



Trees: Recorders of Climate Change

Unit: Little Ice Age
Lesson: 5

Materials & Preparation

Time:

- Preparation: 20 minutes
- Teaching: Part A: 20 min, Part B: 30-40 min

Materials for the Teacher:

- Overhead projector
- Overhead transparency of tree rings (page 5)

Materials for the Class:

- Copies of simulated tree cores (page 6-7)

Materials for Individual Students:

- *Student Page*
- Tree “cookie”
- Magnifying glass (*optional*)
- Metric ruler (mm)
- Pencil

National Science Standards

- Science as Inquiry: Content Standard A
- Earth and Space Science: Content Standard D
- History and Nature of Science: Content Standard G

Colorado Science Standards

- Science: 1, 4.2b, 6d

Learning Goals

Students will

- Identify seasonal and annual growth in a cross section of a tree.
- Understand that thickness of a tree ring is affected by environmental conditions.
- Understand that evidence of past climates is recorded in series of tree rings.
- Learn to interpret past climate conditions from tree ring thickness.
- Collect and analyze tree ring data, testing a hypothesis and drawing conclusions.

What Students Do in this Lesson

Students are introduced to tree rings by examining a cross section of a tree, also known as a “tree cookie.” They discover how tree age can be determined by studying the rings and how ring thickness can be used to deduce times of optimal growing conditions. Next they investigate simulated tree rings applying the scientific method to explore how climatic conditions varied during the Little Ice Age.

Key Concepts

- During each growing season (spring and summer), trees produce new wood in a ring on the outside of the tree trunk located just inside the bark.
- Wood made during the first part of the growing season is light in color and wood made late in the growing season is dark in color.
- A series of concentric rings form during consecutive years of growth. Age is determined by counting the number of rings, oldest to youngest, from the center to the bark.
- A single tree ring is an indicator of growing conditions over a single growing season. A thicker ring may indicate a longer growing season or more water availability depending on the environment and tree species.
- A set of many consecutive tree rings provides information on climate trends during a tree’s lifetime.



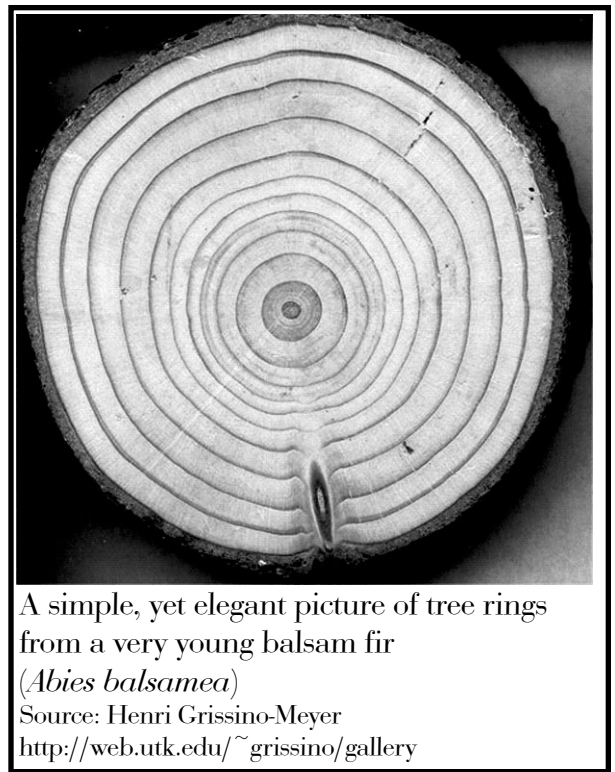
Trees: Recorders of Climate Change

Advanced Preparation

- Prepare a cross-section through a tree trunk (tree “cookie”) for each student (0.5-1” thick and 4-6” diameter is ideal). Contact a local tree trimming service and ask for cuttings or order tree cross-sections from a classroom supply company (allow several weeks for delivery).
- Copy page 5 onto transparency for use during Part A.
- Copy simulated tree cores and cut them apart (You may wish to provide several copies of each simulated tree core.) The dates will need to be kept with each core.
- Place simulated tree cores at stations around the room with signs that indicate the time range.
- Copy Student Page for each student.

