

# Eras of Earth's History

## Reading Preview

### Key Concepts

- What were the major events in the Paleozoic Era?
- What were the major events in the Mesozoic Era?
- What were the major events in the Cenozoic Era?

### Key Terms

- invertebrate • vertebrate
- amphibian • reptile
- mass extinction • mammal

## Target Reading Skill

**Previewing Visuals** Before you read, preview Figure 22. Then write three questions that you have about Earth's history in a graphic organizer like the one below. As you read, answer your questions.

### Earth's History

Q. What geologic events happened during Precambrian Time?

A.

Q.

Lab  
zone

## Discover Activity

### What Do Fossils Reveal About Earth's History?

1. Compare the two fossils in photos A and B. How did these organisms become fossils?
2. Work with one or two other students to study the organisms in the two photos. Think about how these organisms may have lived. Then make sketches showing what each of these organisms may have looked like.

### Think It Over

**Posing Questions** If you were a paleontologist, what questions would you want to ask about these organisms?



As your time machine nears the end of Precambrian Time, you notice that Earth's organisms have begun to change. Along with organisms made up of single cells, living things resembling jellyfish now float in Earth's oceans. You also notice the fronds of feathery, plantlike organisms anchored to the seafloor. Scientists have found fossils of such organisms in Australia, Russia, China, and southern Africa. Fossils like the ones in Figure 18 are more than 600 million years old! But a much greater variety of living things evolved during the next phase of geologic time—the Paleozoic Era.

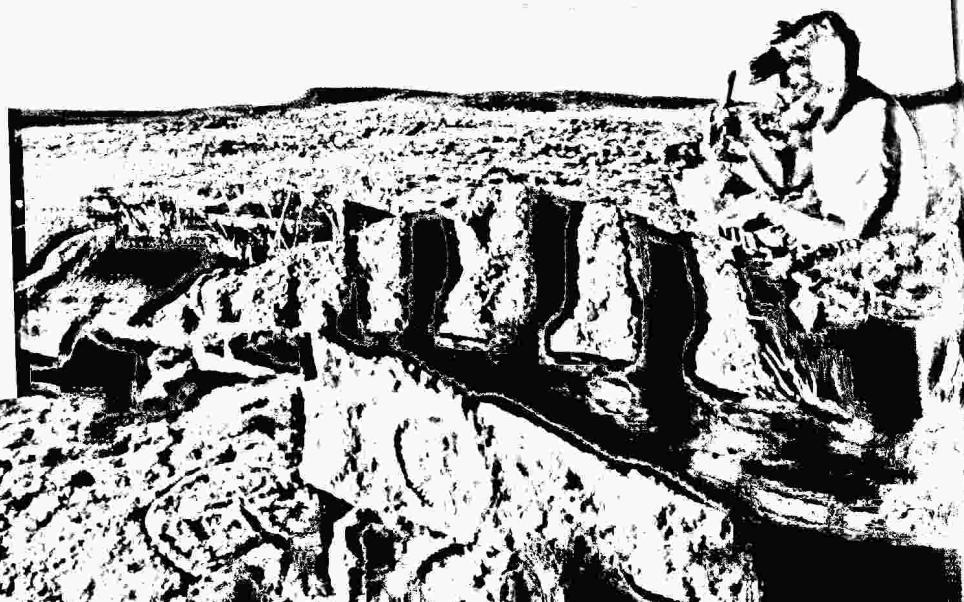


FIGURE 18

### Paleontologist at Work

This paleontologist in Australia is uncovering fossil animals from late Precambrian Time.

