- **Identify** the importance of fossils as evidence of evolution.
- **Explain** how relative and radiometric dating are used to estimate the age of fossils.
- **List** examples of five types of evidence for evolution.

Vocabulary

sedimentary rock
radioactive element
embryology
homologous
vestigial structure

Why It’s Important

The scientific evidence for evolution helps you understand why this theory is so important to the study of biology.



The most abundant fossils are of a freshwater herring, *Knightia oecaena*, which is Wyoming’s state fossil.

The turtle *Cisternum undatum* is from the same fossil formation.

Figure 8

The desert of the Green River Formation is home to pronghorn antelope, elks, coyotes, and eagles. Fossil evidence shows that about 50 million years ago the environment was much warmer and wetter than it is today.

Figure 9

Examples of several different types of fossils are shown here. Which of these would most likely be found in a layer of sedimentary rock?



A Imprint fossils A leaf, feather, bones, or even the entire body of an organism can leave an imprint on sediment that later hardens to become rock.

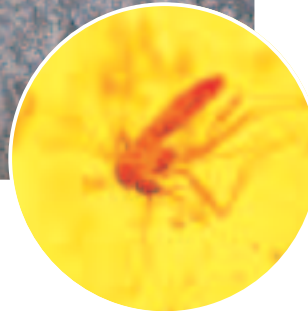
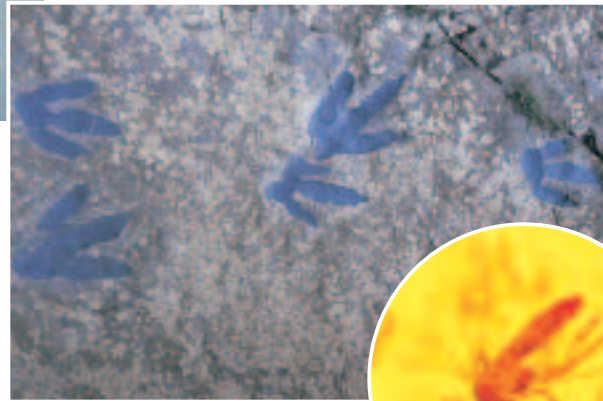


B Mineralized fossils Minerals can replace wood or bone to create a piece of petrified wood as shown to the left or a mineralized bone fossil.



C Frozen fossils The remains of organisms like this mammoth can be trapped in ice that remains frozen for thousands or millions of years.

E Cast Fossils Minerals can fill in the hollows of animal tracks as shown to the right, a mollusk shell, or other parts of an organism to create a cast.



D Fossils in amber When the sticky resin of certain cone-bearing plants hardens over time, amber forms. It can contain the remains of trapped insects.



Earth Science INTEGRATION


Types of Fossils

Most of the evidence for evolution comes from fossils. A fossil is the remains, an imprint, or a trace of a prehistoric organism. Several types of fossils are shown in **Figure 9**. Most fossils are found in sedimentary rock. **Sedimentary rock** is formed when layers of sand, silt, clay, or mud are compacted and cemented together, or when minerals are deposited from a solution. Limestone, sandstone, and shale are all examples of sedimentary rock. Fossils are found more often in limestone than in any other kind of sedimentary rock. The fossil record provides evidence that living things have evolved. Other areas of study in addition to fossils also support the theory of evolution.

Determining a Fossil's Age

Paleontologists use detective skills to determine the age of dinosaur fossils or the remains of other ancient organisms. They can use clues provided by unique rock layers and the fossils they contain. The clues provide information about the geology, weather, and life-forms that must have been present during each geologic time period. Two basic methods—relative dating and radiometric dating—can be used, alone or together, to estimate the ages of rocks and fossils.

Relative Dating One way to find the approximate age of fossils found within a rock layer is relative dating. Relative dating is based on the idea that in undisturbed areas, younger rock layers are deposited on top of older rock layers, as shown in **Figure 10**. Relative dating provides only an estimate of a fossil's age. The estimate is made by comparing the ages of rock layers found above and below the fossil layer. For example, suppose a 50-million-year-old rock layer lies below a fossil, and a 35-million-year-old layer lies above it. According to relative dating, the fossil is probably between 35 million and 50 million years old.

 **Reading Check** *Why can relative dating be used only to estimate the age of a fossil?*

Radiometric Dating Scientists can obtain a more accurate estimate of the age of a rock layer by using 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 can estimate the age of the rock by comparing the amount of radioactive element with the amount of nonradioactive element in the rock. This method of dating does not always produce exact results, because the original amount of radioactive element in the rock can never be determined for certain.



