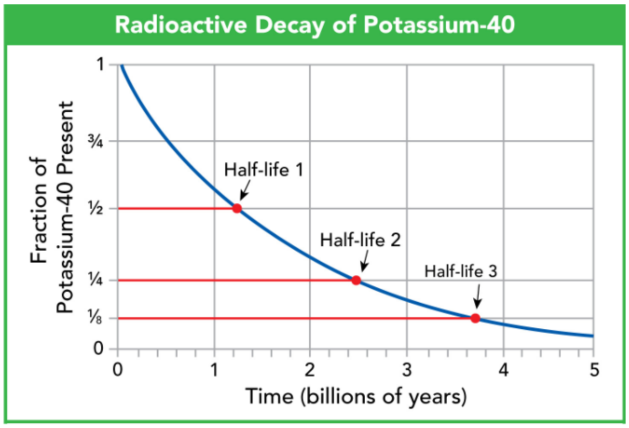
Radiometric Dating

Background

Relative dating tells us the order in which fossil organisms first appeared, but provides no information about a fossil's absolute age in years. One way to date rocks and fossils is radiometric dating. Radiometric dating relies on radioactive isotopes (unstable versions of atoms due to different numbers of neutrons in the nucleus), which decay or break down into stable isotopes at a steady rate. A half-life is the time required for half of the radioactive atoms in a sample to decay. After one half-life, half of the original radioactive atoms have decayed. After another half-life, another half of the radioactive atoms will have decayed. Radiometric dating uses the proportion of radioactive isotopes to stable isotopes to calculate the absolute age (in years) of a sample.

Different radioactive isotopes decay at different rates. (*See figure below for the decay of Potassium-40*) Elements with short half-lives are used to date very recent fossils. Elements with long half-lives are used to date older fossils. Consider how we time sporting events. For a 100-meter dash, a coach depends on the fast-moving second hand of a stopwatch. To time a marathon, the slower-moving hour and minute hands are more useful.



An isotope known as carbon-14, which has a half-life of roughly 5,730 years, is useful for directly dating recent fossils. Carbon-14 is produced at a steady rate in the upper atmosphere. Air contains a tiny amount of carbon-14 in addition to the more common, stable, nonradioactive form, carbon-12. Plants take in carbon-14 when they absorb carbon dioxide during photosynthesis, and animals acquire it when they eat plants or other animals. Once an organism dies, it no longer takes in this isotope, so its age can be determined by the amount of carbon-14 remaining in tissues, such as bone or wood. The relatively short half-life of carbon-14 limits its use to organisms that lived during the last 60,000 years. After 10 half-lives have passed, less than one thousandth (1/1000) of the original carbon-14 remains in a sample.

This lab activity uses pennies to model the behavior of radioactive nuclei.

Procedure

1. Your container should have 50 pennies. Record this starting amount for Trial 0.
2. Shake the container and pour them out over your lab table. Set aside all the pennies that landed with the heads side DOWN. Count the number of pennies remaining HEADS up. Record this number in your data table as the value for Trial 1.
3. Repeat Step 2 with the remaining pennies until you run out of pennies. In other words, when you no longer have any pennies with the heads side facing down.
4. Visit the other lab groups in class to record and share data so you can calculate an average for each trial.

Group Data Table

Trial	Number of Pennies Remaining (heads up)
0	50
1	
2	
3	
4	
5	
6	
7	
8	

Class Data Table

Trial	Group #1	Group #2	Group #3	Group #4	Group #5	Group #6	Group #7	Group #8	AVERAGE
0									
1									
2									
3									
4									
5									
6									
7									
8									

Results & Analysis

1. Describe what a radioactive isotope is.
2. What do the trial numbers in the activity represent? (Refer to the background for a hint.)
3. How does relative dating differ from radiometric dating? How can each type of dating be used when studying fossils?
4. Look at the graph in the background showing the decay of potassium-40, a radioactive isotope of potassium.
    a. Predict how long it would take to have only $^3/_4$ of the original sample of potassium-40
    b. Predict how long it would take to have only $^3/_8$ of the original sample of potassium-40.
    c. Predict how much of the original sample of potassium-40 would remain after five billion years.
5. Compare the "smoothness" of the potassium-40 curve in the background to the smoothness of your group's data points. How are they similar, and how are they different? How does the class average data compare to the graph in the background?
6. How well does this model represent the half-life of a radioactive isotope of an element? What are the limitations of this model?
7. Considering the decay of a radioactive isotope to a stable isotope, would it be possible to calculate how long it would take before the amount of the radioactive isotope reaches zero? Why or why not?