

Objectives

After reading this lesson, you should be able to

- ◆ explain how a rock's relative age is determined.
- ◆ explain how a rock's absolute age is determined.

Relative dating

Method that compares two rock layers to find out which is older

Principle of superposition

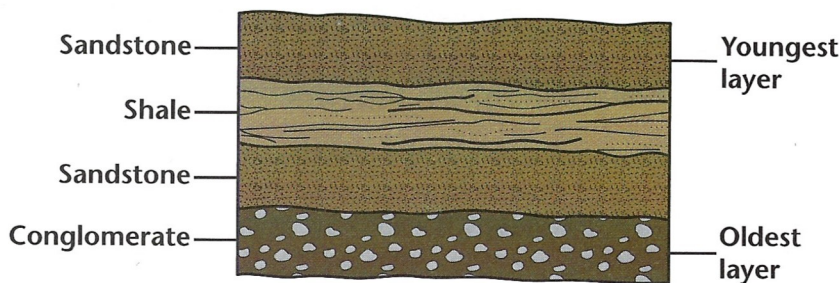
In layers of sedimentary rocks, the oldest layer is on the bottom and the youngest layer is on the top if the layers have not been overturned.

To find the age of a fossil, scientists find the age of the rock in which the fossil was found. How is this done? It's not as difficult as you might think.

Principles of Relative Dating

One way to find the age of a rock is to compare it to other rocks. In this method, called **relative dating**, you place rock layers in order from oldest to youngest without using actual dates. Some basic principles can guide you when using relative dating.

If you are unpacking a box of books, you can be fairly certain that the book on the bottom was put in before the books on top. You can apply this simple idea to relative dating. Look at the layers of sedimentary rock shown in the diagram below. The oldest layer is at the bottom. The **principle of superposition** states that if sedimentary rock layers have not been overturned, the oldest rock layer is on the bottom and the youngest rock layer is on the top. Based on this principle, a fossil found in one layer of rock is older than a fossil found in a layer above it.



Principle of superposition

Principle of crosscutting relationships

A feature, such as a rock structure or a fault, that cuts across rock layers is younger than the rock layers.

Index fossil

Fossil that can be used to establish the relative age of the rock in which the fossil occurs



Did You Know?

Scientists estimate that only about 1 percent of all past organisms became fossils.

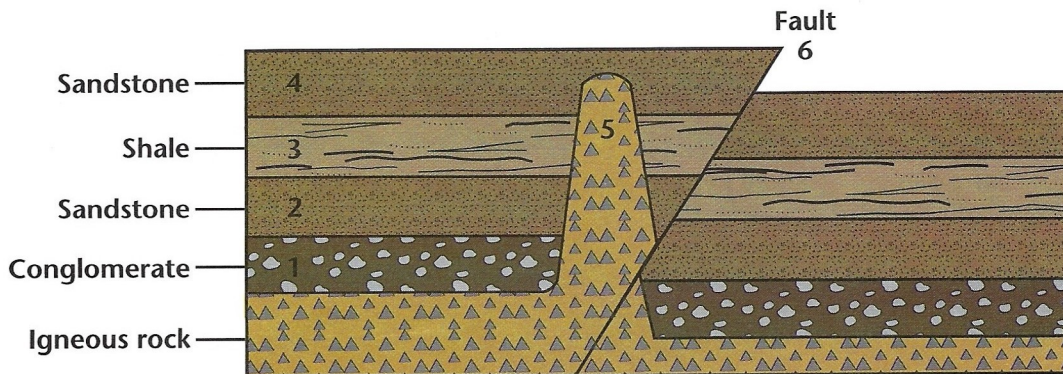
Suppose you saw a nail stuck in a tree trunk. You would realize that the tree grew first and the nail was later pounded into it. A similar principle is used to determine the relative ages of some rocks. According to the **principle of crosscutting relationships**, a rock that cuts through another rock must be younger than the rock it cuts. The diagram below illustrates this principle. The rock features in the diagram are numbered from oldest (1) to youngest (6).

The igneous rock pocket (5) formed when magma forced its way up through cracks in the existing rock layers. According to the principle of crosscutting relationships, this section of igneous rock is younger than the sedimentary rock layers (1 to 4).

The diagram also shows a fault cutting through layers of rock. Using the principle of crosscutting relationships, you can see that the fault (6) occurred after the pocket of igneous rock formed. So the fault is the youngest rock feature.

How do the rock layers in the diagram also show the principle of superposition?

Some fossils, called **index fossils**, can be used to establish the relative ages of rocks that contain these fossils. Index fossils, such as the trilobites shown on page 336, are useful because they are widespread and lived for a relatively short period of time. Therefore, when scientists find an index fossil anywhere in the world, they know the relative age of the rock in which the fossil was found.



