Section 12.2

1 FOCUS

Section Objectives

12.4 **Describe** the different types of fossils and how they form.

12.5 **Identify** the factors that determine if an organism will become a fossil.

12.6 **Explain** how the principle of fossil succession and the theory of evolution help scientists interpret the fossil record.

12.7 **Describe** how geologists use fossils to correlate rock layers and reconstruct past environments.

Reading Focus

Build Vocabulary L2

Compare/Contrast Tables Have students make tables that compare and contrast the different types of fossils, such as molds and casts, carbon films, and trace fossils. Students can list each type of fossil at the top of a column, and add details in the rows below.

Reading Strategy L2

Possible answers include:
a. Fossils are traces or remains of organisms preserved from the geologic past. **b.** Fossils can form by freezing, burial and replacement with minerals, formation of a carbon film, preservation in amber or tar, and formation of trace fossils. **c.** Fossils are used to correlate rock layers, show changes in life forms through time, and provide information on ancient environments.

2 INSTRUCT

Fossil Formation

Integrate Biology L2

Wooly Mammoth The remains of the mammoth found in Siberia are estimated to be about 20,000 years old. The mammoth itself died relatively young—no more than 49 years. Currently, a team of international scientists is studying the specimen. The scientists have discussed cloning the mammoth or using its frozen sperm to fertilize a living elephant when this phase is complete. Have students discuss the pros and cons of these proposals.
Verbal

12.2 Fossils: Evidence of Past Life

Reading Focus

Key Concepts

- What are the different types of fossils?
- What conditions help a fossil to form?
- What major developments helped scientists explain the fossil record?
- How do geologists interpret fossils and rocks?

Vocabulary

- extinct
- fossil
- principle of fossil succession
- theory of evolution
- natural selection
- adaptation
- index fossil

Reading Strategy

Monitoring Your Understanding Draw and complete a chart like the one below. After you finish this section, correct or add details as needed.

Fossils	How Fossils Form	How Fossils are Used
a. ___?___	b. ___?___	c. ___?___

Figure 9 Preserved Remains The permafrost in Siberia preserved the frozen remains of this mammoth for thousands of years. Permafrost is a layer of ice that forms under land in the Arctic.

Wooly mammoths once roamed the cold plains of northern Asia, North America, and Europe. Thousands of years ago, around the end of the last ice age, mammoths became extinct. An **extinct** organism is one that no longer exists on Earth. In the Arctic, scientists often find mammoth fossils, such as the huge tusks in Figure 1. A **fossil** is the remains or traces of an organism preserved from the geologic past.

Types of Fossils

Preserved remains, such as frozen mammoth fossils, are just one type of fossil. **The different types of fossils include petrified fossils, molds and casts, carbon films, preserved remains, and trace fossils.** Each type forms in a different way.

Petrified Fossils Fossils often form when an organism's remains become petrified, or "turned into stone." In this process, mineral-rich water soaks into the small cavities and pores of the original organism. The minerals precipitate from the water and fill the spaces. The petrified wood in Figure 10A formed in this way. Sometimes, minerals replace the cell walls or other solid material of an organism.

Molds and Casts Molds and casts are another common type of fossil. A fossil mold is created when a shell or other structure is buried in sediment and then dissolved by underground water. The mold reflects only the shape and surface markings of the organism. It doesn't reveal any information about its internal structure. Cast fossils (Figure 10B) are created if the hollow spaces of a mold are later filled with mineral matter.

Facts and Figures

Species and Extinction Extinction is a natural part of evolutionary history. Far more than 99 percent of the species that have ever lived still exist today. Although situations differ greatly for different kinds of life forms, the mean existence time for a species is a few million years. This happens for several reasons. Even if Earth's surface remained unchanged, competition for resources, interactions between predators and prey, and genetic drift of geographically separated populations would cause new species to evolve and old species to go extinct. However, Earth's surface changes continuously: Continents move, oceans open and close, and the climate swings wildly over short and long time scales, accelerating evolutionary change through the adaptation of new species to new environments.