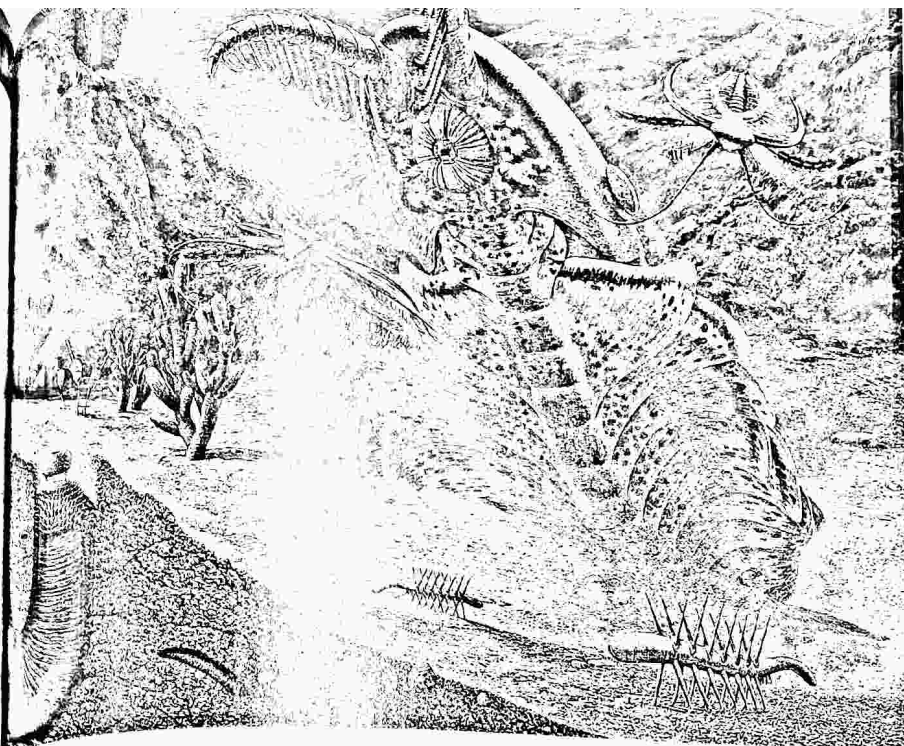


FIGURE 19

### The Cambrian Explosion

During the early Cambrian period, Earth's oceans were home to many strange organisms unlike any animals that are alive today.

## The Paleozoic Era

Your time machine slows. You observe the “explosion” of life that began the Paleozoic Era.

**The Cambrian Explosion** During the Cambrian Period life took a big leap forward. **At the beginning of the Paleozoic Era, a great number of different kinds of organisms evolved.** Paleontologists call this event the Cambrian Explosion because so many new life forms appeared within a relatively short time. For the first time, many organisms had hard parts, including shells and outer skeletons.

At this time, all animals lived in the sea. Many were animals without backbones, or **invertebrates**. Invertebrates such as jellyfish, worms, and sponges drifted through the water, crawled along the sandy bottom, or attached themselves to the ocean floors.

Brachiopods and trilobites were common in the Cambrian seas. Brachiopods were small ocean animals with two shells. They resembled modern clams, but are only distantly related.

**Vertebrates Arise** During the Ordovician (awr duh VISH ee un) and Silurian (sih LOOR ee un) periods, the ancestors of the modern octopus and squid appeared. But these invertebrates soon shared the seas with a new type of organism. **During this time, jawless fishes evolved. Jawless fishes were the first vertebrates.** A **vertebrate** is an animal with a backbone. These fishes had suckerlike mouths, and they soon became common.



FIGURE 20

### Devonian Armored Fish

Paleontologists have found fossils of huge armored fish, like this *Dunkleosteus*, that lived during the Devonian Period.

**Life Reaches Land** Until the Silurian Period, only one-celled organisms lived on the land. But during the Silurian Period, plants became abundant. These first, simple plants grew low to the ground in damp areas. By the Devonian Period (dih VOH nee un), plants that could grow in drier areas had evolved. Among these plants were the earliest ferns. The first insects also appeared during the Silurian Period.

Both invertebrates and vertebrates lived in the Devonian seas. Even though the invertebrates were more numerous, the Devonian Period is often called the Age of Fishes. Every main group of fishes was present in the oceans at this time. Most fishes now had jaws, bony skeletons, and scales on their bodies. Some fishes, like the one in Figure 20, were huge. Sharks appeared in the late Devonian Period.

During the Devonian Period, animals began to invade the land. The first vertebrates to crawl onto land were lungfish with strong, muscular fins. The first amphibians evolved from these lung fish. An **amphibian** (am FIB ee un) is an animal that lives part of its life on land and part of its life in water.

