Section 1 Geologic Time

Earth's surface is constantly changing. Mountains form and erode; oceans rise and recede. As conditions on Earth's surface change, some organisms flourish and then later become extinct. Evidence of change is recorded in the rock layers of Earth's crust. To describe the sequence and length of this change, scientists have developed a *geologic time scale*. This scale outlines the development of Earth and of life on Earth.

OBJECTIVES

- **Summarize** how scientists worked together to develop the geologic column.
- **List** the major divisions of geologic time.

KEY TERMS

geologic column
era
period
epoch

The Geologic Column

By studying fossils and applying the principle that old layers of rock are below young layers, 19th-century scientists determined the relative ages of sedimentary rock in different areas around the world. No single area on Earth contained a record of all geologic time. So, scientists combined their observations to create a standard arrangement of rock layers. As shown in the example in **Figure 1**, this ordered arrangement of rock layers is called a **geologic column.** A geologic column represents a timeline of Earth's history. The oldest rocks are at the bottom of the column.

geologic column an ordered arrangement of rock layers that is based on the relative ages of the rocks and in which the oldest rocks are at the bottom

Rock layers in a geologic column are distinguished by the types of rock the layers are made of and by the kinds of fossils the layers contain. Fossils in the upper, more-recent layers resemble modern plants and animals. Most of the fossils in the lower, older layers are of plants and animals that are different from those living today. In fact, many of the fossils discovered in old layers are from species that have been extinct for millions of years.

Reading Check **Where would you find fossils of extinct animals on a geologic column? (See the Appendix for answers to Reading Checks.)**

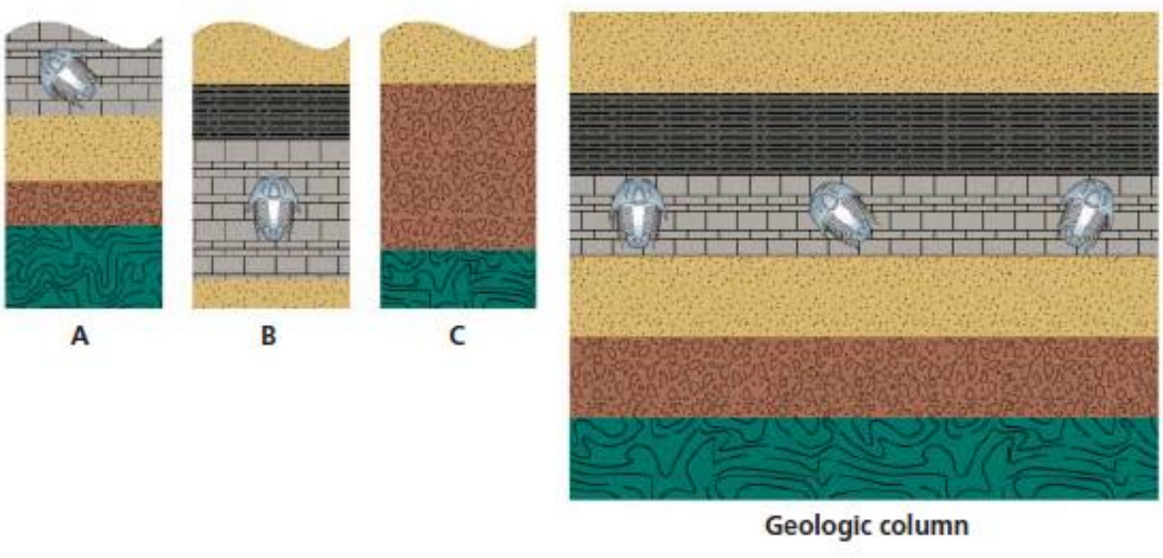


Figure 1 ▶ By combining observations of rock layers in areas A, B, and C, scientists can construct a geologic column. ***Why is relative position important in determining the ages of rock layers?***

Figure 2 ▶ This scientist is collecting rock samples that contain fossilized fungal spores that date the rock to the Triassic Period.

Using a Geologic Column

When the first geologic columns were being developed, scientists estimated the ages of rock layers by using factors such as the average rates of sediment deposition. The development of radiometric dating methods, however, allowed scientists to determine the absolute ages of rock layers with more accuracy.

