## Section 13.1

# 1 FOCUS

### Section Objectives

**13.1** **Describe** the history of the Precambrian time.

**13.2** **Compare** Earth's original atmosphere and geosphere to its atmosphere and geosphere today.

**13.3** **Explain** how scientists know about the conditions on Earth during the Precambrian time.

**Reading Focus**

### Build Vocabulary L2

**Making Flashcards** Have students make flashcards for the vocabulary terms in this section and other terms that are new to them, such as *Precambrian.*

### Reading Strategy L2

1. a. metamorphic rocks
   b. the early continents
   c. they formed during that time
2. d. calcium carbonate
   e. algae
   f. they are evidence of the earliest life on Earth

# 13.1 Precambrian Time: Vast and Puzzling

**Reading Focus**

### Key Concepts

- How much of Earth's history is included in Precambrian time?
- What was the atmosphere and surface like after Earth's formation?
- What evidence exists about conditions during Precambrian time?

### Vocabulary

- shields
- stromatolites

### Reading Strategy

**Building Vocabulary** Use the information about the vocabulary terms in this section to complete these phrases.

1. Shields are composed of a. __?__; are evidence of b. __?__; and are significant to Precambrian time because c. __?__.
2. Stromatolites are composed of d. __?__; are evidence of e. __?__; and are significant to Precambrian time because f. __?__.

As you read in Chapter 12, geologists have many tools at their disposal for interpreting the clues about Earth's past. Using these tools and clues that are contained in the rock record, geologists have been able to unravel many of the complex events of the geological past. Figure 1 shows a scientist examining fossil evidence of ancient life. The goal of this chapter is to provide a brief overview of the history of our planet and its life forms.

**Figure 1** Paleontologists study fossils to learn about ancient life. This researcher is examining the skull of a *Tyrannosaurus rex*.

## Precambrian History

**The Precambrian encompasses immense geological time, from Earth's distant beginnings 4.56 billion years ago until the start of the Cambrian period, over 4 billion years later.** To get a visual sense of this proportion, look at the right side of Figure 2, which shows the relative time span of eras. The Precambrian comprises about 88 percent of the geologic time scale.

Most Precambrian rocks do not contain fossils, which makes correlating rock layers difficult. Many rocks of this great age are metamorphosed and deformed, extremely eroded, and hidden by overlaying strata. As a result, Precambrian history is written in scattered, speculative episodes, like a long book with many missing pages.

