

## Eras of the Geologic Time Scale

### READING WARM-UP

#### Objectives

- Outline the major developments that allowed life to exist on Earth.
- Describe the types of organisms that arose during the four major divisions of the geologic time scale.

#### Terms to Learn

Precambrian time  
Paleozoic era  
Mesozoic era  
Cenozoic era

### READING STRATEGY

**Mnemonics** As you read this section, create a mnemonic device to help you remember the eras of geologic time.

**Precambrian time** the period in the geologic time scale from the formation of the Earth to the beginning of the Paleozoic era, from about 4.6 billion to 543 million years ago

*The walls of the Grand Canyon are layered with different kinds and colors of rocks. The deeper down into the canyon you go, the older the layers of rocks. Try to imagine a time when the bottom layer was the only layer that existed.*

Each layer of rock tells a story about what was happening on Earth when that layer was on top. The rocks and fossils in each layer tell the story. Scientists have compared the stories told by fossils and rocks all over the Earth. From these stories, scientists have divided geologic history into four major parts. These divisions are Precambrian time, the Paleozoic era, the Mesozoic era, and the Cenozoic era.

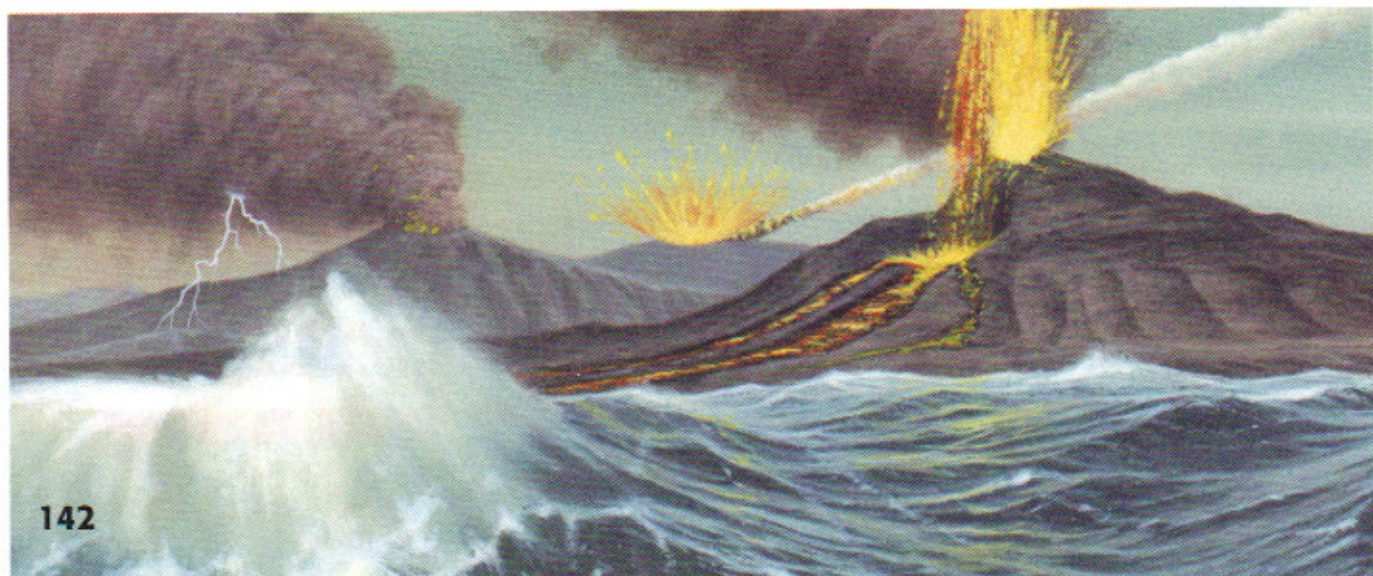
### Precambrian Time

The layers at the bottom of the Grand Canyon are from the oldest part of the geologic time scale. **Precambrian time** (pree KAM bree UIN TIEM) is the time from the formation of Earth 4.6 billion years ago to about 543 million years ago. Life on Earth began during this time.

Scientists think that the early Earth was very different than it is today. The atmosphere was made of gases such as water vapor, carbon dioxide, and nitrogen. Also, the early Earth was a place of great turmoil, as illustrated in **Figure 1**. Volcanic eruptions, meteorite impacts, and violent storms were common. Intense radiation from the sun bombarded Earth's surface.

**✓ Reading Check** Describe the early Earth. (See the Appendix for answers to Reading Checks.)

**Figure 1** This illustration shows the conditions under which the first life on Earth may have formed.





## How Did Life Begin?

Scientists think that life developed from simple chemicals in the oceans and in the atmosphere. Energy from radiation and storms could have caused these chemicals to react. Some of these reactions formed the complex molecules that made life possible. Eventually, these molecules may have joined to form structures such as cells.

