Evidence of Climate Change

Driving Question: What is the evidence that is climate changing?
Synopsis: In this activity, students will rotate around 4 stations, 3 of which show evidence of climate change and one of which (station c: Antarctica) does not. At the end of the session, the students must determine which of the stations did not provide evidence to support climate change.
Rationale: This activity will help the students understand and evaluate the evidence that scientists use to determine whether or not the climate is changing.
Source & Materials:

Station A – Adapted from UCAR's Trees: Recorders of Climate Change
- Tree cookie (http://www.acornnaturalists.com/store/Plant-ID-Kits-Stems-Leaves-Roots-Tree-Rounds-C118.aspx)
- Ruler
- Student handout & pencil
- Calculator (optional)

Station B – Adapted from UCAR's Glaciers: Then and Now
- Glacier images (pdf labeled session 6 station b glaciers)
- Student handout & pencil

Station C – Northeastern Educational Television of Ohio (westernreservepublicmedia.org/antarcti/ozone.htm)
- Internet access
- Student handout & pencil

Station D – lesson by Hilary Clement Olson (ucmp.berkely.edu/fosrec/Olson2.html)
- Images of cores and foraminifera to post at station (optional, attached at end of lesson)
- Student handout & pencil
- Calculator (optional)

Transition: How can we tell if climate is changing? What is considered strong evidence?

Procedure
PREPARATION
1. Set up the four stations around the room and label the stations A – D as per the student handouts.

EXPLORE
1. Explain to the students that since we don't have any written record of what the past climate was like scientists have to look at other evidence to determine what the climate was like thousands and thousands of years ago.
2. Tell them that today they are going to be the scientists and must evaluate the evidence. They must determine if the information that they collect at each station proves that the climate has changed over long periods of time.

3. Have the students rotate around the stations as follows (directions copied from LHS GEMS guide)
    a) Assign each student to one of four groups. Assign each group to a different station.
    b) Pass out the handouts for each station.
    c) Tell the students that when you say rotate they should go to the next station in the alphabet. Those at Station D will go to Station A. Give the students 15 minutes to complete each of the stations. If they complete a station quicker, suggest they finish any incomplete questions on their data sheet from a previous station.
4. After the students have finished the stations, have them to report out on their results. Ask
    a) Did the evidence convince you that the climate has changed over time? Why?
    b) Was there any station that did not seem to support the idea that climate has been changing over very long periods of time? If so, which one?

Station A: Dendroclimatology – Studying Tree Cores

Part A

- ❖ Trees produce rings as they grow each spring and summer.
- ❖ One light band + one dark band = one year of growth
- ❖ Wood made during the first part of the growing season is light in color and wood made late in the growing season is darker.

Look at the tree "cookie" cross-section in front of you. How old was this tree when it was cut? Count the light/dark couplets of rings to estimate age. ________________________

- ❖ 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).
- ❖ Are all of the rings the same thickness? Variations in ring thickness are caused by growing conditions including temperature and water availability.
  Thick rings = "good" growing season,
  Narrow rings = a shorter or dryer growing season.

How many good growing seasons did this tree have? How many shorter or dryer ones were there? Good seasons: _____________

Shorter/dryer seasons: _____________

Part B

So that they don't have to cut down and kill the entire tree, 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.

❖ For this part of the activity, the light colored and darker bands are grouped together so that:

  Each block = a year's growth (light + dark bands)

❖ These 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 = warmer climate
  Thin rings = cooler climate

The Question: Has the climate changed over the last 260 years?

Collect and analyze tree ring data!

1. Take turns measuring 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 Interval	Number of years	Total Thickness (mm)	Average ring thickness
Example	50	200	200 / 50 = 4
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 if you need more room.
a) What does the ring thickness data suggest? *Hint: look on the previous page to determine what different thickness of tree rings mean.*

b) 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?

c) Why do climatologists need at least 30 years of data to describe climate?

Station B: Glaciers – Then and Now

ICE AT WORK
(copied from NationalGeographic.com Kids
http://magma.nationalgeographic.com/ngexplorer/0501/articles/mainarticle.html)

Ice sheets form when more snow falls in winter than can melt in summer. Year after year, the snow piles up. Huge mounds cover the land. The bottom layers of snow slowly turn into ice.

*When the ice grows heavy enough, it starts to move downhill. That's when a sheet of ice becomes a **glacier**. People often describe glaciers as "rivers of ice." Some glaciers were once more than a mile thick. Only the highest mountains poked through the giant ice sheets.*

This has been happening at Glacier National Park for millions of years. Glaciers have slowly moved across the land, changing the landscape. They plowed away the soil. They ground down mountains. They carved out valleys.

