CSI for Trees

Dendrochronology gets upper elementary students thinking like scientists.

By Dartin L. Rubino and Deborah Hanson

The circles and patterns in a tree's stem tell a story, but that story can be a mystery. Interpreting the story of tree rings provides a way to heighten the natural curiosity of students and help them gain insight into the interaction of elements in the environment. It also represents a wonderful opportunity to incorporate nature of science.

As a botanist with a special interest in dendrochronology (tree-ring science) and a professor helping preservice teachers understand and teach nature of science, we found we could combine our interests and use tree rings as a vehicle to effectively present both concepts. In this activity, appropriate for grades 3–6, students make connections with the work of a scientist as they solve a minimystery using tree-ring evidence.

Making "Cookies"

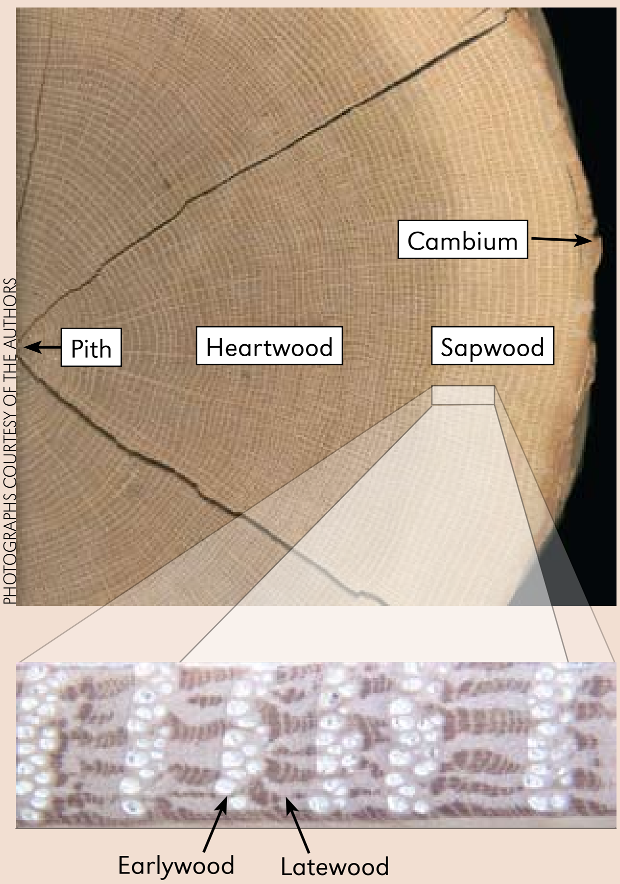
Having a real wood sample for students to observe is preferable, but it is not necessary for this activity. We have made scanned images of tree slices, known as cookies, available online (see NSTA Connection). Cookies can also be obtained from science suppliers (see Internet Resources). We have found that photocopying or scanning cookies so that each student has a cookie worksheet works best, and black-and-white photocopies also work well. For those with a do-it-yourself streak, we've posted instructions for making your own cookies available online (see NSTA Connection).

Providing cookies from different types of trees and from the same type of trees growing in different environments can greatly add to the exercise. For example, students can compare the growth rate and wood anatomy between angiosperms and gymnosperms. Comparing the same species of tree growing in a yard versus a mature forest will also allow students to see how factors such as resource competition greatly influence growth rate and overall size of a tree. Open-grown trees from yards often grow faster and have larger annual rings than forest-grown trees.

Figure 1.

Tree anatomy.

Portion of a cookie showing the anatomy of a woody stem and a blowup of a group of tree rings. The bracket in the lower figure shows one year of growth. Note: The image was produced by simply placing the cookie on a low-cost scanner.



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Engaging Students

Initially, students are asked to make observations about their tree cookie using their senses (with the exception of taste). Magnifying lenses are optional. Students should then be given the opportunity to share their observations with the class and generate a list of questions they have about their tree cookie. Students often ask why the tree rings vary in size and why the earliest-formed rings are often much larger than the later-formed rings. Students also like to share previous experiences, such as how they counted rings on a stump or memorable trees they have encountered (usually large trees). Simple questions about the age of the tree (how many rings), the date of the largest and smallest rings, and the size of the ring in which each student was born and went to school can be asked and discussed. By looking at a cookie, a diary of the tree begins to unfold, and the mystery begins.