The early atmosphere of the Earth did not contain oxygen gas. The first organisms did not need oxygen to survive. These organisms were *prokaryotes* (proh KAR ee OHTS), or single-celled organisms that lack a nucleus.

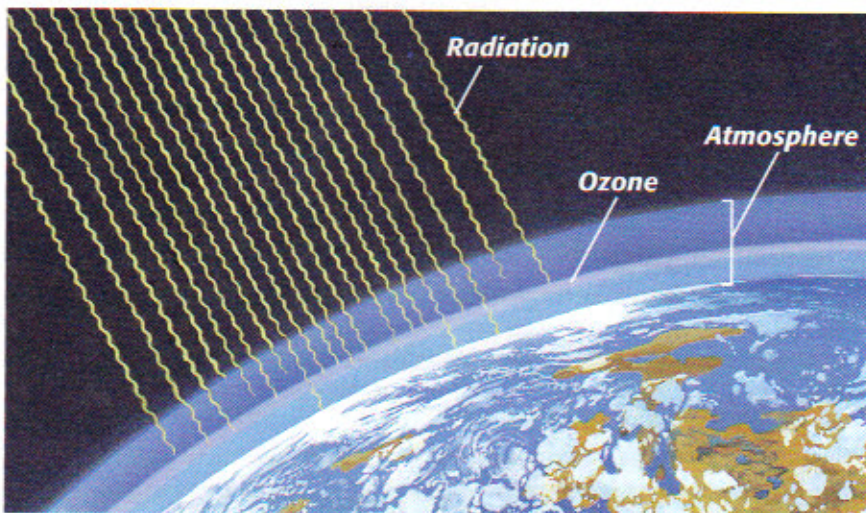
## Photosynthesis and Oxygen

There is evidence that *cyanobacteria*, a new kind of prokaryotic organism, appeared more than 3 billion years ago. Some cyanobacteria are shown in **Figure 2**. Cyanobacteria use sunlight to produce their own food. Along with doing other things, this process releases oxygen. The first cyanobacteria began to release oxygen gas into the oceans and air.

Eventually, some of the oxygen formed a new layer of gas in the upper atmosphere. This gas, called *ozone*, absorbs harmful radiation from the sun, as shown in **Figure 3**. Before ozone formed, life existed only in the oceans and underground. The new ozone layer reduced the radiation on Earth's surface.

## Multicellular Organisms

After about 1 billion years, organisms that were larger and more complex than prokaryotes appeared in the fossil record. These organisms, known as *eukaryotes* (yoo KAR ee OHTS), contain a nucleus and other complex structures in their cells. Eventually, eukaryotic cells may have evolved into organisms that are composed of many cells.



## INTERNET ACTIVITY

For another activity related to this chapter, go to [go.hrw.com](http://go.hrw.com) and type in the keyword **HL5HISW**.



**Figure 2** Cyanobacteria are the simplest living organisms that use the sun's energy to produce their own food.

**Figure 3** Oxygen in the atmosphere formed a layer of ozone, which helps to absorb harmful radiation from the sun.





**Figure 4** *Organisms that first appeared in the Paleozoic era include reptiles, amphibians, fishes, worms, and ferns.*

**Paleozoic era** the geologic era that followed Precambrian time and that lasted from 543 million to 248 million years ago

## The Paleozoic Era

The **Paleozoic era** (PAY lee OH ZOH ik ER uh) began about 543 million years ago and ended about 248 million years ago. Considering the length of Precambrian time, you can see that the Paleozoic era was relatively recent. Rocks from the Paleozoic era are rich in fossils of animals such as sponges, corals, snails, clams, squids, and trilobites. Fishes, the earliest animals with backbones, appeared during this era, and sharks became abundant. **Figure 4** shows an artist's depiction of life in the Paleozoic era.

The word *Paleozoic* comes from Greek words that mean "ancient life." When scientists first named this era, they thought it held the earliest forms of life. Scientists now think that earlier forms of life existed, but less is known about those life-forms. Before the Paleozoic era, most organisms lived in the oceans and left few fossils.

### Life on Land

During the 300 million years of the Paleozoic era, plants, fungi, and air-breathing animals slowly colonized land. By the end of the era, forests of giant ferns, club mosses, horsetails, and conifers covered much of the Earth. All major plant groups except for flowering plants appeared during this era. These plants provided food and shelter for animals.

Fossils indicate that crawling insects were some of the first animals to live on land. They were followed by large salamander-like animals. Near the end of the Paleozoic era, reptiles and winged insects appeared.

The largest mass extinction known took place at the end of the Paleozoic era. By 248 million years ago, as many as 90% of all Paleozoic species had become extinct. The mass extinction wiped out entire groups of marine organisms, such as trilobites. The oceans were completely changed.