FIGURE 21

### The Coal Forest

Forests of the Carboniferous Period later formed coal deposits. Predicting What types of fossils would you expect to find from the Carboniferous Period?

**The Carboniferous Period** Throughout the rest of the Paleozoic, life expanded over Earth's continents. Other vertebrates evolved from the amphibians. For example, small reptiles developed during the Carboniferous Period. **Reptiles** have scaly skin and lay eggs with tough, leathery shells. Some types of reptiles became very large during the later Paleozoic.



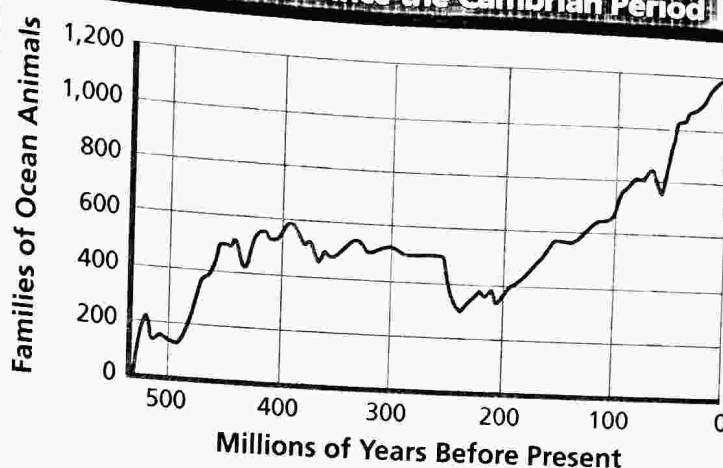


## Mass Extinctions

The graph shows how the number of families of animals in Earth's oceans has changed.

1. **Reading Graphs** What variable is shown on the x-axis? On the y-axis of the graph?
2. **Interpreting Data** How long ago did the most recent mass extinction occur?
3. **Interpreting Data** Which mass extinction produced the greatest drop in the number of families of ocean animals?
4. **Relating Cause and Effect** In general, how did the number of families change between mass extinctions?

Mass Extinctions Since the Cambrian Period



Mass extinctions

During the Carboniferous Period, winged insects evolved into many forms, including huge dragonflies and cockroaches. Giant ferns and cone-bearing plants and trees formed vast swampy forests called "coal forests." The remains of the coal forest plants formed thick deposits of sediment that changed into coal over millions of years.

**Mass Extinction Ends the Paleozoic** At the end of the Paleozoic Era, many kinds of organisms died out. This was a **mass extinction**, in which many types of living things became extinct at the same time. **The mass extinction at the end of the Paleozoic affected both plants and animals, on land and in the seas.** Scientists do not know what caused the mass extinction, but many kinds of organisms, such as trilobites, suddenly became extinct.

**The Supercontinent Pangaea** Scientists hypothesize that climate change resulting from continental drift may have caused the mass extinction at the end of the Paleozoic. **During the Permian Period, about 260 million years ago, Earth's continents moved together to form a great landmass, or supercontinent, called Pangaea** (pan JEE uh). The formation of Pangaea caused deserts to expand in the tropics. At the same time, sheets of ice covered land closer to the South Pole. Many organisms could not survive the new climate. After Pangaea formed, it broke apart again, as shown in Figure 22.



What was Pangaea?

Go **active art**

For: Continental Drift activity  
Visit: PHSchool.com  
Web Code: cfp-1015

# Figure 2 Geologic History

## Precambrian Time

4.6 billion–544 million years ago

544–505 million years ago

505–438 million years ago

438–408 million years ago

408–408 million years ago

## Geologic Events

- Earth forms about 4.6 billion years ago.
- Oceans form and cover Earth about 4 billion years ago.
- First sedimentary rocks form about 4 billion years ago.
- Shallow seas cover much of the land.
- Ancient continents lie near or south of the equator.
- Warm, shallow seas cover much of Earth.
- Ice cap covers what is now North Africa.
- Coral reefs develop.
- Early continents collide with what is now North America, forming mountains.