Explaining Tree Growth

Next, share information about tree growth and tree rings. Each tree ring represents a year in a tree's life. An individual tree ring is made up of a light and dark band (in many trees). The light and dark regions in an individual tree ring represent the yearly *earlywood* and *latewood* growth, respectively (Figure 1). Earlywood, formed in the spring, has visibly larger cells with thin cell walls. The dark section of the ring is the latewood formed in the late spring and summer. These cells are much smaller and harder to see. The size of the cells correlates with the availability of resources. For example, abundant moisture in the spring allows for rapid cell growth, development, and consequently, larger cells. More stressful summer conditions translate to smaller, thicker cells produced by a slower-growing stem. The cycle of yearly *cambial* growth forms a new layer or ring each year. The cambium of the tree consists of specialized cells that produce xylem, or wood, to the inside of the stem and phloem to the outside of the stem. The cambium is the region of cells beneath the bark and adjacent to the woody tissue. When the cambium is active, it will form a new tree ring just under the bark. In other words, the most recently formed ring is the one nearest the bark, and the oldest is in the center of the tree. The width of each tree ring is a visible indication of each year's growth. A wide ring is an indicator of rapid growth and favorable growing conditions (e.g., ample water, light, and space), whereas a small tree ring signals a year of slower, limited growth and limited resource availability.

In addition to individual growth rings, students can easily learn the anatomy of a woody stem and identify the *pith, bark, cambium, sapwood,* and *heartwood* (Figure 1). These are terms of basic woody stem anatomy and provide a basic foundation for future studies. Our ex-

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perience shows that third graders can easily understand these terms. We have made available a PowerPoint presentation with background information, notes, and slides about tree growth and the work of a dendrochronologist (see NSTA Connection).

Elaborating With Inferences

Students should next be given the hypothetical tree-ring diagram (Figure 2). Instruct students that now they will be acting like a scientist to determine what may have happened in that tree's environment based on the tree-ring growth pattern. Initially, the students should make observations of the diagram, available for download (see NSTA Connection). The students should then be encouraged to compare the sizes of each ring.

Challenge the students to determine why they think the rings show different widths: What may have happened in the environment to create such a pattern? It is important to point out to the students that they are now making inferences based on their observations. If inferences and the distinction between inferences and observations are a new concept for the students, a few examples will need to be given. Students should be encouraged to develop at least three inferences from these observations to encourage them to consider many possible scenarios and out-of-the-box creative thinking.

Common inferences from third-grade students include lack of water, lack of sun, or the tree not getting enough of what it needed to grow. Other inferences the teacher might want to include are competition from other trees, natural disasters such as fires or storms, human impacts, and insect infestations. Challenge the students to think of other possibilities. For example, what if the tree started to grow but was in a spot with 10 other tightly clustered trees. How do you think that would affect the tree's growth? What do you think would happen then if a person came and cut down the other 10 trees for firewood? Have the students share ideas with a partner and then together as a group.

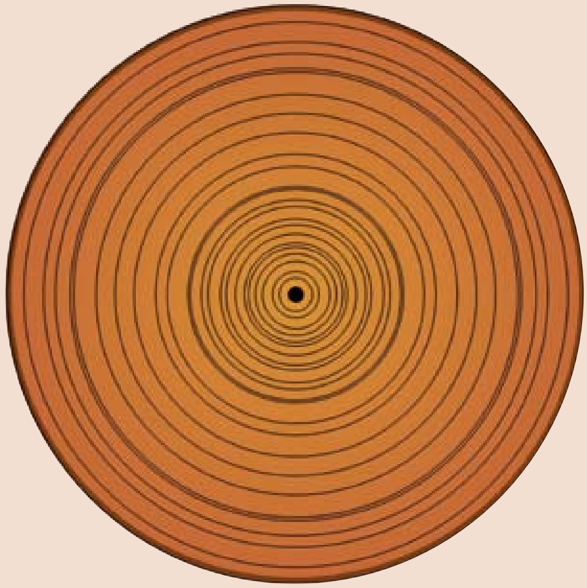
Students should then be asked how they developed their inferences. Why did they think that the lack of moisture would make a small growth ring for that year? It is important to note to the students that when they do this, they are using information from their previous experiences. Scientists do the same thing; even though they try to be objective, they use information from their background, previous experiences, and from their culture when making inferences.

