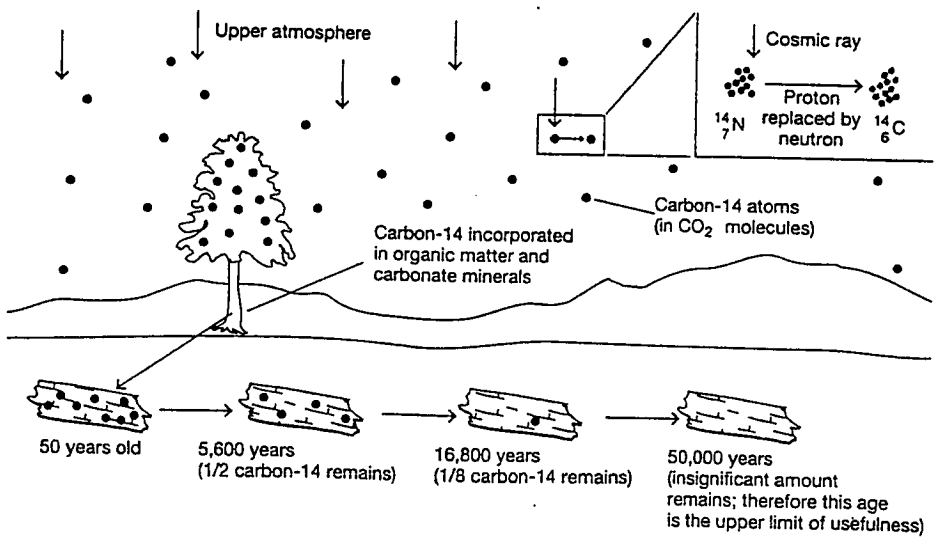
Teaching Activity: Making a Model of Half-Life

Introduction: The discovery of *radioactive elements* in the late 19th century led to the development of an accurate method of determining the absolute age of rocks and fossils, and at the same time providing information about past climate conditions. An atom of a radioactive element (^{14}C, ^{3}H) has an unstable *nucleus*, or center, that breaks down, or decays. During radioactive decay, particles and energy called *radiation* are released by the radioactive element.

As radioactive elements decay they form decay elements. The breakdown of the radioactive element into the decay element occurs at a constant rate. Some decay in a few seconds, others take hundreds, thousand or even millions of years. No matter how long it takes for that element to break down, the rate of decay is absolutely constant. No known force can either speed it up or slow it down.

Parent Element	Half-life (years)	Daughter Element	Type of Decay
Carbon-14	5730	Nitrogen-14	Beta
Potassium-40	1300 million	Argon-40	Electron capture
Rubidium-87	47,000 million	Strontium-87	Beta
Uranium-235	713 million	Lead-207	Seven alpha and four beta
Uranium-238	4510 million	Lead-206	Eight alpha and six beta

Scientists measure this decay rate by a unit called *half life*. The half-life of an element is the time its takes for half of the radioactive element to decay. For example, if you begin with 1 kilogram of a radioactive element, half of that kilogram will decay during one half-life. So at the end of one half-life you will have 0.50 kilograms of the radioactive element that you started with and 0.50 kilograms of the decay element. Half of the remaining element will decay in another half-life and so on. This process continues until the radioactive element has decayed and a completely different element is created. Carbon -14 is radioactive and present in all living things. It has a half-life of 5770 years. At the end of its decay period it will have decayed into nitrogen. Nitrogen is the *decay element* of carbon-14.



The Carbon-14 Cycle

Objective:

To model the half-life of a simulated radioisotope;

Important Terms: Radioisotope, half-life, decay, decay element, nucleus, radioactivity;

Materials: Empty box, 200 pennies, **Student Activity Sheet**, graph paper, ruler;

Procedure:

1. Go over the **Introduction** with the class.
   - Make a transparency of the half-life model for discussion.
   - Be sure that students understand the breakdown process (eg. 0.5, 0.25, etc).

2. Provide groups of students with boxes containing 200 pennies tail up, which represent the atoms of radioactive material. The cover should be placed securely on the box.
   - Instruct students to shake the box with one quick up and down motion.

