Teacher Notes

Background Information

You have probably heard that trees create a layer of wood each year and this results in the tree rings you see when looking at a cut tree stump or log. The thickness of the ring provides some information about the environmental conditions when the tree was growing. Since a layer is created each year, that layer tells you about the conditions the tree encountered the year that the layer was created. If you know the year the tree was cut down, you can even count the layers back, make observations of the layers, and determine the conditions in a specific year. Using tree rings can be particularly valuable as trees have been around for some time in locations where humans were not keeping records about the conditions. In fact, some trees alive today are over 2000 years old.

So, how does this relate to glaciers? Well, when it snows each year in a polar or alpine region, a layer of snow is laid down. Each year a new layer of snow is created, with the oldest being on the bottom and the youngest being on the top. This creates a "layer cake" of snow that, due to the weight of the snow above it, eventually transforms the layers of snow into layers of ice. This is similar to what occurs when you walk through snow or push snow together to make a snowball.

Much like trees have a ring each year, glaciers have a layer each year. When the snow falls, it brings with it anything that is in the atmosphere at that time. So, the layers contains more than water (the snow that transforms into ice), it can contain debris from forest fires and volcanoes, pollen and insects, dust that is picked up by wind blowing over dry regions, bubbles of gases from the atmosphere at that time, and chemical tracers. Some of these materials are easier to see with the eye, such as debris, dust and insects. Others, such as pollen, bubbles of gas, and chemical tracers are harder to be seen. We need to use special tools to observe and analyze them. This lesson is designed to provide students with a simulation of the process that scientists use when analyzing an ice core.

Besides the debris in the layer, the amount of water tells us something about the amount of snow that the glacier received in a given year. A thick layers means that the glacier received a great deal of snow; a thin layer means that the glacier received little snow.

While you are able to see layers at the edge of a glacier or in places where it breaks (crevasses), these often do not allow scientist to see an many layers as clearly as they would like. Therefore, scientists have created equipment that allows them to drill.

Instructional Goals

- Water is stored in many forms on the Earth. In order of abundance, water is stored in oceans, glaciers, groundwater, and surface water (lakes and rivers).
- One layer is laid down in a glacier each year. The new layers are higher on the glacier than the old layers.
- Scientists can look at a glacier from the side, such as where it terminates or at a crevasse, to investigate the layers. But drilling an ice core allows scientists to look at more layers from a variety of locations.
- Ice cores are created with a hollow drill bit. This process is very similar to how you core an apple.
- Observation and inference skills are critical to a scientist interpreting an ice core.
- Timelines can be used to display the information collected from an ice core.
- Each layer contains an amount of water that provides information about the amount of snow that was received that year.
- When snow falls, other materials from the atmosphere come with it. Therefore, each layer contains information about environmental conditions in the atmosphere when that layer was created.
- Scientists can use environmental conditions in the atmosphere to make conclusions about patterns in the overall Earth system at the time a layer was created.

Materials Required to Create Ice Cores (one layer is poured per day):

- 8 Pringles cans (one per group)
- 100 mL graduated cylinder
- Refrigerated water
- Refrigerated water with instant coffee added
- Gravel
- Plastic insects
- Freezer

Materials Required for Each Student Group to Perform Investigation:

- 3’ x 2’ whiteboard or chart paper
- Marker
- Tray to hold ice core
- Ruler
- Background information sheet
- Ice core

Overview

Task 1: Examination of Tree Samples, Discussion of Aging, and Building of Analogy with Layers in Glaciers

Tree rings are an excellent analogue to annual layers in a glacier. An introduction with tree rings might be helpful as it provides students with a more tangible example of what they will be doing with the ice core analysis simulation below. Tree rings can be best observed by looking at a cross section of a tree (sometimes referred to as a “tree cookie”) that has been sanded and shellacked. Tree cookies can be requested from tree trimming companies by educators. The best tree cookie collection has samples from trees of various ages and with evidence of changing environmental conditions (for example, a tree that was in the middle of the forest and then along the fringe of a new parking lot would show a distinct change in its growth rings).

Task 2: Glacier & Ice Core Background

This can be done with a tour of the Byrd Polar Research Center, showings of various videos provided by the center or WOSU, or a brief lecture by the teacher.

Task 3: Searching for Observations

Each student group will be given one of two ice cores. While students will not be told this, one of their cores came from Drill Site A and the other came from Drill Site B. They will be asked to make some observations and list seven of these observations on the whiteboard. Students will be reminded that they have five senses with which to make observations but that they will not be using taste in this instance. This whiteboard should be labeled, “Ice Core Observations.” Student groups will share their observations with the class once whiteboards have been created. The goal of this task is to make sure that students are aware of the full range of observations. Common observations include: it is cold, it is hard, there are layers, some layers are yellow, some layers are brown, some layers are gritty, layers are different thicknesses, there is an object in one of the layers (insect), the surface is slippery (once it starts to melt). During the discussion, the teacher can help students refine their observations. For instance, when students mention that there are many layers, the teacher can ask how many layers they counted. This will provide all groups with a chance to count the number of layers if they have not done so already.

