SCIENTIFIC AMERICAN FRONTIERS

TEACHING GUIDE

www.pbs.org/saf/1406

Coming to America

Activity 2: Grades 9-12

Dating Artifacts

Until a few years ago, most scientists accepted the theory that America's first inhabitants arrived across the Bering Strait about 12,000 years ago. Today, that view is being challenged. Evidence found at several dig sites suggest that humans were present in the Americas at least 4,000 years earlier! Support for this idea comes from radiocarbon dating. It is also inferred from uncovered artifacts dating back 12,000 years.

This activity page will offer:

- An introduction to interpreting an archeological site
- A hands-on experience in understanding layering of artifacts
- The opportunity to create artifact models associated with prehistoric communities

Modeling Radiocarbon

In the late 1940s, radiocarbon techniques were introduced as a tool for archaeological dating. The procedure is based upon half of the radioactive isotope of carbon, called C^{14}. Every 5,730 years, half of the amount of a dead organism's C^{14} will decay. By comparing the amount of C^{14} to the stable carbon isotope C^{12}, scientists can infer the age of a dead organism. In this activity, you'll learn more about C^{14} and see how it is used in dating prehistoric human, animal and plant remains.

Materials

- Clay

Procedure

Making C^{14} - Modeling an Equation

1. In order to form C^{14}, you need to begin with an ordinary atom of nitrogen. Use your clay to construct a nitrogen nucleus. The N^{14} nucleus has seven protons and seven neutrons.
2. When an N^{14} atom gets hit by a cosmic ray, it absorbs another neutron. Instantly, it ejects a proton. This results in an atom with eight neutrons and six protons. Use clay models to illustrate this reaction.

$$N^{14} + n \rightarrow C^{14} + p$$

The Decay C14 - Modeling an Equation

1. Start with a model of C^{14}. Since this nucleus has extra energy (imparted by the earlier collision with a cosmic ray), it is unstable. To regain additional stability, it returns back to its previous N^{14} form. During this change, one neutron changes into a proton and electron. Use clay models to illustrate the reaction:

$$C^{14} \rightarrow N^{14} + e$$

The Decay C14 - Understanding Half Life

1. The decay of C^{14} into N^{14} is not instantaneous. In fact, it takes many years for a significant quanitity of C^{14} atoms to change back to N^{14}. Scientists measure this period in something called a half-life. Shape twenty-four identical balls of clay. These balls represent individual C^{14} atoms.
2. At time zero, there are 24 atoms of C^{14} in our sample. After 5,730 years the C^{14} sample has undergone one half-life. At that time, only half of the C^{14} atoms remain. How many C^{14} atoms remain in this sample after 5,730 years?

3. How many atoms are left after a second half-life has passed?
   How many years have gone by since the original sample was formed?
4. How many atoms are left after a third half-life has passed?
   How many years have gone by since the original sample was formed?

The Critical Ratio C^{12} : C^{14}

1. To obtain a measurement of how much C^{14} has decayed, scientists use a C^{12} : C^{14} ratio. In this analysis, they assume that the amount of C^{12} remains the same over time, while C^{14} decays at a half-life of 5,730 years. Suppose our initial sample has 500 g of C^{12} and 500 grams of C^{14}. What is the C^{12} : C^{14} ? ratio?
2. After 5,730 years how much C^{12} is left?
   How much C^{14} ?
   What is the C12: C^{14} ratio now?
3. After another half-life, how much C^{12} and C^{14} remains?
   What is the ratio of C^{12} : C^{14} ?
4. After another half life, how much C^{12} and C^{14} remains?
   What is the ratio of C^{12} : C^{14} ?

Questions

1. What does the 14 in C^{14} represent?
2. What happens to C12 over time? Explain.
3. Suppose a bone is uncovered that has a C^{12} : C^{14} ratio of 8:1. How old is this bone?

Know Your Geography

Below are several well known archeological sites that offer evidence of prehistoric human habitation. Use Internet or print resources to research each of these areas. Then, use a United States map to uncover their locations:

