Half-Life Dating

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Topic

Half-life dating

Time

1 hour

Safety

Please click on the safety icon to view the safety precautions.

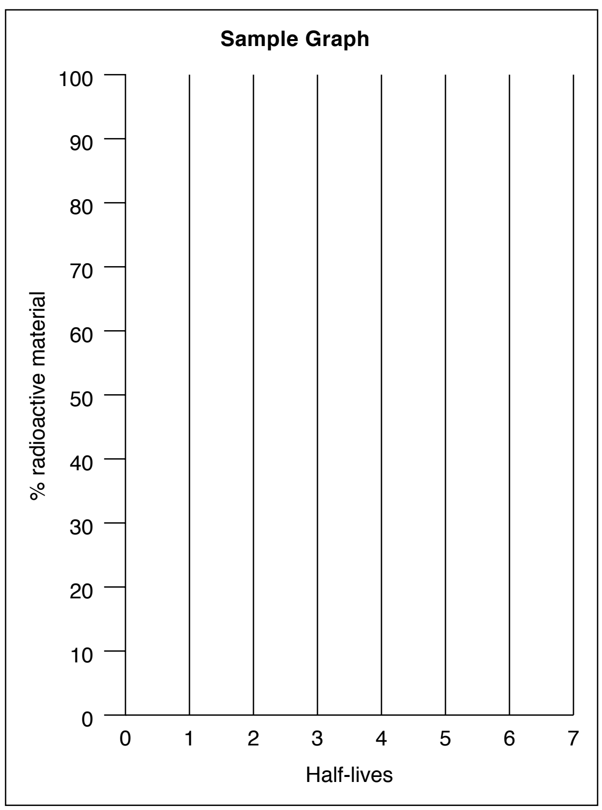
Materials

- two pieces 8½-in. 2 11-in. graph paper
- one piece of cardboard several inches larger than the graph paper
- twelve 10-in. licorice sticks (four red and eight black)
- white glue
- scissors or knife ruler

Procedure

1. Glue one of the two pieces of graph paper to the cardboard. Now draw two identical graphs, following directions below, on the two pieces of graph paper.
2. Draw a vertical scale about 1 in. from the paper's left edge, and label it "% radioactive material" (see sample graph).
3. Draw a horizontal scale and label it "Half-lives."
4. Glue one red licorice stick to the vertical axis of the cardboard-backed graph. Write "100%" on the vertical scale at the top of this stick. (Red licorice represents radioactive material.) Measure the length of the stick, and write "100%" at the corresponding point on the vertical scale of the second graph without the licorice.
5. Divide and label the vertical scales of both graphs to show percentage by 10s, with the height of the licorice stick equaling 100% and the horizontal axis at 0%.
6. Divide the horizontal axes of both graphs at 1-in. intervals. Label from 0 (zero) to 7, with 0 being the point at which the vertical axis intersects the horizontal. Then draw vertical lines at each numbered point up to the height marked at 100% on the vertical axis.
7. Take another red licorice stick and cut it in half. Glue one-half on the cardboard-backed graph on the vertical line marked "1" on the horizontal (half-life) axis. Glue half of a black stick above the red half to create a composite full-length stick. (The black licorice represents the stable material formed as the radioactive material decays.) Mark line 1 of the unbacked graph at the height equal to the red licorice.

8. Now take the other half of the red stick and cut it in half again. Glue one portion onto the cardboard-backed graph on line 2 to represent the amount of radioactive material remaining after 2 half-lives. Above it, add the length of black licorice needed to completely cover the vertical line, and make the stick equal with the others. Again, mark the place on the other graph's line 2 that corresponds to the height of the red licorice on the cardboard-backed graph.
9. Cut the remaining piece of red licorice in half again. Glue and repeat the procedure above, including marking the height of the red licorice on the second graph.
10. Continue until you run out of room on your graph or until the small amount of the remaining licorice makes accurate division impossible.
11. On the graph without the licorice, draw a smoothly curving line that follows the points marked on the vertical lines. You may eat the remaining licorice, but save one whole red stick for further analysis.
12. Assume that each half-life (space between marks on the horizontal axis) represents 5,500 years. Determine the age represented by each red licorice segment. (The half-life of carbon-14, which is commonly used to date plant and animal remains, is about 5,500 years.)
13. Have someone cut the remaining whole piece of red licorice into varying lengths. Assume that the pieces represent amounts of remaining carbon-14. Again, assume that each half-life on the graph is 5,500 years. By finding the correct places for the new pieces of red licorice (carbon-14) on the graph, estimate the age of each new segment.



What's Going On

The ages represented by the segments on the graph are as follows: (1) 5,500 yr (2) 11,000 yr, (3) 16,500 yr, (4) 22,000 yr, (5) 27,500 yr, (6) 33,000 yr, (7) 38,500 yr. You should be able to determine the ages of the additional randomly cut lengths by placing them according to height. For the smallest pieces, it is very difficult to accurately estimate age. This reflects a real problem in half-life dating, which is most accurate between the second and fourth half-lives of an element. After the seventh or eighth half-life of a substance has been reached in a dating procedure, scientists generally begin using a different isotope with a higher percentage of radioactivity present in order to preserve accuracy.