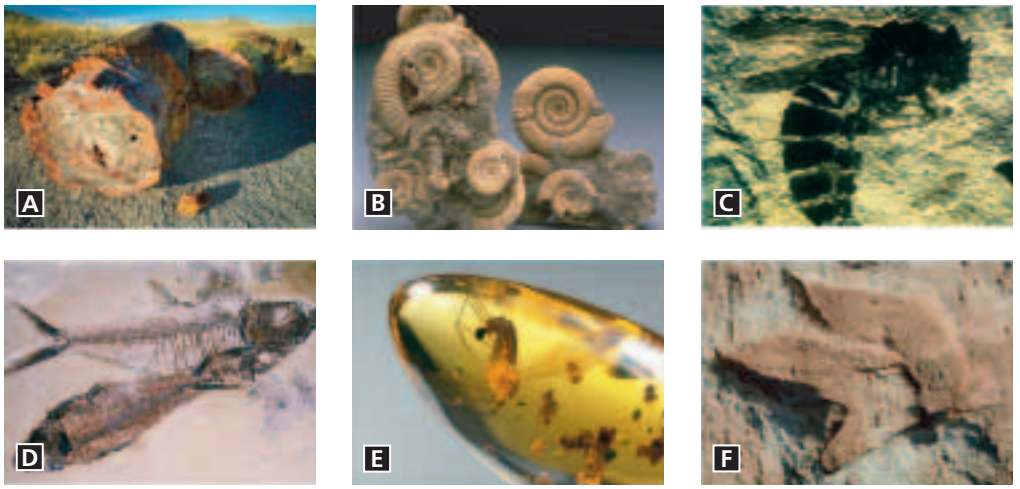

Figure 10 Types of Fossilization Six examples are shown here. **A** Petrified wood in Petrified Forest National Park, Arizona **B** Natural casts of shelled organisms called ammonites **C** A fossil bee was preserved as a thin carbon film. **D** Impressions are common fossils and often show considerable detail. **E** An insect in amber **F** This dinosaur footprint was found in fine-grained limestone near Tuba City, Arizona.

Carbon Films Fossils called carbon films can preserve delicate details of leaves and animal parts. The formation of a carbon film begins when an organism is buried under fine sediment. Over time, pressure squeezes out liquids and gases and leaves behind a thin film of carbon, like that in Figure 10C. Black shale often contains carbon film fossils.

Sometimes, the carbon film itself is lost from a fossil. However, an impression of the fossil may remain. Impressions, like those of the fish in Figure 10D, often show fine details of an animal's structure.

Preserved Remains Sometimes, fossilization preserves all or part of an organism with relatively little change. The mammoth frozen in permafrost is one example. Another example is insects preserved in amber—the hardened resin, or sap, of ancient trees. The fly in Figure 10E was preserved after being trapped in a drop of sticky resin.

Fossils can also form when remains are preserved in tar. Tar is thick petroleum that collects in pools at the surface. The La Brea Tar Pits in Los Angeles, California, have yielded preserved remains of ice-age mammals such as mastodons and sabre-toothed cats.

Trace Fossils Trace fossils are indirect evidence of prehistoric life. Tracks, like those in Figure 10F, are animal footprints made of soft sediment that later changed to sedimentary rock. Burrows are holes made by an animal in sediment, wood, or rock that were later filled with mineral matter and preserved. Some of the oldest known fossils are believed to be worm burrows. Coprolites are fossils of dung and stomach contents. These can often provide useful information regarding the food habits of organisms. Gastroliths are highly polished stomach stones that were used in the grinding of food by some extinct reptiles.

Reading Checkpoint *What is a trace fossil?*

Go Online PLANETDIARY

For: Links on fossils in amber
Visit: PHSchool.com
Web Code: czd-4122

Customize for Inclusion Students

Visually Impaired Whenever possible, use models or samples to help students with visual impairments conceptualize key concepts in the text. This section, for example, offers an excellent opportunity for students to handle various fossil samples. As students study each sample, be sure to tell them which type of fossil they are examining (i.e., mold, impression, or trace fossil). Encourage students to orally describe the textures of the fossils and to try to distinguish among fossil types.

Build Reading Literacy L1

Refer to **p. 334D**, which provides the guidelines for outlining.