### CONNECTION TO Oceanography

**Prehistoric Marine Organisms** Find a variety of pictures and descriptions of marine organisms from the Cambrian period of the Paleozoic era. Choose three organisms that you find interesting. Draw or write a description of each organism. Find out whether scientists think the organism is related to any living group of organisms, and add this information to your description.



## The Mesozoic Era

The **Mesozoic era** (MES oh ZOH ik ER uh) began about 248 million years ago and lasted about 183 million years. *Mesozoic* comes from Greek words that mean “middle life.” Scientists think that the surviving reptiles evolved into many different species after the Paleozoic era. Therefore, the Mesozoic era is commonly called the *Age of Reptiles*.

### Life in the Mesozoic Era

Dinosaurs are the most well known reptiles that evolved during the Mesozoic era. Dinosaurs dominated the Earth for about 150 million years. A great variety of dinosaurs lived on Earth. Some had unique adaptations, such as ducklike bills for feeding or large spines on their bodies for defense. In addition to dinosaurs roaming the land, giant marine lizards swam in the ocean. The first birds also appeared during the Mesozoic era. In fact, scientists think that some of the dinosaurs became the ancestors of birds.

The most important plants during the early part of the Mesozoic era were conifers, which formed large forests. Flowering plants appeared later in the Mesozoic era. Some of the organisms of the Mesozoic era are illustrated in **Figure 5**.

### The Extinction of Dinosaurs

At the end of the Mesozoic era, 65 million years ago, dinosaurs and many other animal and plant species became extinct. What happened to the dinosaurs? According to one hypothesis, a large meteorite hit the Earth and generated giant dust clouds and enough heat to cause world-wide fires. The dust and smoke from these fires blocked out much of the sunlight and caused many plants to die out. Without enough plants to eat, the plant-eating dinosaurs died out. And the meat-eating dinosaurs that fed on the plant-eating dinosaurs died. Global temperatures may have dropped for many years. However, some mammals and birds survived.

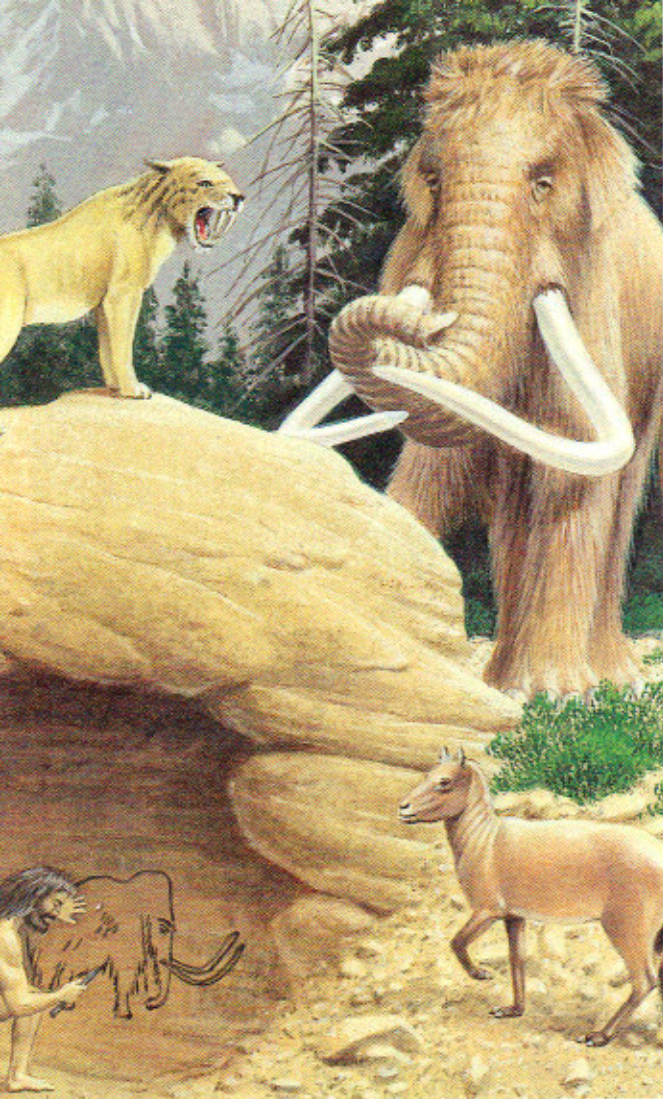
**✓ Reading Check** What kind of event happened at the end of both the Paleozoic and Mesozoic eras?



**Figure 5** The Mesozoic era was dominated by dinosaurs. The era ended with the mass extinction of many species.

**Mesozoic era** the geologic era that lasted from 248 million to 65 million years ago; also called the *Age of Reptiles*





**Figure 6** Many types of mammals evolved during the Cenozoic era.

## The Cenozoic Era

The **Cenozoic era** (SEN uh ZOH ik ER uh) began about 65 million years ago and continues today. *Cenozoic* comes from Greek words that mean “recent life.” Scientists have more information about the Cenozoic era than about any of the previous eras. Fossils from the Cenozoic era formed recently in geologic time, so they are found in rock layers closer to the Earth’s surface. The closer the fossils are to the surface, the easier they are to find.

