PERMAFROST EXPERIMENTS

See the pages below for various lesson plans and activities to complete with students to broaden their understanding of cold climates and permafrost.

PAGES

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Permafrost Demonstration

Did you know?

- Permafrost refers to a thick layer of underground soil that remain frozen year-round.
- Heat from buildings can cause permafrost to thaw.
- Houses are built on **elevated foundations** to help prevent permafrost from thawing.
- Thawing permafrost releases carbon dioxide.

Background

- This lesson is based on "Solid Ground: Permafrost Demonstration". The original lesson can be found at https://answersingenesis.org/kids/science/science-experiments/solid-ground-permafrost-demonstration/.

Time Estimates

- Prep work: about 10 minutes (must be done roughly 24 hours in advance)
- Experiment: about 1 hour
  - This could be extended or shortened by changing how long the mugs sit on the permafrost before conclusions are drawn.

Materials

- 1 large pan (cake pan – 1 to 2 inches deep) for permafrost. Make sure it is large enough to fit 4 mugs without having them touch.
- Soil/dirt (frozen overnight in the pan)
- 4 Identically sized ceramic or glass mugs
- 1 Thermos of hot water (optional)
- A way to boil or heat water
- Ice or water in a mug that is frozen overnight
- Kitchen sponge, small square of styrofoam or other type of foam "insulation"
- 3 plastic building blocks (Legos) or Dominoes
- Timer

Get ready!

- Teachers - Fill the large pan with soil or dirt. Add water to the pan creating a slightly soupy consistency and make sure your ground is level. Then freeze the pan to make “permafrost.” This process should take a day, so make sure to plan ahead.

Go!

- Place one mug on the frozen soil and fill mug with ice.
- Fill the second mug with hot water and place on frozen soil.

- Place building blocks on the frozen soil and place a mug with hot water on top of the blocks.
- Place sponge or foam on frozen soil and place the last mug with hot water on the sponge.
- Make sure that the mugs are not touching each other.
- Make a prediction about what will happen to the soil under each mug.
- Every 10 minutes make sure to replace the hot water that has cooled. (This is where the thermos can be helpful if you do not want to re-heat the water.)

- Observe and measure the changes to the frozen soil.
- Note how the frozen soil responds to each of the different mugs.
- Record your observations on the worksheet.

Record your data

Record initial starting conditions for each mug.

	Mug 1	Mug 2	Mug 3	Mug 4
Position				
Foundation type				
Hot or Cold				

Observe changes in soil over time. What does the soil look like? What does the soil feel like? How has it changed?

Minutes	Mug 1	Mug 2	Mug 3	Mug 4

Think About It – Questions

Permafrost Demonstration

1. Among the mugs filled with hot water, which one had the smallest impact on the permafrost?

2. What happens to the mug that sits directly on the permafrost (frozen soil)?

3. What happens when you add some insulation (sponge or foam barrier) under the mug??

4. What happens when you place the mug on an elevated foundation?

5. What happens under the mug filled with ice?

6. Can you think of other ways to prevent permafrost from thawing underneath warm buildings besides elevating the building off the ground?

7. What buildings in your community have elevated foundations?

8. Do you know what kind of foundation your house is built on?

What happens when permafrost under a building thaws?

Did you know?

- Permafrost refers to a thick layer of underground soil that remains frozen year-round.
- The warming climate is causing permafrost to thaw.
- Heat from a building can cause permafrost to thaw.
- Water can cause permafrost to thaw.

Background

- This lesson is slightly adapted from outreach materials provided by "Hot Times in Cold Places." You can find educational videos and a photo of the lesson set up: www.permafrosttunnel.org

Time Estimates

- Prep work: about 10 minutes (must be done roughly 24 hours in advance)
- Experiment: about 1 hour
  - This could be extended if more time is taken to build and decorate the foundations and the roof.
  - If pressed for time, the experiment can be compressed to 45 minutes by building a simple foundation and skipping the roof.

