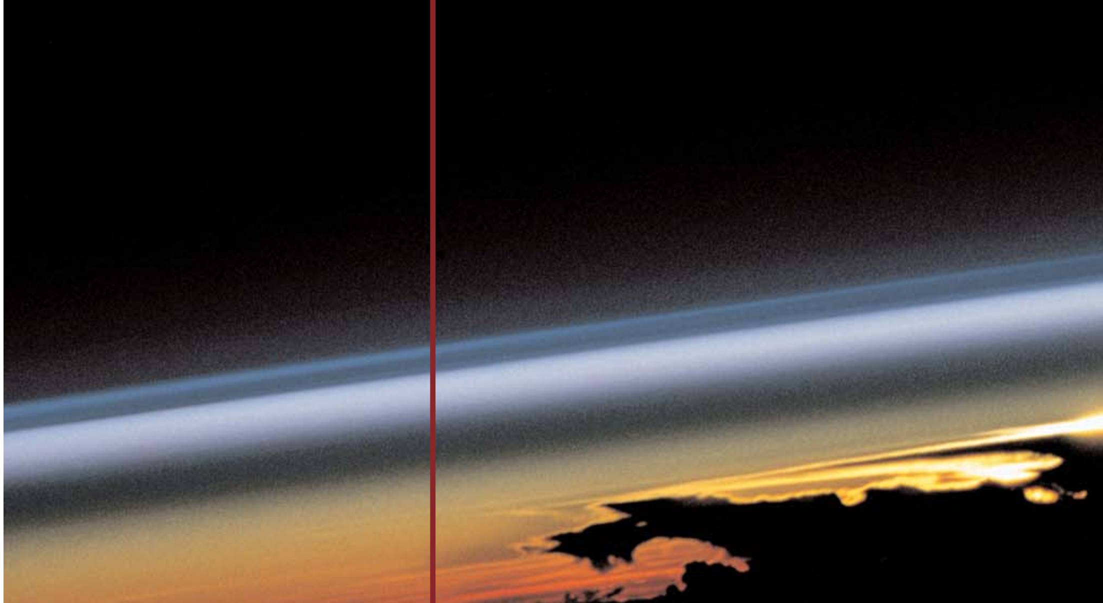
Activity 4

Atmosphere Detective—Scoping out Past Atmospheres

FORCES OF CHANGE

Atmosphere

CHANGE IS IN THE AIR



Smithsonian
National Museum of Natural History

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Atmosphere Detective — Scoping out Past Atmospheres

Overview

Scientific information cannot always come from direct observation of a phenomenon; often it is the result of inferences (deductions) made from indirect observation of such things as soils, ice cores, and fossils. The Smithsonian Institution exhibit *Atmosphere: Change Is in the Air* gives many examples of how scientists deduce information about the atmosphere. This activity will enable students to become familiar with different scientific "ways of knowing" and to begin making their own scientific deductions in preparation for deeper exploration of Earth's atmosphere and climate system.

Suggested Grade Level

6–8

Alignment with National Standards

National Science Education Standards

Science As Inquiry, Grades 5–8, Content Standard A: As a result of activities in grades 5-8, all students should develop abilities to do scientific inquiry and understandings about scientific inquiry.

Life Sciences, Grades 5–8, Content Standard C: All organisms must be able to obtain and use resources, grow, reproduce, and maintain stable internal conditions while living in a constantly changing external environment.

Earth and Space Science, Grades 5–8, Content Standard D: The earth processes we see today, including changes in atmospheric composition, are similar to those that occurred in the past.

Fossils provide important evidence of how life and environmental conditions have changed.

Time

One class period (40–50 minutes)

Materials

- Computer with internet connection
- Slices of recently cut logs or branches so annual rings can be seen in cross section
- Graph paper
- Colored pencils

Vocabulary

DENDROCHRONOLOGY — study of annual growth rings in trees to determine the timing of past events

DEDUCTION OR DEDUCE — conclusion reached by studying evidence; to reach such a conclusion

PALEOCLIMATOLOGY — study of ancient climates

PHOTOSYNTHESIS — process by which plants use chlorophyll and sunlight to make sugar and oxygen from water and carbon dioxide

EOCENE EPOCH — period of Earth's history 35 to 55 million years ago

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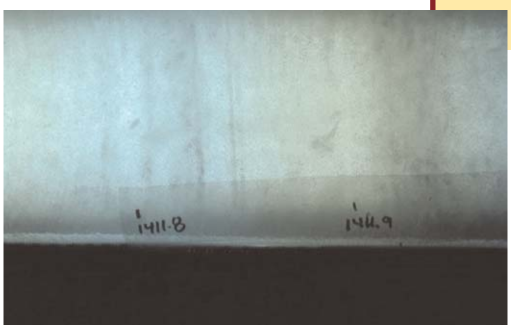
OBJECTIVES