However, what happens to ice if the temperature gets warmer?

Glacier Name	How much time passed between pictures (# of years)?	Things in the two photographs that are the SAME…	Things in the two photographs that are DIFFERENT…

Answer the following questions and be prepared to discuss them after the activity:

- What stayed the same? What changed?

- Do all the glaciers in this sample follow the same pattern? Are they growing, retreating, or staying the same?

- What climate conditions encourage glacier growth and glacier retreat?

- What might account for glacier retreat today?

- As glaciers get smaller, how might this affect the Earth?

Station C: Antarctica – 90 degrees south

Go on the internet to find the answers to the following questions. Make sure to find a reliable source and to list the source of your information below.

1. What are the layers of the earth's atmosphere?

   Source ____

2. What is ozone?
   Source ____

3. What are chloroflurocarbons (CFC's) and where do they come from?

   Source ____

4. What is global warming?

   Source ____

5. What is the ozone hole and where is it located?

   Source ____

6. What is the greenhouse effect?

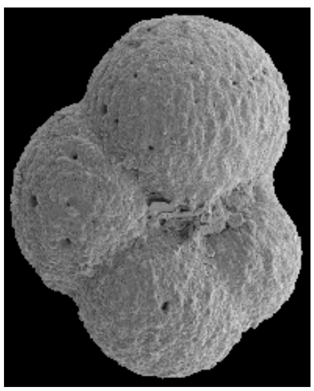
   Source ____

Station D: Climate Analysis Using Planktonic Foraminifera

You have been given samples of different layers of sediment collected from the bottom of the ocean. Each layer represents a different period of time. Your layers represent time from the present to 160,000 years ago.

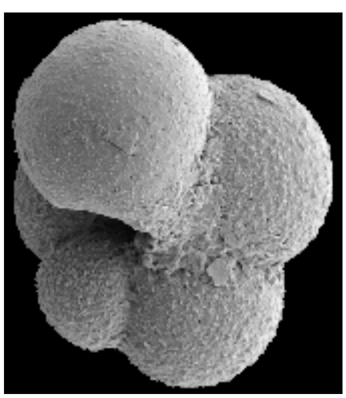
Along with sand and dirt brought in from the land, each layer is also made up of very tiny organisms called foraminifera, which can only really be seen under a microscope. One particular species of foraminifera, *Neogloboquadrina pachyderma*, (see the pictures below) is an excellent recorder of water temperature throughout long periods of time.

- When the earth faces cold temperatures, the ocean water is also cold and *Neogloboquadrina pachyderma* forms its test (shell) such that it coils to the left



http://bprc.osu.edu/foram/species/neogloboquadrina_pach.htm

- When the earth faces warm temperatures, the ocean water is also warm and *Neogloboquadrina pachyderma* forms its test (shell) such that it coils to the right



http://bprc.osu.edu/foram/species/neogloboquadrina_pach.htm

http://ucmp.berkely.edu/fosrec/Olson2.html

To determine whether the climate was cooler or warmer over time, you have counted how many of this species coil to the left and how many coil to the right in each layer or sample. Your data is recorded in Table 1.

1) Complete the worksheet in Table 1 by calculating the total number of *Neogloboquadrina pachyderma* for each sample and the percentages of right- and left-coiling forms of the species. You must calculate percentage data so that your information is not biased by the total number of foraminifera present in the sample.