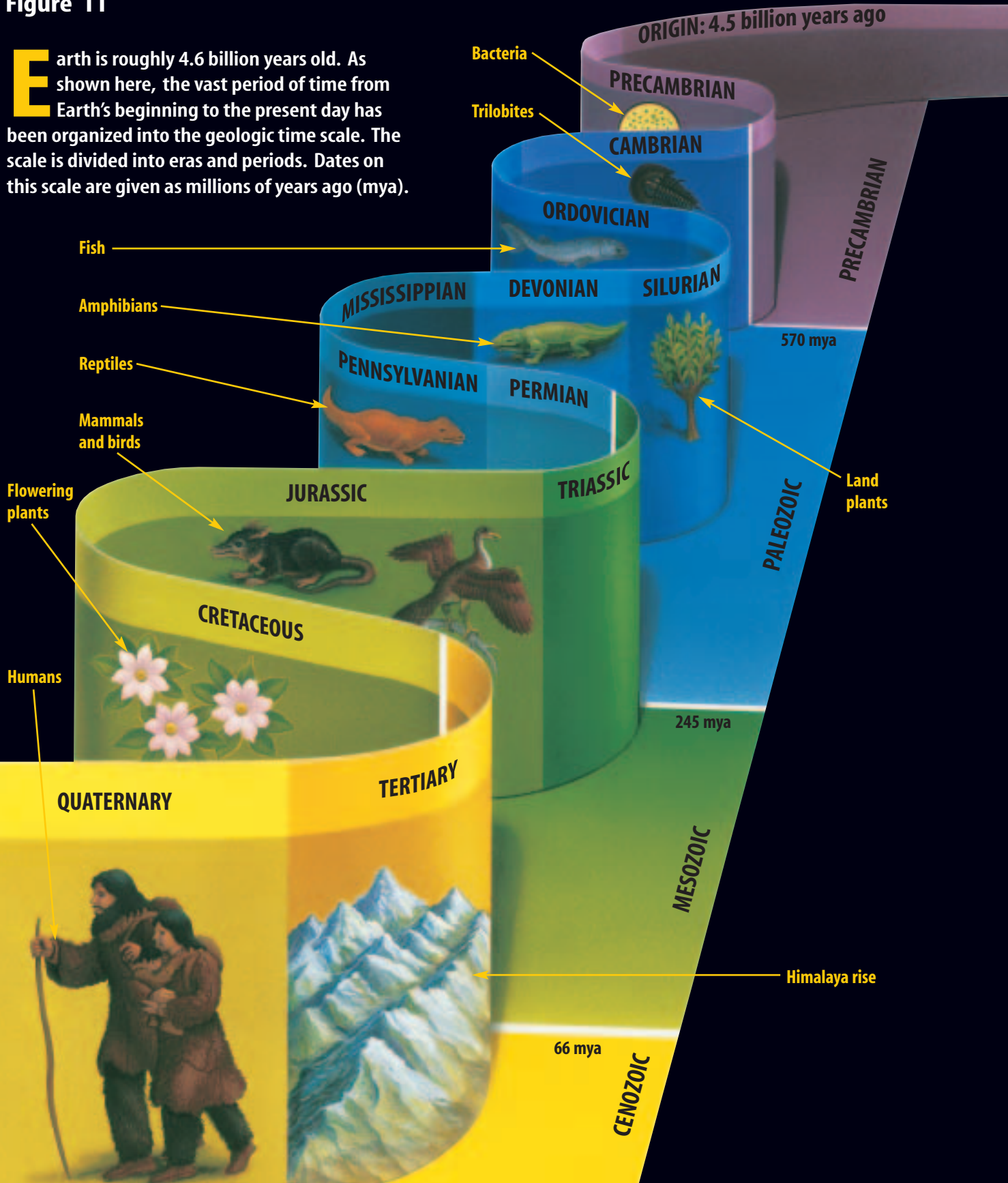
Data Update Visit the Glencoe Science Web site at science.glencoe.com for news about recent fossil discoveries. In your Science Journal, write a brief report describing how one of these discoveries was made and what it reveals about past life on Earth.

Figure 10
In Bryce Canyon, erosion by water and wind has cut through the sedimentary rock, exposing the layers. Fossils found in lower layers of sedimentary rock are usually older than the fossils found in upper layers.



Figure 11

Earth is roughly 4.6 billion years old. As shown here, the vast period of time from Earth's beginning to the present day has been organized into the geologic time scale. The scale is divided into eras and periods. Dates on this scale are given as millions of years ago (mya).



Fossils and Evolution

Fossils provide a record of organisms that lived in the past. However, the fossil record has gaps, much like a book with pages missing. The gaps exist because of an incomplete rock record, and because most organisms do not become fossils. This means that the fossil record will always be incomplete. By looking at fossils, scientists conclude that many simpler forms of life existed earlier in Earth's history, and more complex forms of life appeared later, as shown in **Figure 11**. Fossils provide indirect evidence that evolution has occurred on Earth.

Almost every week, fossil discoveries are made somewhere in the world. When fossils are found, they are used to help scientists understand the past. Scientists can use fossils to make models that show what the organisms might have looked like. From fossils, scientists can sometimes determine whether the organisms lived in family groups or alone, what they ate, what kind of environment they lived in, and many other things about them. Most fossils represent extinct organisms. From a study of the fossil record, scientists have concluded that more than 99 percent of all organisms that have ever existed are extinct now.