Facilitating the Lesson: Part A

- Familiarize students with their tree “cookie” cross-section.
 - Explain that trees produce rings as they grow each spring and summer.
 - Ask students to describe the tree ring colors. Is there a pattern to the light and dark rings? Explain that wood made during the first part of the growing season is light in color and wood made late in the growing season is darker. A light and a dark band together are the growth during one year.
- Explain to students that the study of the ages of tree rings is called *dendrochronology* (“dendro” is Latin for tree and chronology is the study of a time sequence).
 - Ask students how old their tree was when it was cut. (Students should count the light/dark couplets of rings to estimate age.)
 - Ask students which rings they think are youngest. Which are the oldest? (There may be multiple hypotheses suggested by your students. If so, discuss the likelihood of each hypothesis, leading students to understand that the outer ring is, in fact, the youngest.)
 - If the time that the tree was cut is known, have students count backwards to find the ring that represents the student’s year of birth.
- Explain to students that past climates can be interpreted based on how the tree rings formed. This is called *dendroclimatology*.
 - Ask students if all the rings are the same thickness. They will likely notice that some rings are thicker than others. This can be for many reasons, but mainly the variations in ring thickness relate to growing conditions. In high latitude areas, tree growth is limited by the length of the growing season, which is controlled by temperature. In other environments, tree growth is greatly controlled by water availability.
 - Tree ring thickness can vary from year to year. Review with students that thick rings indicate a “good” growing season, narrow rings indicate a shorter or dryer growing season. Ask students to



A simple, yet elegant picture of tree rings from a very young balsam fir (*Abies balsamea*)
Source: Henri Grissino-Meyer
<http://web.utk.edu/~grissino/gallery>



Trees: Recorders of Climate Change

identify which year had the best growing season.

- Tell students that there are two ways to study tree rings. Scientists can use cross-sections, but this is typically only done if the tree has died, because the process kills the tree. Instead, scientists usually take cores from living trees to study the rings. When a tree is cored, a small cylinder of wood is pulled out, smaller than the diameter of a drinking straw. Coring does not harm the tree. The rings can be studied from the cylindrically-shaped core. (Show overhead transparency of tree coring: page 5.)

Facilitating the Lesson: Part B

- Show students the simulated tree rings that they will use for this activity. They are made to look like tree cores (except they are flat). The simulated tree rings group the light colored and darker band so that each interval along the simulated tree ring core indicates a year's growth.
- Explain that the simulated tree ring samples are based on data from trees from high northern latitudes where the length of the growing season controls ring thickness. Since the length of the growing season is based on the temperature, thick rings will form when the climate is warmer and thin rings will form when the climate is cooler. The simulated rings cover a period from about 1402 to 1960.
- Pass out Student Pages and rulers and familiarize students with the directions before beginning. Students will make a hypothesis (or do this as a class), collect data, and make interpretations.
 - Instruct students to develop a *hypothesis* about the climate over the total time interval. Explain that the class will test the hypothesis by collecting data from tree rings. After studying the tree ring data, they will either accept the hypothesis or reject the hypothesis.
 - *Data collection*: Instruct students to visit each station and measure the total thickness of the tree rings for each time interval in millimeters (model this procedure for students), recording the thickness in the appropriate place in the data table on the Student Page.
 - *Data analysis*: Instruct students to divide their measurement for each time interval by the number of years in each interval to get average ring thickness for each time interval. Record this in the table.
 - *Interpretation*: Have students answer the thought questions on their student page and discuss answers as a group.
- In summary, describe that paleoclimatologists use a variety of "proxies" to interpret past climate. These proxies indicate the relative temperature but are an indirect record of it. Ask students if they think that the tree rings are a source of direct or indirect evidence of past climates.

Background Information

Dendrochronology: The study of the growth of tree rings

Dendroclimatology: The study of the relationship between climate and tree growth in an effort to reconstruct past climates

The growth layers of trees, called rings, preserve an interesting record of environmental conditions over the lifespan of the tree. They record evidence of environmental events such as floods, droughts, insect attacks, forest fires, lightning strikes, and even earthquakes. Many consecutive tree rings also record longer term and more subtle changes in climate over time.

Each year, new wood grows on the outside of the tree trunk, just under the bark. A year's growth is called a tree



Trees: Recorders of Climate Change

ring. Each tree ring is made of a band of light colored wood produced early in the growing season (spring and early summer) and a dark colored band produced late in the season (late summer and early fall). Counting the rings of a tree will determine its age.