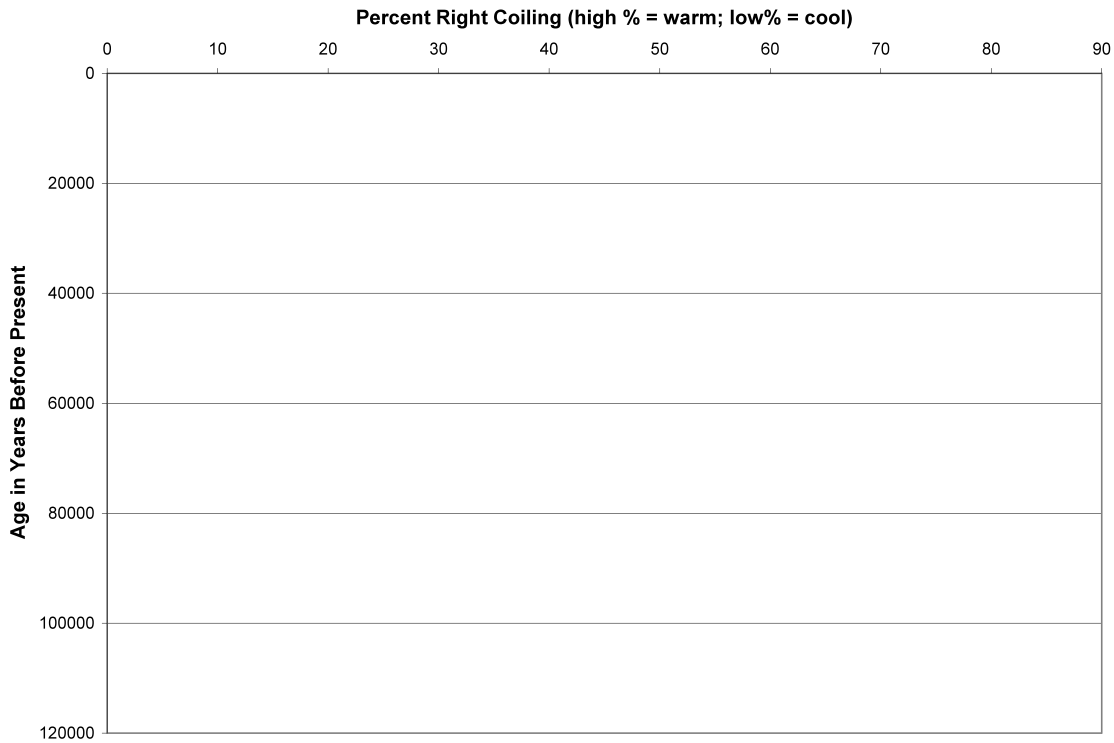
To calculate the percentage data for each sample, use the following equation:

% Right coiling *Neogloboquadrina pachyderma* = # of right coiling / the total # of *Neogloboquadrina pachyderma* (left coiling + right coiling)

Table 1. *Neogloboquadrina pachyderma* coiling rations worksheet

Age (years ago)	Right coiling *Neogloboquadrina pachyderma*	Left coiling *Neogloboquadrina pachyderma*	Total number *Neogloboquadrina pachyderma* (# of right coiling + # of left coiling)	% Right coiling *Neogloboquadrina pachyderma* (# of right coiling / total # of *Neogloboquadrina pachyderma*)	% Left coiling *Neogloboquadrina pachyderma* (# of left coiling / total # of *Neogloboquadrina pachyderma*)
0	230	50	280	82%	18%
10,000	220	75			
20,000	70	230			
30,000	45	300			
40,000	50	302			
50,000	65	389			
60,000	20	140			
70,000	56	287			
80,000	63	267			
90,000	212	56			
100,000	120	23			
110,000	87	45			
120,000	203	66			
130,000	56	205			
140,000	45	332			
150,000	89	135			
160,000	123	166			

2) Next, use graph paper to plot your results on the next page.

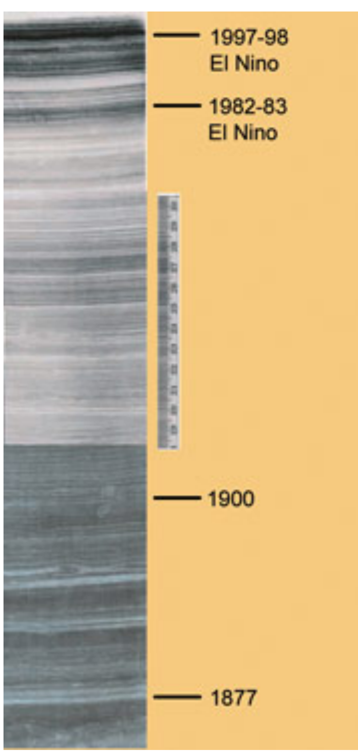


3) Analyze your graph and make an interpretation of the climatic history on our planet during the last 160,000 years. Was it only cool or warm over the entire 160,000 years? If not, when was it cool and when was it warm? How do you know this?

4) Can you think of any explanations for why the climate would change in the past?

