Paleoclimates and Pollen

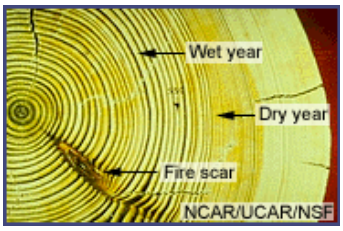
Modified with permission from Global Climates - Past, Present, and Future, S. Henderson, S. Holman, and L. Mortensen (Eds.). EPA Report No. EPA/600/R-93/126, U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC. 25 - 38.

Background

Evidence found in the fossil record indicates that in the distant past, the earth's climate was very different than it is today. There have also been substantial climatic fluctuations within the last several centuries, too recently for the changes to be reflected in the fossil record. Since these changes are important to understanding potential future climate change, scientists have developed methods to study the climate of the recent past.

Although human-recorded weather records cover only the last few hundred years or so, paleoclimatologists and paleobotanists have found ways of identifying the kinds of plants that grew in a given area, from which they can infer the kind of climate that must have prevailed. Because plants are generally distributed across the landscape based on temperature and precipitation patterns, plant communities change as these climatic factors change. By knowing the conditions that plants preferred, scientists can make general conclusions about the past climate.

How do paleobotanists map plant distribution over time? One way is to study the pollen left in lake sediments by wind-pollinated plants that once grew in the lake's vicinity. Sediment in the bottom of lakes is ideal for determining pollen changes over time because it tends to be laid down in annual layers (much like trees grow annual rings). Each layer traps the pollen that sank into the lake or was carried into it by stream flow that year.



To look at the "pollen history" of a lake, scientists collect long cores of lake sediment, using tubes approximately 5 centimeters (cm) in diameter. The cores can be 10 m long or longer, depending upon the age of the lake and amount of sediment that's been deposited. The removed core is sampled every 10 to 20 cm and washed in solutions of very strong, corrosive chemicals, such as potassium hydroxide, hydrochloric acid, and hydrogen fluoride. This harsh process removes the organic and mineral particles in the sample except for the pollen, which is composed of some of the most chemically resistant organic compounds in nature. Microscope slides are made of the remaining pollen and examined to count and identify the pollen grains.

Because every plant species has a distinctive pollen shape, botanists can identify from which plant the pollen came. Through pollen analysis, botanists can estimate the composition of a lake area by comparing the relative amount of pollen each species contributes to the whole pollen sample. Carbon dating of the lake sediment cores gives an approximate age of the sample.

Scientists can infer the climate of the layer being studied by relating it to the current climatic preferences of the same plants. For example, they can infer that a sediment layer with large amounts of western red cedar pollen was deposited

during a cool, wet climatic period, because those are the current conditions most conducive to the growth of that species.

Why are scientists who study climate change interested in past climates? First, by examining the pattern of plant changes over time, they can determine how long it took for plant species to migrate into or out of a given area due to natural processes of climate change. This information makes it easier to predict the speed with which plant communities might change in response to future climate change. Second, by determining the kinds of plants that existed in an area when the climate was warmer than at present, scientists can more accurately predict which plants will be most likely to thrive if the climate warms again.

In this activity, students will examine pictures of pollen grains representing several species that show the structural differences that scientists use for identification. Students will analyze model soil samples with material mixed in to represent pollen grains. They will determine the type and amount of "pollen" in the samples and, using information provided to them, determine the type of vegetation and age of their samples. Then they will make some conclusions about the likely climate at the time the pollen was shed.

You will gather your own 'soil' for the samples and then use one of these data sets to interpret it:

- From a lake in Washington State just south of the glacial limit of the last ice age, reflecting the climatic changes that accompanied the end of the ice age to the present.
- From a peat bog in Colorado, which accumulates pollen in a fashion similar to a lake.

Choose the set that might seem most interesting to your students. The only difference between them is that the Washington data set records 5 distinct climatic layers, with 11 different plant species, whereas the Colorado data set records 6 climatic layers, with 12 distinct plant species.

Learning Goals

1. Students will understand that plant pollen is physically distinct in size and shape in different plant species.
2. Students will understand that plant pollen may survive for long periods of time in sediment deposits, providing a record of plant species in the area.
3. Students will understand that climates naturally undergo changes that can be monitored with pollen data.

Alignment to National Standards

National Science Education Standards

- Unifying Concepts and Processes, Grades K to 12, pg. 118: "Changes in systems can be quantified. Evidence for interactions and subsequent change and the formulation of scientific explanations are often clarified through quantitative distinctions - measurement. Mathematics is essential for accurately measuring change."
- Earth and Space Science, Earth's History, Grades 5 to 8, pg. 160, Item #2: "Fossils provide important evidence of how life and environmental conditions have changed."