Scientists seldom cut down a tree to analyze its rings. Instead, core samples are extracted using a borer that's screwed into the tree and pulled out, bringing with it a cylinder of wood about 4 millimeters in diameter. The hole in the tree is then sealed to prevent disease (see images of this process on page 5).

Tree rings are an example of climate proxy data, providing indirect evidence of past climates. Scientists can use tree-ring patterns to reconstruct regional patterns of climatic change. The amount of tree growth depends upon various local environmental conditions. At high latitudes, the amount of tree growth is mostly controlled by temperature. Trees grow thicker rings when the growing season is longer and narrower rings when the growing season is shorter. The length of the growing season is related to the climate, namely the temperature. If the rings are a consistent thickness throughout the tree, the climate likely did not vary over the lifespan of the tree.

The simulated tree rings used in the second part of this activity were developed based on the results of a study by Briffa et al. (2001) in which the ring patterns of 387 trees from northern latitudes were used to interpret temperature variations over the past 600 years. Since the thickness of the simulated tree rings is based on the results from many trees, it shows an average trend. Typically, climatologists require at least 30 years of data to establish understanding of climate. To understand changes in climate requires even more data. Generally, dendroclimatologists use large databases of tree ring data to compare the records of many trees, and interpret when, where, and how quickly climates have changed.

Extensions

- Take a field trip to take core samples from local trees with a core tool and then analyze the tree rings.

Additional Resources

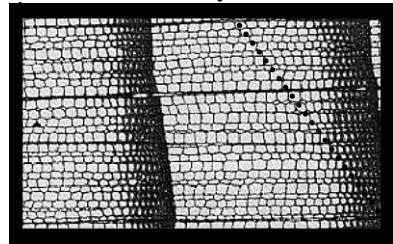
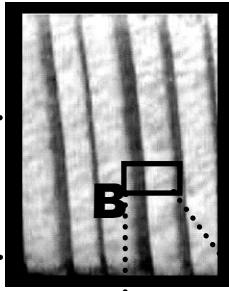
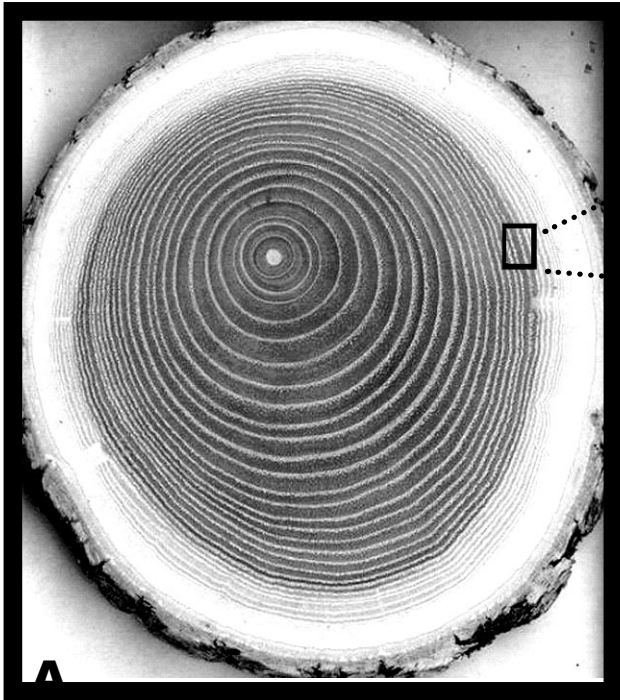
- Project LEARN: <http://www.ucar.edu/learn>
- Tree Rings: A Study of Climate Change (NASA) <http://vathena.arc.nasa.gov/curric/land/global/treestel.html>
- Trees as Indicators of Climate Change, by Keith Briffa: <http://www.cru.uea.ac.uk/cru/annrep94/trees>
- Tree Rings: A cursory look at these well-known features, by Paul James: <http://www.microscopy-uk.net/mag/artjan02/treering.html>
- Briffa, et al., 2001, Low-frequency temperature variations from a northern tree ring density network, *Journal of Geophysical Research*, Vol. 106, no. D3, pp. 2929-2941.
- Sources of tree cross-sections:
 - NOAA Tree Ring Slide Set: http://www.ngdc.noaa.gov/paleo/slideset/tree_rings.html
 - Science Kit & Boreal Laboratories <http://sciencekit.com/default.asp>
 - Carolina Biological Supply Company <http://www.carolina.com/>



Trees: Recorders of Climate Change

Note: Copy this page onto transparency for use with overhead projector.

