Old Ice and Radioactive Decay

Primary Subject: Science

Grade Level: 6-9

Students Should Be Able to:
- Understand the concept of half-life
- Describe the process of carbon-14 dating
- Relate the analogy of the M&M to C-14 dating methods and the dating of ice cores

Part 1: Establish Background
Introduce students to atoms, isotopes, radioactivity, and the process of using radioactive carbon-14 as a dating technique via lecture, notes, and discussion.

Students should be able to Answer the following questions:

> *What does it mean when something is radioactive?*
>
> *What is half life?*
>
> *How can radiocarbon dating be used to determine the age of an organic artifact?*

Part 2: Hands-on Activity
Introduce this activity as an analogy to radiocarbon dating, so that students will consider what they know about using the predictable nature of radioactive isotopes while performing the activity. This activity should serve as a review of radioactive decay and half life.

Materials

Each student, pair, or group will need the following:
- 100 candy pieces (M&M's, coins, etc.) in a resealable bag
- Student Activity Sheet

Part 3: Making Connections
Have students read the Making Connections information page independently.

NOTE: While the current limit on carbon dating is believed to be about 60,000 years, it is still disputed among scientists. This number has changed significantly since the 1950s due to improvements in technology. The development of accelerator mass spectroscopy (AMS) dating in the late 1970s now allows a date to be obtained from a very small sample. For more information see Curry 2004.

Part 4: Application
Remind the students that the half life of potassium is 1.5 billion years. Break the students into groups of 2-3 and figure out the first word problem.

A: 1.5 billion years

Regroup as a class and discuss what the students have come up with. Ask them how they got their answer, what the process looked like, what they found confusing, etc. Then, have them answer the second question.

A: 3 billion years old

Regroup as a class and discuss what the students have come up with. Ask them how they got their answer, what the process looked like, what they found confusing, etc.

NOTE: The oldest Antarctic ice is only estimated to be roughly 2.5 million years old, and is therefore not old enough to be even one half-life old. With several other climatic conditions coming into play, Antarctic scientists are working with math that is much more involved. These numbers were simply created to introduce the concepts we use in a straightforward way so that students can get a basic understanding of what we do.

(Optional) **Part 5:** Website Extension Activity
Depending on computer access, have students work in groups of 2-3 to answer the questions. Regroup as a class and discuss the answers to the questions.

Name:________________________ **Date:**_______________

Radioactive M&Ms

What you need:

• plastic bag
• One bag of M&Ms (can use coins)

Directions:

1. Open your bag and count your M&Ms and record the number in the table below.
2. Put the M&Ms back into the bag and seal the bag and gently shake for 10 seconds.
3. Gently pour out candy.
4. Count the number of pieces with the print side up. These atoms have "decayed." Record the number in the table below.
5. Return only the pieces with the print side down to the bag. Reseal the bag.
6. Consume the "decayed" atoms.
7. Gently shake the sealed bag for 10 seconds.
8. Continue shaking, counting, and consuming until all the atoms have decayed. Make sure you record the numbers in the table each time, with the number of decayed atoms being cumulative.

Half-life	# of Un-decayed Atoms	# of Decayed Atoms
1		
2		
3		
4		
5		
6		
7		
8		

Reflection Questions:

9. In terms of radioactive decay, what does the whole bag of M&Ms represent?

10. What do the M&Ms that you set aside represent?

11. Determine the half-life of your M&Ms by finding out how many periods of shaking it took for approximately half of the atoms to decay. What is the half-life?