Scientists can now use geologic columns to estimate the age of rock layers that cannot be dated radiometrically. To determine the layer's age, scientists compare a given rock layer with a similar layer in a geologic column that contains the same fossils or that has the same relative position. If the two layers match, they likely formed at about the same time. The scientist in **Figure 2** is investigating the ages of sedimentary rocks.

Divisions of Geologic Time

The geologic history of Earth is marked by major changes in Earth's surface, climate, and types of organisms. Geologists use these indicators to divide the geologic time scale into smaller units. Rocks grouped within each unit contain similar fossils. In fact, a unit of geologic time is generally characterized by fossils of a dominant life-form. A simplified geologic time scale is shown in **Table 1.**

Because Earth's history is so long, Earth scientists commonly use abbreviations when they discuss geologic time. For example, Ma stands for *mega-annum,* which means "one million years."

QuickLAB 30 min

Geologic Time Scale

Procedure

1. Copy the table shown at right onto a piece of **paper.**
2. Complete the table by using the scale 1 cm is equal to 10 million years.
3. Lay a **5 m strip of adding-machine paper** flat on a hard surface. Use a **meterstick,** a **metric ruler,** and a **pencil** to mark off the beginning and end of Precambrian time according to the time scale you calculated. Do the same for the three eras. Label each time division, and color each a different color with **colored pencils.**
4. Pick two periods from the geologic time scale. Using the same scale that was used in step 2, calculate the scale length for each period listed. Mark the boundaries of each period on the paper strip, and label the periods on your scale.

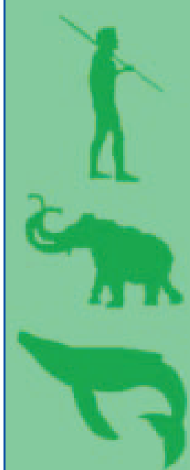
Era	Length of time (years)	Scale length
Precambrian	4,058,000,000	
Paleozoic	291,000,000	DO NOT WRITE
Mesozoic	185,500,000	IN THIS BOOK
Cenozoic	65,500,000 (to present)	

5. Decorate your strip by adding names or drawings of the organisms that lived in each division of time.

Analysis

1. When did humans appear? What is the scale length from that period to the present?
2. Add the lengths of the Paleozoic, Mesozoic, and Cenozoic Eras. What percentage of the geologic time scale do these eras combined represent? What percentage of the geologic time scale does Precambrian time represent?

Table 1 ▼

Geologic Time Scale				
Era	**Period**	**Epoch**	**Beginning of Interval in Ma**	**Characteristics from geologic and fossil evidence**
Cenozoic 	Quaternary	Holocene	0.0115	The last glacial period ends; complex human societies develop.
		Pleistocene	1.8	Woolly mammoths, rhinos, and humans appear.
	Tertiary	Pliocene	5.3	Large carnivores (bears, lions) appear.
		Miocene	23.0	Grazing herds are abundant; raccoons and wolves appear.
		Oligocene	33.9	Deer, pigs, camels, cats, and dogs appear.
		Eocene	55.8	Horses, flying squirrels, bats, and whales appear.
		Paleocene	65.5	Age of mammals begins; first primates appear.
Mesozoic 	Cretaceous		146	Flowering plants and modern birds appear; mass extinctions mark the end of the Mesozoic Era.
	Jurassic		200	Dinosaurs are the dominant life-form; primitive birds and flying reptiles appear.
	Triassic		251	Dinosaurs appear; ammonites are common; cycads and conifers are abundant; and mammals appear.
Paleozoic 	Permian		299	Pangaea comes together; mass extinctions mark the end of the Paleozoic Era.
	Carboniferous	Pennsylvanian Period	318	Giant cockroaches and dragonflies are common; coal deposits form; and reptiles appear.
		Mississippian Period	359	Amphibians flourish; brachiopods are common in oceans; and forests and swamps cover most land.
	Devonian		416	Age of fishes begins; amphibians appear; and giant horsetails, ferns, and seed-bearing plants develop.
	Silurian		444	Eurypterids, land plants and animals appear.
	Ordovician		488	Echinoderms appear; brachiopods increase; trilobites decline; graptolites flourish; atmosphere reaches modern O_2-rich state.
	Cambrian		542	Shelled marine invertebrates appear; trilobites and brachiopods are common. First vertebrates appear.
Precambrian time			4,600	The Earth forms; continental shields appear; fossils are rare; and stromatolites are the most common organism.