TREE RINGS



Images of tree rings at different levels of magnification

A. Large cross-section (Henri Grissino-Meyer <http://web.utk.edu/~grissino/gallery>)

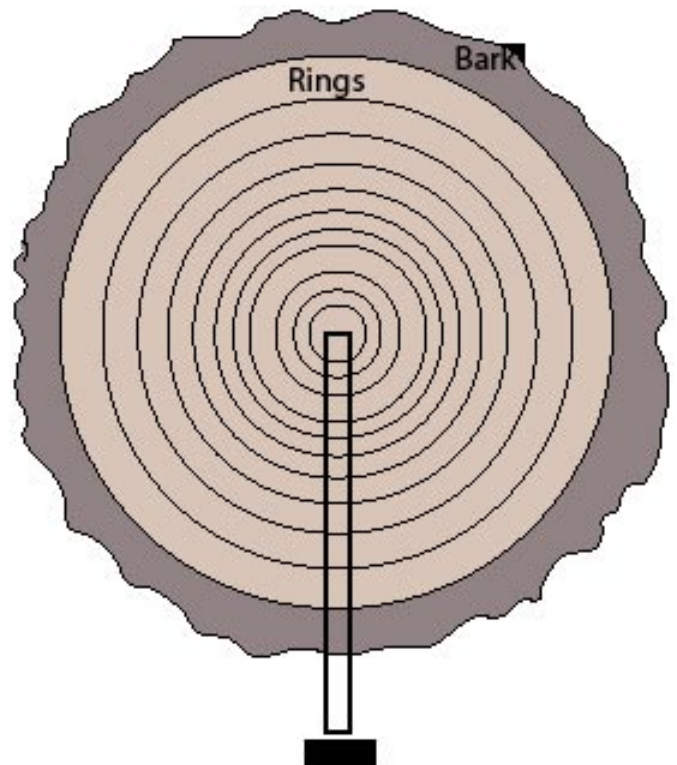
B. Close up of rings (Caspar Amman, NCAR)

C. Close up of cells (Caspar Amman, NCAR)

TREE CORING



Image: NOAA



Simulated Tree Cores

Copy this page (and the following page) and cut individual simulated tree cores apart for use with Part B of this activity.

1402-1449	1450-1499	1500-1549	1550-1599	1600-1649	1650-1699

Simulated Tree Cores (continued)

Copy this page and cut individual simulated tree cores apart for use with Part B of this activity.

1700-1749	1750-1799	1800-1849	1850-1899	1900-1960



Trees: Recorders of Climate Change

Name _____

Date _____ Class _____

The Question: Has the climate changed over the last 600 years?

Make a hypothesis.

A hypothesis is a statement about how something works or how something happened. Based on the question above, make your own hypothesis. Write it in the space below.

Collect and analyze tree ring data!

1. Measure the total length of the tree ring core at each station. Make your measurements in millimeters. Write each measurement into the "total thickness" column of the table.
2. Fill in the number of years of each time interval in the "number of years" column.
3. Divide each "total thickness" measurement by the "number of years" to get the average ring thickness for each time interval. Use at least one decimal place (example: 2.3).

Time intervals	Number of years	Total Thickness (mm)	Average ring thickness
Example	50	200	$200/50=4$
1402-1449			
1450-1499			
1500-1549			
1550-1599			
1600-1649			
1650-1699			
1700-1749			
1750-1799			
1800-1849			
1850-1899			
1900-1960			

What's does it all mean? Answer these questions on the back of this page.

1. Based on ring thickness data, can you accept your hypothesis, or reject it?
2. Based on the ring thickness data, would you speculate that some intervals were warmer or cooler than others? If so, which was the warmest interval? Which was the coolest interval?
3. How certain are you of your interpretations? Would you like to see more evidence? If so, what type of evidence and from what time interval?
4. Doing research often brings up more research questions. What's sorts of questions would you want to look into for future research? List at least two questions.
5. Why do climatologists need at least 30 years of data to describe climate?