12.2 Fossils: Evidence of Past Life

Reading Focus

Key Concepts

- What are fossils?
- What determines if an organism will become a fossil?
- What is the principle of fossil succession?

Vocabulary

- fossil
- 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. ___?___

Fossils are important tools for interpreting the geologic past. **Fossils are the remains or traces of prehistoric life. They are important components of sediment and sedimentary rocks.** Knowing the nature of the life forms that existed at a particular time helps researchers understand past environmental conditions. Further, fossils are important time indicators. They play a key role in correlating rocks of similar ages that are from different places.

Fossil Formation

There are many types of fossils. **The type of fossil that is formed is determined by the conditions under which an organism died and how it was buried.**

Unaltered Remains Some remains of organisms—such as teeth, bones, and shells—may not have been altered, or changed, hardly at all over time. It is far less common to find the remains of an entire animal, including flesh. In Siberia, archaeologists recently found a fully preserved, frozen mammoth, shown in Figure 9. This is an excellent example of unaltered remains.

Altered Remains The remains of an organism are likely to be changed over time. Fossils often become petrified, or "turned into stone." When a fossil is petrified, 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 log of petrified wood in Figure 10E shows the result. In other instances, the cell walls or other solid material of an organism are replaced with mineral matter. Sometimes the microscopic details of the replaced structure are preserved.

Figure 9 Unaltered Remains Frozen animals are an extreme and unusual type of fossilization.

Section 12.2

1 FOCUS

Section Objectives

12.5 **Define** fossils and **explain** how fossils are made.

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

12.7 **State** the principle of fossil succession.

Reading Focus

Build Vocabulary

L2

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

Reading Strategy

L2

Possible answers include:
a. Fossils are traces or remains of once-living prehistoric organisms. **b.** Fossils can form by freezing or drying, burial and replacement with minerals, carbonization, preservation in amber, and solidification of indirect evidence. **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

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. 343–346). 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

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

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 accurately reflects only the shape and surface markings of the organism. It doesn't reveal any information about its internal structure. Cast fossils (Figure 10F) are created if the hollow spaces of a mold are later filled with mineral matter.

A type of fossilization called carbonization is particularly effective in preserving leaves and delicate animal forms. Carbonization occurs when an organism is buried under fine sediment. As time passes, pressure squeezes out the liquid and gaseous components of an organism and leaves behind a thin residue of carbon, like that shown in Figure 10A. Black shale often contains abundant carbonized remains. If the carbon film is lost from a fossil preserved in fine-grain sediment, a replica of the surface, or an impression, may remain. The impression may still show considerable detail. An impression is shown in Figure 10B.

Delicate organisms, such as insects, are difficult to preserve, so they are relatively rare in the fossil record. For a fossil of an insect to form, the insect must be protected from any pressure that would crush it. Some insects have been preserved in amber—the hardened resin of ancient trees. The fly in Figure 10C was preserved after being trapped in a drop of the sticky resin.

Indirect Evidence

Trace fossils are indirect evidence of prehistoric life. Tracks, like those in Figure 10D, are animal footprints made in soft sediment that was later compacted and cemented. 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 are three types of fossils?*

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.

Conditions Favoring Preservation

Two conditions are important for preservation: rapid burial and the possession of hard parts. The soft parts of a dead animal are usually eaten by scavengers or decomposed by bacteria. However, if the remains are buried quickly by sediment, they are protected from the environment. Then there is a chance that the organism will become a fossil. In addition, organisms have a better chance of being preserved if they have hard parts such as shells, bones, and teeth. Fossils of hard parts dominate the fossil record even though fossils of soft-bodied animals such as jellyfish and worms do exist.

Reading Checkpoint *Why are soft parts of dead animals rarely preserved?*

Fossils and Correlation

In the late 18th century, William Smith, an English engineer and canal builder, demonstrated the usefulness of fossils to geology. He found that fossils weren't randomly distributed throughout the rock layers he cut through. Instead, each layer contained a distinct assortment of fossils that did not occur in the layers above or below it. Smith also noted that sedimentary rock layers in distant areas could be identified and correlated by the distinct fossils they contained.

