Name______________________
Date___________________
Per___________

Introduction

The discovery of radioactivity in the late 1800's allowed scientists to develop new methods of determining the absolute age of rocks. Since it's not safe for us to play with radioactive isotopes, we will use pennies to simulate radioactive decay. The plastic box in this lab represents an imaginary rock. Suppose that 100 heads-up pennies in your box represent atoms of an imaginary radioactive element called Headsium. When Headsium "decays", it becomes a different imaginary element called Tailsium, which is stable (non-radioactive). After you shake the box for 15 seconds, approximately half the pennies will have decayed (flipped over) to stable Tailsium. Thus 15 seconds is the half-life of Headsium.

Materials: Plastic box with lid, 100 pennies, zip-lock bag

Procedure:

1) Place 100 pennies heads-up in the box.
2) Close the box and shake it vigorously for 15 seconds
3) Remove and count "stable" Tailsium atoms, then place them in the zip-lock bag.
4) Record in Table 1 the TOTAL number of Tailsium "decayed so far under the heading "Number of stable Tailsium".
5) Record in Table 1 the number of Headsium remaining in the box under the heading "Number of Radioactive Headsium".
6) After placing the Tailsium "atoms" in the bag, close the bag and put the Tailsium bag in the box.
7) Repeat steps 2-6 three more times, recording the results each time. At this point, you will have simulated 4 half-lives.

Results:

Table 1

Number of Half-lives	Number of Stable Tailsium	Number of Radioactive Headsium
0		
1		
2		
3		
4		

Prepare a graph above by plotting the number of half-lives on the X-axis and the number of radioactive Headsium on the Y-axis.

Check for understanding:

Any event that happens at a steady rate over a long period of time can be considered a clock. Like a ticking clock, radioactive elements decay to stable non-radioactive elements at a steady rate. For example, half of the Uranium-238 in an igneous rock will decay to non-radioactive Lead-206 in 4.5 billion years. Another example is Carbon-14; half the C-14 will decay to stable Nitrogen every 5760 years.

1. Describe the appearance of your graph line. Is it straight or curved?

2. How many undecayed Headsium atoms would remain in a sample of 600 Headsium after three half-lives?

3. If 175 Headsium remain from a sample of 2800, how many half-lives would have passed?

4. You are a geologist who is about to stake claim to a diamond deposit, but first you need to know the age of the igneous rocks in the area. In your fancy laboratory, you measure the Headsium and Tailsium in the igneous rock and discover that one-eighth of the Headsium remains.
   - How many half-lives have passed?
   - If the half-life of the Headsium were 150 million years, how long ago did the igneous rock crystallize? **Show your work.**

5. I'm going to give you $1,000 (dream on!) but you must spend only ½ of it in the first year, ½ of the balance the second year, etc. One year thus represents one half-life of the $1,000.
   - If you spend the maximum allowed each year, at the end of what year would you have $31.25 left?
   - How much would be left after 10 half-lives?

Teacher Notes for Half-life Activity

This activity was originally designed by Jim LaFortune, a colleague of mine in the science department at Moscow Jr. High School. It is designed to be implemented in a 47-minute class period.

This activity does require some prior preparation. You will need a plastic box (with a lid) about shoe box size for each pair of students (we found some made by Rubbermaid works pretty well). You will need to go to the bank and secure enough pennies so that each pair of students has 100 pennies to use plus additional 50 or so pennies to account for escapees. We also purchased small Zip-Lock freezer bags to put the Tailsium pennies in. Isolating the pennies that have “decayed” keeps them from re-entering the radioactive element pool. We started putting the pennies into the Zip-Lock bags after piloting the lab the first year. Students were coming away from the lab thinking that once a radioactive element decayed, it left the rock, never to return. By putting the pennies into the Zip-Lock bag, closing it up and then reinserting it back into the box, the model seemed more accurate. We have tried using different zippered sandwich bags but they do not seem to hold up to the rigor of shaking.

The activity needs little introduction beyond that which is presented on the activity sheet. I had my students read the night before the lab that portion of their text pertaining to radioactive decay which also helped. Just a word of caution: students realize that this activity is loud and will play it up (which makes the lab more fun). Students over exuberance sometimes results in multiple pennies ejected from the box which then scatter over the classroom. When this happens, just have them record the pennies as they land (heads-up or tails-up) on the floor (heads-up or tails-up). If the penny ends up heads up, back in the box it goes; if tails up, into the bag. If you do this activity 5 or 6 times during the day, plan on something for a headache at the end of the day.

In the Check for understanding portion of the activity, some students will use proportions and their graph to solve the problem. Others will use a running total created by cutting each remaining number of radioactive elements in half the desired number of times. For ease of correcting, the latter method works better but as long as students show how they arrived at the answer and the method is correct their responses should be considered correct.