12. If period of shaking of the bag equals 1,000 years of time, what is the half-life in years of your M&Ms?

Name:________________________ **Date:______________**

Old Ice and Radioactive Decay

Making Connections:

How do scientists know how old those giant redwood trees in the Northwest are? Just how long ago did the dinosaurs roam the Earth? By now you now that much of this information is the result of our knowledge of radioactivity and carbon-dating. In the case of carbon dating, living organisms accumulate carbon-12 and carbon-14 in their bodies through the consumption of organic matter. This ratio is the same as what is found in their surrounding environment. When a living organism dies, it stops taking in new carbon. While carbon-12 is stable isotope, carbon-14, with a half-life of 5,700 years, is unstable and starts to decay. By looking at the ratio of carbon-12 to carbon-14 in the sample and comparing it to the ratio in a living organism, it is possible to determine the age of a formerly living thing fairly precisely. Because the half-life of carbon-14 is 5,700 years, it is only reliable for dating objects up to about 60,000 years old. The ice in Antarctica is far older than this, in fact, the ice at Allan Hills, Antarctica can be up to 2.5-2.8 millions years old! So how can we determine the age of this ancient ice?

The principle of carbon-14 dating applies to other isotopes as well. Potassium is an extremely common element. Although most potassium isotopes aren't radioactive, one of them is. Potassium-40 decays into argon-40. Although potassium is a solid, argon is a gas. When rock is melted (think lava and ash), all the argon in the rock escapes, and when the rock solidifies again, only potassium-40 is left. The melting of the rock and releasing of any argon set the potassium-argon clock to zero. Potassium-40 has a half-life of 1.5 billion years! As time passes, argon accumulates as a result of radioactive potassium decay. When scientists analyze these rocks and compute the ratio of argon to potassium, they can determine how long it's been since the lava or ash cooled.

Volcanic ash is often found in ice cores collected from Antarctica. When volcanoes erupt, the ash that they release into the atmosphere also get trapped in glacial ice in the form of tiny bubbles of air trapped between ice crystals. By measuring the ratio of K to Ar in ash from a volcanic eruption, the age of the eruption, and therefore the age of the ice in which the ash is found, can be determined. Using this knowledge, Antarctic researchers are determining the age of ice in Antarctica.

Name:_________________________ **Date:**_______________

Practice:

Europa, one of Jupiter's moons, is an icy environment just like Antarctica. Due to limitations in technology, as Jupiter's moons are very far away, scientists are unsure just how old the ice is up there. The following sample problems are intended to give you practice in potassium-argon dating.

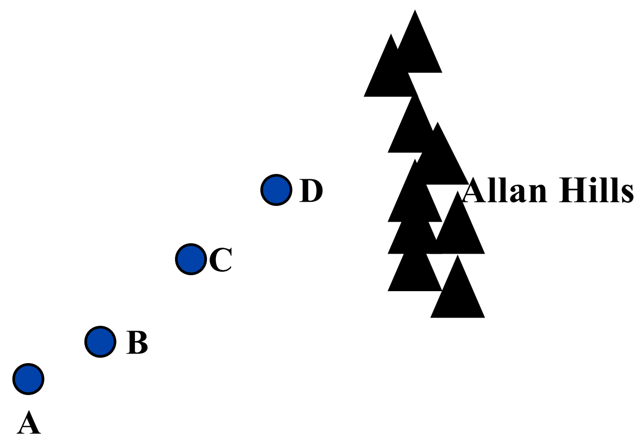
1. *A scientist has taken an ice core sample from Jupiter's moon Europa that contains 200 kg of Potassium-40 and 200 kg of Argon-40, how long ago did this ice form?*

2. *The scientists then sample another piece of ice core and the measurements now read 100 kg of Potassium-40 and 300 kg of Argon-40. How long ago did this ice form?*

Name:_________________________ **Date:_______________**

Extension Activity

Researchers at Allan Hills Antarctica have collected several sample ice cores, and have determined their ages. According to their calculations, the ice from site A is 100,000 years old, the ice from site B is 1.2 million years old, and the ice from site C is 1.8 million years old. Go to http://cci.um.maine.edu/~carreh9/STUDY_SITE.html, and read the information. After you have done this, answer the questions below.



1. What is unusual about the ice in Allan Hills?

2. Where is the oldest ice found?

3. Where is the younger ice found?

4. Why is this so?

5. Knowing this, estimate the age of the ice collected from site D on the map above.