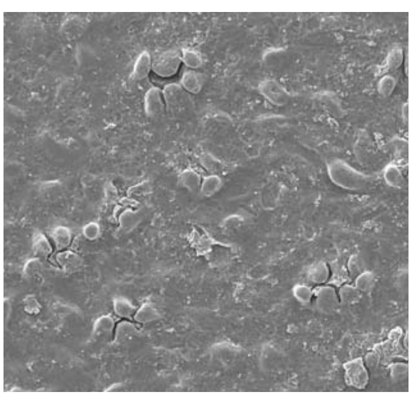
Students will be able to:

1. List at least two methods scientists use to study past climates
2. Explain the difference between direct observation and deduction
3. Define and explain the science of dendrochronology and use it to make their own deductions about climate
4. Calculate and graph weather trends and translate them into tree ring data



Scientists study ice cores and plant fossils like the ones pictured here to learn more about past atmospheres. A close-up of an ice core reveals climate clues from the cold Younger Dryas period (top) and a magnification of a fossil Ginkgo leaf, 55 million years ago, Wyoming, shows the individual leaf pores (bottom).

Photo © Richard Alley, Pennsylvania State University



Scott Wing © Smithsonian Institution

Background

Atmosphere: Change Is in the Air summarizes the development of Earth's atmosphere since Earth was formed about 4.6 billion years ago, and it describes the importance of the atmosphere to living things.

To deduce what the atmosphere has been like for billions of years, paleontoogists, geologists, and paleoclimatologists study rocks, ancient soils, plants, and fossils. Scientists study the current state of the atmosphere using everything from sophisticated satellite data to monitoring the growth of plants.

Here are some examples of how scientists study past atmospheres:

1. Decreases in atmospheric CO_2 have been linked to ice ages over the past million years, when ice sheets periodically blanketed much of the Northern Hemisphere. Scientists studying air bubbles trapped in cores of ancient ice from Greenland and Antarctica found that continental ice sheets advanced when CO_2 in the atmosphere decreased.

2. Tiny pores, or stomata, on Ginkgo leaves act like little mouths to let in CO_2 used in photosynthesis. As the amount of CO_2 in the atmosphere increases, leaves can take in the same amount of CO_2 with fewer pores. Careful counting under a microscope shows that the density of pores on fossil Ginkgo leaves is about the same as the density of pores on leaves of living Ginkgo trees. This finding suggests that the amount of CO2 in the atmosphere during the Eocene Epoch, which was an unusually warm period, was not very different from present levels and that some factor

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Open-top chambers used to study the effects of elevated atmospheric CO_2 on a marsh community on a sub-estuary of the Chesapeake Bay

Photo Bert Drake © Smithsonian Institution

El Niños can leave their "signatures" in tree rings. Thick rings in trees from the American Southwest can indicate an El Niño. These rings are from a Douglas fir tree that lived in New Mexico 500 years ago.

Photo © Christopher Baisan, LTRR, University of Arizona

Background (continued)

other than atmospheric CO_2 was responsible for warm Eocene climates. Some paleoclimatologists think that warmth at the poles was the result of higher atmospheric levels of water vapor or methane, which, like CO_2, are greenhouse gases. Methane may have created clouds of ice crystals that held in heat over the poles like a planetary ski cap.

3. Through photosynthesis, plants use carbon dioxide to make oxygen and help regulate the amount of both gases in the atmosphere. Since plants grow faster and use more CO_2 when CO_2 levels are high, some people believe that plants can absorb much of the excess CO_2 produced by burning fossil fuels. Dr. Bert Drake, plant physiologist at the Smithsonian Environmental Research Center near Annapolis, Maryland, has studied plant responses to CO_2 under controlled conditions longer than anyone else. He's found that growing conditions such as the amount of rainfall can alter plants' responses to CO_2. Dr. Drake warns that there are limits to plant growth and to plants' ability to remove CO_2 from the atmosphere.

