Fossil Dating

Earth is a very old place. According to recent evidence, it is around 4.6 billion years old.

Geologists call this vast amount of time **geologic time**. We know about past life by looking at remnants, marks, or traces of life-forms trapped in rock. Rocks hold the key to much of what we know about Earth's history and the **evolution** of life on this planet.

Fossils are evidence of ancient life. Most fossils are body fossils or trace fossils. **Body fossils** are rocks made from parts of the **organism**. The hard parts, such as shells, bones, and teeth, are most likely to become fossils. **Trace fossils** preserve evidence of activities. These rocks most often show tracks, tail-drag marks, burrows, impressions, and droppings.

Trace fossils, like these trilobites, are impressions left in mud that hardened to rock. Millions of years later, these impressions provide clues about how and where the animals lived.

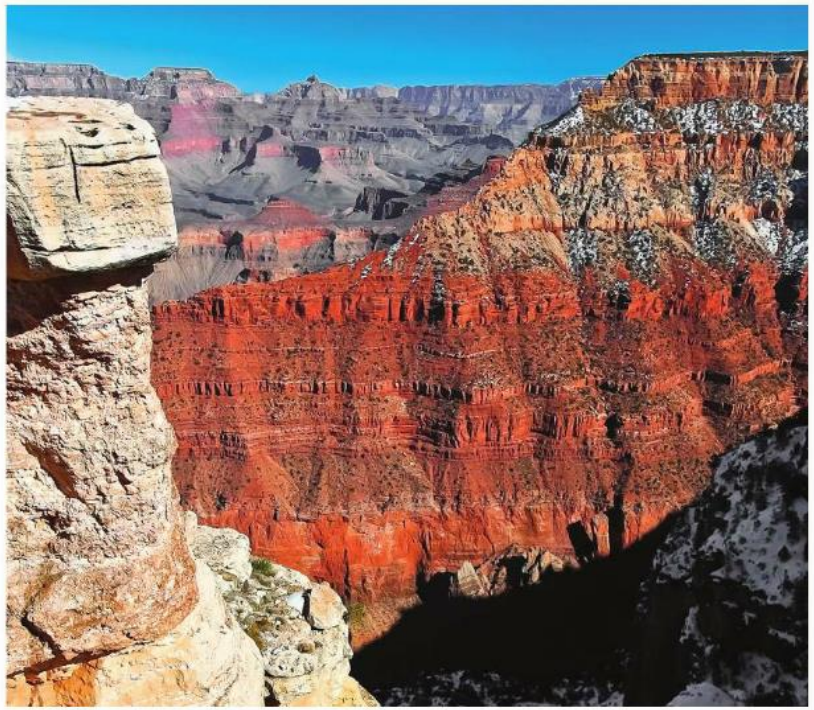
Ammonites are among the most common fossils found today. These squidlike predators lived inside spiral shells and were abundant in Earth's ocean from the Devonian through the Cretaceous period.

- *Paleozoic* means "ancient animal life." The Paleozoic era included a group of extinct marine arthropods called **trilobites**. This era included corals, **brachiopods** (an early marine organism with two hard shells or "valves"), early fish, and early amphibians. Plants of this era included early conifers and ferns.
- *Mesozoic* means "middle animal life." It is sometimes called the age of the dinosaurs.
- *Cenozoic* means "recent animal life." It is sometimes called the age of mammals because so many new kinds of mammals appeared during this era.

Each era is divided up into periods that reflect the fossil record. The geologic time scale is constantly being tested and revised. Geologists improve the model with new information from fossils and data.

Think Questions

1. **The Devonian period is considered the Age of Fishes. Would you expect to find a tetrapod (animal with four legs) fossil closer to the Carboniferous period or the Silurian period? Why?**
2. **Certain kinds of shells are always found in rock layers lower than layers with plant fossils. Dinosaur fossils show up only in layers above or with plant fossils. What does this tell you about when these organisms lived?**
3. **What information would you need to find a more precise age of dinosaurs and plants?**
4. **Would you expect to find fish fossils in rocks 550 million years old? Explain.**



Colorful layers of sandstone, shale, and limestone make up the Grand Canyon. These sedimentary rocks contain evidence about how Earth's organisms and environments have changed over time.