- Cactus Hill, Virginia

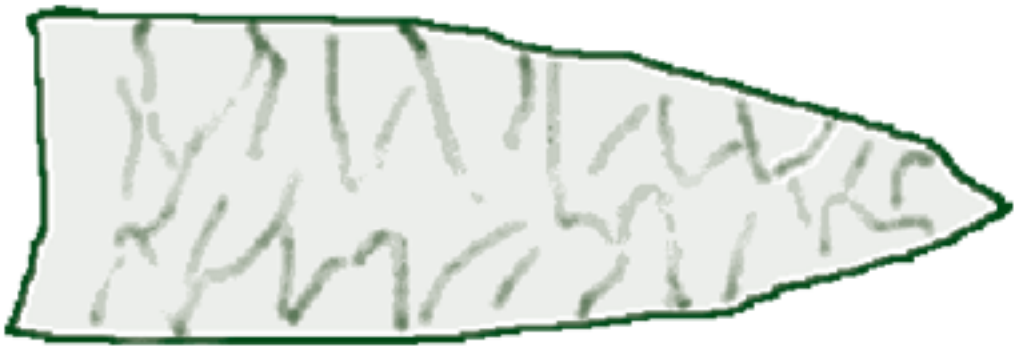
- Meadowcroft, Pennsylvania
- Topper, South Carolina
- Clovis, New Mexico
- Kennewick, Washington
- Santa Rosa Island, California

Prehistoric Interview

Work in groups of three. Imagine that one of you is a modern TV personality who hosts a sensationalist and sometimes volatile interview show. One of your guests is a prehistoric human who lived at the Clovis site. The other is a prehistoric human who lived 4,000 years earlier at the Topper, South Carolina site. Working together, develop a script for a TV show in which the personalities compete for the title of first American. Although the story will have elements of humor, it should communicate scientific findings and offer insight into the controversy unearthed by these recent dig site discoveries.

Made a Model

This drawing illustrates a Clovis point. As you have learned, a good deal of American prehistory has been based on the significance of this tool. The surface of the point has a flaked appearance, produced as pieces of this flat rock (chert) were chipped away. Use modeling clay to shape a representation of this important archeological find.



Web Connection

Who Were the First Americans?

http://www.sciam.com/article.cfm?articleID=000333F5-D417-1C73-9B81809EC588EF21&pageNumber=3&catID=2

This is the online version of the article *"Who Were the* First Americans?," published in the September 2000 issue of Scientific American.

Timing is Everything

http://archaeology.about.com/cs/datingtechniques/a/timing.htm

This site offers an overview of archeological dating techniques.

Paleoamerican Origins

http://www.jqjacobs.net/anthro/paleoamerican_origins.html

The site offers a scholarly analysis of paleoamerican origins

Infinity Program 7

http://www.drtruth.org/Infinity7.html

This site offers a rich presentation of C14 dating.

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The Decay C^{14} - Understanding Half Life

1. The decay of C^{14} into N^{14} is not instantaneous. In fact, it takes many years for a significant quanitity of C^{14} atoms to change back to N14. Scientists measure this period in something called a half-life. Shape twenty-four identical balls of clay. These balls represent individual C14 atoms.
2. At time zero, there are 24 atoms of C^{14} in our sample. After 5,730 years the C^{14} sample has undergone one half-life. At that time, only half of the C^{14} atoms remain. How many C^{14} atoms remain in this sample after 5,730 years?
   (12)
3. How many atoms are left after a second half-life has passed?
   (6)
   How many years have gone by since the original sample was formed?
   (11,460 years.)
4. How many atoms are left after a third half-life has passed?
   (3)
   How many years have gone by since the original sample was formed?
   (17,190 years.)

C^{12} : C^{14} - The Critical Ratio

1. To obtain a measurement of how much C^{14} has decayed, scientists use a C^{12} : C^{14} ratio. In this analysis, they assume that the amount of C^{12} remains the same over time, while C^{14} decays at a half-life of 5,730 years. Suppose our initial sample has 500 g of C^{12} and 500 grams of C^{14}. What is the C^{12} : C^{14} ratio?
   (1:1)
2. After 5,730 years how much C^{12} is left?
   (500 g)
   How much C^{14}?
   (250 g)
   What is the C^{12} :C^{14} ratio now?
   (2:1)
3. After another half-life, how much C^{12} and C^{14} remains?
   (C^{12} = 500 g, C^{14} =125)
   What is the ratio of C^{12} : C^{14}?
   (4:1)
4. After another half life, how much C^{12} and C^{14} remains?
   (C^{12} = 500 g, C^{14} =62.5)
   What is the ratio of C^{12} : C^{14}?
   (8:1)

Questions

1. What does the 14 in C^{14} represent?
   (The atom's atomic mass.)
2. What happens to C12 over time? Explain.
   (The C^{12} amount remains the same. Unlike C^{14}, C^{12} is a stable isotope that does not decay.)
3. Suppose a bone is uncovered that has a C^{12} : C^{14} ratio of 8:1. How old is this bone?
   (17,190 years.)