Outline Have students create an outline of Section 12.2 (pp. 342–346). Outlines should follow the head structure used in the text. Major headings are shown in green and subheadings are shown in blue. Ask: **Based on your outlines, what are the two major concepts of this section?** *(Fossil Formation and Fossils and Correlation)*
Verbal

Teacher Demo

Charcoal and Fossil Fuels L2

Purpose Students will observe the formation of charcoal.

Materials wooden splints, Bunsen burner, test tube, test tube stand

Procedure Attach the test tube to the stand. Tilt the tube so that its mouth is slightly higher than its end. Place four wooden splints in the test tube. Heat the test tube until the splints turn black. At the same time, light a splint and hold it in the mouth of the test tube.

Expected Outcomes Students will observe that charcoal is formed in the bottom of the test tube. Explain that charcoal is a form of carbon; it is produced when an organic material, such as wood, does not have enough oxygen to burn completely. Also explain that the splint in the mouth of the test tube burns because gas is released by the reaction that changes burning wood into charcoal. This gas is similar to natural gas, a fossil fuel.
Visual

Go Online PLANETDIARY

Find links to additional activities and have students monitor phenomena that affect Earth and its residents.

Answer to . . .

Reading Checkpoint *Indirect evidence of prehistoric life such as an animal track or burrow*

Fossils and Correlation

Build Science Skills

L2

Using Models Have students work in small groups to make model mold-and-cast fossils. Provide each group with clay, a plastic container, beaker, plaster of Paris, and water. Have students line the bottom of the plastic container with clay. They should then press the shell into the clay. After removing the shell, have students mix water and plaster of Paris in the beaker until it reaches a creamy consistency. Tell them to pour the plaster of Paris into the plastic container and let the mixture set overnight. The next morning, they should gently remove the model cast from its mold. **Kinesthetic, Interpersonal**

Integrate Biology

L3

Paleontology and Biogeography Tell students that there are two scientific fields that combine the study of Earth's geologic history with the study of how Earth's life forms evolved. Most students will know something about paleontology. Paleontologists study the evolution of life forms as preserved in the fossil record. Few students will have heard of biogeography. Biogeographers study how changes in Earth's landmasses have affected evolution over geologic time. For example, biogeographers study the colonization of volcanic islands by life forms that subsequently evolve into new species. They also study how continental drift has affected evolution. One famous example of the latter is called "The Great Faunal Exchange." This refers to the movement of animal species (such as the mountain lion and armadillo) between North America and South America when the two continents became joined a few million years ago. Ask for volunteers to research the relationship between biogeography and evolution on the Internet and report their findings to the class.

Conditions For Fossilization

All the fossils that geologists have found, arranged by their relative ages, make up the fossil record. But the fossil record includes only a fraction of the different kinds of organisms that have lived on Earth. Why? Some organisms are more likely than others to be preserved as fossils. **Two conditions that favor preservation of an organism as a fossil are rapid burial and the possession of hard parts.**

For a fossil to form, the remains of an organism must be buried quickly by sediment. Sediment protects the soft parts of a dead animal from being eaten by scavengers or decomposed by bacteria.

Organisms also have a better chance of being preserved if they have hard parts such as shells, bones, and teeth. Fossils of hard parts are more common than fossils of soft-bodied animals.

Fossils and the History of Life

During the 1700s and 1800s, some scientists thought that fossils might provide clues to the history of life on Earth. **Two major scientific developments helped scientists explain the fossil record: the principle of fossil succession and the theory of evolution.** According to the first, the fossil record showed that certain sets of organisms were characteristic of different periods in Earth's past. According to the second, living things had evolved, or changed, over time.

Fossil Succession

The **principle of fossil sucession** states that fossil organisms succeed one another in a definite and determinable order. Therefore, any time period can be recognized by its fossil content. This principle was developed by William Smith, an English engineer. Smith found that fossils weren't randomly distributed through rock layers. Instead, each layer contained a distinct assortment of fossils that did not occur in the layers above or below it. Smith's observations were confirmed by many geologists who followed.

Figure 11 This extinct water-dwelling mammal, *Ambulocetus natans*, evolved about 45 million years ago in south Asia. *Ambulocetus,* which means "walking whale," represents one stage in the evolution of modern whales from land animals.