Benchmarks for Science Literacy, Project 2061, AAAS

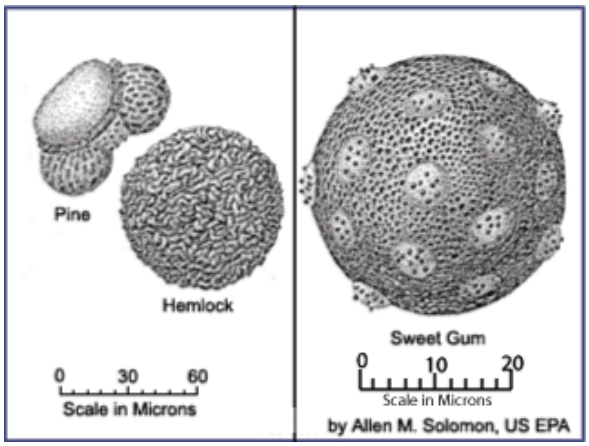
- The Earth, Grades 6 to 8, pg. 69, Item #6: "Climates have sometimes changed abruptly in the past as a result of changes in the earth's crust, such as volcanic eruptions or impacts of huge rocks from space. Even relatively small changes in atmospheric or ocean content can have widespread effects on climate if the change lasts long enough."

Grade Level/Time

- **Grade level:** 7 to 9
- **Time:**
  - Teacher preparation: 90 minutes
  - Introduction/background information for students: 30 minutes
  - Student activity: 45 minutes
  - Class discussion/analysis: 20 minutes

Materials

- A copy of the pollen picture *(link displays graphic on its own page for easier printing)* for each pair of students. An excellent example of different pollen types is found in the October 1984 issue of National Geographic on pg. 492-493.



- One large graduated cylinder (1000 mL at least) for the "sediment" column. Only one is needed as a demonstration for the class. (If you do not have access to a cylinder, a transparent 2 liter pop bottle could also be used.)
- Five different types of "sediment" if you use the Washington data and six if you use the Colorado data (any soil, sand, potting mixture, etc. that can be layered to show the five or six distinct layers). You will need enough for the sediment column and corresponding "samples."
- One of the following for each pair of students:
  - A small, re-sealable plastic bag for the sediment layer sample
  - A pie pan for the sediment layer sample
  - Tables of the different "pollen" colors showing which colors represent which plants and information about the climatic requirements for each plant species (Battle Ground Lake, WA Tables 1 & 3, or Black Hawk, CO Tables 2 & 4)
  - Tweezers or forceps
  - A worksheet for the data set you've chosen *(click to access the worksheets)*

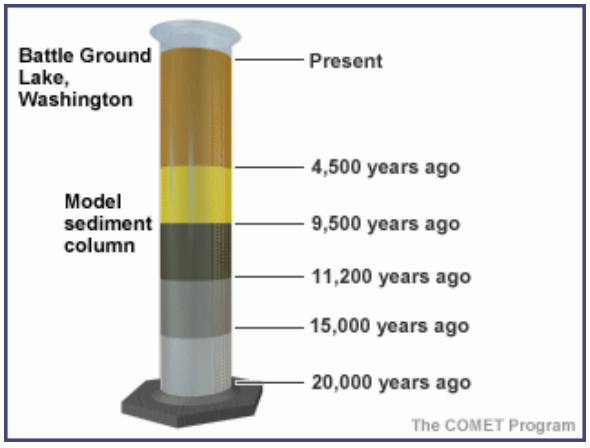
- Eleven (for Washington data) or twelve (for Colorado data) different colors of paper "dots" (from a hole punch) or shaped confetti to serve as pollen analogs
- One permanent marker to label the bags

Preparation

This activity involves a significant amount of teacher preparation. You may want to enlist several students to help in the preparation and set-up. The activity procedural instructions are also included in the Student Guide.

These exercises were developed based on actual pollen data collected from a lake in southwest Washington State and a peat bog in the Rocky Mountains. You can use either or both, just be careful not to confuse the worksheets. Other regions of the country may have similar pollen records available. The botany departments of local universities may be able to provide information on locally relevant pollen data that you can adapt to this exercise.

1. Layer five (or six) different kinds of soil (garden soil, sand, fine gravel, potting mixture, peat moss, vermiculite, perlite, or similar material) into the graduated cylinder so they form five (or six) distinct layers. This represents the sediment core with which the students will work. Label the layers with their respective ages as shown. The example shown represents the Battle Ground Lake, Washington sediment core.



