Lesson 2.4

TREE-RING DATING

Polished stone axe from Halifax County, North Carolina, ca. AD 1000.

Subjects: science, social studies, mathematics, language arts.
Skills: knowledge, comprehension, application, analysis, evaluation.
Strategies: computation, observation, forecasting, discussion, scientific inquiry.
Duration: 45 to 60 minutes.
Class Size: any.

Objectives

In their study of dendrochronology, students use activity sheets and a discussion to:

- apply principles of dendrochronology to determine a tree's age and to recognize climatic variation;
- analyze and experience how archaeologists can sometimes use tree rings to date archaeological evidence and study past climates.

Materials

For the teacher, transparencies of the "Master Sequence," "The Stump," and "Be a Dendrochronologist" activity sheets. For students, scissors, glue, or Scotch tape, and a copy of "Be a Dendrochronologist" activity sheet. Optionally, slices of tree stumps or limbs.

Vocabulary

Cambium: the thin layer of living, dividing cells just under the bark of trees; these cells give rise to the tree's secondary growth.

Dendrochronology: the study of the growth rings in trees to reconstruct climate variations and to determine the age of trees, beams, and other timbers.

Increment borer: a hollow instrument used to drill into the center of a tree to remove a long narrow cylinder of wood (called a core sample).

Tree rings: the concentric circles visible in cross sections of tree trunks and limbs; each pair of light and dark rings represents a year's growth.

Background

Dendrochronology (den-droh-cruh-NOL-uh-gee) means "the study of tree time." Usually called tree-ring dating, dendrochronology is a science based on the fact that every growth season a tree adds a new layer of wood to its trunk. Over time, these yearly growth layers form a series of light and dark concentric circles, or *tree rings*, that are visible on cross sections of felled trees. Archaeologists sometimes study the ring patterns in beams or other pieces of wood from archaeological sites to help date the sites; they may also study the ring patterns to infer the local climatic history.

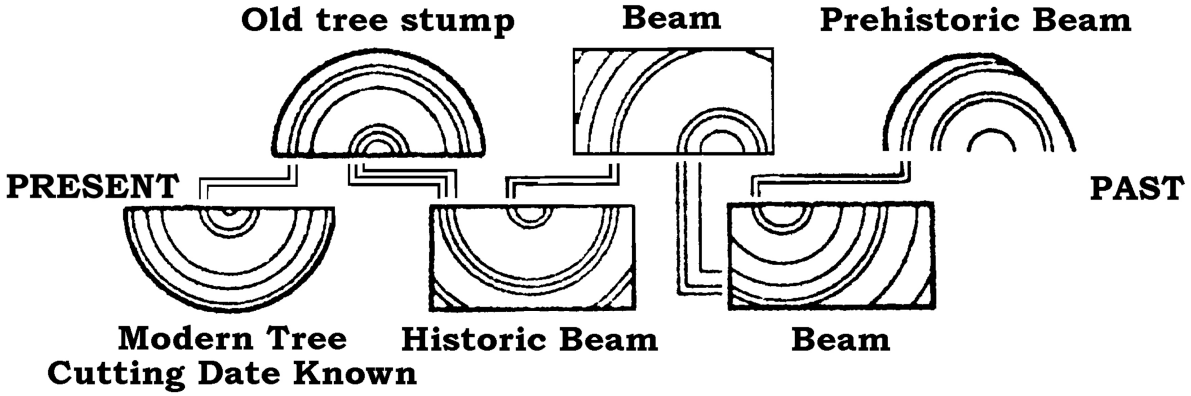
Tree-ring analysis requires observation and pattern recognition. Each year a tree's growth ring has two parts; one is wide and light colored, and the other is narrow and dark. The light part is

the early wood. This grows during the wet spring and early summer when the tree has a lot of sap, and the *cambium* cells giving rise to the trunk growth are large and thin walled. As the summer winds down and the transition to the cooler autumn occurs, the tree's growth rate slows. This results in the cambium cells becoming smaller and thicker-walled. By winter, when the sap finally stops flowing, a smooth dark ring marks the end of the tree's annual growth. By counting the dark ring segments, scientists can tell a tree's age if the cross section of the trunk is complete.