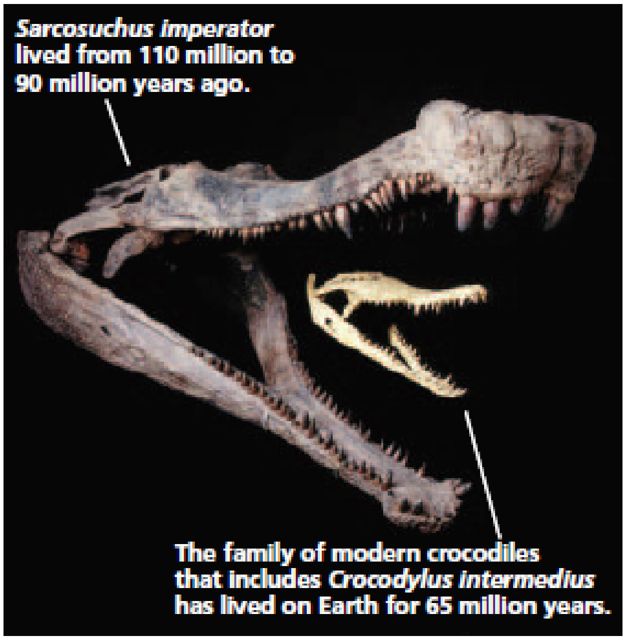


Figure 3 ▶ Crocodilians have lived on Earth for more than two geologic eras without major anatomical changes.

Eons and Eras

The largest unit of geologic time is an *eon*. Geologic time is divided into four eons—the Hadean eon, the Archean eon, the Proterozoic eon, and the Phanerozoic eon. The first three eons of Earth's history are part of a time interval commonly known as *Precambrian time*. This 4 billion year interval contains most of Earth's history. Very few fossils exist in early Precambrian rocks, so dividing Precambrian time into smaller time units is difficult.

After Precambrian time the Phanerozoic eon began. This eon, as well as most eons, is divided into smaller units of geologic time called **eras.** The first era of the Phanerozoic eon was the *Paleozoic Era* which lasted about 291 million years. Paleozoic rocks contain fossils of a wide variety of marine and terrestrial life forms. After the Paleozoic Era, the *Mesozoic Era* began and lasted about 186 million years. Mesozoic fossils include early forms of birds and of reptiles, such as the giant crocodilian shown in **Figure 3.** The present geologic era is the *Cenozoic Era,* which began about 65 million years ago. Fossils of mammals are common in Cenozoic rocks.

era a unit of geologic time that includes two or more periods

period a unit of geologic time that is longer than an epoch but shorter than an era

epoch a subdivision of geologic time that is longer than an age but shorter than a period

Periods and Epochs

Eras are divided into shorter time units called **periods.** Each period is characterized by specific fossils and is usually named for the location in which the fossils were first discovered. Where the rock record is most complete and least deformed, a detailed fossil record may allow scientists to divide periods into shorter time units called **epochs.** Epochs may be divided into smaller units of time called *ages*. Ages are defined by the occurrence of distinct fossils in the fossil record.

Section 1 Review

1. **Summarize** the reasons that many scientists had to work together to develop the geologic column.
2. **Describe** the major events in any one period of geologic time.
3. **Explain** why constructing geologic columns is useful to Earth scientists.
4. **List** the following units of time in order of length from shortest to longest: *year, period, era, eon, age,* and *epoch.*
5. **Name** the three eras of the Phanerozoic Eon, and identify how long each one lasted.
6. **Compare** geologic time with the geologic column.

CRITICAL THINKING

7. **Analyzing Relationships** When a scientist discovers a new type of fossil, what characteristic of the rock around the fossil would he or she want to learn first?
8. **Predicting Consequences** How would our understanding of Earth's past change if a scientist discovered a mammal fossil from the Paleozoic Era?

CONCEPT MAPPING

9. Use the following terms to create a concept map: *geologic time, Precambrian time, Paleozoic Era, Mesozoic Era, Cenozoic Era, period,* and *epoch.*