Relative Dating

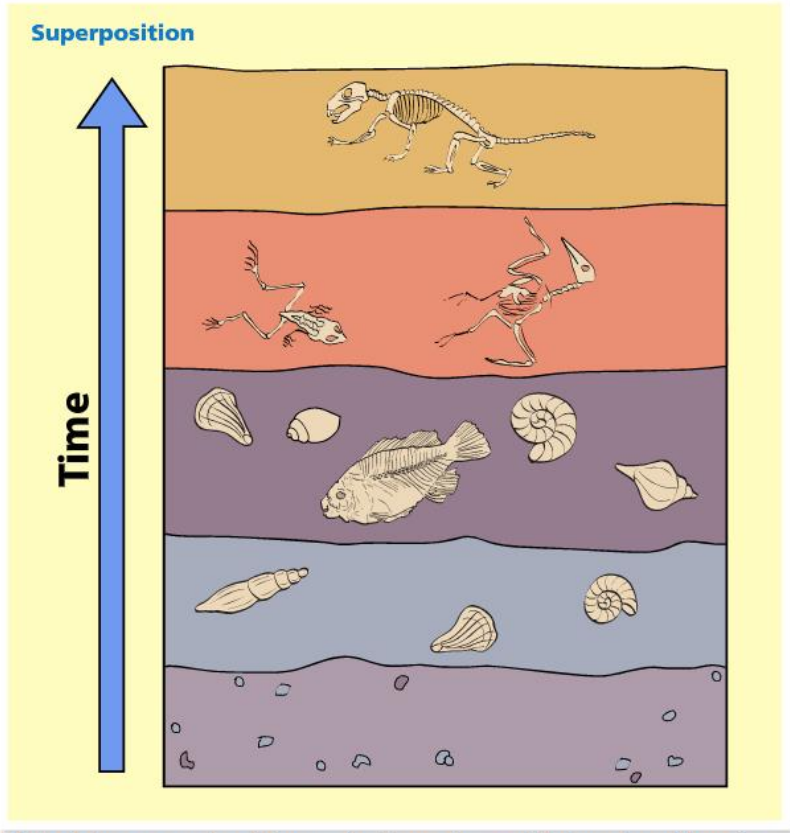
Most fossils are in **sedimentary rock**. Sedimentary rock forms over thousands, sometimes millions, of years. First, **particles** of gravel, sand, and mud settle on the bottoms of rivers, lakes, and the ocean. Little by little, those **sediments** pile up. Sediments also form in the desert. There, particles of dry sand drift and build up. Sediments sometimes cover dead organisms. The soft parts of organisms usually decay or are eaten. But the hard parts of organisms can remain. As sediments build up, the remains are buried deeper and deeper. The sediments become compressed and form rock around what remains of the organism.

Think Question

Fossils are relatively rare. Why don't we find more?

In the 1600s, Nicolaus Steno (1638–1686) figured out how sedimentary rocks form. The Danish scientist said that lower layers of rock were laid down first. They are usually older than the layers of rock above. This rule is the **principle of superposition**.

This principle allows **paleontologists** to compare fossil ages. A fossil in a lower layer of sedimentary rock is most likely older than a fossil found above it. This useful rule tells us the relative age of fossils. But it does not tell us how old a fossil or rock is. To do that, we look at the **atoms** in the rock.



Relative dating compares the relative age of rock layers. In general, the lower the rock layer, the older it is and the older the fossils it contains.

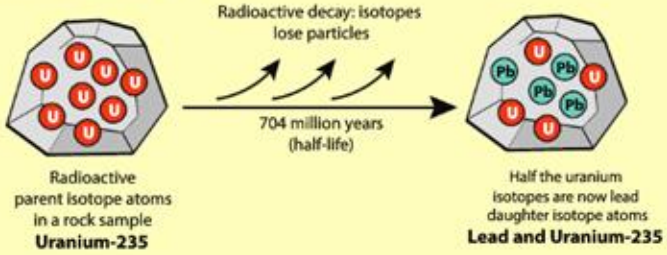
Absolute Dating

All matter is made of particles called atoms. Each atom is an element, such as carbon, potassium, uranium, or oxygen. Atoms are made of even smaller particles. In any one element, the number of smaller particles can vary. For example, carbon comes in three forms: carbon-12, carbon-13, and carbon-14. Each form has a different number of particles and is called an **isotope**. A **radioactive isotope** loses small particles at a fairly constant rate. Gradually, it changes into a different isotope. If it loses enough particles, it can change into a different element. This is radioactive decay.

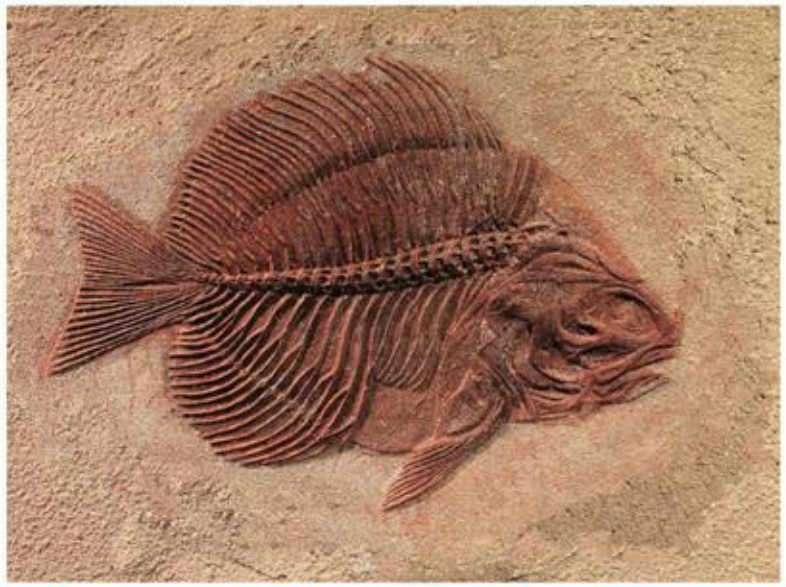
Different radioactive isotopes decay at different rates. Depending on the isotope, it can take minutes to millions of years for half of the radioactive isotope in a sample to decay. This time is the half-life of the isotope. Isotopes with a long half-life are used to date rocks. For example, the half-life of uranium-235 is 704 million years. It takes 704 million years for half of a sample of uranium-235 to turn into another element, lead. By measuring the ratio of uranium to lead in a rock sample, geologists can calculate when the rock formed. For example, if a rock is 50 percent uranium-235 and 50 percent lead, we know it is 704 million years old. Once you know the age of the rock, you know the age of the fossils in that rock.