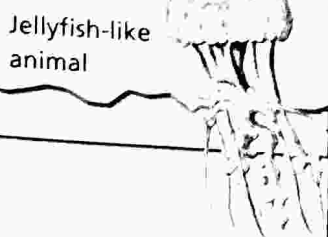
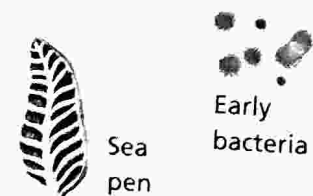
## Development of Life

- Bacteria appear about 3.5 billion years ago.
- Soft-bodied, multi-cellular organisms develop late in the Precambrian.
- First mass extinction probably occurs near the end of the Precambrian.

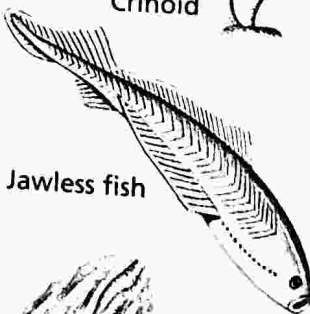
- Great "explosion" of invertebrate life occurs in seas.
- Invertebrates with shells appear, including trilobites and mollusks.

- Invertebrates dominate the oceans.
- Early vertebrates—jawless fish—become common.

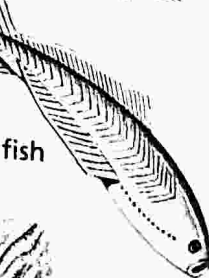
- Fish with jaws develop.
- Land plants appear.
- Insects and spiders appear.



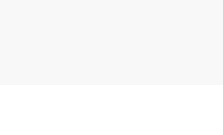
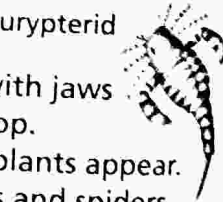
Sponges



Crinoid



Jawed fish



# **Paleozoic Era** 251-252 million years ago

## **Devonian**

408-360 million years ago

## **Carboniferous** 360-286 million years ago

**Mississippian**  
360-320 million years ago

**Pennsylvanian**  
320-286 million years ago

## **Permian**

286-245 million years ago

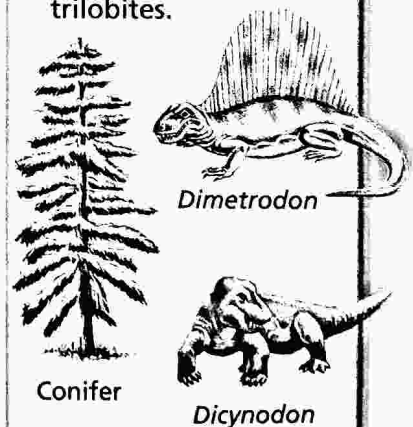
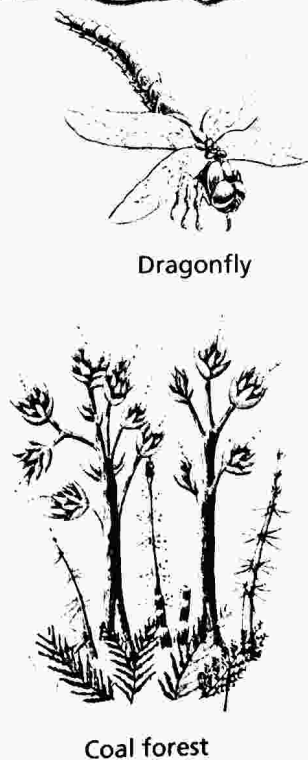
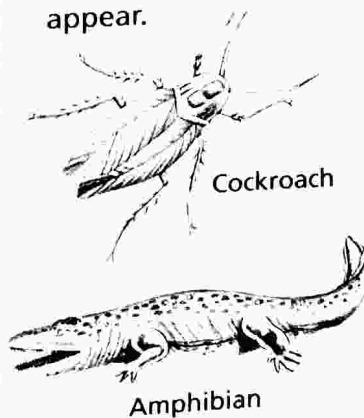
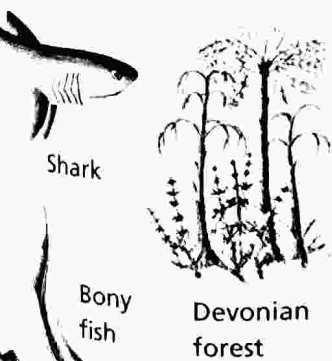
### **Geologic Events**

