Thermal Energy Design Challenge
Featured Scientist – Emilie Beaudon

Emilie Beaudon is a glaciologist who travels to icy slopes around the globe to collect frozen records of past climates. Just like a detective, she investigates microscopic 'clues' in old ice to find out what the environment was like during ancient times. Some of the clues in ice cores include plant fragments, salts, gas bubbles, soot, or metal particles. Her favorite 'clue' to study is mineral dust particles.

As a child, Emilie was so impressed and fascinated by the gigantic volcanic eruption of Mt Pinatubo and by the Vatnajökull glacial burst that she decided she would study Earth's natural processes. Later on, Emilie obtained a master's degree in Earth Sciences in France and then earned a PhD in Glaciology at the University of Lapland (Finland).

Dr. Beaudon is now a senior researcher and member of the ice core paleoclimatology research group at the Byrd Polar and Climate Research Center (The Ohio State University, Columbus, Ohio). Since the first time she touched an ice core 17 years ago, she has retrieved and analyzed ice from both the polar regions and from mountaintop glaciers. She is now leading a project to understand the environmental 'message' carried by dust stored in glaciers and its link to monsoons.

Thermal Energy Design Challenge

When you put on layers to stay warm in the winter, or use a cooler to keep food cool, have you ever wondered about the science of thermal energy transfer? How *does* your insulated mug keep the liquid hot and how *does* your cooler keep food frozen? In fact, did you wonder how both of these devices can actually work to keep objects *hot* or *cold*? Many devices are designed to maintain the temperature of an object without being plugged into an electrical outlet, and even those that are plugged in, such as refrigerators, use designs and materials that reduce the effort needed to maintain the temperature, thus saving on resources

In this activity, make your own ice storage device using simple at-home materials and a little bit of imagination! Challenge yourself to create something that traps cold air inside and keeps warm outside air out.

Thermal Energy Design Challenge

Keep It Cool

Background Information

When you put on layers to stay warm in the winter, or use a cooler to keep food cool, have you ever wondered about the science of thermal energy transfer? How *does* your insulated mug keep the liquid hot and how *does* your cooler keep food frozen? In fact, did you wonder how both of these devices can actually work to keep objects *hot* or *cold*? Many devices are designed to maintain the temperature of an object without being plugged into an electrical outlet, and even those that are plugged in, such as refrigerators, use designs and materials that reduce the effort needed to maintain the temperature, thus saving on resources

Ice cores are an example of something that needs to remain frozen when they are transported. Coring ice is one method used to measure atmospheric conditions. When layers of snow fall on a glacier or ice sheet, these layers trap air and dust from the atmosphere, which can be collected and measured by drilling an ice core. These ice cores are taken from remote places across the world, including mountaintop glaciers in the Andes Mountains and in the middle of the Antarctic ice sheet. When ice cores are drilled, they must be transported back to the Byrd Center in order to be analyzed and stored in the -30^{o}F freezer. In order to successfully transport the ice cores to the freezer, they need to be contained in a device that is lightweight, easy to carry in a backpack, and can keep an ice core below freezing for days. The device is designed to reduce the transfer of thermal energy from the exterior (which can be warm as it travels on trucks and airplanes) to the interior. Many glaciers are also very bright because of their location above clouds and reflection of light off of the snow. So, the device needs to limit the transformation of light energy to thermal energy.

Using our knowledge of thermal energy transfer and transformation, our teams designed a container for storing and transporting ice cores. To prevent heat transfer into the cores from warmer air and objects surrounding the device, several layers of material are used to insulate the ice core. This includes three layers of cardboard and a layer of foam. This is very similar to how a high-quality cooler uses layers of plastic and foam to keep your beverages cold in the summer.

In addition to insulation, reflection also plays a role in preventing light energy that strikes the device from being transformed into heat transfer that would then warm the ice cores inside of the box. For example, black pavement on a sunny day will transform more light energy into thermal energy than white concrete. To prevent light energy on the glacier from transferred into thermal energy, the ice core container is wrapped in a reflective material, such as foil.

Although there are many ways to transport an ice core, utilizing our understanding of thermal energy transfer and transformation allows us to develop a cost effective, light, and efficient method for storing and transporting ice cores.