Principle of crosscutting relationships

Absolute dating

Method that determines the actual age of a rock or fossil

Radioactive element

Element that breaks apart, or decays, to form another element

Half-life

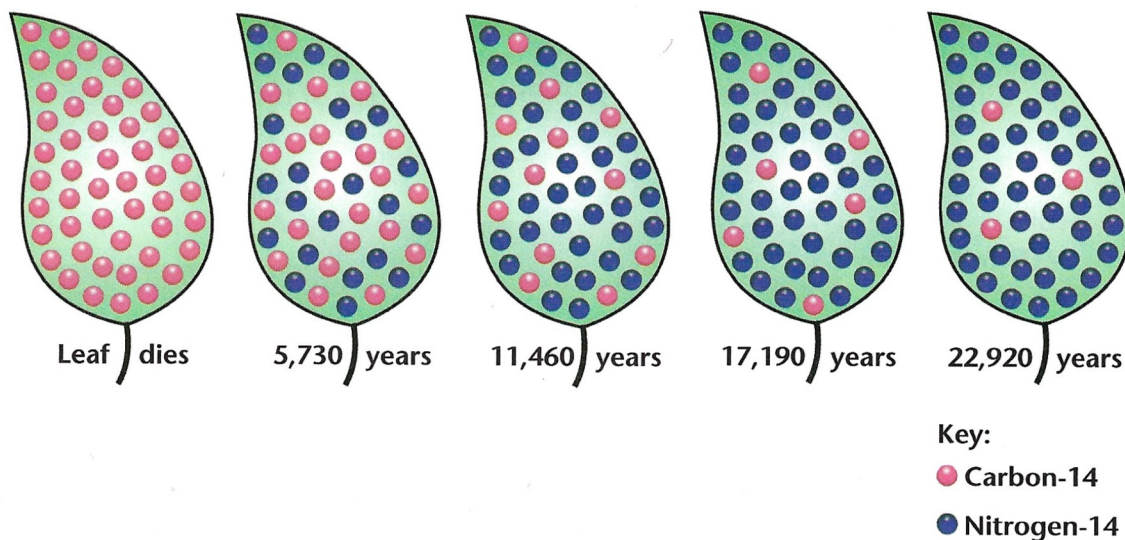
Length of time it takes for half of the atoms of a radioactive element to decay

Absolute Dating Using Half-Life

Relative dating is useful, but **absolute dating** is more specific. Scientists use absolute dating to find the absolute age, or actual age, of a rock or fossil. Absolute dates are measured in years, just as your age is.

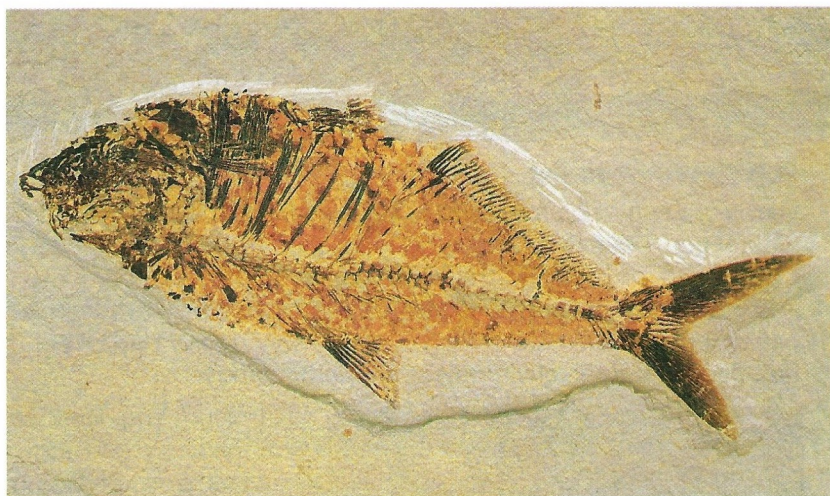
Scientists find the absolute age of a rock by studying certain **radioactive elements** the rock contains. Radioactive elements break apart, or decay, to form other elements. This decay happens at a constant rate. The length of time it takes for half of the atoms of a radioactive element to decay is the element's **half-life**. By comparing the amounts of different elements in a rock, scientists can determine the absolute age of the rock.

For example, the radioactive element carbon-14, a form of carbon, is used in absolute dating of some fossils. All living things contain carbon-14. When an organism dies, the carbon-14 starts to decay, forming nitrogen-14. The diagram below shows the rate of decay. The half-life of carbon-14 is 5,730 years. After 5,730 years, half of the carbon-14 is decayed. Every 5,730 years after that, half of the remaining carbon-14 decays. By measuring the amount of carbon-14 and nitrogen-14 in a sample, scientists can determine how many years ago the organism died.



After about 50,000 years, almost all carbon-14 in an organism has decayed to nitrogen-14. Therefore, carbon-14 cannot be used to date fossils older than 50,000 years. Other radioactive elements with longer half-lives are used to determine the absolute age of older fossils and rocks.

For example, uranium-238 occurs in some igneous rocks and decays to form lead-206. The half-life of uranium-238 is about 4.5 billion years. Scientists can compare the uranium-238 content of a rock to its lead-206 content. From such a comparison, they can determine the absolute age of the rock. Using this method on meteorites, scientists have determined the age of the earth to be 4.6 billion years old.



This well-preserved fossil was discovered in Wyoming. According to absolute dating methods, this ancient fish lived about 40 million years ago.

The Ages of Rocks and Fossils

Directions Compare and contrast the two terms below. Explain how they are alike and how they are different.

relative dating—absolute dating

1. How are they alike? _____

2. How are they different? _____

Directions Answer the questions.

3. Give an example of an index fossil and tell how scientists might use such a find.

4. What is the principle of superposition? _____

5. What is the principle of crosscutting relationships? _____

6. How does the half-life of a radioactive element help determine the age of a rock or fossil?

Directions Identify each term below with a method of dating rocks. On the line, write R for relative dating or A for absolute dating.

7. carbon-14 _____

8. radioactive
element _____

9. half-life _____

10. determining
actual age _____

11. comparing layers _____

12. crosscutting _____

13. uranium-238 _____

14. index fossil _____

15. superposition _____