- Seas rise and fall over what is now North America.
- Appalachian Mountains begin to form.
- North America and Northern Europe lie in warm, tropical region.
- Deserts become larger in tropical regions.
- The supercontinent Pangaea forms as all continents join together.



### **Development of Life**

- Age of Fishes begins as sharks and fish with scales and bony skeletons become common.
- Trilobites and corals flourish in the oceans.
- Lungfish develop.
- First amphibians reach land.
- Great swamp forests of huge, woody trees cover eastern North America and parts of Europe.
- First true reptiles appear.
- Winged insects appear.
- Reptiles become dominant on land.
- Warm-blooded reptiles appear.
- Mass extinction of many marine invertebrates, including trilobites.



## Geologic History

### Triassic Era

245–208 million years ago

#### Geologic Events

- Pangaea holds together for much of the Triassic.
- Hot, dry conditions dominate the center of Pangaea.

208–144 million years ago

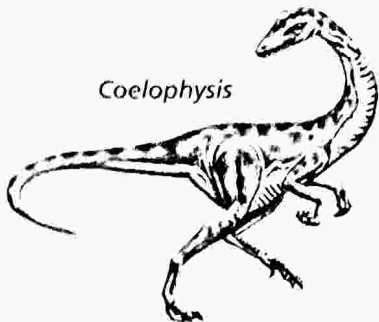
- Pangaea breaks apart as North America separates from Africa and South America.

#### Development of Life

- Age of Reptiles begins.
- First dinosaurs appear.
- First mammals, which evolve from warm-blooded reptiles, appear.
- First turtles and crocodiles appear.
- Conifers, palmlike trees, and ginkgo trees dominate forests.



*Morganucodon*



*Coelophysis*



*Cycad*

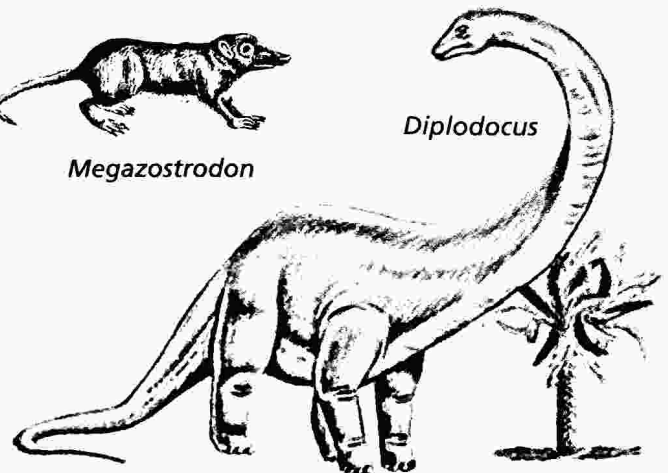


*Archaeopteryx*

- Largest dinosaurs thrive, including *Stegosaurus*, *Diplodocus*, and *Apatosaurus*.
- First birds appear.
- First flying reptiles, pterosaurs, appear.



*Megazostrodon*



*Diplodocus*

**Cretaceous**

144–66 million years ago

**Tertiary**

66–1.8 million years ago

**Quaternary**

1.8 million years ago to the present

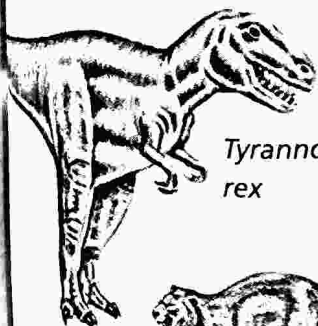
**Geologic Events**

- Continents move toward their present-day positions, as South America splits from Africa.
- Widespread volcanic activity occurs.
- The Rocky Mountains and Himalayas form.
- Continents continue to move into present-day positions.
- Continental glacier covers Antarctica.
- Thick glaciers advance and retreat over much of North America and Europe, parts of South America and Asia, and all of Antarctica.

