Fossils and Studying Earth's Past

What Are Fossils?

Fossils are the remains of plants, animals, or other organisms that lived in the distant past. They can include leaves, bones, shells, microbes, or other organic matter that was buried and preserved. Even "traces" of organisms such as footprints or root tracks can become fossilized. These are called "trace fossils." Fossils are formed over many thousands to millions of years.

This dinosaur footprint is an example of a trace fossil.

How Do Fossils Form?

Fossils can be formed in different ways. One of the most common ways is called "permineralization." In this process, empty spaces within a buried bone are filled with minerals that come from the groundwater. A modern cow bone and a fossil dinosaur may look quite similar at first glance. However, if you look at the cross-section of a cow bone, you will see many small holes. In the fossil bone, these holes will be filled with minerals. A fossil of a dinosaur bone will feel heavier than a modern cow bone of similar size because the dinosaur bone has essentially turned to stone.

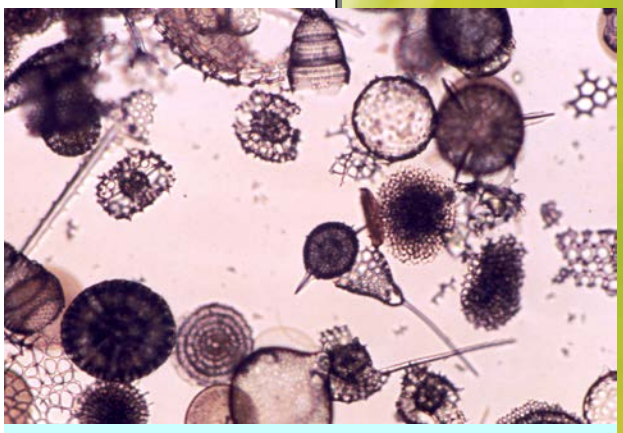
Other common types of fossils are casts and molds. These fossils are formed when organic material, such as a leaf, is completely dissolved and only the impression or "mold" of the leaf is left. In some cases, minerals from the groundwater fill in this empty space, creating what is called a "cast." There are several other ways fossils can be formed, depending on the chemistry of the burial site.

Petrified logs are fossilized through the process of permineralization.

How Are Fossils Found?

Paleontologists are scientists who study fossils. Large fossils can be found along eroding slopes or during construction projects. They are then carefully dug out for further study. Other fossils are so small they cannot be seen without a microscope. These are called "microfossils." They include tiny aquatic plants and animals called plankton, plant pollen, insect parts, and charcoal, to name just a few. These types of fossils are found in layers of rock, lake mud, ocean sediment, and even polar ice sheets that have built up

over long periods of time. In the laboratory, scientists extract these tiny fossils from the other material. They then identify and count the fossils using a microscope.



Microscopic fossils or "microfossils" can be identified and counted under the microscope. Comparing samples can show changes in environmental variables, such as vegetation, water chemistry, or atmospheric temperature through time.

How Can We Tell How Old a Fossil Is?

An important aspect to studying fossils is determining how old they are. Scientists can determine the age of a fossil in various ways. Some methods provide "absolute" ages. This means that we can say approximately how old the fossil is in years. Other methods provide "relative" ages. This is simply whether the fossil is older or younger than other fossils or rocks. Absolute dates are considered more precise than relative dates. However, with either type, the older the fossil is, the more difficult it is to date with precision.

A common method for finding the absolute age of a fossil is radiometric dating. Radiocarbon dating is an example of this type of dating. Carbon is in the air we breathe, and all living things contain much of this chemical element. However, carbon occurs in two forms, C-13 and C-14. Plants and animals take up C-14 from the air while they are alive. After a plant or animal dies the C-14 in its body begins to break down into C-13, which is the more stable form of carbon. This process happens at a known rate. Therefore, by measuring how much C-14 is left in a fossil, scientists can determine how old the fossil is. This technique is often used for dating human remains and artifacts from archaeological sites. If an object is older than 60,000 years or so, all of the C-14 will be gone and this dating method will not work. Most fossils are older than 60,000 years, so other types of radiometric dating are used instead, but the basic process is the same.

In this undisturbed rock sequence, fossils are progressively older in each lower layer.