Every radioactive element decays (becomes stable) at a unique rate. The half-life of an element is the amount of time it takes for half of a given number of atoms of that element to become stable. The age of objects that contain radioactive isotopes with known half-lives can thus be calculated by determining the percentage of radioactive material remaining. In this experiment, you constructed a model that demonstrates the principle of half-life dating.

Connections

In the late 1940s, by comparing carbon-14 and carbon-12 in a sample, scientists discovered that radioactive dates could be determined. Now, after improving their techniques and with new technological advances, scientists are able to date events back to the last Ice Age.

Safety Precautions

READ AND COPY BEFORE STARTING ANY EXPERIMENT

Experimental science can be dangerous. Events can happen very quickly while you are performing an experiment. Things can spill, break, even catch fire. Basic safety procedures help prevent serious accidents. Be sure to follow additional safety precautions and adult supervision requirements for each experiment. If you are working in a lab or in the field, do not work alone.

This book assumes that you will read the safety precautions that follow, as well as those at the start of each experiment you perform, and that you will *remember* them. These precautions will not always be repeated in the instructions for the procedures. It is up to you to use good judgment and pay attention when performing potentially dangerous procedures. Just because the book does not always say "be careful with hot liquids" or "don't cut yourself with the knife" does not mean that you should be careless when simmering water or stripping an electrical wire. It *does* mean that when you see a special note to be careful, it is extremely important that you pay attention to it. If you ever have a question about whether a procedure or material is dangerous, stop to find out for sure that it is safe before continuing the experiment. To avoid accidents, always pay close attention to your work, take your time, and practice the general safety procedures listed below.

PREPARE

- Clear all surfaces before beginning work.
- Read through the whole experiment before you start.
- Identify hazardous procedures and anticipate dangers.

PROTECT YOURSELF

- Follow all directions step by step; do only one procedure at a time.
- Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eyewash, and first-aid kit.
- Make sure that there is adequate ventilation.
- Do not horseplay.
- Wear an apron and goggles.
- Do not wear contact lenses, open shoes, and loose clothing; do not wear your hair loose.
- Keep floor and work space neat, clean, and dry.
- Clean up spills immediately.
- Never eat, drink, or smoke in the laboratory or near the work space.
- Do not taste any substances tested unless expressly permitted to do so by a science teacher in charge.

USE EQUIPMENT WITH CARE

- Set up apparatus far from the edge of the desk.
- Use knives and other sharp or pointed instruments with caution; always cut away from yourself and others.
- Pull plugs, not cords, when inserting and removing electrical plugs.
- Don't use your mouth to pipette; use a suction bulb.
- Clean glassware before and after use.
- Check glassware for scratches, cracks, and sharp edges.
- Clean up broken glassware immediately.

- Do not use reflected sunlight to illuminate your microscope.
- Do not touch metal conductors.
- Use only low-voltage and low-current materials.
- Be careful when using stepstools, chairs, and ladders.

USING CHEMICALS

- Never taste or inhale chemicals.
- Label all bottles and apparatus containing chemicals.
- Read all labels carefully.
- Avoid chemical contact with skin and eyes (wear goggles, apron, and gloves).
- Do not touch chemical solutions.
- Wash hands before and after using solutions.
- Wipe up spills thoroughly.

HEATING INSTRUCTIONS

- Use goggles, apron, and gloves when boiling liquids.
- Keep your face away from test tubes and beakers.
- Never leave heating apparatus unattended.
- Use safety tongs and heat-resistant mittens.
- Turn off hot plates, bunsen burners, and gas when you are done.
- Keep flammable substances away from heat.
- Have a fire extinguisher on hand.

WORKING WITH MICROORGANISMS

- Assume that all microorganisms are infectious; handle them with care.
- Sterilize all equipment being used to handle microorganisms.

GOING ON FIELD TRIPS

- Do not go on a field trip by yourself.
- Tell a responsible adult where you are going, and maintain that route.
- Know the area and its potential hazards, such as poisonous plants, deep water, and rapids.
- Dress for terrain and weather conditions (prepare for exposure to sun as well as to cold).
- Bring along a first-aid kit.
- Do not drink water or eat plants found in the wild.
- Use the buddy system; do not experiment outdoors alone.

FINISHING UP

- Thoroughly clean your work area and glassware.
- Be careful not to return chemicals or contaminated reagents to the wrong containers.
- Don't dispose of materials in the sink unless instructed to do so.
- Wash your hands thoroughly.
- Clean up all residue, and containerize it for proper disposal.
- Dispose of all chemicals according to local, state, and federal laws.

BE SAFETY-CONSCIOUS AT ALL TIMES