Materials

- Large tray (to hold the permafrost while it is thawing)
- For the permafrost:
  - Water
  - Dirt
  - Freezer
  - Medium-sized container to freeze the permafrost in (like a shallow bin, cake pan
- For the houses:
  - Small loaf pans or small rectangular containers (for the base of houses)
  - Hot water
  - Popsicle sticks for roofs and foundations of houses

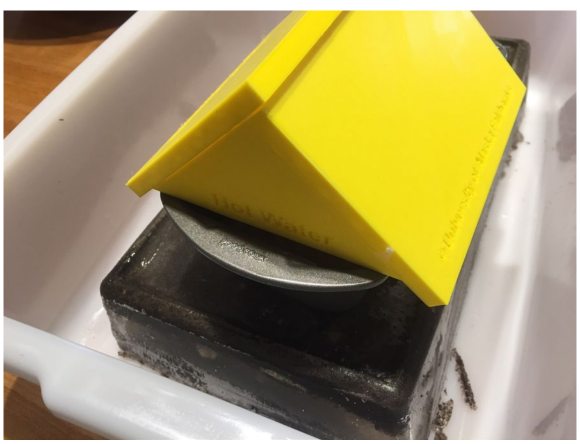
Get ready!

- Teachers – you will need to make permafrost before you conduct this experiment. This takes a day so be sure to plan ahead.
  - Put some soil or dirt in the medium-sized pan. Fill the tray with water and freeze the soil / water mixture.
  - Try to make sure the permafrost is relatively uniform and freezes on an even surface.
- While the permafrost is freezing, students can build their houses. Use the popsicle sticks to create a roof. Use more popsicle sticks to make an **elevated** foundation. Elevated means lifted off the ground.

Image courtesy of "Hot Times in Cold Places" website.

Go!

- Once the permafrost is frozen, you are ready to go! Remove the permafrost from the container it was frozen in and place it in the large tray.
- Place the popsicle stick foundation on the permafrost. Place one of the small pans (“houses”) onto the popsicle foundation. This part of the experiment represents a house that is built on an elevated foundation.
- Place the other small pan directly onto the permafrost. This part of the experiment represents a house that is built directly on permafrost.
- Fill the small pans with hot water. Make sure to put the roofs on, so they look like warm houses (our roof is a yellow model, instead of popsicle sticks).



- Make predictions about what you think will happen. What will happen to the permafrost underneath each “house”?
- Watch what happens and record the results on the worksheet

Predictions

Permafrost Thawing Under Buildings

How do you think the permafrost will change over time for each house? Will the change be different?
Why do you think this is?

Record Your Observations

Observe changes in permafrost over time.

Minutes	Directly on Permafrost	Stilt Foundation

Permafrost Thawing Under Buildings

Think About It – Questions

1. What happens to the house that sits directly on the permafrost?

2. What happens to the house that has an **elevated** foundation?

3. Why do you think there is a difference?

4. When you lift the model houses what does the permafrost underneath feel like? Is there a difference between what the permafrost feels like under the house with the elevated foundation and the house sitting directly on the permafrost?

5. Can you think of other ways to prevent permafrost thaw underneath warm buildings besides elevating the building off the ground?

6. What buildings in Point Lay have elevated foundations?

Thermal Image Scavenger Hunt

Did you know?

- Normally infrared radiation, or heat, is invisible to human eyes.
- Thermal imaging cameras translate infrared radiation, or heat, into colors.
- Thermal imaging cameras are used by engineers and scientists to discover where heat is traveling in or from a building.

Materials

- Thermal imaging camera

Get ready!

- Try to use the thermal imaging camera so you are familiar with how it works. You might try using it to look at a person. What areas are the warmest? Which areas are the coldest? HINT – compare a person's core temperature to that in their hands.
- This lesson works best in the fall or winter when it is cold outside.

Go! See if you can find the following images.

- [ ] A car or snow machine that has been turned off for at least a few hours AND one that was just turned off.
- [ ] The window in a building and the surrounding wall. Which part – the window or the wall – is leaking the most heat to the outdoors?
- [ ] A door and the surrounding wall. Is there an area that is leaking heat to the outdoors? Is the door better at holding heat inside the building, or is the wall better?
- [ ] The roof of a building. Is there heat leaking out of the roof to the air?
- [ ] The floor of a building. Is there heat leaking out of the floor to the air?
- [ ] A baseboard inside a building. Is the heating system currently on or off? Can you tell from the picture?
- [ ] An oven in a kitchen. Is it on or off? Can you tell from the picture?

The window frames in this image are much warmer than surrounding air – this means that the materials are transferring heat from inside the house to the outside. That's lost energy! A material that was a better **insulator** would help keep heat inside the house where it can ensure people are warm.

Where else on this house is leaking heat to the outdoors?

EXPLORING SNOW

Did you know?