**Development of Life**

Magnolia

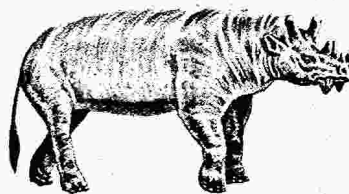
- First flowering plants appear.
- Dinosaurs, including *Tyrannosaurus rex*, dominate.
- First snakes appear.
- Mass extinction at end of period causes disappearance of many land and marine life forms, including dinosaurs.
- Flowering plants thrive.
- First grasses appear.
- Age of Mammals begins.
- Modern groups such as horses, elephants, bears, rodents, and primates appear.
- Ancestors of humans evolve.
- Mammals, flowering plants, and insects dominate land.
- Modern humans evolve in Africa about 100,000 years ago.
- Giant mammals of North America and Eurasia become extinct when the Ice Age ends about 10,000 years ago.



*Tyrannosaurus rex*



Creodonts



*Uintatherium*



*Plesiadapis*



*Hyracotherium*



*Megatherium*



*Homo sapiens*





FIGURE 23

### Flying Reptile

*Dimorphodon* was a flying reptile that lived during the Jurassic Period. Like dinosaurs, flying reptiles became extinct at the end of the Cretaceous period.

**Comparing and Contrasting** How is *Dimorphodon* similar to the bird in Figure 24?

## The Mesozoic Era

Millions of years flash by as your time machine travels. Watch out—there's a dinosaur! You're observing an era that you've read about in books and seen in movies.

**The Triassic Period** Some living things survived the Permian mass extinction. These organisms became the main forms of life early in the Triassic Period (try AS ik). Plants and animals that survived included fish, insects, reptiles, and cone-bearing plants called conifers. **Reptiles were so successful during the Mesozoic Era that this time is often called the Age of Reptiles.** About 225 million years ago, the first dinosaurs appeared. Mammals also first appeared during the Triassic Period. A **mammal** is a warm-blooded vertebrate that feeds its young milk. Mammals probably evolved from warm-blooded reptiles. The mammals of the Triassic Period were very small, about the size of a mouse or shrew. From these first small mammals, all mammals that live today evolved.

**The Jurassic Period** During the Jurassic Period (joo RAS ik), dinosaurs became the dominant animals on land. Scientists have identified several hundred different kinds of dinosaurs. Some were plant eaters, while others were meat eaters. Dinosaurs "ruled" Earth for about 150 million years, but different types lived at different times.

One of the first birds, called *Archaeopteryx*, appeared during the Jurassic Period. The name *Archaeopteryx* means "ancient wing thing." Many paleontologists now think that birds evolved from dinosaurs.



**FIGURE 24**

**Early Bird**

The artist of the illustration (left) has given *Archaeopteryx* colorful feathers. From a fossil (right), paleontologists can tell that *Archaeopteryx* was about 30 centimeters long, had feathers and teeth, and also had claws on its wings.

**The Cretaceous Period** Reptiles, including dinosaurs, were still the dominant vertebrates throughout the Cretaceous Period (krih TAY shus). Flying reptiles and birds competed for places in the sky. The hollow bones and feathers of birds made them better adapted to their environment than the flying reptiles, which became extinct during the Cretaceous Period. The Cretaceous Period also brought new forms of life. Flowering plants like the ones you see today evolved. Unlike the conifers, flowering plants produce seeds that are inside a fruit. The fruit helps the seeds survive.

**Another Mass Extinction** At the close of the Cretaceous Period, about 65 million years ago, another mass extinction occurred. Scientists hypothesize that this mass extinction occurred when an object from space struck Earth. This object was probably an asteroid. Asteroids are rocky masses that orbit the sun between Mars and Jupiter. Once in many millions of years, an asteroid may collide with Earth.