Theory of Evolution

Geologists had noticed that fossils from older rock layers were very different from the fossils in younger layers. English naturalist Charles Darwin developed a theory that helped to explain this fact.

In 1859, Darwin set forth the **theory of evolution**, which states that life forms have changed over time, or evolved, from simpler to more complex forms. To explain why evolution occurs, Darwin proposed the mechanism of natural selection. In **natural selection**, individuals that are better adapted to their environment are more likely to survive and reproduce than others of the same type. Organisms that are less well adapted are likely to become extinct.

Facts and Figures

Early attempts at determining Earth's age included a method based on the deposition of sediment. Some scientists thought that if they could determine both the rate of sediment accumulation and the total thickness of sedimentary rock that had been deposited throughout Earth's history, they could estimate the length of geologic time. To do this, scientists divided the rate of sediment accumulation into the total thickness of the sedimentary rock. However, estimates of Earth's age varied each time the method was attempted. The calculated age of Earth ranged from 3 million to 1.5 billion years.

Adaptation drives the process of evolution. Organisms possess certain traits, called **adaptations**, that affect their ability to survive and reproduce. Organisms that are well adapted to their environment survive. They pass on their traits to later generations. Thus, over time, one type of organism can evolve into a different type. For example, 50 million years ago, the ancestors of modern whales were land-dwelling mammals. The fossil record shows that, over millions of years, these mammals evolved adaptations for life in the oceans.

Reading Checkpoint *What is an adaptation?*

Interpreting the Fossil Record

The principle of fossil succession and the theory of evolution helped geologists to interpret the fossil record. **Geologists used fossils to improve the correlation of rock layers and reconstruct past environments.**

Fossils and Correlation

Geologists today use index fossils and groups of fossils to correlate rock layers. An **index fossil** is the fossil of an organism that was geographically widespread and abundant in the fossil record, but that existed for only a limited span of time. The presence of an index fossil in rock layers at different locations means that the layers are of roughly the same age.

Rock layers, however, do not always contain a specific index fossil. In this case, geologists can use groups of fossils to establish the relative age of the rock, as shown in Figure 12.

Go Online active art

For: Index fossil activity
Visit: www.PHSchool.com
Web Code: czp-4122

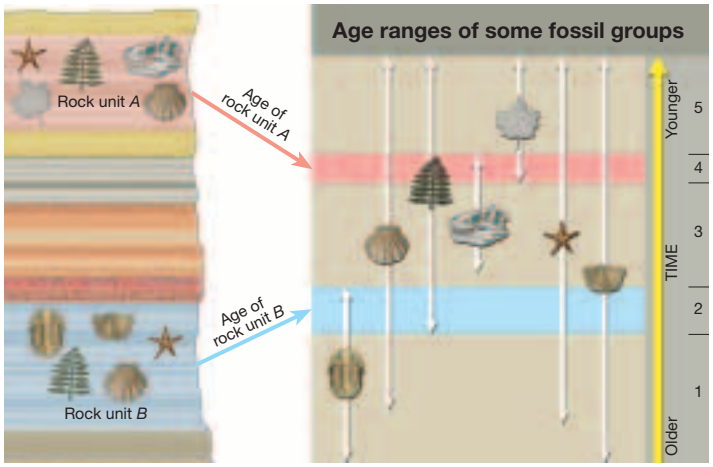

Figure 12 Correlating With Fossils Overlapping ranges of fossils help date rocks more exactly than using a single fossil. The fossils contained in rock unit A all have overlapping age ranges in time 4. The fossils in rock unit B have overlapping age ranges in time 2. Therefore, rock unit A was deposited in time 4, and rock unit B was deposited in time 2.

Interpreting the Fossil Record

Use Visuals

L1

Figure 12 Ask: **Which time range represents the oldest period? How do you know?** *(Time 1 represents the oldest period. This is indicated by the arrow at the far right of the diagram.)* **Can you use this diagram to determine the actual ages of the rocks or fossils? Why or why not?** *(The diagram provides information about the relative ages of rocks and fossils; it cannot be used to determine actual ages.)*
Visual, Logical

Go Online active art

For: Index Fossil activity
Visit: PHSchool.com
Web Code: czp-4122
Students interact with an index fossil activity online.