More Clues About Evolution

Besides fossils, what other clues do humans have about evolution? Sometimes, evolution can be directly observed. Plant breeders observe evolution when they use cross-breeding to produce genetic changes in plants. The development of antibiotic resistance in bacteria is another direct observation of evolution. Entomologists have noted similar rapid evolution of pesticide-resistant insect species. These observations provide direct evidence that evolution occurs. Also, many examples of indirect evidence for evolution exist. They include similarities in embryo structures, the chemical makeup of organisms including DNA, and the way organisms develop into adults. Indirect evidence does not provide proof of evolution, but it does support the idea that evolution takes place over time.

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. A tail and gills or gill slits are found at some point in the embryos of fish, reptiles, birds, and mammals, as **Figure 12** shows. Fish keep their gills, but the other organisms lose their gill slits as their development continues. Fish, birds, and reptiles keep their tails, but many mammals lose theirs. These similarities suggest an evolutionary relationship among all vertebrate species.



Earth Science INTEGRATION

Many organisms have a history that has been preserved in sedimentary rock. Fossils show that the bones of animals such as horses and whales have become reduced in size or number over geologic time, as the species has evolved. In your Science Journal, explain what information can be gathered from changes in structures that occur over time.

Figure 12
Similarities in the embryos of fish, chickens, and rabbits show evidence of evolution.

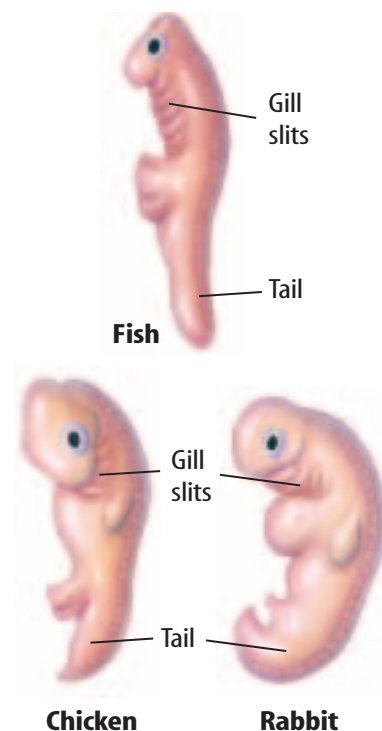




Figure 13
A porpoise flipper, frog forelimb, human arm, and bat wing are homologous. These structures show different arrangements and shapes of the bones of the forelimb. They have the same number of bones, muscles, and blood vessels, and they developed from similar tissues.

Homologous Structures What do the structures shown in **Figure 13** have in common? Although they have different functions, each of these structures is made up of the same kind of bones. Body parts that are similar in origin and structure are called **homologous** (hoh MAH luh gus). Homologous structures also can be similar in function. They often indicate that two or more species share common ancestors.

 **Reading Check** *What do homologous structures indicate?*

Vestigial Structures The bodies of some organisms include **vestigial** (veh STIH jee ul) **structures**—structures that don't seem to have a function. Vestigial structures also provide evidence for evolution. For example, manatees, snakes, and whales no longer have back legs, but, like all animals with legs, they still have pelvic bones. The human appendix is a vestigial structure. The appendix appears to be a small version of the cecum, which is an important part of the digestive tract of many mammals. Scientists hypothesize that vestigial structures, like those shown in **Figure 14**, are body parts that once functioned in an ancestor.

Figure 14
Humans have three small muscles around each ear that are vestigial. In some mammals, such as horses, these muscles are large. They allow a horse to turn its ears toward the source of a sound. Humans cannot rotate their ears, but some people can wiggle their ears.



DNA If you enjoy science fiction, you probably have read books or seen movies in which scientists re-create dinosaurs and other extinct organisms from DNA taken from fossils. DNA is the molecule that controls heredity and directs the development of every organism. In a cell with a nucleus, DNA is found in genes that make up the chromosomes. Scientists compare DNA from living organisms to identify similarities among species. Examinations of ancient DNA often

provide additional evidence of how some species evolved from their extinct ancestors. By looking at DNA, scientists also can determine how closely related organisms are. For example, DNA studies indicate that dogs are the closest relatives of bears.

Similar DNA also can suggest common ancestry. Apes such as the gorillas shown in **Figure 15**, chimpanzees, and orangutans have 24 pairs of chromosomes. Humans have 23 pairs. When two of an ape's chromosomes are laid end to end, a match for human chromosome number 2 is formed. Also, similar proteins such as hemoglobin—the oxygen-carrying protein in red blood cells—are found in many primates. This can be further evidence that primates have a common ancestor.



Figure 15
Gorillas have DNA and proteins that are similar to humans and other primates.

Section 2 Assessment

1. How are relative dating and radiometric dating used by scientists?
2. Why are fossils important evidence of evolution? Describe five different kinds of fossils.
3. Explain how DNA can provide some evidence of evolution.
4. Describe three examples of direct evidence for evolution.
5. **Think Critically** Compare and contrast the five types of evidence that support the theory of evolution.