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In relative dating, scientists use the "law of superposition." This law states that layers of sediment or rock are laid down over time so that younger layers will lie above older layers. As long as the layers are not disturbed, we can dig down through older and older layers. We can then determine the age of any fossils we find *relative* to other fossils in the layers above or below.

What Can Fossils Tell Us?

Fossils tell us a lot about the history of life on Earth. For example, the oldest fossils that have ever been found are about 3.4 billion years old. They are a simple form of bacteria. In comparison, modern humans have been here for a very short period of time. The first human fossils are only about 250,000 years old.

Ammonites went extinct together with many other sea creatures and most dinosaurs around 65 million years ago. This mass extinction marked the end of the Cretaceous geologic time period.

Fossils also let us see how different forms of life have changed or evolved over long periods of time. We can see how some types of fish developed small leg-like limbs. Later, these strange fish evolved into amphibian-like land animals. The fossil record also shows how birds evolved from certain types of reptiles, and how modern humans evolved from early primates.

Another fascinating thing that the fossil record demonstrates is that almost all of the organisms that have ever lived on Earth have gone extinct. That is, they no longer exist on Earth. Species have gone extinct continually throughout geologic time. New species continually emerge as well. However, the fossil record also shows a number of major "extinction events." These were times when a large fraction of Earth's plants and animals died out within a relatively short period of time. Scientists believe that many of these events were caused by rapid, large-scale climate change. Such changes could be caused by a large asteroid hitting Earth, among other things.

There is a bright side, however. The fossil record also shows that mass extinctions are usually followed by the rapid development of many new species. These plants and animals quickly fill environments left vacant by the extinct ones.

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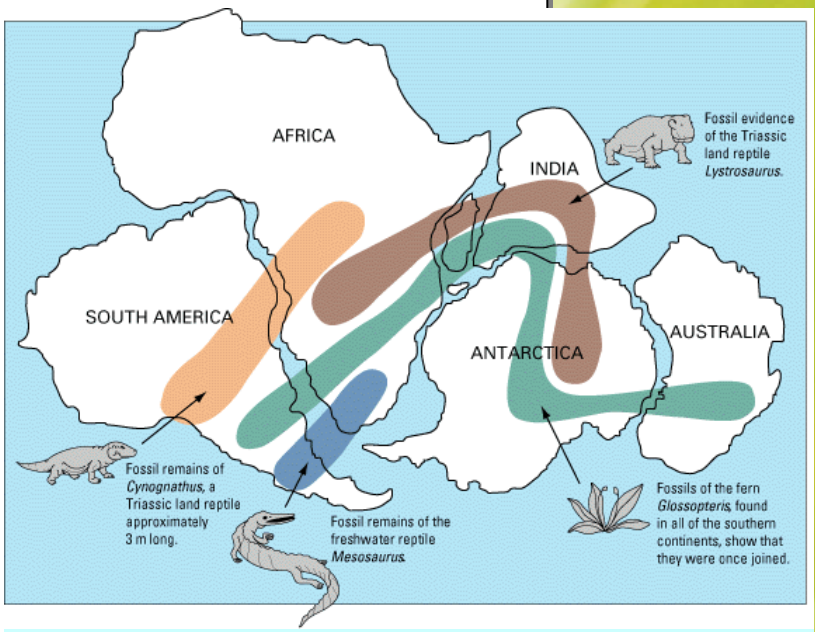
Finally, the fossil record shows us that long ago, Earth looked very different than it does today. In fact, the continents have been moving very slowly for hundreds of millions of years.



The fossil record shows how Earth's continents belonged to one "supercontinent" about 200 to 300 million years ago.

Consider the land reptile *Lystrosaurus*, which lived during the Triassic geologic time period (200 to 250 million years ago). These fossils have been found on Africa, India, and Antarctica. Likewise, fossils of the reptiles *Cynognathus* and *Mesosaurus* have been found in South America and Africa. During the Permian period (250 to 300 million years ago), the tree fern *Glossopteris* lived on all five major continents. These places have very different climates today. However, they must have had similar climates in the past. This suggests that the continents were once connected. This enormous "supercontinent" is called "Pangaea."