Figure 2.

Hypothetical tree-ring sample

(available online; see NSTA Connection)

The dark dot in the center is the pith. It is formed during the first year of growth. The innermost ring is 1950, and the outermost is 1973. Bark is not shown in this figure.

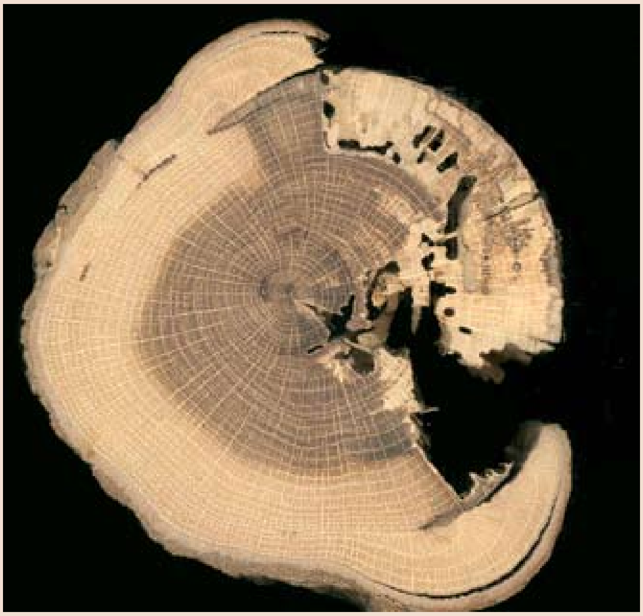


During the activity, make connections between the work of a real scientist and what the students are doing. Research indicates that explicit teaching is necessary for students to make these connections (Khishfe and Abd-El-Khalick 2002). Comments such as the following will remind students they are doing the work of scientists:

- Scientists make observations. They use the information collected from their five senses as evidence to document what they see, hear, feel, and smell. They take measurements and record as many observations that they can.
- Sometimes scientists use tools such as magnifying lenses or microscopes to extend their senses and see details that they normally would otherwise not detect.
- Data collection and analysis can be performed in the field and in the lab to create a more complete picture of what is occurring in nature.
- All of the information scientists collect becomes evidence that will be used in the future to best explain and infer what has happened or is happening in the natural world.
- Scientists do research and compare their data with other documented evidence to solve problems.

Dendochronology

Dendrochronologists use the "story" written in tree rings to answer a multitude of questions, and many subfields of dendrochronology exist. For example, dendrochronologists can use tree rings to determine when forest fires have occurred by dating fire scars in trees (a tree surviving a forest fire may form anomalous rings around a charred section of the stem; top photograph). Dendrochronologists can also use tree rings to determine when buildings were erected. By studying the tree-ring patterns in the timbers of historically-constructed buildings, one can determine when a tree was cut down and incorporated into a building (bottom photograph). Tree rings can also be used to study historic climatic conditions. Dendrochronologists can use growth patterns to determine when climatic events, such as droughts, occurred even if climatic data is not available for a particular time period.



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Journaling in a science notebook is another way that the students could gain insight about the work of a scientist. Collecting and recording observations and data are part of the daily routine of a scientist.

Next, the students should be asked how they would go about finding out what happened to their tree. Which inference may be the most likely? The students soon realize that they need more information to solve this mystery. The information they need will come from the county clerk's office via a document we created to accompany the hypothetical tree-ring diagram. The document contains a natural plot report for the location of the tree with precipitation, land use, insect activity, and natural disaster data for the area (see NSTA Connection for download). This background information can be shared or passed out to individual students or teams. As the students collect and read the information, it is a good time to remind them that they are gathering evidence to help them solve their mystery and that science is based on many types of evidence.

Evaluating the Evidence

After the students have had a few minutes to review the new evidence, they should look at each of the inferences they initially made. Is the inference still a possibility? Why or why not? What evidence did they find to support keeping or discarding this idea? Is more evidence still needed? Do they have questions that cannot be answered? After looking at their evidence, what do they think happened to the tree? The students should then create the story of their tree using the evidence they have collected.