Because the width of tree rings varies with growing conditions, scientists also learn about local climate during the tree's lifetime by comparing the rings' different widths. Tree rings vary in thickness from year to year. For instance, higher rainfall and a longer growing season produces a wider ring than a year with low rainfall and prolonged cold. From recording tree-ring patterns in several geographic areas, scientists have found that all the region's trees have the same pattern.

An astronomer, Dr. Andrew E. Douglass, developed dendrochronology about 1913. Based at the University of Arizona in Tucson, Douglass wanted to know how sun spot activity affected climate, and his research soon led him to pioneering tree-ring analysis. Douglass was among the first to notice that trees in a geographic area develop the same growth-ring patterns because they experience the same climatic conditions. He reasoned if he could trace patterns far enough back in time, he could outline a history of regional climate and see if sun spots could be related.

Douglass used a bridging method to create his chronology. First he studied recently cut trees whose dates he knew. This initial step was critical because by knowing the cut date, Douglass knew when each tree added its last growth ring. This, in turn, let him determine the year each tree started growing. The calculation was straightforward: count the dark rings inward and subtract that number from the year the tree was cut. As Douglass matched and recorded ring patterns from trees of different ages, he confirmed that their patterns overlapped during the years the trees simultaneously lived.



Establishing a tree-ring sequence by means of the bridging method.

After establishing this basic sequence, Douglass next studied wood from trees whose dates he did not know. He observed that the year a tree was chopped down could be determined by matching its ring pattern with the pattern of a tree whose cut year he knew. For example, say Douglass observed on his preliminary sequence that a drought occurred in 1900, appearing on trees as a very narrow growth ring. Experience told him this narrow ring would be in all the region's trees, but at different positions on the stump because of their different ages. Faced with wood whose felling date he did not know, Douglass would search out the ring identifying the

drought year and match it to his sequence. At that point, determining the year the tree was chopped down was, again, straightforward. For instance, if two growth rings exist above the drought year, the tree was cut in 1902. Douglass extended this bridging exercise by studying ring patterns visible in old wooden beams, some preserved in the pueblos (houses) of early Native Americans living in his study area. Ultimately, he charted a tree ring sequence to about AD 500.

Dendrochronologists have since used Douglass's technique to make master sequences for several parts of the country. Most reflect regional growth patterns for distinct species. Much of this work focused on regions in the arid Southwest where ancient pinyon pines still live or exist as beams in old houses. In some places there, master sequences extend as far back as 8,700 years.

Recently, scientists have begun constructing sequences in the East. It is a more difficult and less precise task for two reasons. The relatively abundant rainfall and milder winters tend to blur trees' annual growth layers; most look so much alike that creating a bridge by matching rings is difficult. Also, the East's humid, temperate climate decays wood beams quickly, so a sequence is limited in how far back in time it reaches. Nonetheless, scientists find they can construct limited sequences for certain tree species in places where seasons are more pronounced or the rains less dependable. One kind of tree whose chronology can be charted is the oak in the higher reaches of the Appalachians. Another kind is the bald cypress, which grows well in wet areas like coastal swamps.

Dendrochronologists make master tree-ring sequences by drawing vertical lines on a piece of paper at the end of every tree ring. To the eye, the sequence looks like a series of parallel lines, with the width between each line the same as the width of each tree ring. Known dates are matched to the tree rings on the sequence. Each time the dendrochronologist gets a new piece of wood, he or she makes a graph of its ring patterns and then slides it along the master sequence until the patterns match. So framed, the scientist can compute the cutting date of the piece of wood.

Archaeologists in some parts of the country find dendrochronology useful for dating sites. This is particularly true in the Southwest. Many ancient ruins there still have wood preserved in their walls and roofs, and even charcoal from burned structures or cooking fires can sometimes show clear tree-ring patterns. Dendrochronology gives archaeologists other clues about past life, as well. By studying many pieces of wood from an early village, archaeologists learn about things such as how the village grew and how houses were remodeled or when the village was abandoned and re-occupied. For example, when people returned to an abandoned village after several years, they would repair, replace, and sometimes remodel the buildings using new wood. The year they returned can be read from this wood's tree rings.