Image from http://blogs.oregonstate.edu/paleo/files/2008/03/sediment_core.jpg

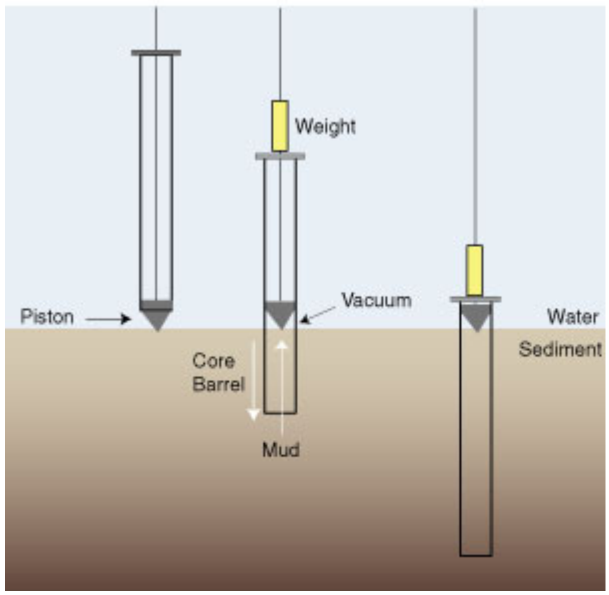
This is an example of a sediment core from the bottom of the ocean that was cut in half. A long, round tube is shoved into the ocean bottom and pulled back up with sediment inside. The scientists then cut it in half and use one half for their research and the other to keep as a record. Notice the different layers in the core.

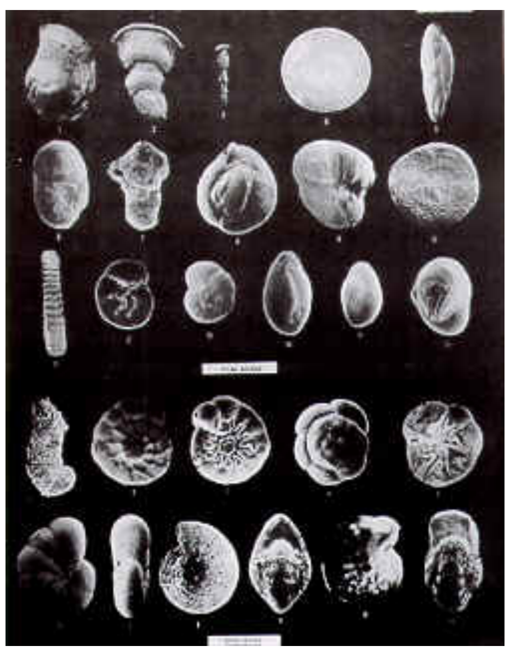


Sometime an x-ray is taken of the cores. This is an example of what it looks like. The years next to the core tell which year the sediment layer is from.

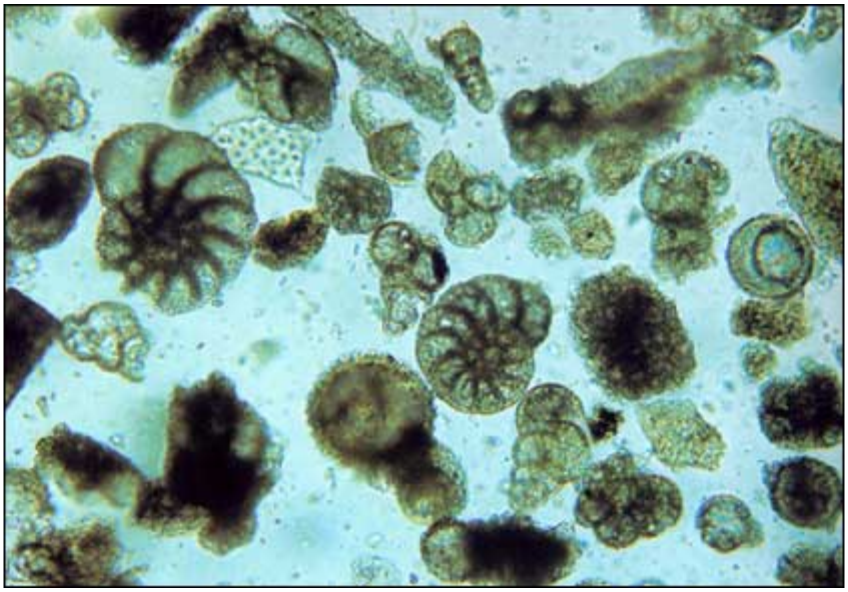
d from UCAR’s Climate Discovery Teacher’s Guide Lesson 5
http://eo.ucar.edu/educators/ClimateDiscovery/

The corer is lowered to just above the sediment-water interface, with the piston at the bottom of the core barrel. The piston is then fixed in one place by a cable while a weight pushes the core barrel into the sediment. Because the core barrel is moving, but the piston isn't, a vacuum develops between the piston and the mud. This vacuum allows the mud to rise easily into the core barrel despite the friction which would otherwise cause the mud to drag along the sides of the barrel.





Typical fossil foraminifera from Florida Bay. These microscopic fossils are the size of sand grains. These species can be matched with different sets of environmental conditions. (http://www.floridabay.org/pub/bw_report/murkypast.shtml)



More examples of foraminifera under a microscope