Half Lives Tell the Whole Story (or Hot Pinkium)

I. Background

Topic: Radioactive Dating
Time: 45 minutes
Level: 7th Grade
Text Used: This is adapted from Investigating Science with Dinosaurs by Craig Munsart.

II. Standards Addressed

Grade 7:
Standard 4d: Students know that evidence from geologic layers and radioactive dating indicates Earth is approximately 4.6 billion years old and that life on this planet has existed for more than 3 billion years.
High School Chemistry:
Standard 11c: Students know some naturally occurring isotopes of elements are radioactive, as are isotopes formed in nuclear reactions.
Standard 11f: Students know how to calculate the amount of a radioactive substance remaining after an integral number of half lives have passed.

III. Concepts Students Will Know

Radioactive—the an atom that is not stable so it gives off particles
Half-life--the time it takes for half of something radioactive to change into another form that isn't radioactive
Radioactive dating--a method scientists use to figure out how old something is by looking at how much of a radioactive element that is in a rock, etc

IV. Materials (per group, 2 students each)

32 2-colored squares in a Ziploc™
"Bone" in plastic cover sheet
Data table
Data table overhead
Radioactive dating reading
Pencil

V. Procedure

A. Introduction/Hook:

As students enter, they science journal the question: "How old is the earth? What are some ways you think scientists might tell how old the earth is?" Discuss.

B. Background:

1. If it is not mentioned, point out the vocabulary words on the board. Ask them to look for these words as the class is reading. Read "How Do We Know How Old Things Are?"
2. Talk through any hard points and review vocabulary.
3. Choose two students to model how this works. Ask the students to begin at one end of the room and give each specific directions. One student should take 2 steps every time you say go; the other student should travel half the distance, then half of the remaining distance, etc. each time you say go. When they finish, ask "From our reading which one of these is like radioactive decay?"

C. Activity:

1. Explain that they will be looking at how scientists look at radioactive decay. They will be looking at the radioactive element "Pinkium" which turns into "Carbonium". This is a lot like how Carbon-14 turns into Nitrogen-14.Explain that only living things can take in pinkium.
2. Distribute the 2 colored squares, the bones and the data table. Have students place the 32 squares pink side up on the bone.
3. Remind students that only living things can take in pinkium. Fill in the top three columns of the line "Living Animal" in the data table. Solicit from them how many parts pinkium and carbonium they have. Tell them there have been no half lives because the organism is still living. Skip the calculated age temporarily.

4. Tell the students the animal is now dead and now the radioactive decay has started. During each half life, half of the pinkium that is in the bone will turn into the new stable element carbonium. We will call these half lives trials.
5. Walk students through trial one. Explain half of the pinkium has now turned into carbonium (we show this by flipping the squares over). Solicit the answer to what is half of 32.
6. Guide students in completing the first 3 blanks of trial 1. Students should now have 16 pinkium papers and 16 carbonium papers. The bone has gone through one half-life.
7. Briefly discuss trial 2. Decide what is half of the remaining pinkium (8) and turn these for trial 2. Fill in trial 2 on the chart: 8 pinkium, 24 carbonium, trials 2.
8. Tell students to complete through trial 6 using the same method. Remind them that the pinkium should not be bent torn or destroyed. Remind students to enter the data at the end of each trial.
9. Pont out that the half life of pinkium is 1,500 years. Point out that the living animal would be new or living since no decay is happening yet. Fill in that trial 1 takes 1,500 years.
10. Let students complete this last data column, concluding that the bone is 9,000 years old.
11. Plot the data on the graph using x for pinkium and o for carbonium. Pinkium begins at 32 and carbonium begins at 0. Take predictions on what the graph will look like. Student finish graph.
12. Discuss what would happen in additional trials. Emphasize that pinkium never reaches 0.
13. Students complete summary questions, then discuss.

VI. Processing Questioning, Discussion, and Assessment

See Activity # 10, 11 and 12. Students will also complete the questions mentioned in #13.

VII. Extension/Integration

A. Math Connection: with calculators, students can multiply 32 (or whatever number) by .5, then the answer by .5, etc. to show that the answer will get smaller and smaller, but not reach 0.