As master sequences are done for the East, North Carolina archaeologists may also find dendrochronology helpful in dating sites, especially where old logs or beams from structures built after Europeans arrived still exist. They have already benefited from a sequence recently developed from bald cypress trees. This sequence has allowed archaeologists to date dugout canoes found on the bottom of Lake Phelps in northeastern North Carolina. These canoes, some of which are nearly 4,400 years old, were made from large cypress trunks by Indians living in the area. As archaeologists continue their research, they may learn more about what the climate was like. This information can give more complete answers to questions like how climate influenced where people lived, what kinds of foods they grew, and what wild plants and animals were available to them.

Archaeologists are careful when taking samples of wood from sites; they want to keep the material intact as much as possible. Therefore, rather than slice through or remove a beam from an old structure, scientists use an *increment borer*. When drilled into the wood sample, this

hollow instrument removes a long thin tube of wood, leaving a hole that is only about the size of a soda straw. This method of core removal is also used on living trees so that the tree does not have to be cut down.

Wooden beams, building materials, and charcoal provide a wealth of information about past cultures. However, people sometimes destroy this evidence. In the Southwest, visitors to ancient Indian ruins have pulled apart thousand-year-old houses and used the beams in campfires. In the Southeast, people have dug in sites without archaeological supervision and moved wooden beams and charcoal from their original location; then archaeologists cannot tell their context. It is very important to our knowledge about the past that we do not disturb or destroy sites.

Setting the Stage

1. Share background information. (Optional: project the "Master Sequence" transparency and explain how the sequence is created.)
2. Using "The Stump" activity sheet, show students how to count tree rings and discuss the basic knowledge that can be learned from the study of tree rings.
3. Answer questions on "The Stump" activity sheet.

Procedure

1. If possible, bring in an increment borer and a core sample. Foresters with state and federal agencies might lend these to you. Explain how the borer is used and how the sample can be read, as in "The Stump" activity.
2. Give each student a copy of the "Be a Dendrochronologist" activity sheet. It depicts cross sections of two beams from log cabins at different archaeological sites in the mountains of western North Carolina. Have students cut out the core samples. The innermost solid line represents the first year's growth. The students match their core samples to the master sequence depicted at the top of the activity sheet. They glue or tape the samples from each core onto the master sequence to see how the beams overlap. Ask students to make some calculations. How old was the tree each beam came from? What is the cut date for each tree? Which tree was younger? (You may want to demonstrate or work along on the overhead projector.)
3. After students have dated the beams and put them in chronological order, ask them to make some observations about the climate at these sites. What might have been the weather conditions at that time? How would the weather have affected Cherokee farmers living in the mountain valleys?
4. Share preservation information from the "Background."

Closure

Have students create a summary statement about the importance of tree-ring dating to archaeology. Have them also make a statement about the importance of preserving wood samples in archaeological sites.

Evaluation

Students complete "Be a Dendrochronologist" activity sheet and turn it in for evaluation.

Extensions

1. Instead of using "The Stump" activity sheet, teachers can use "tree cookies." These are

polished cross-sections of tree stumps and limbs. Tree Cookies may be available in your area from the U.S. Forest Service or environmental education organizations, such as Project Learning Tree.

2. Have students do Project Learning Tree's "Tree Cookies" activity (1993, pp. 289–292).

Sources

Fagan, Brian M. 1994. *In the Beginning: An Introduction to Archaeology*. 8th ed. New York: Harper Collins.

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Phipps, Richard L., and J. McGowan. 1994. "Tree Rings: Timekeepers of the Past." Pamphlet. U.S. Geological Survey, Department of the Interior, Denver.

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Smith, Shelley J., Jeanne M. Moe, Kelly A. Letts, and Danielle M. Paterson. 1993. *Intrigue of the Past: A Teacher's Activity Guide for Fourth through Seventh Grades*. Washington, D.C.: Bureau of Land Management, U.S. Department of the Interior. [This lesson is adapted from "Archaeology and Tree-Ring Dating" on pp. 56–62, courtesy of the Bureau of Land Management.]

Ward, H. Trawick, and R. P. Stephen Davis, Jr. 1999. *Time Before History: The Archaeology of North Carolina*. Chapel Hill: University of North Carolina Press. [The image in this lesson's main heading is taken from Figure 3.10.]

"The Stump" Activity Sheet Answers:

1. The current year minus three.
2. 16 years old
3. The year it was cut minus 16.
4. In the sixth year.
5. In the eighth year.