Skill Builder Activities

6. Interpreting Scientific Illustrations

According to **Figure 11**, what was the longest geological era? What was the shortest era? During what period did mammals appear?

For more help, refer to the Science Skill Handbook.

7. **Using Percentages** The Cenozoic Era represents about 66 million years. Approximately what percent of Earth's 4.6-billion-year history does this era represent? **For more help, refer to the Math Skill Handbook.**

The Evolution of Primates

As You Read

What You'll Learn

- **Describe** the differences among living primates.
- **Identify** the adaptations of primates.
- **Discuss** the evolutionary history of modern primates.

Vocabulary

primate
hominid
Homo sapiens

Why It's Important

Studying primate evolution will help you appreciate the differences among primates.

Figure 16

The ability to rotate the shoulder in a complete circle allows humans to swim through water and tree-dwelling primates to travel through treetops.



Primates

Humans, monkeys, and apes belong to the group of mammals known as the **primates**. All primates have opposable thumbs, binocular vision, and flexible shoulders that allow the arms to rotate. These shared characteristics could indicate that all primates may have evolved from a common ancestor.

Having an opposable thumb allows you to cross your thumb over your palm and touch your fingers. This means that you can grasp and hold things with your hands. An opposable thumb allows tree-dwelling primates to hold on to branches.

Binocular vision permits you to judge depth or distance with your eyes. In a similar way, it allows tree-dwelling primates to judge the distances as they move between branches. Flexible shoulders and rotating forelimbs also help tree-dwelling primates move from branch to branch. They also allow humans to do the backstroke, as shown in **Figure 16**.

Primates are divided into two major groups. The first group, the prosimians (pro SIH mee uhnz), includes lemurs and tarsiers like those shown in **Figure 17**. The second group, the anthropoids (AN thruh poydz), includes monkeys, apes, and humans.





A



B

Figure 17

Tarsiers and lemurs are active at night.

A Tarsiers are commonly found in the rain forests of Southeast Asia.

B Lemurs live on Madagascar and other nearby islands.

Hominids About 4 million to 6 million years ago, humanlike primates appeared that were different from the other primates. These ancestors, called **hominids**, ate both meat and plants and walked upright on two legs. Hominids shared some characteristics with gorillas, orangutans, and chimpanzees, but a larger brain separated them from the apes.

African Origins In the early 1920s, a fossil skull was discovered in a quarry in South Africa. The skull had a small space for the brain, but it had a humanlike jaw and teeth. The fossil, named *Australopithecus*, was one of the oldest hominids discovered. An almost-complete skeleton of *Australopithecus* was found in northern Africa in 1974. This hominid fossil, shown in **Figure 18**, was called Lucy and had a small brain but is thought to have walked upright. This fossil indicates that modern hominids might have evolved from similar ancestors.

Figure 18

The fossil remains of Lucy are estimated to be 2.9 million to 3.4 million years old.



TRY AT HOME
Mini LAB

Living Without Thumbs

Procedure

1. Using **tape**, fasten down each of your thumbs next to the palm of each hand.
2. Leave your thumbs taped down for at least 1 h. During this time, do the following activities: eat a meal, change clothes, and brush your teeth. Be careful not to try anything that could be dangerous.
3. Untape your thumbs, then write about your experiences in your **Science Journal**.

Analysis

1. Did not having use of your thumbs significantly affect the way you did anything? Explain.
2. Infer how having opposable thumbs could have influenced primate evolution.



Figure 19
Many of the oldest humanlike skeletons have been found in this area of east Africa.

Early Humans In the 1960s in the region of Africa shown in **Figure 19**, a hominid fossil, which was more like present-day humans than *Australopithecus*, was discovered. The hominid was named *Homo habilis*, the handy man, because simple stone tools were found near him. *Homo habilis* is estimated to be 1.5 million to 2 million years old. Based upon many fossil comparisons, scientists have suggested that *Homo habilis* gave rise to another species, *Homo erectus*, about 1.6 million years ago. This hominid had a larger brain than *Homo habilis*. *Homo erectus* traveled from Africa to Southeast Asia, China, and possibly Europe. *Homo habilis* and *Homo erectus* are thought to be ancestors of humans because they had larger brains and more human-like features than *Australopithecus*.

Reading Check Why was *Homo habilis* given that name?

Humans

The fossil record indicates that *Homo sapiens* evolved about 400,000 years ago. By about 125,000 years ago, two early human groups, Neanderthals and Cro-Magnon humans, as shown in **Figure 20**, probably lived at the same time in parts of Africa and Europe.

Neanderthals Short, heavy bodies with thick bones, small chins, and heavy browridges were physical characteristics of Neanderthals (nee AN dur tawlz). They lived in family groups in caves and used well-made stone tools to hunt large animals. Neanderthals disappeared from the fossil record about 30,000 years ago. They might represent a side branch of human evolution and might not be direct ancestors of modern humans.

Figure 20
The skull of a Neanderthal can be compared with the skull of a Cro-Magnon. What differences can you see between these two skulls?