Scientists unearth fragile fossils with great care. Then they date the fossils by finding out the age of the surrounding rock.

Radioactive Decay



How old are fossils found in a sample of rock that is half uranium-235 and half lead? Would rock that had a higher percentage of uranium-235 be older or younger?



Could scientists use carbon dating to find out when this fossilized fish lived and died? It depends upon when it died. Carbon dating cannot be used to date fossils more than 50,000 years old.

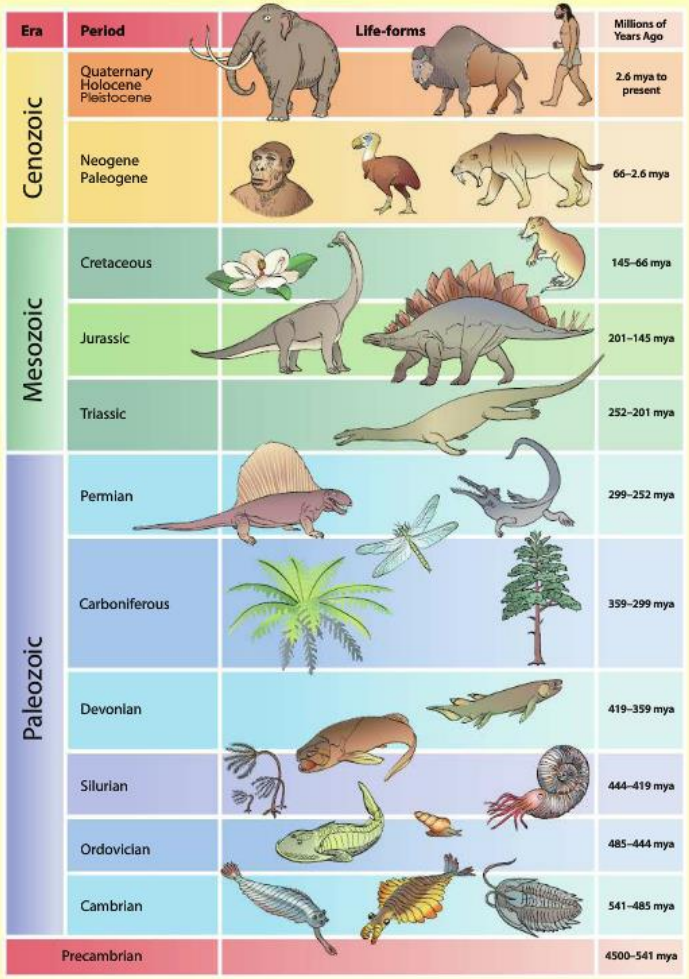
Using Carbon-14

Carbon-14 has a half-life of 5,730 years. Paleontologists use this isotope to measure the age of fossils of organisms that lived in the last 50,000 years or so. Carbon-14 occurs in the upper atmosphere. All living organisms take in carbon-14. When an organism dies, it no longer takes in carbon-14. Instead, the carbon-14 in the remains decays to form another isotope of carbon, carbon-12. By measuring the amount of carbon-14 and carbon-12 in a sample of bone, hair, or wood in a fossil organism, scientists can determine how long ago it died.

Think Question

Why isn't carbon-14 used to date rock that is millions of years old?

Geologic Time Scale



The geologic time scale is a model based on major changes in the fossil record.

Geologic Time Scale

Geologists and paleontologists use relative and absolute dating to estimate the ages of sedimentary rock and fossils. They have used the **fossil record** to develop a model called the geologic time scale. This model describes what we know about how old something is or when something happened during the history of life on Earth.

Study the geologic time scale presented on the left. It shows when different kinds of organisms first appeared. **Eras** are broad spans based on typical life-forms at that time. *Zoic* refers to animal life.

Crinoid fossils are some of the oldest fossils on Earth. These marine animals first appeared in the Ordovician period. Their descendants still exist in deep ocean waters.