Task 4: Creating and Sharing a Diagram

Student groups should be asked to erase their list of observations, divide their whiteboard into two halves, and create a detailed diagram of the ice core on one half of the whiteboard. The diagram should be detailed enough to share during a presentation and include all of the observations identified in Task 3. Groups should be encouraged to use labels, different colors of markers, and a legend so that their diagram is easily understood.

Once diagrams have been created, groups will be asked one at a time to stand up and share their diagram in 20 to 30 seconds using their whiteboard. Students will start to see both differences in the way that information was presented and also that the information itself is different (since there are two types of ice cores they are working with).

The teacher should not force students to realize that there are two types of ice cores too quickly but rather see if students arrive at this conclusion on their own. Once presentations have concluded and students are aware that the ice cores are not identical, students should be asked to sort the whiteboards into two groups based on similarities. At this point, students groups should use only their whiteboards and not the ice cores themselves. Once the sorting of whiteboards in complete, ice cores can be placed side-by-side to confirm whether they are the same.

Task 5: Using the Diagram and Background Information to Create a Timeline

In this last task, students will use their observations, with additional background information, to make inferences about the conditions in the atmosphere that would have created their ice core. Start by having students label the years for each of the layers on their diagram if the top one was created in the year 1800. Students need to realize that newer layers are created on top of older layers (similar to the fact that the newest pancake is always on the top of the pile). Therefore, the second layer from the top is from 1799, the next is 1798, etc.

Next, have groups read the supplemental reading that has been provided. Group members can read it independently or one person can read it to the group.

On the other half of their whiteboard, groups should write "Atmosphere Inferences" and create a timeline identifying key events that occurred during each year recorded in their ice core. Information can include: high snowfall years, moderate snowfall years, low snowfall years, and years with forest fires or volcanic eruptions. Once timelines have been created, results can be shared so that the entire class can see how the conditions at the two sites were not identical. Students should be reminded that they have created a first pass at a timeline based on characteristics observed with the human eye, but physical and chemical methods used in laboratories (with more time and more sophisticated equipment) can yield information about the average temperature of the atmosphere, the composition of gases in the atmosphere, and amounts of other trace materials present in the atmosphere.

Teacher Preparation Information

In order to prepare the synthetic ice core, you will need a waterproof tube (Pringles cans work well, especially the new larger size). Small volumes of water will be poured into the can and frozen overnight. This process will be repeated to build up layers of ice one at a time. Two different types of ice core will be built with the instructions below.

Different volumes of water will be poured into the cans and various objects can be placed within the layers to simulate materials that would have been deposited. Plastic insects simulate insects, sand simulates volcanic debris or wildfire soot, and dissolved coffee simulates dust. Other materials, such as pollen, gas bubbles, and specific chemical tracers are difficult to simulate since students will only be analyzing the cores visually and they will not be able to melt their sample.

Once the cores are poured and frozen, the Pringles can should be torn away. Ice cores should last one full day. They last longer by setting the freezer to the coldest setting and storing the cores in a cooler or freezer between class periods (be careful, the cores can freeze together if they are not placed in separate bags). Plastic containers can be purchased or vinyl gutter and end caps used to create trays. This both catches the melting water coming off the ice cores and stops the cores from rolling off tables.

Ice Core from Lower in Drill Site A		
Layer	Material Used to Create	Interpretation of Layer
1	110 mL water, also insert a string with a tag that says TOP	average precipitation year
2	60 mL water with dissolved instant coffee, plastic insect	low precipitation year, dust
3	160 mL water	high precipitation year
4	160 mL water	high precipitation year
5	110 mL water, teaspoon of gravel	average precipitation year, volcanic or forest fire debris
6	60 mL water with dissolved instant coffee, teaspoon of gravel	low precipitation year, dust, volcanic or forest fire debris
7	60 mL water with dissolved instant coffee	low precipitation year, volcanic or forest fire debris
8	110 mL water	average precipitation year

Ice Core from Lower in Drill Site B		
Layer	Material Used to Create	Interpretation of Layer
1	110 mL water, also insert a string with a tag that says TOP	average precipitation year
2	160 mL water	high precipitation year
3	110 mL water, teaspoon of gravel	average precipitation year, volcanic or forest fire debris
4	110 mL water	average precipitation year
5	110 mL water	average precipitation year
6	160 mL water	high precipitation year
7	60 mL water with dissolved instant coffee	low precipitation year, dust
8	110 mL water, plastic insect	average precipitation year

Reading About the Past Before There Were Books

Ice cores provide scientists with a way to learn about environmental conditions in the past before people were around to write records. Snow falls on a glacier each year creating a new layer of snow. As time passes more layers are created, one each year. This results in a “layer cake” of snow. The weight of the snow at the top of the glacier starts to compress the snow below. This ultimately results in a “layer cake” of ice.

