Data Analysis

Radiometric Dating

Scientists can determine the age of a fossil through the process of radiometric dating. This technique uses calculations that are based on a radioisotope's steady rate of decay. Isotopes are atoms of the same element that have different numbers of neutrons. For example, all carbon atoms have six protons, but the number of neutrons may vary. The most common carbon isotope has six neutrons in its nucleus. Because the atomic mass of an atom is equal to the sum of protons and neutrons in its nucleus, this isotope is known as carbon-12, or ^{12}C. In the isotope carbon-14, or ^{14}C, there are still six protons but eight neutrons, which add up to 14.

Many elements have multiple isotopes, most of which are stable. However, some isotopes are unstable, or radioactive. This means that they give off radiation as they decay or break down over time. Decay rates differ widely and are known for each isotope. Figure 13 lists a few radioactive isotopes that are used in radiometric dating.

FIGURE 13: Isotopes Used in Radiometric Dating

Isotope (parent)	Product (daughter)	Half-life (years)
rubidium-87	strontium-87	48.8 billion
uranium-238	lead-206	4.5 billion
potassium-40	argon-40	1.3 billion
carbon-14	nitrogen-14	5730

This decay of any radioisotope happens at a known, constant rate and is expressed as the isotope's half-life. A *half-life* is the amount of time it takes for half of the original mass of the isotope to decay into the product, or daughter isotope. By measuring the amount of parent isotope remaining along with the amount of daughter isotope remaining, you can calculate a ratio. This is known as the decay-product ratio.

The isotope ^{14}C is commonly used to date recent remains. Organisms absorb carbon through eating and breathing, so ^{14}C is constantly being resupplied. When an organism dies, its intake of carbon stops, but the decay of ^{14}C continues.

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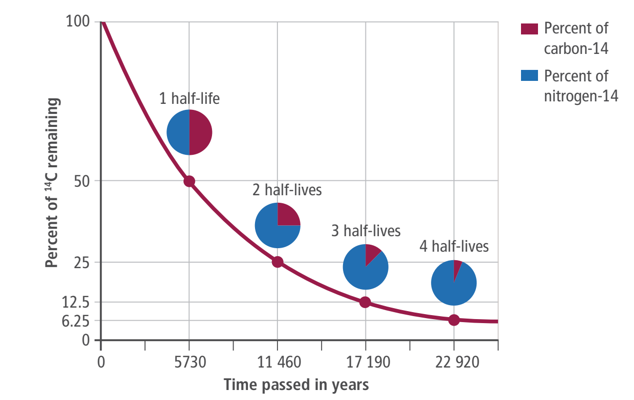
FIGURE 14: Carbon-14 Decay



The half-life of ^{14}C is roughly 5700 years, which means that after 5700 years, half of the ^{14}C in a fossil will have decayed into ^{14}N, its decay product. The other half remains as ^{14}C. After 11,400 years, or two half-lives, 75 percent of the ^{14}C will have decayed. One quarter of the original ^{14}C remains.

The predictability of radiometric dating gives scientists a reliable tool to calculate the age of almost any fossil or rock sample. The oldest known rocks have been dated using radioisotopes. These were small crystals discovered in Australia that were calculated to be about 4.4 billion years old. Advances in the technology have made the process so precise that the margin of error is reported to be less than one percent.

Use the figures to answer the following questions.

1. If a rock contains 75 percent of the decay product, how many half-lives have passed?
2. If you measured the age of a fossil using ^{14}C dating and determined its age to be about 17,000 years old, how much of the rock should be made of ^{14}N?
3. If you are examining rock layers that are suspected to be about 20 million years old, which radioactive isotope would you use? Explain your answer.

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