When the asteroid hit Earth, the impact threw huge amounts of dust and water vapor into the atmosphere. Many organisms on land and in the oceans died immediately. Dust and heavy clouds blocked sunlight around the world for years. Without sunlight, plants died, and plant-eating animals starved. This mass extinction wiped out over half of all plant and animal groups. No dinosaurs survived.

Not all scientists agree that an asteroid impact alone caused the mass extinction. Some scientists think that climate changes caused by increased volcanic activity were partly responsible.

**FIGURE 25**

**The End of the Dinosaurs**

Many scientists hypothesize that during the Cretaceous an asteroid hit Earth near the present-day Yucatán Peninsula, in southeastern Mexico.



**What major groups of organisms developed during the Mesozoic Era?**

## Life and Times

1. Place these events in their correct order: continental glaciers retreat; first fish appear; oldest fossils form; human ancestors appear; "explosion" of invertebrates occurs; dinosaurs become extinct; Pangaea forms.

2. Draw a timeline and graph these dates:

3.5 billion years ago  
544 million years ago  
400 million years ago  
260 million years ago  
65 million years ago  
3.5 million years ago  
20,000 years ago

Choose a scale so the oldest date fits on the paper.

**Interpreting Data Match** each event with the correct date on your timeline. How does the time since the dinosaurs became extinct compare with the time since the oldest fossil formed?

## The Cenozoic Era

Your voyage through time continues on through the Cenozoic Era—often called the Age of Mammals. During the Mesozoic Era, mammals had a hard time competing with dinosaurs for food and places to live. **The extinction of dinosaurs created an opportunity for mammals.** During the Cenozoic Era, mammals evolved to live in many different environments—on land, in water, and even in the air.

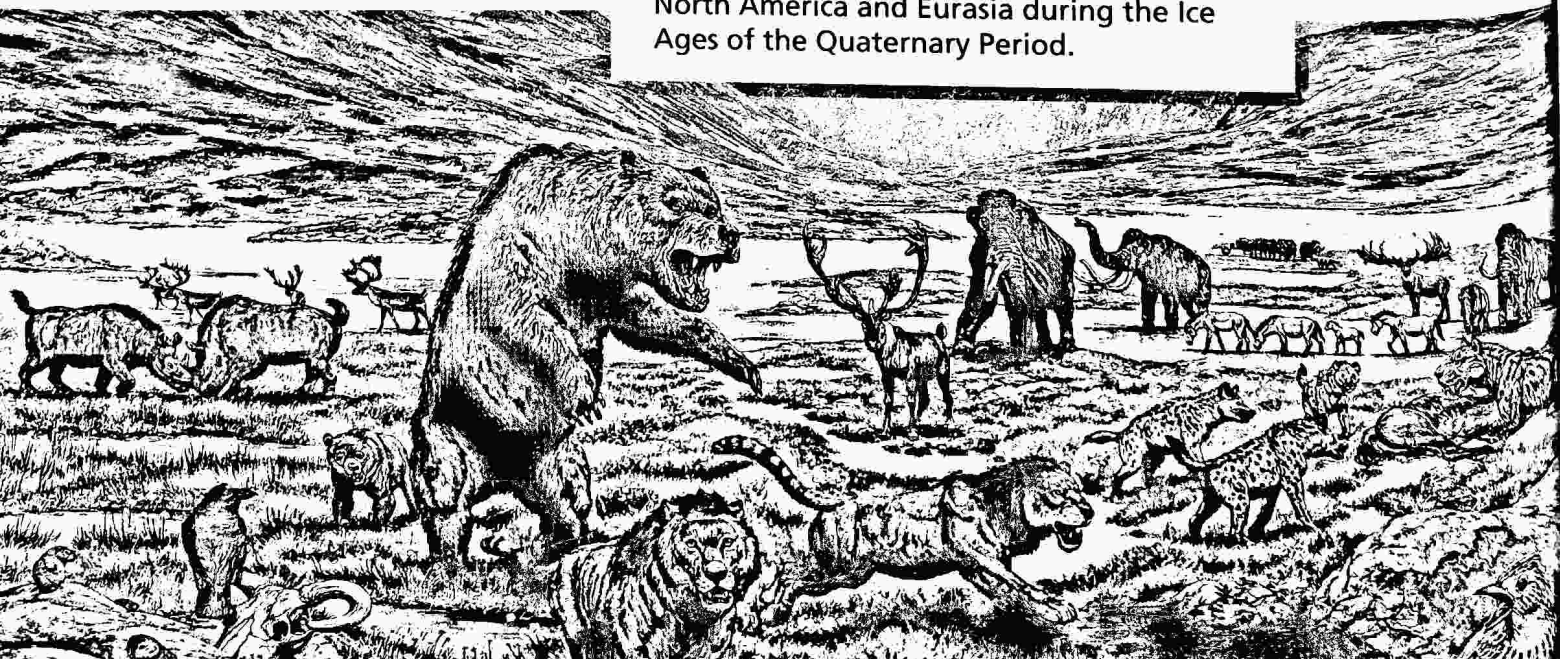
**The Tertiary Period** During the Tertiary Period, Earth's climates were generally warm and mild. In the oceans, marine mammals such as whales and dolphins evolved. On land, flowering plants, insects, and mammals flourished. When grasses evolved, they provided a food source for grazing mammals. These were the ancestors of today's cattle, deer, sheep, and other grass-eating mammals. Some mammals became very large, as did some birds.

