

## Skills Practice Lab

# Determining the Age of Artifacts Using C-14

Have you ever found an arrowhead or piece of pottery when you were walking through a recently plowed field or looking at a building excavation? Human-made objects, or artifacts, are sometimes found in such areas. Artifacts often are reminders that people from other cultures inhabited Earth thousands of years ago. If you can determine how old an artifact is and you know what cultures existed during the time the artifact was made, you might be able to determine what culture the object came from. This information can help you determine how those people lived.

How can artifacts be dated? Several methods are used, depending on how old the object is and its composition. Most of these methods are based on radioactivity. Many radioisotopes are present in nature and undergo radioactive decay. As they decay, they undergo changes in their nuclei, and they become different elements. As time passes, the amount of the radioisotope in a sample decreases at a regular rate, known as the radioisotope's half-life. One half-life is the amount of time it takes for half of the radioisotope in a sample to decay.

If an artifact was made from materials that were once living, its age can often be determined by using the radioisotope carbon-14 (C-14). The half-life of this carbon isotope is 5730 years. How can C-14 be used to determine the ages of organic artifacts? Most of the carbon dioxide in the atmosphere is formed from C-12, which is not radioactive. However, a small percentage of atmospheric carbon dioxide contains C-14 instead of C-12. Along with the carbon dioxide molecules containing C-12, these radioactive molecules are taken into green plants to be used during photosynthesis. While a plant lives, the C-14 decays, but it is also replaced. Thus, the amount of C-14 in the plant remains constant. Animals eat plants or other animals that eat plants. In this way, the C-14 in plants is passed along to animals. After a plant or animal dies, no more C-14 enters it. The C-14 present in the dead organic material continues to decay, so its amount decreases over time.

In this lab, you will determine the ages of various organic artifacts by comparing the amounts of C-14 remaining in those artifacts with the amounts that were initially present in them.

## OBJECTIVES

**Compute** the ages of several artifacts from information provided and the half-life of C-14.

**Determine** the cultural sources of the artifacts by using a timeline.

## MATERIALS

- calculator
- pen or pencil
- sheet of paper

## Determining the Age of Artifacts Using C-14 *continued*

### Procedure

1. Examine **Table 1**. The artifacts listed there could have been discovered at a site in the Ohio River valley, where many prehistoric and historic native American civilizations made their homes. The timeline on this page and the next shows the native American civilizations that lived in the Ohio River valley and when they lived there.
2. On a separate sheet of paper, calculate the nearest whole number of half-lives that have passed since each artifact was made. Use the following equation, in which the variable  $n$  is the number of half-lives.

$$\left(\frac{1}{2}\right)^n = \frac{\text{current amount of C-14 in the artifact}}{\text{initial amount of C-14 in the artifact}}$$

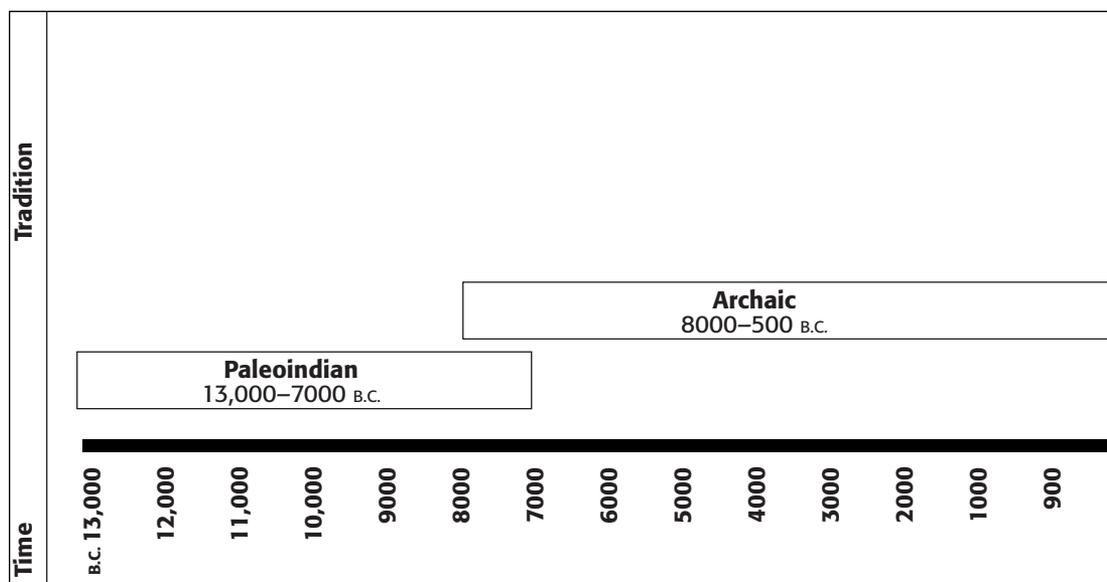
For example, suppose by making comparisons with similar living materials, scientists determine that an artifact originally contained 2.964 g of C-14. When the artifact is dated, it contains 0.7235 g of C-14.

$$\left(\frac{1}{2}\right)^n = \frac{0.7235 \text{ g}}{2.964 \text{ g}} = 0.2441$$

For this example, the quotient, 0.2441, is approximately equal to  $\frac{1}{4}$ . Because

$$\frac{1}{4} = \left(\frac{1}{2}\right)\left(\frac{1}{2}\right) = \left(\frac{1}{2}\right)^2, \text{ approximately two half-lives have passed.}$$

3. Record the number of half-lives in **Table 2**. If the number cannot be determined, write “cannot determine” across the blank spaces for that artifact.