**Reading Checkpoint** *Why are specific events in Precambrian history difficult to determine?*

## Geologic Time Scale

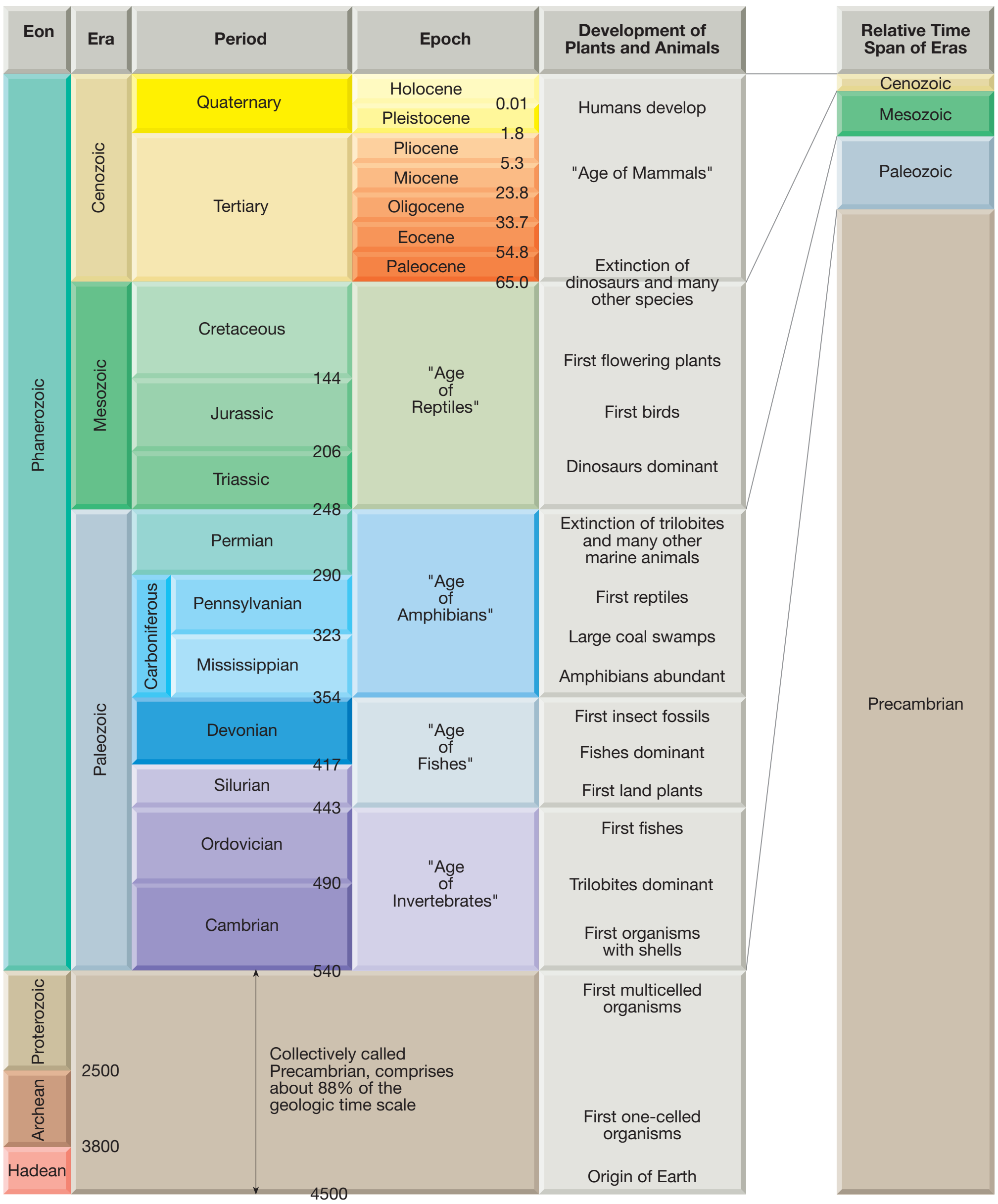


**Figure 2** Numbers on the time scale represent time millions of years before the present.
**Analyzing** ***The Precambrian accounts for approximately what percentage of geologic time?***



# 2 INSTRUCT

## Precambrian History

### Use Visuals L1

**Figure 2** Point out to students that this is a visual representation of Earth's history. Advise students that they should try to get a good understanding of how this figure works, and they should look back at it frequently as they go through the other sections of this chapter. Ask: **Name the eon, era, period, and epoch in which we live.** *(Phanerozoic, Cenozoic, Quaternary, Holocene)* **About how many years ago did the first land plants appear?** *(443 million years ago)* **During what period did the first organisms with shells appear?** *(Cambrian)* **How many years ago did Earth form?** *(4500 million years ago, or 4.5 billion years ago)*
**Visual**

## Customize for English Language Learners

Use Transparency 162 to make a photocopy of the geologic time scale on p. 365 for students. Encourage them to take notes in their primary language or in English on their copy. Have English language learners work together to understand the large amount of information presented in this chapter and organize it, using the geologic time scale.

### *Answer to . . .*

**Figure 2** *Precambrian time accounts for approximately 88 percent of geologic time.*

Reading Checkpoint *Most Precambrian rocks do not contain fossils, which makes correlating rock layers difficult. Many Precambrian rocks are metamorphosed and deformed, extremely eroded, or hidden by overlaying strata.*

## Build Reading Literacy L1

Refer to **p. 216D** in **Chapter 8,** which provides the guidelines for comparing and contrasting.