Scientists can see the layers where the glacier breaks open at places called crevasses, but using hollow drills, they can drill ice cores at other locations that allow them to see more layers. The benefit of drilling ice cores is that the core can be taken back to the laboratory to analyze and, since a new layer is created each year, the more layers that scientists can observe the more years into the past they can investigate.

The layers of ice provide information about the amount of snow that the glacier received in a given year. A thicker layers means that the glacier received more snow; a thinner layer means that the glacier received less snow. The layer of ice also contains materials such as debris from forest fires and volcanoes, dust picked up by winds, and living materials such as pollen and insects. Many of these materials can be see with the naked eye. Other materials, such as chemical tracers, cannot be seen with the naked eye and more sophisticated ways are used to analyze for these materials.

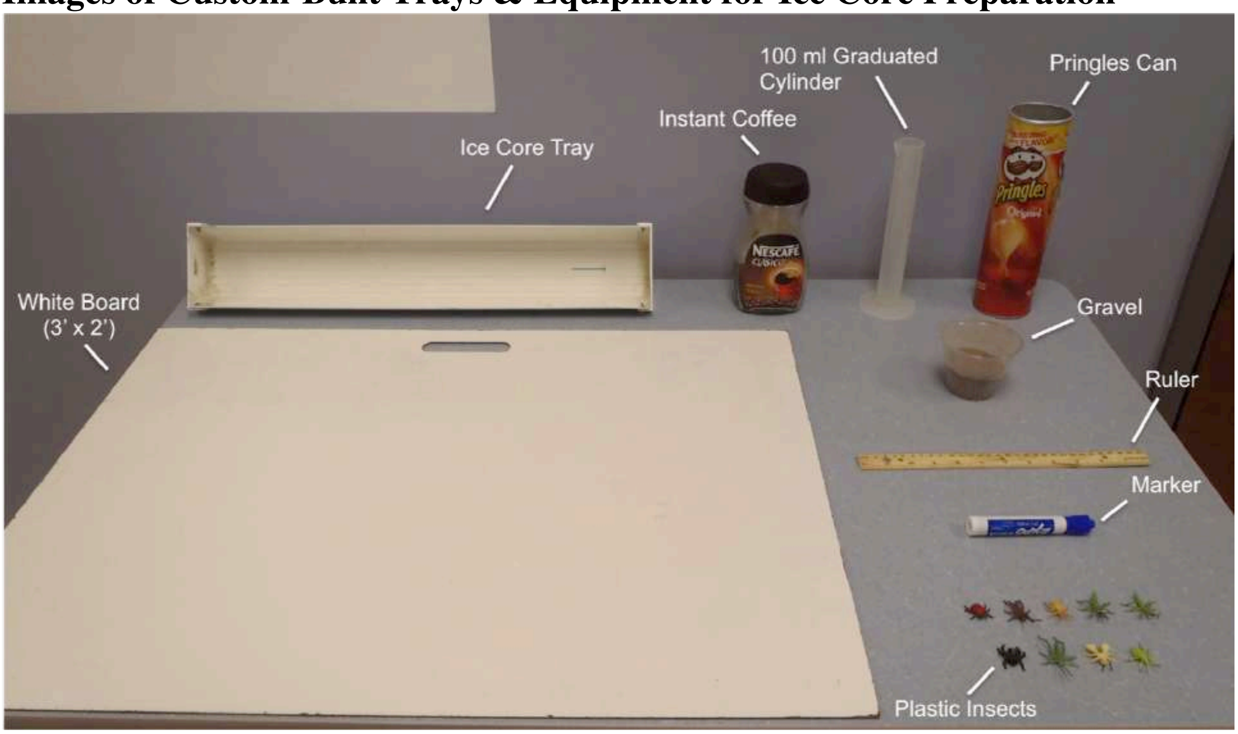
Scientists can use different clues in the ice to determine the exact year a particular layer was created. Knowing the age of one layer and keeping in mind that deeper layers are older than shallow layers, scientists can use their observations and inferences to determine a timeline of environmental conditions for the past.

References

WOSU
Byrd Polar Media
Additional Online Resources on Glaciers and Ice Cores

Appreciation
Thank you to Dr. Carol Landis, Nathan Patrick, Dave, etc. for assistance in creating this lesson.

Images of Custom-Built Trays & Equipment for Ice Core Preparation



Images of Students Completing the Laboratory Exercises

Images of Ice Core Samples


Images from Ice Core Drilling Projects on Nevado Sajama by Researchers from Byrd Polar Research Center

Photos provided by Dr. Lonnie Thompson at The Ohio State University.