**The Quaternary Period** The mammals that had evolved during the Tertiary Period eventually faced a changing environment. **Earth's climate cooled, causing a series of ice ages during the Quaternary Period.** Thick continental glaciers advanced and retreated over parts of Europe and North America. Then, about 20,000 years ago, Earth's climate began to warm. Over thousands of years, the continental glaciers melted, except in Greenland and Antarctica.

FIGURE 26

### Ice-Age Environment

Large mammals roamed the ice-free parts of North America and Eurasia during the Ice Ages of the Quaternary Period.



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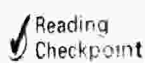
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In the oceans, algae, coral, mollusks, fish, and mammals thrived. Insects and birds shared the skies. On land, flowering plants and mammals such as bats, cats, dogs, cattle, and humans—just to name a few—became common.

The fossil record suggests that modern humans, or *Homo sapiens*, may have evolved as early as 100,000 years ago. By about 12,000 to 15,000 years ago, humans had migrated around the world to every continent except Antarctica.

Your time machine has now arrived back in the present. You and all organisms on Earth are living in the Quaternary Period of the Cenozoic Era. Is this the end of evolution and the changing of Earth's surface? No, these processes will continue as long as Earth exists. But you'll have to take your time machine into the future to see just what happens!



Reading  
Checkpoint

How did Earth's climate change during the Quaternary Period?



FIGURE 27

#### Ice Age Art

An early ancestor of modern humans painted these beautiful images of animals in a cave in France more than 15,000 years ago.

## Section 6 Assessment

2. **Target Reading Skill Previewing Visuals**  
Compare your questions and answers about Figure 22 with those of a partner.

### Reviewing Key Concepts

1. a. **Listing** What are the periods of the Paleozoic Era?
- b. **Describing** How did Earth's organisms change during the first period of the Paleozoic?
- c. **Relating Cause and Effect** What event do scientists think may have caused the mass extinction at the end of the Paleozoic?
2. a. **Reviewing** Which group of animals was dominant during the Mesozoic Era?
- b. **Inferring** How was their small size helpful to the mammals of the Mesozoic?
- c. **Developing Hypotheses** Many scientists think that the asteroid impact at the end of the Cretaceous prevented plant growth for many years. Although many dinosaurs were plant eaters, some were meat eaters. Develop a hypothesis to explain why no dinosaurs survived.

3. a. **Identifying** What term do scientists apply to the Cenozoic Era?
- b. **Inferring** What conditions allowed so many different kinds of mammals to evolve during the Cenozoic Era?

### Writing in Science

**Description** Suppose that you are going on a tour of Earth during one era of geologic time. Write a paragraph describing the organisms and environments that you see on the tour. Your tour should include at least one stop in each geologic period of the era you chose.