Ice Cores: Unlocking Past Climates
Module 2: Recovering Ice Cores

Overview
Technological design is a critical component of many scientific ventures. This lesson challenges students to design a device that keeps an ice core frozen for 24 hours. After watching the video, students design and test an ice storage unit that keeps the ice frozen for 24 hours. Throughout the design process student teams share and critique their plans.

Content Objectives
Students will

- Describe the physical properties of ice
- Investigate freezing point depression and insulating properties of various materials
- Design an ice storage unit

Process Objectives
Students will

- Design, test, and revise strategies for preserving ice cores
- Design investigations for evaluating various forms of ice, freezing point depression, and insulating properties of various materials

Assessment Strategies

- Student presentations
- Ice storage unit evaluation

Grade Level: 5-8

Suggested Time: 3-5 class periods

Materials

- Ice core molds, e.g. small tin cans with smooth sides, popsicle molds
- A variety of coolers (students may bring these from home, place limits on the size and weight of the cooler)
- materials for enhancing cooler efficiency or constructing coolers, e.g. sheets of Styrofoam, cardboard, newspaper, plastic
- construction tools, e.g. scissors, tape, string
- An assortment of ice packs
- Ice in a variety of forms, e.g. cubes, crushed, blocks
- Dry ice (optional, use with caution)
- Gloves, towels, or other materials for handling the ice
- Tools for working with the ice, e.g. chisels, mallets, tongs, spoons
- Thermometers
- Styrofoam cups
- Rock salt and/or calcium chloride to lower the freezing point of the ice (required if students are testing freezing point depression)
- Stop watches

- Beakers (50 or 100 mL)

Procedures

Transporting & Preserving Ice Cores

Advance Preparation: Prepare ice cores by filling molds ¾ full of water. Place in freezer until frozen solid all the way through. Ice cores should remain in the freezer until students are ready to test their ice storage unit.

1. Engage students by showing the *Recovering Ice Cores* video
    a. Before showing the video surprise students by taking a block of ice out of a cooler and plopping it down on a desk. Ask students to generate a list of characteristics of the ice. After the list has been generated, return the ice to the cooler. As you are returning the ice to the cooler, pull out a much smaller ice cube and ask students how they would remove this ice cube from the block of ice without extensive damage to the larger block of ice. Allow students to brainstorm about how to remove a sample from the block of ice without destroying or causing significant damage to the block. Transition to the video by telling the class that scientists not only remove ice samples from glaciers, but they also transport the frozen samples long distances.
    b. During the video ask students to note challenges scientists face when harvesting, transporting, and preserving ice cores.
    c. After the video ask students to share their lists of challenges scientists face. Cluster the items on the list into several broad categories. Add this list of challenges to the previously generated list of ice characteristics.
    d. Ask students how their thinking about how to remove a small sample from a large block of ice has changed since watching the video. Transition to the challenge by telling students that they will now face one of the same challenges scientists working with ice cores face; keeping them frozen while they move them from the glacier to the lab.

2. Challenge students to construct a device that will keep an ice core frozen and uncontaminated for 24 hours.
    a. Organize students into teams with 3-4 students per team.
    b. Set the stage with the following scenario: A team of climate scientists is harvesting ice cores from the Quelccaya Ice Cap in the Andes Mountains. They have just discovered that the ice storage units they planned to use to get the ice cores down the mountain have been damaged. There is no way a refrigerator truck or other modern transportation can be used. They are using pack animals to get the ice cores off the mountain. They must find a way to keep the ice cores frozen while the pack animals carry them down the mountain. They have to use the materials they have with them to solve the problem. You have some of the same materials in your classroom. The only other thing the scientists have on hand is some small coolers. How do you think they should solve this problem?
    c. Show students the ice cores they will be working with and the array of tools and materials they may work with to construct their ice storage unit. Challenge them to develop a design that will keep the ice core frozen and uncontaminated for 24 hours. Students may bring additional materials from home.

d. Set some parameters to make the challenge more realistic and interesting. Suggested parameters could include:
    i. Size limits-this could be specific dimensions, e.g. 25 cm X 20 cm x 30 cm, or total volume 4.25 L.
    ii. Weight limits-this could include the container and all materials used to keep the ice core frozen.
    iii. Materials limits-this could be applied to the type of cooler brought from home, the amount of ice each team can use, the amount of any other material made available to the teams, e.g. 6 meters of tape
    iv. Cost limits-consider providing each team with a "development grant" that provides funds for purchasing materials. The grant may be delivered in play money or a statement of funds available for electronic transfer. Teams must then purchase the materials they want to use from the classroom "stock room". To do this simply make up a price list and determine how much "funding" to award to each team.
e. Before beginning to design the ice storage units, teams should conduct some materials tests before beginning to design their ice storage unit. They could test,
    i. Various forms of ice, e.g. a large chunk, cubes, or crushed ice
    A possible experiment would be to put an equal mass of each form of ice into separate calorimeters and then mass the ice that remains after 20 minutes. A simple calorimeter can be made by putting one fast-food coffee cup inside another. Put the lid on and insert the thermometer into one of the opening in the lid.
    ii. Ice with rock salt added
    A possible experiment would be to put equal amounts of ice into separate calorimeters. Add rock salt to one and then put the lids on the calorimeters. Quickly insert a thermometer into the calorimeters and record the temperature. Record the temperature at regular intervals for 20 minutes.
    iii. Insulating qualities of materials, e.g. cardboard, Styrofoam, bubble wrap
    A possible experiment would be to construct boxes slightly bigger than a small beaker. Before sealing the box, fill the beaker with ice. After 20 minutes unseal the box and measure the remaining ice. Be sure to put the same quantity of ice in each beaker if multiple materials are being tested.
f. After testing is complete, allow teams adequate time to design their ice storage unit. Teams should prepare a presentation that describes how they plan to build the prototype. The presentation should include diagrams that illustrate the finished product.
g. Bring the class back together for team presentations. Ask one representative from each team to present their plans to the remaining teams. The presentations should be short (1-2 minutes). Teams should ask questions and provide feedback about design strengths and suggestions for improving the design.
h. Give teams time to make any modifications to their plans.
i. Teams now build and test their designs. Building should take approximately one class period. After the prototypes are built, have students put the ice core inside. Prior to putting the ice core inside, students should measure the volume and mass of the ice core. The ice core should be wrapped to protect it from contamination. The next day students should open their ice storage units, measure the remaining ice core, and share their findings with the class.

j. Finish by having students reflect on how this experience helped them understand the challenges scientists working with ice cores face.

Additional content support for teachers:

- Colligative Properties, http://www.chemistryexplained.com/Ce-Co/Colligative-Properties.html