3. Students should then remove the cover and take out all the pennies that are heads up.
   - In the **Data Table** students should record the number of pennies removed and the number of pennies remaining.

4. Students should repeat steps 2-3 until all the pennies have been used up (or 20 times).

5. When students have complete the modeling part of the activity, they should prepare a line graph of their data.
   - Y-axis: Number of Radioactive Atoms
   - X-axis: Elapsed Time

5. When they have completed compiling and graphing their data, students should answer the **Analysis and Comprehension** question.

Student Activity Sheet: Making a Model of Half-Life

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As radioactive elements decay they form decay elements. The breakdown of the radioactive element into the decay element occurs at a constant rate. Some decay in a few seconds, others take hundreds, thousand or even millions of years. No matter how long it takes for that element to break down, the rate of decay is absolutely constant. No known force can either speed it up or slow it down.

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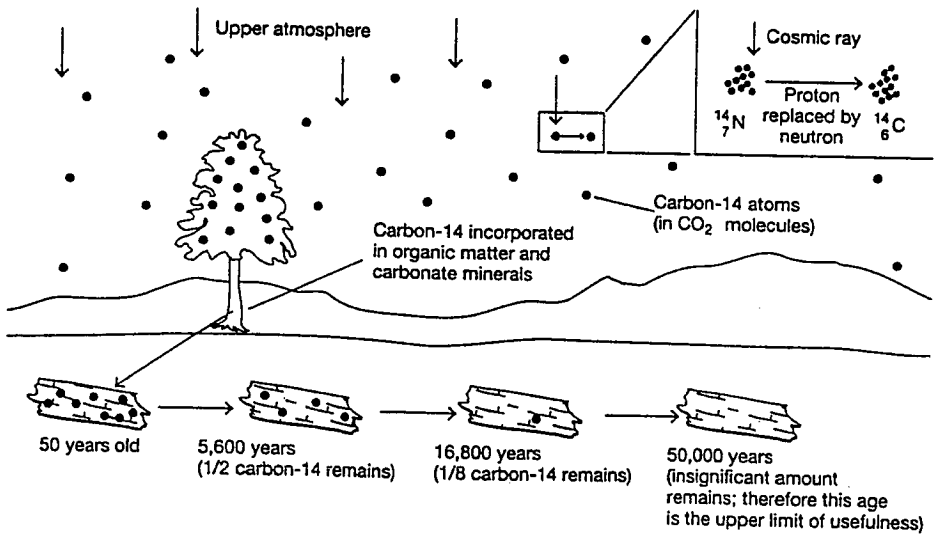

The Carbon-14 Cycle

Objective:

- To model the half-life of a simulated radioisotope;

Procedure:

1. Read over and discuss the Introduction with the rest of your class.
    - Be sure that you understand the breakdown process:
      0.50 -> 0.25 -> etc.,

2. With your group, begin the modeling part of the activity.
    - Shake the box of pennies once up and down.
    - Take off the cover and remove the pennies that are head up.
    - Records the number of pennies removed and the number of pennies remaining on the **Data Table.**

3. Repeat #2 until all of the pennies are used up.

4. Prepare a line graph of your data:
   Label the Y-axis : Number of Radioactive Atoms
   Label the X-axis: Number of Decayed Atomss

5. Answer the questions in the **Analysis and Comprehension** section.

Student Activity Sheet #1

PART I: DATA TABLE: RADIOACTIVE DECAY

ELAPSED TIME	NUMBER OF RADIOACTIVE ATOMS	NUMBER OF DECAYS
0	200	0

PART II: ANALYSIS AND COMPREHENSION

1. What do the pennies in the model represent?

_____

_____

2. What do the coins with heads up represent? _____

_____

Student Activity Sheet #2

3. What is the half-life of your radioactive sample? _____

4. Would the half-life for your sample be different if 1000 pennies were used? Why?_____

_____

5. How many half-lives would it take before carbon -14 transforms into a stable element?_____

6. What would be the upper age of its usefulness in dating fossils or other materials? _____

7. How does the model demonstrate the concept of half-life? _____

_____

_____

8. What would be a limitation of the isotopes used for radiometric dating? _____

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