During the Cenozoic era, many kinds of mammals, birds, insects, and flowering plants appeared. Some organisms that appeared in the Cenozoic era are shown in **Figure 6**.

**Reading Check** What does *Cenozoic* mean?

## The Age of Mammals

The Cenozoic era is sometimes called the *Age of Mammals*. Mammals have dominated the Cenozoic era the way reptiles dominated the Mesozoic era. Early Cenozoic mammals were small, forest dwellers. Larger mammals appeared later in the era. Some of these larger mammals had long legs for running, teeth that were specialized for eating different kinds of food, and large brains. Cenozoic mammals have included mastodons, saber-toothed cats, camels, giant ground sloths, and small horses.

## MATH Focus

**Relative Scale** It’s hard to imagine 4.6 billion years. One way is to use a *relative scale*. For example, we can represent all of Earth’s history by using the 12 h shown on a clock. The scale would begin at noon, representing 4.6 billion years ago, and end at midnight, representing the present. Because 12 h represent 4.6 billion years, 1 h represents about 383 million years. (Hint:  $4.6 \text{ billion} \div 12 = 383 \text{ million}$ ) So, what time on the clock represents the beginning of the Paleozoic era, 543 million years ago?

**Step 1:** Write the ratio.

$$\frac{x}{543,000,000 \text{ years}} = \frac{1 \text{ h}}{383,000,000 \text{ years}}$$

**Step 2:** Solve for  $x$ .

$$x = \frac{543,000,000 \text{ years} \times 1 \text{ h}}{383,000,000 \text{ years}} = 1.42 \text{ h}$$

**Step 3:** Convert the answer to the clock scale.

$$1.42 \text{ h} = 1 \text{ h} + (0.42 \times 60 \text{ min/h})$$

$$1.42 \text{ h} = 1 \text{ h } 25 \text{ min}$$

So, the Paleozoic era began 1 h 25 min before midnight, at about 10:35.

### Now It’s Your Turn

1. Use this method to calculate the relative times at which the Mesozoic and Cenozoic eras began.





## The Cenozoic Era Today

We are currently living in the Cenozoic era. Modern humans appeared during this era. The environment and landscapes that we see around us today are part of this era.

However, the climate has changed many times during the Cenozoic era. Earth's history includes some periods called *ice ages*, during which the climate was very cold. During the ice ages, ice sheets and glaciers extended from the Earth's poles. To survive, many organisms migrated toward the equator. Other organisms adapted to the cold or became extinct.

When will the Cenozoic era end? No one knows. In the future, geologists might draw the line at a time when life on Earth again undergoes major changes.

**Cenozoic era** the most recent geologic era, beginning 65 million years ago; also called the *Age of Mammals*

## SECTION Review

### Summary

- The Earth is about 4.6 billion years old. Life formed from nonliving matter long ago.
- Precambrian time includes the formation of the Earth and the appearance of simple organisms.
- The first cells did not need oxygen. Later, photosynthetic cells evolved and released oxygen into the atmosphere.
- During the Paleozoic era, animals appeared in the oceans and on land, and plants grew on land.
- Dinosaurs dominated the Earth during the Mesozoic era.
- Mammals have dominated the Cenozoic era. This era continues today.

### Using Key Terms

1. Use each of the following terms in a separate sentence: *Precambrian time*, *Paleozoic era*, *Mesozoic era*, and *Cenozoic era*.

### Understanding Key Ideas

2. Unlike the atmosphere today, the atmosphere 3.5 billion years ago did not contain
  - a. carbon dioxide.
  - b. nitrogen.
  - c. gases.
  - d. ozone.
3. How do prokaryotic cells and eukaryotic cells differ?
4. Explain why cyanobacteria were important to the development of life on Earth.
5. Place in chronological order the following events on Earth:
  - a. The first cells appeared that could make their own food from sunlight.
  - b. The ozone layer formed.
  - c. Simple chemicals reacted to form the molecules of life.
  - d. Animals appeared.
  - e. The first organisms appeared.
  - f. Humans appeared.
  - g. The Earth formed.

### Math Skills

6. Calculate the total number of years that each of the geologic eras lasted, rounding to the nearest 100 million. Then, calculate each of these values as a percentage of the total 4.6 billion years of Earth's history. Round your answer to the units place.

### Critical Thinking

7. **Making Inferences** Which chemicals probably made up the first cells on Earth?
8. **Forming Hypotheses** Think of your own hypothesis to explain the disappearance of the dinosaurs. Explain your hypothesis.



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