Based on Smith's observations and the findings of many geologists who followed, one of the most important principles in historical geology was formulated. **The principle of fossil succession states that fossil organisms succeed one another in a definite and determinable order. Therefore, any time period can be recognized by its fossil content.**

Based on the rock record from around the world, geologists have identified an order of fossils: an Age of Trilobites, an Age of Fishes, an Age of Coal Swamps, an Age of Reptiles, and an Age of Mammals. These "ages" correspond to particular time periods and are characterized by distinct and abundant fossils. This same order of dominant organisms is found on every continent.

Once fossils were recognized as time indicators, they became the most useful means of correlating rocks of similar age in different regions. Geologists pay particular attention to **index fossils. Index fossils are widespread geographically, are limited to a short span of geologic time, and occur in large numbers.** Their presence provides an important method of matching rocks of the same age. Rock formations, however, do not always contain a specific index fossil. Then groups of fossils are used to establish the age of a rock layer. Figure 11 shows how an assemblage of fossils can be used to date rocks more precisely than using only one kind of fossil.

Fossils and Correlation

Build Science Skills

L2

ACTIVITY

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**

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.

Answer to . . .

Reading Checkpoint *Sample answers: petrified remains, molds, casts, impressions, and trace fossils*

Reading Checkpoint *They are destroyed by decomposition.*

Use Visuals

L1

Figure 11 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

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.

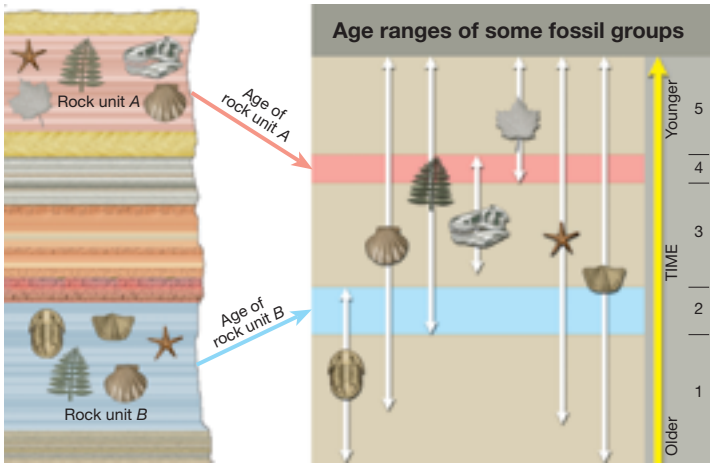

Figure 11 Overlapping ranges of fossils help date rocks more exactly than using a single fossil. The fossils contained in rock unit A all have overlapping age ranges in time 4. The fossils in rock unit B have overlapping age ranges in time 2.

Interpreting Environments

Fossils can also be used to interpret and describe ancient environments. For example, geologists can conclude that a region was once covered by a shallow sea when the remains of certain clam shells are found in the limestone of that region. 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. These examples illustrate how fossils can help unravel the complex story of Earth history.

Section 12.2 Assessment

Reviewing Concepts

1. What are fossils?
2. What conditions are necessary to insure fossilization?
3. What is the principle of fossil succession?

Critical Thinking

4. **Sequencing** Describe how a clam might become a fossil.
5. **Inferring** The remains of a large animal are found in a cave along with a large pile of fossilized dung. How can you incorporate this dung into your studies of this unknown animal?

Connecting Concepts

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

Section 12.2 Assessment

1. remains or traces of once-living, prehistoric organisms
2. quick burial, possession of hard parts
3. Specific groups of fossils occur in particular rock layers. Each layer differs, and changes in life forms can be observed from layer to layer.
4. Sample answer: 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.
5. Sample answer: You could analyze the dung for evidence of the food the animal ate. You could possibly determine if the animal was a carnivore or herbivore. You might be able to make inferences about the animal's jaw structure.