Thermal Energy Design Challenge

Materials Required to Create an Ice Core Device (for each group

- 1/2 Cup of Frozen Water In a Ziploc Bag*
- Plastic Baggie*
- Napkin*
- Packing Tape*
- Newspaper
- Black Paper
- White Paper*
- Cardboard*
- Aluminum Foil
- Fleece
- Styrofoam

- ***OR: use the underlined materials plus 3-5 items from your recycling bin**

Materials Required for Planning

- Measuring Cup/Spoons
- Paper and Writing Tool for Brainstorming
- Baking Sheet or Tray for Moving Materials
- Location Where Devices Can Be Places for ~30 Minutes (ideally with sun exposure)

Detailed Instructions

Task 1: Creating a Diagram (15 to 20 minutes)

Using a pen and paper, supplied materials, and knowledge of thermal energy transfer, spend 10-15 minutes to brainstorm how to construct your ice core device. Your drawing should be similar to a blueprint. You do not have to use every item in your model but consider using as many items as necessary and useful. Use labels and different colors of markers, so your diagram is easily understood. Labels should outline how materials are used and how they will either reduce the transfer of thermal energy to the ice core (conduction or convection) or reduce the transformation of light energy to thermal energy (radiation).

Task 2: Use the Diagram and Background Information to Create an Ice Core Device (10 to 15 minutes)

In this task, use your blueprints, the provided materials, and background information to construct your ice core device. You do not have to use all of the materials, but try not to use more items that you planned for. Once your capsule is built, insert the frozen water into its place and put your completed ice core device, with ice core inside, outside in the sun for 30 minutes.

When the 30 minutes are over, remove the ice core from your device and measure the meltwater from the thawing ice using a measuring cup or spoons. If there was a lot of melt, consider what could have caused the heat to transfer to your ice. If there was very little melt – great work! Consider what helped keep the ice cool!

Thermal Energy Design Challenge

Using your new knowledge of thermal energy transfer and after thinking about the success of your device, revisit your original design and write recommendations for revising your original device.

To learn more about thermal energy transfer and ice cores visit:

PBS: https://www.pbslearningmedia.org/resource/lsps07-sci-phys-thermalenergy/thermalenergy-transfer/
Physics Classroom: https://www.physicsclassroom.com/class/thermalP/Lesson-1/Methods-ofHeat-Transfer
Ice Core Activity: https://byrd.osu.edu/create-classroom-ice-cores

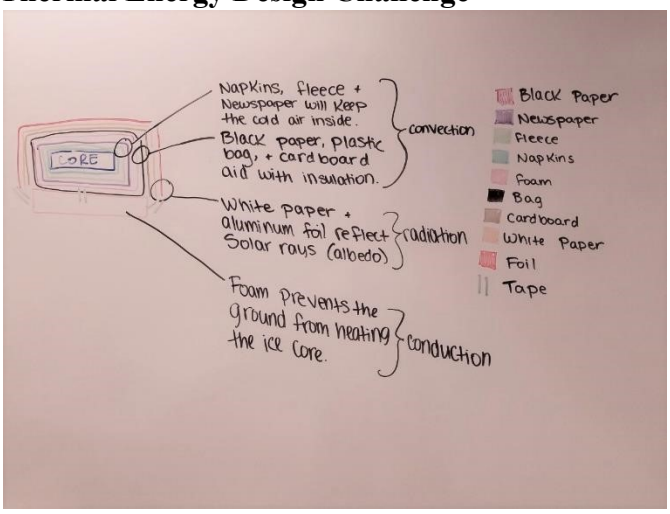
Photo Tutorial

Step 1 - Materials:

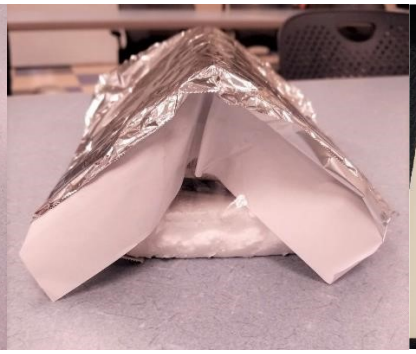
Step 2 – Design:

Step 3 – Explain your reasoning:

Thermal Energy Design Challenge



Step 4 – Build!


Step 5 – Test and Evaluate

Keep It Cool

Name: _____

Goal

Keep an ice core frozen by avoiding 1) the transfer of thermal energy to the interior of your ice core container and 2) limiting the transformation of light energy to thermal energy.

Challenge

Design and construct an ice core container by using the materials listed below. There are no limits to the size of the device. However, it should be able to independently hold the ice core and easily remove it at the conclusion.

Materials Available

Ice Core (1/2 cup frozen water)	Newspaper Sheet (1)	Aluminum Foil (1)
Plastic Baggie (1)	Black Paper Sheet (1)	Fleece* (1)
Napkin (3)	White Paper Sheet (1)	Foam* (1)
Packing Tape (0.3 meter)	Cardboard Piece(1)	Items from your recycling bin (3-5)

*avoid damaging these items

Design Diagram for Ice Core Container with Features Labeled

Amount of Meltwater:

Resigned Ice Core Container with Features Labeled

List of Features with the Purpose of Each Provided