Facts and Figures

Living Fossils Relative dating using fossils works best with organisms that go extinct quickly, living for a very limited amount of time. However, there are some organisms that have managed to remain on Earth for extremely long periods of time, largely unchanged. They have survived and thrived through different climates and different populations of predators and competitors. Examples of these "living fossils" include the gingko tree, platypus, crocodile, frilled shark, coelacanth fish, purple frog, cedar wood wasp, and horseshoe crab. Their fossils cannot be used to narrowly determine the time they lived.

Answer to . . .

Reading Checkpoint *Trait that enables an organism to survive and reproduce*

3 ASSESS

Evaluate Understanding L2

Have students use their outlines of this section to quiz one another on key concepts.

Reteach L1

Use Figures 9 and 10 to review the different types of fossils and how they form.

Connecting Concepts

The law of superposition states that the oldest rocks are at the bottom of a sequence of rocks. The principle of fossil succession states that layers of rock contain specific fossils that change from layer to layer. Thus, the oldest fossils would be in the oldest layer of rock, which in turn would be at the bottom.

Figure 13 Fossil corals found in Texas limestone show this part of Texas was covered by a warm, tropical sea about 300 million years ago.

Fossils and Past Environments Fossils can also be used to reconstruct ancient environments. Because organisms evolve with adaptations suited to particular environments, fossils provide clues to the characteristics of those environments. For example, fossil teeth with flat surfaces suitable for grinding might be from an animal that ate grasses. If fossil pollen from grasses were abundant in the same rock layer, geologists could infer that the animal probably lived in a grassland.

Fossils can help geologists build an even more detailed picture of a past environment. Suppose geologists find fossil clam shells in limestone. They can infer that the region was once covered by a shallow sea. The geologists might also be able to conclude the approximate position of the ancient shoreline by observing the types and locations of fossils. For instance, fossil animals with thick shells capable of withstanding pounding waves must have lived near shorelines.

Fossils can also indicate the former temperature of the water. Certain present-day corals require warm and shallow tropical seas—like those around Florida and the Bahamas. When similar corals are found in ancient limestones, they indicate that a Florida-like marine environment must have existed when the corals were alive.

Section 12.2 Assessment

Reviewing Concepts

1. List the different types of fossils.
2. Describe the conditions that favor the formation of fossils.
3. In your own words, define the principle of fossil succession and the theory of evolution.
4. Describe two ways that geologists can use fossils to interpret Earth's history.

Critical Thinking

5. **Comparing and Contrasting** How are petrified fossils and carbon fossils similar? How are they different?
6. **Sequencing** Describe how a clam might become a fossil.
7. **Applying Concepts** What is the role of natural selection in evolution?
8. **Inferring** Look at Figure 12 on p. 345. Can any of the fossils in the diagram be used as an index fossil? Explain why or why not.

Connecting Concepts

Relating Ideas How are the law of superposition and the principle of fossil succession related?

Section 12.2 Assessment

1. Petrified fossils, molds and cases, carbon films, preserved remains, and trace fossils
2. quick burial, possession of hard parts
3. According to the principle of fossil succession, specific groups of fossils occur in particular rock layers. Each layer differs, and changes in life forms can be observed from layer to layer. According to the theory of evolution, life forms have evolved, or changed over time, through natural selection.
4. To correlate rock layers and to reconstruct past environments
5. Both preserve the shape of an organism, but in different ways. In a petrified fossil, minerals replace the matter that made up the organism, forming a three-dimensional "copy." In a carbon film fossil, traces of carbon from the organism may remain. Or, the carbon may be lost, leaving only a delicate impression.
6. The shell falls to the bottom and is buried under mud and sediment. Mineral-rich water soaks into the pore spaces, leaving minerals behind. Over time, the shell becomes incorporated into the mud. As the mud turns to rock, the shell becomes a fossil.
7. Through natural selection, organisms with traits that are well adapted to the environment survive and reproduce. Over time, this can lead to the evolution of a new species.
8. None of the fossils would be ideal as an index fossil because none is limited to a single rock unit. But the trilobite, mammal skull, and leaf might be of some use since they each occur in only two rock units.