"Be a Dendrochronologist" Activity Sheet Answers:

1. Climate and the years the site was occupied.

2. It could be skewed. However, if archaeologists find that some beams date well before the others at a site, they would suspect that the early beams had been re-used.

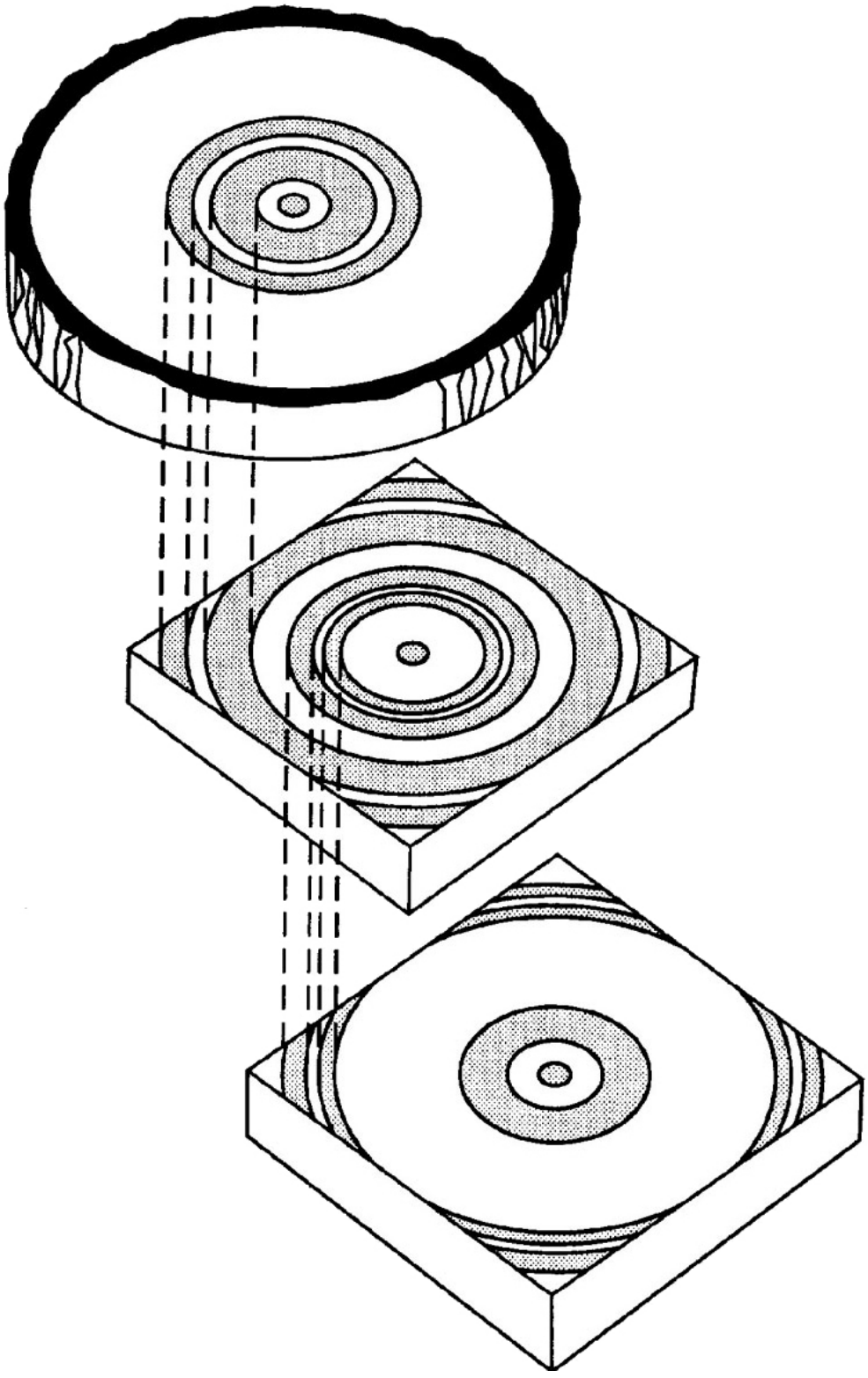
3. Removing beams removes information about the site's date and climate. Moving beams around confuses the record, and archaeologists cannot then tell to which room the dated beam belongs.