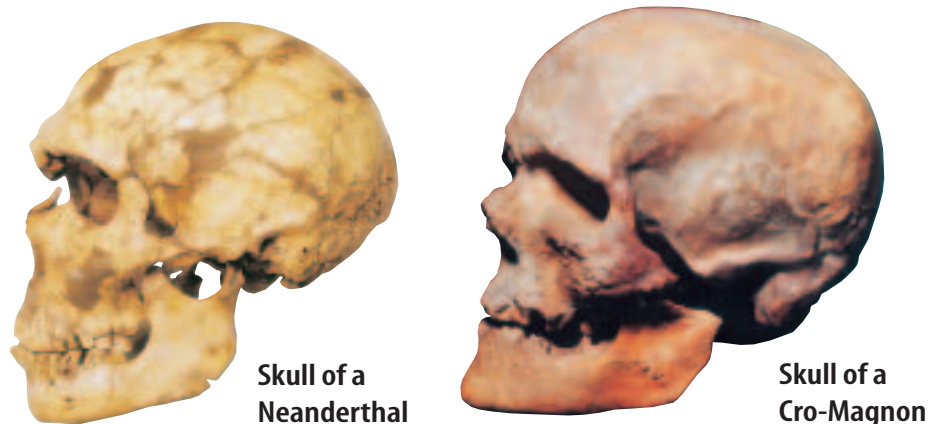




Figure 21
Paintings on cave walls have led scientists to hypothesize that Cro-Magnon humans had a well-developed culture.

Cro-Magnon Humans Cro-Magnon fossils have been found in Europe, Asia, and Australia and date from 10,000 to about 40,000 years in age. Standing about 1.6 m to 1.7 m tall, the physical appearance of Cro-Magnon people was almost the same as that of modern humans. They lived in caves, made stone carvings, and buried their dead. As shown in **Figure 21**, the oldest recorded art has been found on the walls of caves in France, where Cro-Magnon humans first painted bison, horses, and people carrying spears. Cro-Magnon humans are thought to be direct ancestors of early humans, *Homo sapiens*, which means “wise human.” Evidence indicates that modern humans, *Homo sapiens sapiens*, evolved from *Homo sapiens*.

Section 3 Assessment

1. Describe at least three kinds of evidence that suggest that all primates might have shared a common ancestor.
2. What is the importance of *Australopithecus*?
3. Describe the differences and similarities among Neanderthals, Cro-Magnon humans, and early humans.
4. Which group do most scientists consider to be direct ancestors of modern humans?
5. **Think Critically** Propose a hypothesis about why teeth are the most abundant fossils of hominids.

Skill Builder Activities

6. **Concept Mapping** Make a concept map to show in what sequence the different groups of hominids appeared. Use the following terms: *Homo sapiens sapiens*, Neanderthal, *Homo habilis*, *Australopithecus*, *Homo sapiens*, and Cro-Magnon human. **For more help, refer to the Science Skill Handbook.**
7. **Communicating** Write a story in your Science Journal about what life would be like for you if you did not have thumbs. **For more help, refer to the Science Skill Handbook.**

Activity

Design Your Own Experiment

Recognizing Variation in a Population

When you first observe a flock of pigeons, you might think all the birds look alike. However, if you look closer, you will notice minor differences, or variations, among the individuals. Different pigeons might have different color markings, or some might be smaller or larger than others. Individuals of the same species—whether they're birds, plants, or worms—might look alike at first, but some variations undoubtedly exist. According to the principles of natural selection, evolution could not occur without variations. What kinds of variations have you noticed among species of plants or animals?

Recognize the Problem

How can you measure variation in a plant or animal population?

Form a Hypothesis

Make a hypothesis about the amount of variation in the fruit and seeds of one species of plant.

Possible Materials

fruit and seeds from one plant species
metric ruler
magnifying glass
graph paper

Goals

- **Design** an experiment that will allow you to collect data about variation in a population.
- **Observe, measure, and analyze** variations in a population.

Safety Precautions



Do not put any fruit or seeds in your mouth. Wash your hands after handling plant parts.



Test Your Hypothesis

Plan

1. As a group, agree upon and write out the hypothesis statement.
2. **List** the steps you need to take to test your hypothesis. Be specific. Describe exactly what you will do at each step. List your materials.
3. **Decide** what characteristic of fruit and seeds you will study. For example, you could measure the length of fruit and seeds or count the number of seeds per fruit.
4. **Design** a data table in your Science Journal to collect data about two variations. Use the table to record the data your group collects as you complete the experiment.
5. **Identify** any constants, variables, and controls of the experiment.
6. How many fruit and seeds will you examine? Will your data be more accurate if you examine larger numbers?
7. **Summarize** your data in a graph or chart.

Do

1. Make sure your teacher approves your plan before you start.
2. Carry out the experiment as planned.
3. While the experiment is going on, write down any observations you make and complete the data table in your Science Journal.