4. Dendrochronology is the study of tree rings. In areas where there are seasonal changes in temperature and precipitation, many tree trunks and branches form annual growth rings. The ring closest to the bark is the newest ring; the rings at the center are the oldest rings. Each year's growth ring consists of a lighter ring from the beginning of the growing season, called the earlywood, and a darker ring at the end of the growing season, called the latewood. In general, the better the growing conditions, the wider the rings. In any given area, the growth rings are similar from tree to tree. Older trees can be matched to younger ones to give information through many years about such things as climate (temperature and precipitation) and events including fires, insect infestation, or pollution. Tree rings from a tree that grew from 1950 to 1980, for example, will have ten years' worth of rings that overlap with rings from a tree that grew from 1970 to 2005 (1970 to 1980). Putting the rings together gives a picture of growing conditions form 1950 to 2005.

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Spondylus shell from the National Museum of Natural History collection.

Activity

1. Divide students into groups of three or four.
2. Pick two or three of the groups and assign them to work on local dendrochronology for the activity. Either let the other groups select different regions of the United States or assign them regions for the activity.
3. Give the students the background information for the assignment and the necessary vocabulary.
4. Distribute the activity sheet and explain what each group needs to do to complete the activity.
5. Give groups enough time to complete their activity sheet.
6. When everyone has finished, give groups time to compare their sketches of tree rings with each other and with the actual cross-section of a tree trunk.

Extensions

The El Niño phenomenon occurs every three to seven years and is characterized by warmer than usual temperatures in the Pacific Ocean. The result is more rain than usual on the west coast of North and South America and a drought in Asian nations bordering the Pacific.

A mollusk shell found in Peru has shown climatologists that El Niño events have been occurring for at least 15,000 years. You can learn how they know what they know by visiting: http://forces.si.edu/elnino/edu/nino_clues_from_the_past.pdf. What is the mollusk (animal with a hinged shell) and how is it connected to El Niño? How do scientists know that thousands of years ago, people living in Peru understood that connection? Use what you've learned about the mollusk on the El Niño interactive at http://www.forces.si.edu/.

Learning More

For another look at tree rings, visit http://interactive2.usgs.gov/learningweb/teachers/globalchange_time_lesson.htm

References

http://forces.si.edu
http://fyp.ngdc.noaa.gov
http://www.ncdc.noaa.gov/paleo/slides/slideset/18/18_357_slide.html

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Activity Sheet

1. Go to the National Oceanic and Atmospheric Administration (NOAA) site "Find Your Place" at http://fyp.ngdc.noaa.gov/ Click on United States Counties, and then click on GHCN Monthly Precipitation to bring up a list of states and counties. Groups assigned to study the local area should find the county closest to their location. Other groups should select states from several different areas of the United States.

2. From the monthly precipitation charts, obtain data for rainfall (precipitation) for your study area for the past ten years.

3. For each year, calculate the average rainfall for the months from March to June and from July to October by adding the precipitation amounts together and dividing by the number of months.

4. Create a paper line graph with the years on the x-axis and rainfall on the y-axis. There will be two lines on the graph — one for the earlywood (March to June) and the latewood (July to October). Draw each line in a different color. The line for the earlywood will almost always be higher on the y-axis than the line for the latewood.

5. For an example of how tree rings look go to: http://www.ncdc.noaa.gov/paleo/slides/slideset/18/18_357_slide.html

6. Use the graph to create a set of relative annual tree rings, adding on to one another, with the oldest year at the center of the rings and the most recent year at the outermost edge. Each annual ring will have a ring representing the earlywood when the tree does most of its growing, and a ring representing the latewood. The earlywood is always wider than the latewood. When rainfall is high, the rings should be wider than when rainfall is low.

   For example: In 1999 spring rainfall was 20 cm, later rainfall was 10 cm. In 2000, spring rainfall was 10 cm, later rainfall was 2 cm. Using a scale of 1:10, the first ring would be 2 cm in diameter (the earlywood in 1999). The next ring would be 3 cm (2 + 1), representing the latewood of 1999. The next ring would be 4 cm in diameter (2 +1 +1) for the earlywood in 2000. The next ring would be 4.2 cm (2 + 1 + 1 +.2) for the latewood in 2000).

7. Compare tree rings that you've drawn from different areas of the country

   What state has the largest set of tree rings?

   Which has the smallest?

   What can you determine about rainfall from the size of the tree rings?

   What state has the greatest difference between earlywood rings and latewood rings?

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Activity Sheet (continued)

Within a given set of tree rings, are there some rings that are especially wide or narrow?

If you were a farmer, which tree rings represent years that might have been difficult for growing your crops? Why?

8. Look at the pieces of tree trunk or branches that you have. Identify the annual rings. What can you tell about the tree's growth from the variations in the size of the tree rings?

   Does the width of rings in the set of relative rings you drew for your area look similar to the width of the tree rings?

   What environmental conditions besides rainfall could affect the growth of the tree and its rings?