**Compare and Contrast** Have students compare and contrast Earth's original atmosphere to the atmosphere that exists on Earth today. Ask: **How is today's atmosphere similar to Earth's original atmosphere?** (*Both contain nitrogen, argon, carbon dioxide, and water vapor.*) **How is today's atmosphere different from Earth's original atmosphere?** (*Today's atmosphere contains oxygen, while the original atmosphere did not.*)
**Verbal, Visual**

**Precambrian Rocks** Looking at Earth from the space shuttle, astronauts see mostly ocean and much less land area. Over large expanses of the continents, the orbiting space scientists gaze upon many Paleozoic, Mesozoic, and Cenozoic rock surfaces, but few Precambrian surfaces. The lack of Precambrian rock illustrates the law of superposition—Precambrian rocks in these regions are buried from view underneath more recent rocks. Precambrian rocks do show through the surface where younger strata are extensively eroded, such as in the Grand Canyon and in some mountain ranges. However, large core areas of Precambrian rocks dominate the surface of some continents, mostly as deformed metamorphic rocks. These areas are called **shields** because they roughly resemble a warrior's shield in shape. For example, in North America, the Canadian Shield encompasses 7.2 million square kilometers, which is equal to about 10 states of Texas put together. See Figure 3.

**Much of what we know about Precambrian rocks comes from ores mined from shields.** The mining of iron, nickel, gold, silver, copper, chromium, uranium, and diamonds has provided Precambrian rock samples for study. Surveys to locate ore deposits also have revealed much about the rocks.

Reading Checkpoint *What are shields?*

**Earth's Atmosphere Evolves** Earth's atmosphere is unlike that of any other body in the solar system. No other planet has the same life-sustaining mixture of gases as Earth.

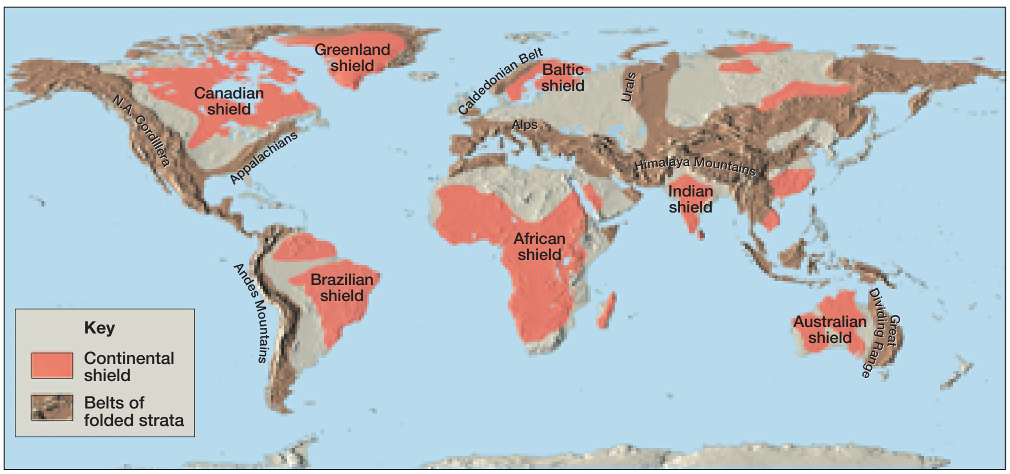


**Figure 3** Remnants of Precambrian rocks are the continental shields. They are largely made up of metamorphosed igneous and sedimentary rocks.



## Facts and Figures

Precambrian rocks are economically valuable due to their high concentration of valuable ores. However, fossil fuels (oil, natural gas, and coal) are notably absent in Precambrian rocks. This is probably because prior to 540 million years ago, there were no land plants to form coal swamps and no animals to form petroleum. Fossil fuels became much more common in rock layers formed after the "Cambrian explosion" of life on Earth.

Today, the air you breathe is a stable mixture of nitrogen, oxygen, a small amount of argon, and trace gases like carbon dioxide and water vapor. But our planet's original atmosphere, several billion years ago, was far different.

Early in Earth's history, the high-velocity impact of nebular debris caused at least the outer shell of our planet to melt. After this period of bombardment subsided, Earth slowly cooled and the molten surface solidified into a crust. The gases that had been dissolved in the molten rock were gradually released. **Earth's original atmosphere was made up of gases similar to those released in volcanic eruptions today—water vapor, carbon dioxide, nitrogen, and several trace gases, but no oxygen.**

As the planet continued to cool, the water vapor condensed to form clouds, and great rains began. At first the rain water evaporated in the hot air before reaching the ground or quickly boiled or evaporated when it did reach the ground. This evaporation sped up the cooling of Earth's surface. Torrential rains continued and slowly filled low areas, forming the oceans. This rain and the forming of the oceans reduced not only the water vapor in the air but also the amount of carbon dioxide, which became dissolved in the water. A nitrogen-rich atmosphere remained.