B. Local Connections: Radioactive dating helps us date many local artifacts.
Dating bones of Chumash found at Arlington Springs: http://www.sbnature.org/chumash/timel.htm
Dating Shell beads: http://www.californiaprehistory.com/reports01/rep0020.html
Dating Rock Art: http://www.asa-online.org/library/asabulletin_v24i1.pdf
Dating of the recent pygmy mammoth find:
http://www.sbnature.org/htmls/mammoth.htm

C. Literature Connections:
Dating Dinosaurs and Other Old Things by Karen Liptak (Ages 12+)

VIII. Resource List

A. Background information:
Radiometric Dating: http://www.dc.peachnet.edu/~pgore/geology/geo102/radio.htm
How Carbon-14 Dating Works: http://www.howstuffworks.com/carbon-14.htm/
Visual Decay Model: http://lectureonline.cl.msu.edu/~mmp/applist/decay/decay.htm
Radioactive Decay Calculator: http://www.bioscience.org/urllists/decay.htm

B. Existing Activities: This is a fairly standard activity with many variations. Here are a few I found:

1. At the elementary school level:
   - Using dice http://www.iit.edu/~smile/ph9495.html
   - Using candy corn http://www.iit.edu/~smile/ph9004.html
2. At the middle school level:
   - Using pennies http://www.exploratorium.edu/snacks/radioactive_decay.html
   - Using M&M's http://www-ed.fnal.gov/samplers/hsphys/activities/ctshalfstud.html
     http://www.esc20.k12.tx.us/etprojects/formats/webquests/spring2001/oconnor/chwq/M&MGrid.pdf
3. A high school series of 3 lessons can be found at sciencenetlinks.com.
   - Isotopes of Pennies: This lesson develops the idea of isotopes having different masses using pennies made before 1982 and after 1982.

http://www.sciencenetlinks.com/lessons.cfm?DocID=176

- Radioactive Decay: A Simulation of a Half-life using M&M's. http://www.sciencenetlinks.com/lessons.cfm?DocID=178
- Frosty the Snowman Meets His Demise: An Analogy to Carbon Dating using partially melted ice. http://www.sciencenetlinks.com/lessons.cfm?DocID=171

How Do We Know How Old Things Are?

In the early 1800's, many scientists thought the earth was very old. But they didn't have reliable ways of estimating how old the earth really was. Some scientists tried to use the salinity of the ocean (how salty it is). Other scientists looked at how thick the rock layers were in different places.

It wasn't until the early 1900's that a French scientist found a new more reliable way to find the ages of things. All the matter in the world is made up of tiny particles called atoms. He discovered that some atoms give off smaller particles. These atoms are unstable and we call them ***radioactive***. Radioactive atoms eventually turn into other types of atoms that are stable. The process of a radioactive atom turning into a stable atom is called ***radioactive decay***.

Radioactive atoms decay at different rates. A ***half-life*** is the time it takes for half of something radioactive to change into another form that is more stable. Each time it goes through a half-life the object loses half of that type of radioactive atom. When there are lots of atoms together that are the same, they are called an element. The element keeps the same name as the atom, as in gold, oxygen, and mercury.

When scientists know the rate at which an atom decays, they can look for that specific element to figure out how old the object is. This method, called radioactive dating, works backwards to roughly predict the age of something based on the amount of one or more radioactive elements.

Some radio active elements are:

Element	Half-Life
Oxygen-14	71.0 seconds
Plutonium-246	10.9 days
Cobalt-60	5.26 years
Carbon-14	5,730 years
Chlorine-36	310,000 years
Potassium-40	1.28 millions years
Uranium-235	710 million years
Uranium-238	4.5 billion years
Vanadium-50	6,000,000,000,000 000 years

Not all radioactive elements happen naturally and can be used to date rocks or living things! The kinds we normally use are:

Element	Useful Range
Carbon-14	100 years - 30,000 years
Potassium-40	100,000 years - 4,500,000,000 years
Uranium-235	10,000,000 years - 4,600,000,000 years
Uranium-238	10,000,000 years - 4,600,000,000 years

Pinkium: What did You Learn?

After finishing your data table and graph, answer the following questions. Use complete sentences for numbers 4, 5, and 6.

1. How old is the bone after 6 half lives? _____

2. How much carbonium would be present in trial 8? _____

3. After how many half lives was carbonium at 30? _____

4. Will the amount of pinkium ever reach 0? Why or why not? _____

_____

_____

_____

_____

5. What do you see happening in the graph? (What happens to pinkium? Carbonium?)

_____

_____

_____

_____

6. How does radioactive dating help us figure out how old something is? _____

_____

_____

_____

_____

Fill in the vocabulary words.

Radioactive_____

_____

Half-life _____

_____

_____

Radioactive dating _____

_____

_____