Analyze Your Data

1. **Calculate** the mean and range of variation in your experiment. The range is the difference between the largest and the smallest measurements. The mean is the sum of all the data divided by the sample size.
2. **Graph** your group's results by making a line graph for the variations you measured. Place the range of variation on the *x*-axis and the number of organisms that had that measurement on the *y*-axis.



Draw Conclusions

1. **Explain** your results in terms of natural selection.
2. What factors did you use to determine the amount of variation present?
3. Suggest reasons why one or more of the variations you observed in this activity might be helpful to the survival of the individual.

Communicating Your Data

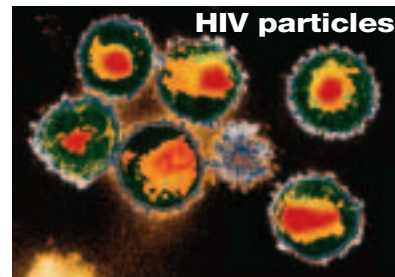
Create a poster or other exhibit that illustrates the variations you and your classmates observed.



Wong-Staal was on one of the two teams that first identified HIV as the virus that causes AIDS.

Fighting

The first cases of AIDS, or acquired immune deficiency syndrome, in humans were reported in the early 1980s. AIDS is caused by the human immunodeficiency virus, or HIV. It is most likely that HIV first occurred in nonhuman primates, evolving into a form that could infect humans. For the first two decades of the battle against HIV and AIDS, it looked like the virus might win. Teams of scientists from many fields, and in many parts of the world, are part of the ongoing counterattack.



A major problem in AIDS research is the rapid evolution of HIV. When HIV multiplies inside a host cell, new versions of the virus are produced as well as identical copies of the virus that invaded the cell.

New versions of the virus can soon outnumber the original version. That's why HIV is so hard to fight—a treatment that works against today's HIV might not work against tomorrow's version.

These rapid changes in HIV also mean that different strains of the virus exist in different places around the world. That means most vaccines, which are still in the experimental stage, and treatments developed in the United States work only for AIDS patients who contracted the virus in the United States. This leaves AIDS sufferers in some parts of the world without effective treatments. Also, treatments might work for only a short period of time. Traditional vaccines quickly become useless. So, researchers such as geneticist Flossie Wong-Staal at the University of California in San Diego, must look for new ways to fight the evolving virus.

Working Backwards

Flossie Wong-Staal is taking a new approach. Her research focuses on how HIV uses host human cells. First, her team identifies the parts of a human cell that HIV depends on. Next, the team looks for parts of the human cell that HIV needs but the human cell doesn't need. Then the team looks for a way to remove—or inactivate—that unneeded part. This technique limits the virus's ability to multiply.

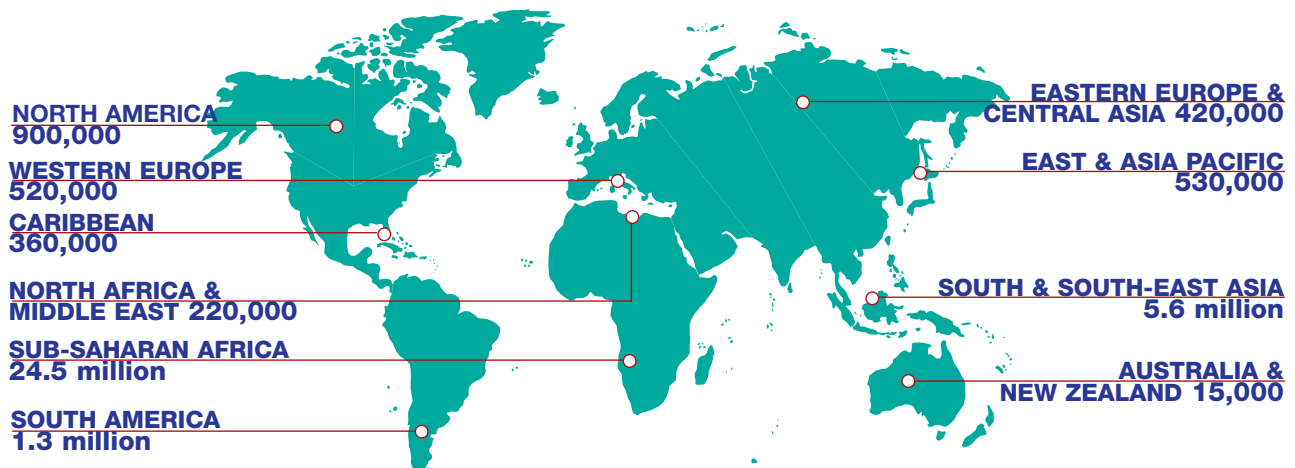
Wong-Staal's research combines three important aspects of science—a deep understanding of how cells and genes operate, great skill in the techniques of genetics, and great ideas. Understanding, skill, and great ideas are the best weapons so far in the fight to conquer HIV.

the Battle Against

Scientists around the world are trying to keep up with a constantly changing virus

HIV

Adults and children living with HIV/AIDS - total: 34.3 million



SOURCE: JOINT UNITED NATIONS PROGRAM ON HIV/AIDS, 1999

[CLICK HERE](#)

CONNECTIONS Research Use the Glencoe Science Web site and other sources to determine which nations have the highest rates of AIDS infection. Which nation has the highest rate? Where does the U.S. rank? Next, find data from ten years ago. Have the rankings changed?