4. Beam B is the oldest. Tree A was 14 years old when it was cut. Tree B was 13 years old when it was cut. Tree A start growing 190 years ago. Tree B started growing 199 years ago. Tree A was cut 177 years ago. Tree B was cut 187 years ago.

5. Tree A: no dry cycles, two wet cycles. Tree B: two dry cycles, two wet cycles.

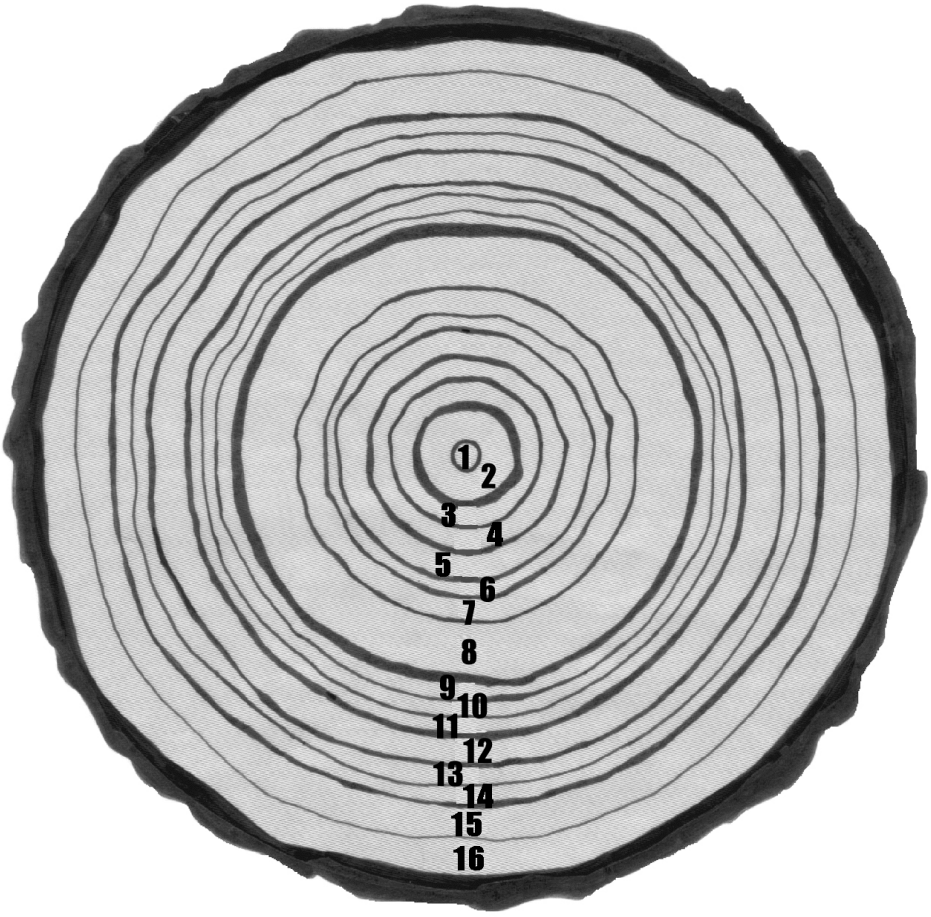
6. Examples: availability of food and water and other resources might change; survival might depend on adapting to these changes; human populations might change.

Master Sequence



The Stump

Name:



This tree was cut 3 years ago. Write that year:

How old was the tree?