The first life forms on Earth did not need oxygen. **Later, primitive organisms evolved that used photosynthesis and released oxygen.** These organisms, primarily cyanobacteria, did not adapt to Earth's atmosphere. They actually influenced it, dramatically changing the make up of Earth's atmosphere by using carbon dioxide and releasing oxygen. Slowly, the oxygen content of Earth's atmosphere increased. The influence the ancestors of plants had on the atmosphere is a good example of how Earth operates as a giant system in which living things interact. The Precambrian rock record suggests that much of the first free oxygen did not remain free because it combined with iron. Iron combines with oxygen to form iron oxides, or rust, at any opportunity.

Once the available iron finished reacting, oxygen began to accumulate in the atmosphere. By the beginning of the Paleozoic era—about 4 billion years into Earth's existence—the fossil record reveals abundant ocean-dwelling organisms that require oxygen to live. These fossils show that the composition of Earth's atmosphere has evolved together with its life forms, from an oxygen-free envelope to today's oxygen-rich environment. **Oxygen began to accumulate in the atmosphere about 2.5 billion years ago.**

**Reading Checkpoint** *How did Earth's oceans form?*

### Q & A

**Q** *The era names refer to "ancient," "middle," and "recent" life. What is the origin of period names?*

**A** There is no overall scheme for naming the periods; rather, these names have diverse origins. Several names refer to places that have prominent strata of that age. For example, the Cambrian period is taken from the Roman name for Wales (Cambria). The Permian is named for the province of Perm in Russia, while the Jurassic period gets its name from the Jura Mountains located between France and Switzerland.



## Build Reading Literacy L1

Refer to **p. 446D** in **Chapter 16**, which provides guidelines for sequencing.

**Sequence** As students read Earth's Atmosphere Evolves, ask them to create a flowchart showing the steps from the formation of Earth's early atmosphere to today's atmosphere. *(Sample answer: Earth's outer shell melts → Earth's crust cools and solidifies, releasing volcanic gases → water vapor condenses into clouds → torrential rainfall → oceans form → water vapor and carbon dioxide fill the oceans leaving less of those gases in the atmosphere → a nitrogen-rich atmosphere results)*

**Visual, Verbal**

## Integrate Biology L2

**Origin of Life on Earth** The heterotroph hypothesis is one explanation of how life first evolved on Earth. It states that the first living things functioned like cells. These organisms obtained nutrition from their environment (were heterotrophic), because the early oceans were rich in minerals and dissolved gases. These primordial life-forms released carbon dioxide, which accumulated in the atmosphere until the development of autotrophs that made their own food by using carbon dioxide, water, and sunlight. As these autotrophs performed photosynthesis, they released more oxygen into the air, which created an environment where the earliest oxygen-breathing organisms could develop. Ask: **Where do you think the minerals and dissolved gases in the early oceans came from?** *(carried down from the atmosphere by the rain and out of undersea thermal vents at places such as mid-ocean ridges)* **How did early heterotrophs change the atmosphere?** *(released carbon dioxide)* **How did autotrophs change the atmosphere?** *(released oxygen)*

**Verbal**

## Facts and Figures

Precambrian rocks contain a great deal of iron ore, mostly as the mineral hematite ($Fe_2O_3$). These iron-rich sedimentary rocks probably formed when Earth's oxygen levels became great enough to react with the iron dissolved in shallow lakes and seas. Because most of Earth's free oxygen results from plant photosynthesis, the formation of extensive Precambrian deposits of iron ore is linked to life in the sea. This connection led to much excitement over the discovery of extensive hematite deposits on Mars by NASA's rovers Spirit and Opportunity.