As the students communicate their story, many teachable moments will arise. This will be a great time for the students to see how they based their story on the evidence they gathered. Students initially will assume a good growth year is due to rain, but when they gather further information, the students begin to see that other factors, like logging of the area and a resulting lack of competition, might be responsible for the growth. Usually one group is surprised at the outcome of their story. This is a good opportunity to indicate the tentative nature of science and how scientists may change their thoughts based on new evidence or looking at existing evidence in a new way.

One aspect of nature of science that is hard for students to understand is how scientists use their creativity in science. Students can begin to understand how scientists can put their ideas and data together in unique ways or use their creativity and background experiences as each story is different, although the evidence is the same. Also, it is important to note that the scientists use many methods to solve problems. How we solved this mystery may be different than the next question the scientist may seek to solve. This scenario is open-ended. Many possibilities exist for the small growth rings in 1962 and 1969. In some instances, scientists do not know for sure what may have happened; they make the best inference or prediction they can based on the information they have. After the students have completed the activity, it would be helpful to compare their work to the story of a dendrochronologist. The students should point out times when the scientist made observations, developed inferences from those observations, and gathered evidence to support the ideas generated. Ask the students if they think the first idea generated by the scientist was the final idea. Was it possible that the scientist changed his or her idea during the activity? What might have caused the scientist to change his or her mind? Do you think the scientist was being creative in solving this mystery? Did you notice how the scientist was gathering different pieces of evidence together and meshing various pieces of the puzzle together to solve the mystery? In doing so, the scientist was using his or her creativity and imagination to solve the mystery. Did we in our activity do any of these things? Did we make observations and inferences? Use evidence? Change our ideas based on new evidence we found or maybe looked at it in a new way? Use our personal creativity and maybe some of our previous experiences and knowledge to solve the mystery? When we did, we were behaving just like real scientists!

If students are using tree rings from local samples, they can investigate the history of their area to see how close their inferences are to the true story of their tree. Through personal interviews, newspaper reports, or other data sources, the students can investigate the factors that may influence tree growth. Websites, such as *NOAA.gov*, can provide yearly precipitation amounts for regions across the United States. This information can then be traced to the local habitat to see the influence on tree-ring size and could be graphed to see what patterns exist.

Extending Learning

By incorporating nature of science aspects, students can start to realize the true work of a scientist and debunk any misconceptions they may have about science and scientists (Lederman 1992). Unfortunately, one-on-one sessions with real scientists cannot easily happen in every elementary classroom, but through activities such as this one, students can connect and explain their work through the eyes of a dendrochronologist. Adding the nature of science themes to one's classroom teaching can be as simple as looking for and explicitly focusing on these golden opportunities when they occur. An ordinary activity can be transformed into a lesson that includes nature of science themes simply by adding a few key statements and questions throughout a lesson. ■

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References

Khishfe, R., and F.S. Abd-El-Khalick. 2002. Influence of explicit and reflective versus implicit inquiry-oriented instruction on sixth graders' views of nature of science. *Journal of Research in Science Teaching* 39 (7): 551–578.

Lederman, N.G. 1992. Students' and teachers' conceptions about the nature of science: A review of the research. *Journal of Research in Science Teaching* 29 (4): 331–359.

Internet Resources

Set of Tree Rounds
www.enasco.com/product/SB25029N?ref=rel_item

Tree Rounds
www.outsourcesolutionsllc.com/science.html

NSTA Connection

Download a PowerPoint presentation on tree rings, tree-ring photos, the tree-ring diagram worksheet, and the county clerk document worksheet at *www.nsta.org/SC0910*.

Connecting to the Standards

This article relates to the following *National Science Education Standards* (NRC 1996):

Content Standards

Grades K–8

Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Standard C: Life Science

- Characteristics of organisms (K–4)
- Organisms and environments (K–4)
- Structure and function of living systems (5–8)

Standard G: History and Nature of Science

- Science as a human endeavor (K–8)
- Nature of science (5–8)

National Research Council (NRC). 1996. *National science education standards*. Washington, DC: National Academy Press.