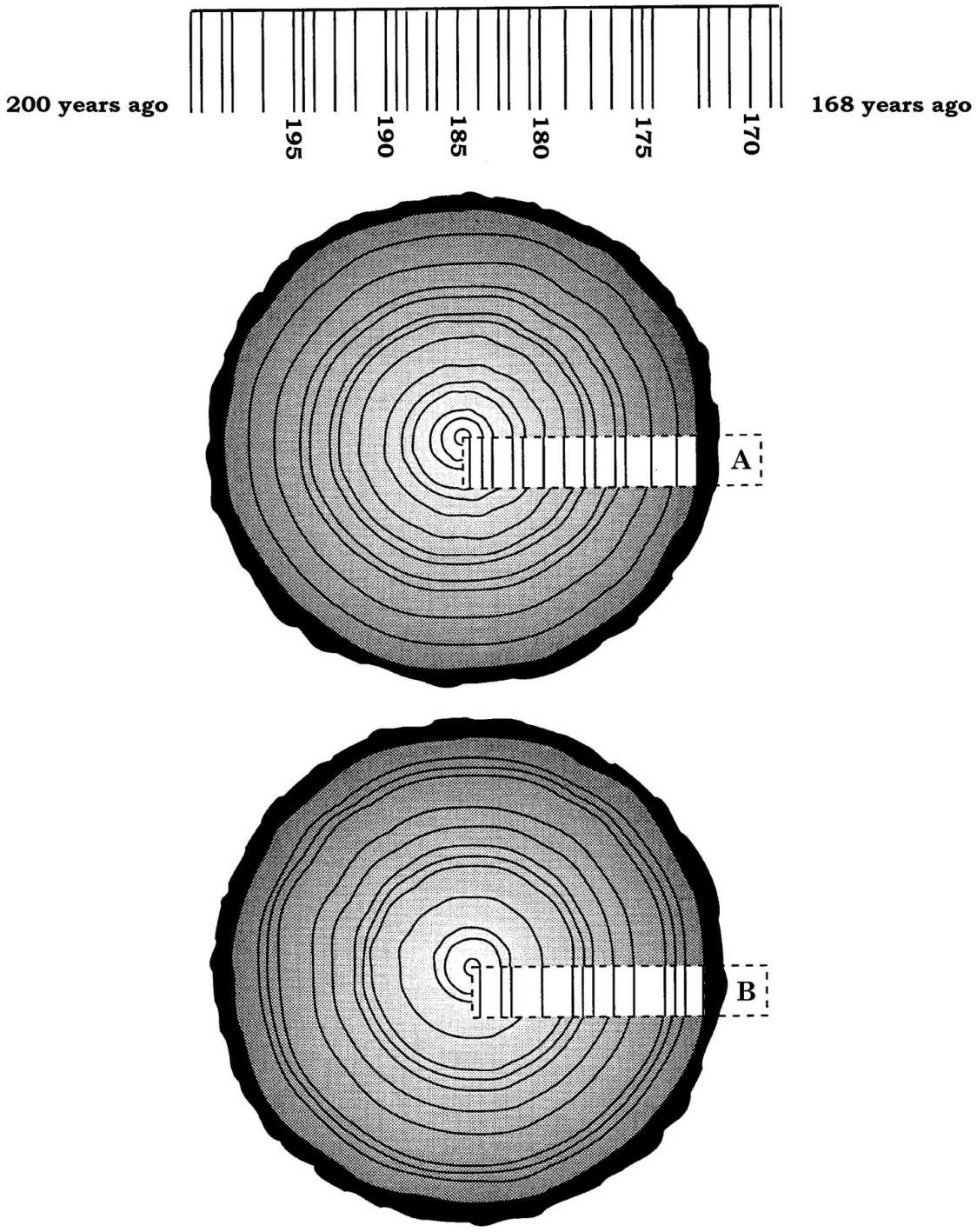
What year did the tree start growing?

Find the ring that grew the year you were born. Was it a wet or dry year?

In what year of growth was there the least rainfall?

In what year of growth was there the most rainfall?

Be a Dendrochronologist (page 1)



Adapted from Dendrochronology/Tree Rings worksheet © 1986, courtesy of Barbara Gronemann, Southwest Learning Systems. Dates changed to reflect North Carolina example.

Be a Dendrochronologist (page 2) **Name:**

1. What can a tree tell us? Name two things archaeologists can learn about a site from tree rings.

2. How is the tree-ring record affected if ancient people used wood beams from older sites when building new homes?

3. What happens to the archaeological record if someone removes a beam or even places it somewhere else on the site?

4. Refer to the diagram on page 1 of your activity sheet and answer the following questions:

- Which beam is the oldest?
- How old was Tree A when it was cut?
- How many years ago did Tree A start growing?
- How many years ago was Tree A cut?
- For Tree A, list the number of dry cycles (two or more dry years).
- For Tree A, list the number of wet cycles (two or more wet years).
- How old was Tree B when it was cut?
- How many years ago did Tree B start growing?
- How many years ago was Tree B cut?
- For Tree B, list the number of dry cycles (two or more dry years).
- For Tree B, list the number of wet cycles (two or more wet years).

5. How might climatic changes have affected the lifeways of ancient people?