**Determining the Age of Artifacts Using C-14** *continued*

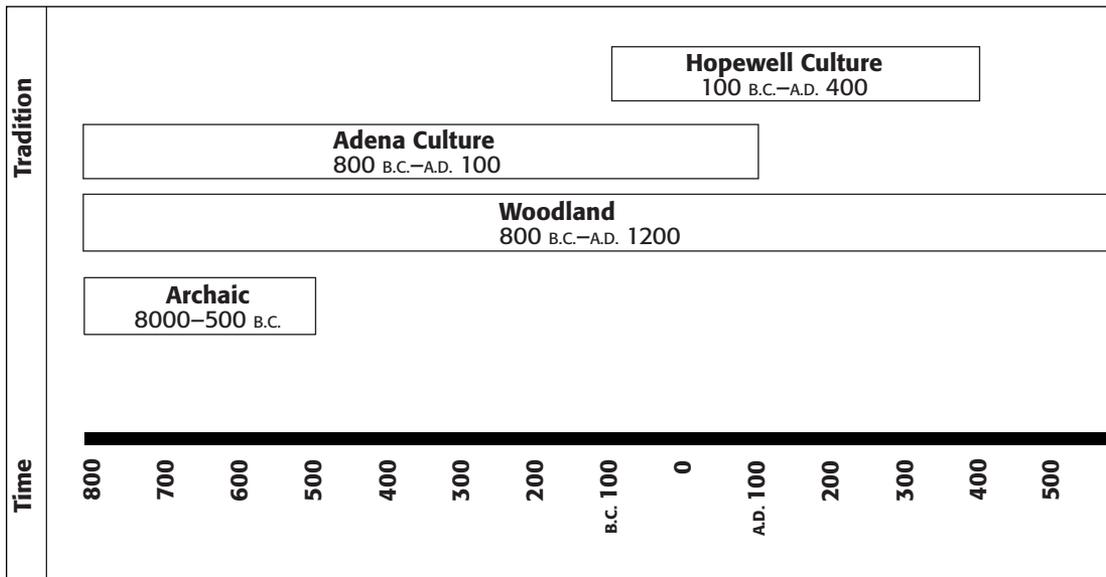
4. Determine the age of each artifact, if it can be determined, from the number of half-lives that have passed since the artifact was made. To do this, multiply the number of half-lives by the half-life of C-14. For example, an artifact that has existed for three half-lives of C-14 is  $3 \times 5730$  years, or 17,190 years old. Record your results in **Table 2**.

**TABLE 1 INFORMATION ABOUT ARTIFACTS**

| Artifact    | Estimated initial amount of C-14 present (g) | Current amount of C-14 present (g) |
|-------------|--|------------------------------------|
| Cloth       | 1.436  | 0.353                              |
| Bone        | 2.343  | none detected                      |
| Leather     | 1.322  | 0.08232                            |
| Wooden pole | 0.05334                                      | 0.02592                            |
| Spearhead   | 0  | 0                                  |

**TABLE 2 CONCLUSIONS ABOUT ARTIFACTS**

| Artifact    | Number of half-lives | Age of artifact (yr) | Cultural source of artifact |
|-------------|----------------------|----------------------|-----------------------------|
| Cloth       |                      |                      |                             |
| Bone        |                      |                      |                             |
| Leather     |                      |                      |                             |
| Wooden pole |                      |                      |                             |
| Spearhead   |                      |                      |                             |



## Determining the Age of Artifacts Using C-14 *continued*

### Analysis

**1. Summarizing Data** What did you learn about the work of an archaeologist from doing this lab?

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**2. Analyzing Data** After approximately nine half-lives have passed, too little C-14 remains in an object for the amount to be useful in dating the object. What is the minimum age of the bone listed in **Table 1**? Show your calculations.

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**3. Analyzing Data** Compare the ages of the artifacts with the times when the cultures existed as shown on the timeline. From the calculated age of an artifact, decide which culture was the source of the artifact. Record your answers in **Table 2**.

### Conclusions

**1. Drawing Conclusions** Why weren't the age and cultural source determined for the artifacts for which the number of half-lives could not be determined?

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**2. Drawing Conclusions** Why was no C-14 present in the spearhead?

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### ~~Extensions~~

~~**1. Research and Communications** Find out how C-14 dating has been used in determining the ages of relics, such as the ruins at Pompeii. Prepare an oral or written report, including any effects the age has on the authenticity of the relic.~~

~~**2. Research and Communications** Contact a radiology department in a hospital to find out which radioisotopes are used in medical diagnoses and treatments. Find out the importance of using radioisotopes with short half-lives to minimize damage caused to cells in the human body by radiation.~~