STEM IN THE LAB

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Idaho National Laboratory

RADIO-CARBON DATING

Figuring out the age of fossils, bones, and other artifacts found in the Earth's crust is difficult. No one was around when they were buried, and no one could record in a history book the time they were laid in the Earth's crust. Recorded history only goes back a few thousand years, but Earth has been around for millions of years and things have been dying and being buried for most of that time. In the 1940's, scientists developed a process for determining the age of items found in Earth's crust. This method uses the characteristics of radiation (energy from atoms) to tell the age of the fossil. Many atoms give off radiation and most of the time people see radiation as a dangerous thing. But Radio-Carbon dating (the process discovered by Willard Libby to age bones in the 1940's) is a good use of radiation that helps us in this case to age once living items.

There are other uses of radiation that are helpful to humans. At Idaho National Laboratory, the Advanced Test Reactor and other reactors are used to develop radioactive isotopes to help in medical disease diagnosis, to help in building material strength analysis, and to produce battery materials for space exploration.

GRADE LEVELS: 5-9

VOCABULARY

Radioactivity- *the nucleus of an atom losing particles of energy slowly over time.*

Geologic Time- *the long period of time occupied by the earth's geologic history.*

Nuclear Reactor- *an apparatus or structure in which fissile material can be made to undergo a controlled, self-sustaining nuclear reaction with the consequent release of energy.*

Element Half-Life Decay- *The amount of time it takes for half an initial amount to disintegrate. In nuclear chemistry, (radioactive) half-life is defined, for a simple radioactive decay process, as the time required for the activity to decrease to half its value by that process.*

Chemical Isotopes- *When an element's atoms have different numbers of neutrons, they are said to be* isotopes *of that element. For example, Elemental Carbon has 6 neutrons and has an isotope which is used in dating items from the Earth's crust which has 8 neutrons. We say it is Carbon-14 (it is radioactive), while regular elemental carbon is Carbon-12, which is not radioactive.*

MATERIALS

- *Some heavy paper (like card stock or even cardboard).*
- *Scissors or a hole punch.*
- *Some markers, crayons, or colored pencils (8 to 10 colors).*
- *Some paper to make a table to record the decay information.*
- *Poster board for the extension (If you are going to make it).*

PROCEDURE

1. *Cut out or punch 50 circles (the size does not matter but smaller is better than bigger). Circles from the hole punch are nice, but small and harder to organize.*
2. *Mark two circles at a time with the same color (you can use the colors over and over but keep them in groups of two) for a total of 25 groups of two.*
3. *Make a chart to record the half-life decays of your isotope of Carbon 14. You need 6 columns and 7 rows. Go through 6 decays (example to follow):*

Chart: ***CARBON-14 HALF-LIFE DECAY***

Decay #	*#of atoms to start*	*#of atoms decayed*	*#of atoms remaining*	*#of years each decay*	*#of years old*
1					
2					
3					

4. *After each decay, there is only half of the atoms left. Because each time half of the atoms are reduced by losing the neutron that are radioactive. This is half-life decay. In this example, you will only do 6 decays but in real life this process goes on forever because the radioactivity is never completely reduced, even though it gets small after 7-8 decays.*
5. *Begin the first decay by recording 50 atoms in the "atoms to start column." Now, remove 25 of the circles of any color from the 50. Then, record 25 atoms decayed and 25 atoms remain- 5730 years for each decay and 5730 years old.*
6. *For decay number 2 in the chart, record 25 atoms to start. Remove 12 ½ atoms (take scissors and cut one atom in half). Record 12½ decayed, 12½ remaining, 5730 years for each decay, and 11,460 years old. (Each time the number of years for the decay is still 5730 but the years old adds 5730 to the total each decay. 5,730 becomes 11,460 which becomes 17,190 years and so on through each decay).*
7. *Keep cutting the same- already cut- atom for each half-life after number 2 (for number 3, you will half it again to ¼ and after number 4 it will be cut again in half to 1/8 and so on to the last half-life).*
8. *Make more or less circles and redo the decays of a longer or shorter half-life element or fewer or more decays of Carbon-14.*

QUESTIONS

1. *How old is the bone after 6 decays?*
2. *How many atoms are left after 6 decays?*
3. *How many half-lives does it take until it is all gone?*
4. *How many half-lives is it until there is less than one atom remaining?*
5. *If we started with a tablespoon of a sample (about 10 grams, which is a small sample and it had 200,000 atoms in it) how much would be remaining after 6 half-lives?*

THE SCIENCE BEHIND IT

Slowly over time, radioactive Carbon 14 loses its extra neutrons to drop from 8 down to 6 and become regular Carbon 12. They fall out of the nucleus of each atom as energy loss. Every radioactive element decays this way. Some elements lose them faster (in a second or two) and some lose them much slower (many years). Carbon 14 loses them slowly. It loses half of them every 5730 years- that means Carbon 14 has a half-life of 5730 years. Some other element half-lives: Hydrogen is 12.32 years, Plutonium is 24,100 years, Cesium is 30.17 years, Californium is 2.6 years, and Francium is 22 minutes.

Radio-Carbon dating works by measuring the amount of radioactive Carbon 14 left in the sample (bone or fossil) right now. We know how much living tissue had in it when it was alive and now the difference between the current samples' amount. The amount when the plant or animal was alive is calculated to find the number of half-lives since death. Then using the length of the half-life, the scientist can calculate the number of years the bone or fossil is. This process can be used for any living organism because we all have Carbon 14 in our tissues.

EXTENSIONS

- *Look up a geologic time chart on the internet and create your own version of the timeline with names of each of the ages and pictures and drawings that go with each age. Pick one that is colorful and creative to use for your template.*
- *Using the same Geologic Time chart. Pick your favorite time period and explore the earth's crust, climate, plants, and animals that may have existed. Now, make a billboard on a larger piece of paper (newsprint) or poster board to highlight the time period and what you liked about it. Make it colorful and creative.*
- *Look up the half-life lengths for twenty different atomic isotopes and create a half-life chart. Some elements have more than one isotope of themselves, so it could be fun to use more than one isotope of the same element in your chart.*

RESOURCES

- *https://www.ducksters.com/science/chemistry/radiation_and_radioactivity.php*

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