## *Answer to . . .*

**Reading Checkpoint** *Shields are large areas of Precambrian rocks that resemble a warrior's shield in shape.*

**Reading Checkpoint** *Earth's oceans formed from the water vapor that was released from molten rock. This water vapor then fell as rain into low areas, forming Earth's oceans.*

## Build Science Skills

L2

**Applying Concepts** Students learned the law of uniformitarianism in Chapter 12. Activating this knowledge here will help them remember that law and help them retain more information about stromatolites. Ask: **What does the law of uniformitarianism state?** *(The present is the key to the past because the processes that occur today are the same as the processes that occurred long ago.)* **How did scientists use this law to determine that stromatolites were fossils?** *(Stromatolite fossils look like deposits made by modern algae.)*
**Verbal, Logical**

# 3 ASSESS

## Evaluate Understanding

L2

Have students create a five-question quiz for this section. Students should then trade quizzes, answer the questions, and grade each other's answers.

## Reteach

L1

Have students color-code and illustrate their own version of the geologic time scale. They can then add additional illustrations of life-forms or the positions of landmasses described in this section. Students should then keep this sheet and add to it as they read the rest of the chapter.

Math Practice

**Solution**
**8.** The circle graph should be similar to the bar portion that makes up Figure 2.

**Answer to . . .**

**Figure 4** *calcium carbonate*

**Figure 4** Stromatolites are among the most common Precambrian fossils.
**Interpreting** ***What are stromatolites made of?***

**Precambrian Fossils** Precambrian fossils are disappointing if you are expecting to see fascinating plants and large animals, for these organisms had not yet evolved. **The most common Precambrian fossils are stromatolites.** Stromatolites are distinctively layered mounds or columns of calcium carbonate, as shown in Figure 4. They are not the remains of actual organisms but are material deposited by algae. Stromatolites are indirect evidence of algae because they closely resemble similar deposits made by modern algae.

Stromatolites did not become common until the middle Precambrian, around 2 billion years ago. Although stromatolites are large, most actual organisms preserved in Precambrian rocks are microscopic. Remains of bacteria and blue-green algae have been discovered, which extend the record of life back beyond 3.5 billion years.

Many of these ancient fossils are preserved in chert—a hard, dense chemical sedimentary rock. Chert must be sliced very thin and studied under a powerful microscope to see the bacteria and algae fossils within it. These fossils are the most primitive organisms, called prokaryotes. More advanced organisms called eukaryotes evolved later, and are among billion-year-old fossils discovered.

The development of eukaryotes may have dramatically increased the rate of evolutionary change. Plant fossils date from the middle Precambrian, but animal fossils date to the late Precambrian. Many are trace fossils. Trace fossils are not fossils of the animals themselves but rather impressions of their activities, such as trails and worm holes.

## Section 13.1 Assessment

### Reviewing Concepts

1. What time span is encompassed by Precambrian time?
2. Describe the components that made up Earth's first atmosphere.
3. Why did the amount of oxygen in Earth's atmosphere increase dramatically?
4. What kinds of fossils of Precambrian life have been found?
5. Describe how shields play an important role in providing information about Earth's formation.

### Critical Thinking

6. **Comparing and Contrasting** Compare and contrast Earth's early atmosphere with today's atmosphere.
7. **Inferring** Why did life not develop on the other planets in our solar system?

Math Practice

8. Using Figure 2, create a circle graph that shows the percentages of relative time encompassed by the Cenozoic, Mesozoic, Paleozoic, and Precambrian eras. Then estimate the percentage of time in Earth's history that humans have existed.



## Section 13.1 Assessment

**1.** Precambrian time encompasses 4.56 billion years.
**2.** Earth's first atmosphere was probably made up of nitrogen and small amounts of water vapor, carbon dioxide, and other trace gases.
**3.** The evolution of organisms that used photosynthesis caused the release of increasing amounts of oxygen into the atmosphere.
**4.** stromatolites, microscopic organisms, prokaryotes, trace fossils
**5.** Shields are large areas of Precambrian rocks that are on the surface. Shields contain large amounts of ore, which can be analyzed.
**6.** Earth's early atmosphere probably contained water vapor, carbon dioxide, nitrogen, and several trace gases, but no oxygen. Today the atmosphere contains oxygen.
**7.** Other planets did not develop an atmosphere that would be conducive to life. It is likely that the condensation of water vapor was an essential part.