SCIENCE
Online

For more information, visit
science.glencoe.com

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Reviewing Main Ideas

Section 1 Ideas About Evolution

1. Evolution is one of the central ideas of biology. It is an explanation of how living things have changed in the past and a basis for predicting how they might change in the future.
2. Charles Darwin developed the theory of evolution by natural selection to explain how evolutionary changes account for the diversity of organisms on Earth.
3. Natural selection includes concepts of variation, overproduction, and competition.

4. According to natural selection, organisms with traits best suited to their environment are more likely to survive and reproduce. *What traits make this bird suited to its watery environment?*



Section 2 Clues About Evolution

1. Fossils provide evidence for evolution. *How are imprint fossils like the one to the right formed?*
2. Relative dating and radiometric dating can be used to estimate the age of fossils.
3. The evolution of antibiotic-resistant bacteria, pesticide-resistant insects, and rapid genetic changes in plant species provides direct evidence that evolution occurs.



4. Homologous structures, vestigial structures, comparative embryology, and chemical similarities in DNA and other substances provide indirect evidence of evolution. *How does DNA provide evidence of evolution?*



Section 3 The Evolution of Primates

1. Primates include monkeys, apes, and humans. Hominids are humanlike primates. *What are the common characteristics of primates?*
2. The earliest known hominid fossil is *Australopithecus*.
3. *Homo sapiens* are thought to have evolved from Cro-Magnon humans at least 400,000 years ago.



After You Read

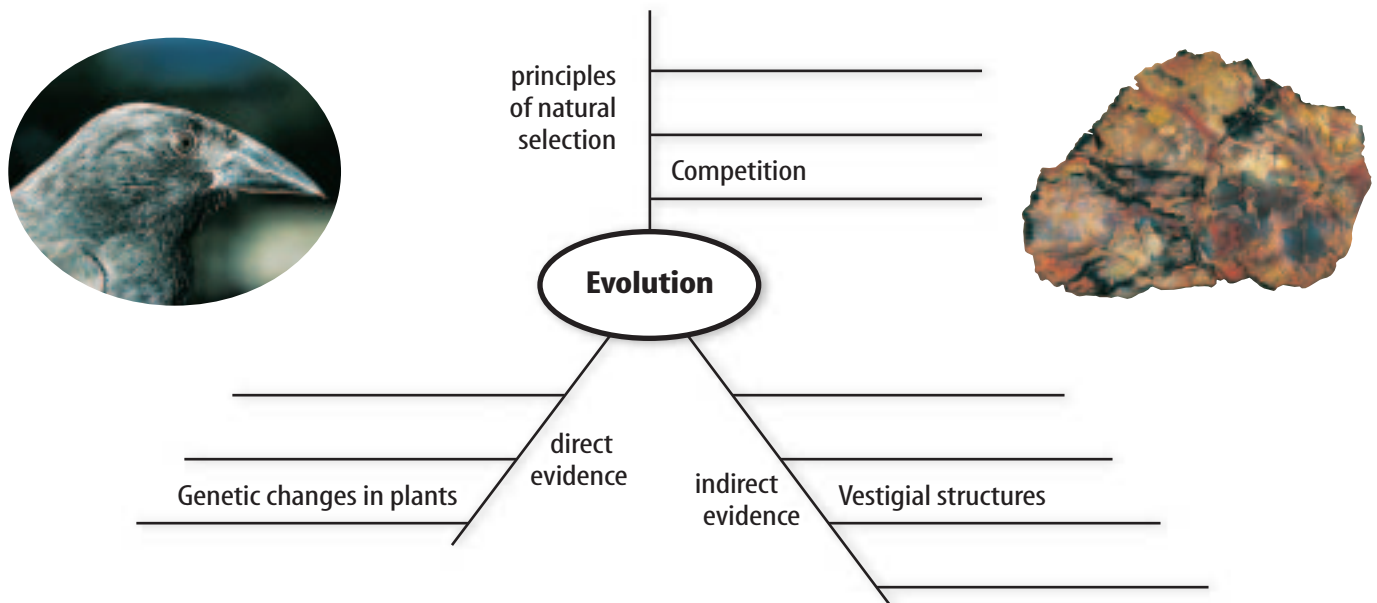
FOLDABLES Reading & Study Skills



Using what you learned, predict how primates might change and write your ideas under the *Future* tab of your Foldable.

Visualizing Main Ideas

Complete the following spider map on evolution.



Vocabulary Review

Vocabulary Words

- | | |
|------------------------|---------------------------|
| a. adaptation | j. punctuated equilibrium |
| b. embryology | k. radioactive element |
| c. evolution | l. sedimentary rock |
| d. gradualism | m. species |
| e. hominid | n. variation |
| f. <i>Homo sapiens</i> | o. vestigial structure |
| g. homologous | |
| h. natural selection | |
| i. primate | |

Using Vocabulary

Replace each underlined phrase with the correct vocabulary words.

