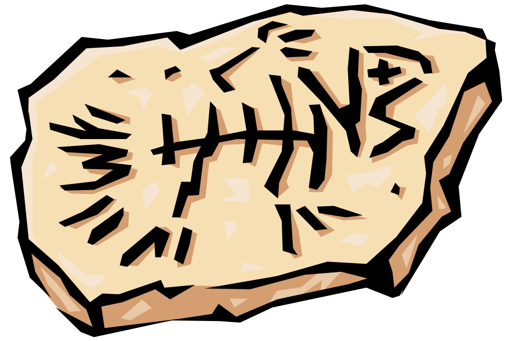
Determining a Fossil’s Age Mini-Lab



Problem:
Write this into your lab book:
How can you simulate radioactive half-life?

Background Information
Radioactive isotopes are used to date fossils and rocks. The dating is based on knowing four things:

1. the amount of the radioactive isotope in the rock when it formed
2. the element into which the isotope decays
3. the rate of decay
4. the amounts of isotope and new element in a rock or fossil

Isotopes are a version of an element with different number of neutrons from the usual version. Carbon can exist as ^{12}C, ^{13}C and ^{14}C. Certain isotopes are unstable and in order to reach a stable state, they release some of their subatomic particles. Sometimes these are harmful to the human body. In trace quantities, these are not harmful. These particles, (alpha and beta) are what constitutes its radioactivity. This type of isotope is called radioisotope.

All living organisms have some form of carbon. Inside each human are millions of ^{14}C radioactive atoms. As these isotopes decay we continue to replace them with foods we eat. However, once we die we cannot longer replace the isotopes. Over time the ^{14}C will decay to become stable isotopes. After thousands of years there will be no more ^{14}C in the dead organic material that was once you. By looking at the proportion of ^{14}C to other isotopes, we can get an idea of the age of a fossil.

However, rocks don’t eat and some do not contain carbon at all, so ^{14}C is not possible. Instead other radioisotopes are examined, such as ^{40}K (potassium-40). Once the minerals have hardened the number reduces as the radioisotopes decays into more stable forms.

The percentage or proportion of isotope decay can be transformed into years. This is determined by the time it takes half the radioactive isotope in a substance to decay. This is referred to as half-life. It takes 1.3 billion years for half of the radioactive isotope K-40 in a sample to decay (to change into Ar-40). This time is K-40’s half life. When a rock such as volcanic lava forms, it is assumed that the amount of K-40 in the rock is 100 percent and the amount of Ar-40 is 0 percent.

Procedure:

1. Place 100 pennies on the lab station.
2. Arrange the pennies so that their “head” sides are facing up. Each “head” represents an atom of K-40 and each “tail” represents and atom of Ar-40.
3. Record the number of “heads” present at the start of the experiment (should be 100).
4. Gather the pennies into a cup and shake the cup well. Let the shake represent one half life of K-40, which is 1.3 billion years.
5. Pour the pennies back onto the lab station and record the number of “heads” that are facing up.
6. Remove all the “tails” pennies. They will no longer be used in the procedure.
7. Repeat steps 4-6 for a total of 5 half lives (five shakes).
8. Collect class data to determine the average number of “heads” present at each half life.

Analysis

1. Create a data table in which you record the number of half lives that have passed, the years since the fossil was formed, and the number of 40-K atoms left in the sample.
2. Graph the average number of K-40 atoms (Y-axis) over time (X-axis). Connect the points with a smooth line. Remember, each half life represents 1.3 billion years.
3. Answer the following in complete sentences:
    a. Define the term “half life.” What procedural part of the simulation represented a half-life period of time?
    b. Pretend you are attempting to determine the age of a rock sample. Use your graph to read the rocks age is it has:
        i. 70% of its original K-40 amount.
        ii. 35% of its original K-40 amount.
        iii. 10 % of its original K-40 amount.
    c. Explain how scientists might use K-40 radioactive dating to approximate a fossil’s age.