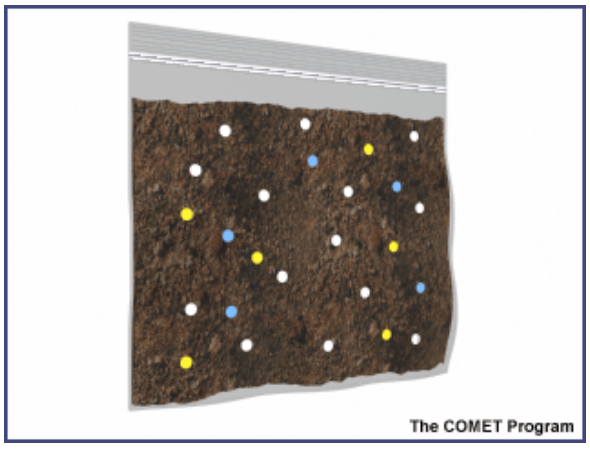
2. Choose 11 (or 12) different colors of paper or confetti shapes to represent the "pollen" grains. We have suggested colors and confetti shapes in the tables linked below; however, you can make your own choices. **To avoid confusion later, make certain that you note any changes on all tables. This is very important!**

3. Count out the different color pollen grains by using the "dots" from a standard hole punch or shaped confetti.

4. Prepare a sample of each "sediment" layer in the column (five or six). You may need to duplicate some of the samples so each pair of students gets one sample.

    - Use one re-sealable plastic bag for each sediment layer sample.
    - Using a permanent marker, label each bag with its number, Layer 1 being the "oldest" and Layer 5 (or 6) the most recent.
    - Fill each bag with approximately one cup of the material that represents a sediment layer in the core. For example, if sand represents Layer 1, place one cup of sand in the plastic bag marked Layer 1. If you chose a dark soil for Layer 2, place one cup of dark soil in the plastic bag marked Layer 2 and so on until all layers in the column have one (or more) corresponding samples.

5. Using Table 1 (WA) or Table 2 (CO) as a guide, put approximately 25 paper dots (or confetti) into each sample bag to represent the pollen found in that layer.



Procedure

You are ready to begin the activity with your class.

1. Ask the students to carefully examine the pictures of the different pollen types, noting the structural differences in each type. Discuss those differences and how scientists can use them to identify the plants from which they were shed.

2. Display the sediment column and discuss the way that sediment is laid down in lakes, how it traps pollen, and how scientists obtain the lake sediment cores.

3. Hand out one sediment layer sample, pie pan, tweezers (or foreceps), worksheet, and table to each pair of students. Explain that each sample contains "pollen" from the species prevalent at the time of deposition. Students should empty the contents of their sample into the pie pan, then

    - Sift through the sample to separate out the pollen from the sediment
    - Determine from the key (Table 3 (WA) or Table 4 (CO)) what species of plants are represented
    - Determine what percentage of the total pollen comes from each species

4. If possible, rotate the samples so each sediment layer is examined by at least two groups.

5. If more than one pair of students worked on any sediment layer, ask them to get together and come to a consensus on what plants they have found and the relative abundances. The worksheet can be used to keep track of the percentage of plants found in each layer. From the key (Table 3 (WA) or Table 4 (CO)), have students come to a consensus on what the climate must have been like at the time of deposition.

6. Ask each group studying a sediment layer to report their conclusions to the class, then, as a class, build a consensus on the pattern of climate change represented by this sediment column. Students can complete their worksheets with data provided by those studying different sediment layers.

7. Once a class consensus has been reached, you may wish to share the conclusions of the Washington and Colorado studies and view maps of the sites *(click on each link below)*

    - The Paleoclimate of Battle Ground Lake, Southern Puget Trough by Dr. Cathy Whitlock, paleoclimatologist
    - The Paleoclimate of Blackhawk, Colorado by the University of Colorado's Science Discovery Program

8. When finished, ask the students to carefully replace the pollen samples in the sample bags with the sediment material. These samples can be used again.

Assessment Ideas

- Construct a hypothetical lake containing two of the sediment layers selected from the key the students have already used to determine climate. Show the raw data from the layers and ask the students to determine in writing, the climatic history of the area.

Modifications for Alternative Learners

- This is a complex activity for English Language Limited (ELL) students, in terms of the learning outcomes expected. Pair ELL students up with students who can serve as guides through the activity.

When you're finished with the activity, click on To Student Guide or Back to Activities List at the top of the page.

Back to Top