- Layers of deposition might contain many different kinds of fossils.
- The muscles that move the human ear appear to be of no obvious use.
- Forelimbs of bats, humans, and seals are similar in origin.
- Opposable thumbs are a characteristic of this group of mammals.
- The study of early development of species can provide evidence of evolution.
- The principles of this mechanism of evolution include variation and competition.
- Modern humans likely evolved directly from Cro-Magnons.



Study Tip

Make a plan. Before you start your homework, write a checklist of what you need to do for each subject. As you finish each item, check it off.

Checking Concepts

Choose the word or phrase that best answers the question.

- What is an example of adaptation?
 - a fossil
 - gradualism
 - camouflage
 - embryo
- What method provides the most accurate estimate of a fossil's age?
 - natural selection
 - radiometric dating
 - relative dating
 - camouflage
- What do homologous structures, vestigial structures, and fossils provide evidence of?
 - gradualism
 - food choice
 - populations
 - evolution
- Which model of evolution shows change over a relatively short period of time?
 - embryology
 - adaptation
 - gradualism
 - punctuated equilibrium
- What might a series of helpful variations in a species result in?
 - adaptation
 - fossils
 - embryology
 - climate change
- What describes organisms that are adapted to their environment?
 - homologous
 - not reproducing
 - forming fossils
 - surviving and reproducing
- What is the study of an organism's early development called?
 - adaptation
 - relative dating
 - natural selection
 - embryology
- What animal group(s) have opposable thumbs and binocular vision?
 - all primates
 - hominids
 - humans only
 - monkeys only

- Which of the following is a principle of natural selection?
 - inheritance of acquired traits
 - Unused traits become smaller.
 - Organisms produce more offspring than can survive.
 - the size of an organism
- A hominid fossil has the same number of bones in its hand as a gorilla. What type of evidence for evolution does this represent?
 - DNA
 - embryology
 - vestigial structures
 - homologous structures

Thinking Critically

- How would Lamarck and Darwin have explained the large eyes of an owl?
- Using an example, explain how a new species of organism could evolve.
- How is the color-changing ability of chameleons an adaptation?
- Describe the processes a scientist would use to figure out the age of a fossil.
- Explain how a species could adapt to its environment. Give an example.

Developing Skills

- Predicting** Predict what type of bird the foot pictured below would belong to. Explain your reasoning.



17. Interpreting Data Each letter below represents a chemical found in different species of bacteria. Which species are closely related?

Chemicals Present in Bacteria Species	
Species 1	A, G, T, C, L, E, S, H
Species 2	A, G, T, C, L, D, H
Species 3	A, G, T, C, L, D, P, U, S, R, I, V
Species 4	A, G, T, C, L, D, H

18. Forming Hypotheses Frog eggs are common in ponds in spring. Make a hypothesis as to why ponds are not overpopulated by frogs in summer. Use the concept of natural selection to help you.

19. Comparing and Contrasting Compare and contrast Cro-Magnon humans and modern humans, *Homo sapiens sapiens*.

20. Concept Mapping Make an events chain of the events that led Charles Darwin to his theory of evolution by natural selection.

Performance Assessment

21. Collection With permission, collect fossils from your area and identify them. Show your collection to your class.

22. Brochure Assume that you are head of an advertising company hired by Charles Darwin. Develop a brochure to explain Darwin's theory of evolution by natural selection.

TECHNOLOGY

Go to the Glencoe Science Web site at science.glencoe.com or use the Glencoe Science CD-ROM for additional chapter assessment.

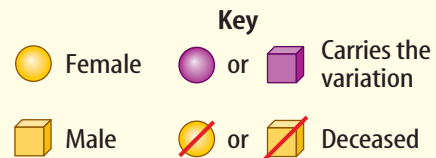
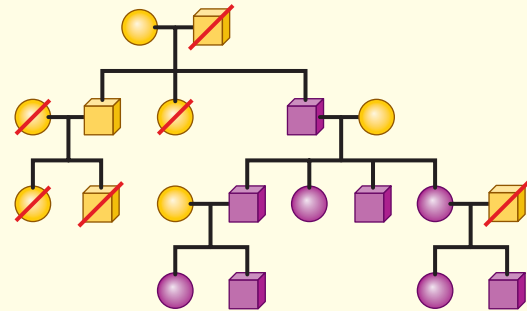
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CONTENTS



Test Practice

A scientist studied a genetic variation in a large family of birds. She made the pedigree below to show how the variations within the family appeared.



Study the pedigree and answer the following questions.

- Which of the following is most likely the scientist's conclusion from these data?
 - Female birds of this species die more often than the males.
 - The variation helps the birds survive and reproduce.
 - Birds of this species lay one or two eggs.
 - The genetic variation only helps one of the two sexes.
- To which offspring is this genetic variation most often passed along?
 - all offspring
 - some females and males
 - only the father's daughters
 - males only