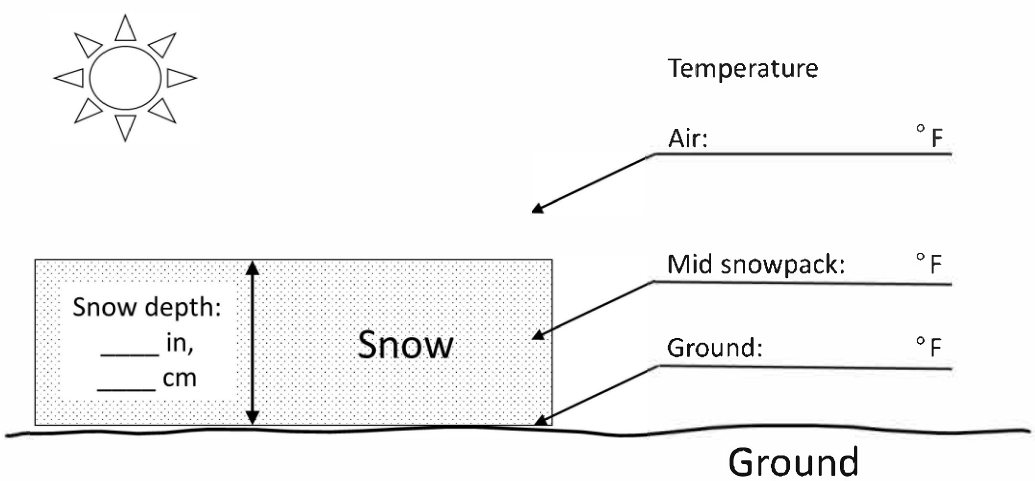
- Snow forms when frozen ice crystals fall from a cloud.
- Snow crystals can have many different shapes.
- Snow traps air and is a good insulator. (An *in-su-la-tor* keeps the temperature of an object the same.)

Get ready!

- Dress warm! Bring a shovel, measuring tape and thermometer.
- Find an undisturbed patch of snow.
- Dig through the snow until you hit the ground; scrape one side wall of your hole smooth.

Record measurements

- With your thermometer, measure the temperature of
  - the air above the snow
  - the snow in the middle of the snowpack
  - the ground below the snowpack
- Use the measuring tape to see how thick the snowpack is.
- Write your data on the lines in the diagram below:



- Look at the snow crystals: What shapes can you find towards the top and bottom of the snowpack?

____

Think about it

- Where did you find the lowest temperature? ____
- Where did you find the highest temperature? ____
- Some small animals spend the winter in or below the snowpack. Can you think of any?

____

Measuring Snow Depth and Temperature

Did you know?

Snow is very important in the Arctic environment. It insulates the ground from cold winter air, providing shelter for plants and animals who stay warmer beneath the snow cover. In spring, snowmelt becomes an important source of water in the Arctic landscape.

Scientists monitor snow depth and air temperature to know how cold the ground is. Less snow means less insulation and colder ground. More snow keeps the ground warmer and can lead to permafrost thaw, especially in places where snow berms form along roadsides, snow fences and other infrastructure. If there is more snow, there will also be more water flowing into lakes and rivers next summer. If there is late snow, birds and plants may be in trouble.

Scientists working on our project at the University of Alaska Fairbanks want to know: What is the threshold? How much snow can be on the landscape given recent climate trends before ice-rich permafrost degrades? This is where young scientists in the community can help by measuring the depth of snow, air temperature, and ground surface temperature in different places and at different times throughout the winter.

Get ready

- In spring, plan to take your measurements in the morning before the day warms up.
- Equipment: Measuring stick, 4 temperature sensors (thermistors) and a data logger with digital display
- Handheld GPS (or camera with GPS enabled to geotag photos)
- Datasheet to record your data (on back of this page)
- Put the measuring stick with the sensors outdoors ~30 minutes before you plan to start.
- Watch the video on how to use the equipment to measure snow.

Measure and record

- Choose a variety of locations to measure snow depth and temperature. Some good places are:
    - Near buildings and other infrastructure (examples: along roads where snowplows leave snow, between houses, beneath elevated houses, along snow fence and other places with snowdrifts)
    - In undisturbed locations further away from human infrastructure
- Press the button on top of the HOBO data logger to turn it on. Follow instructions in the video.
- If the snow has a wind-packed crust on top, first use a pole to make a small hole in the snow to prevent the thermistors being damaged or dislodged when measuring stick is pushed through the icy crust.
- Record the snow depth and the temperature of each for each channel on the datasheet.
- Record the geolocation using the handheld GPS or by taking a photo from the spot.
- When you are finished using the equipment for the day, press the power button on the data logger again to turn it off so the battery doesn't drain.
- Back inside, enter your data in the Excel worksheet. Give each record a unique ID number. Save your photos in the same folder with your data. Either record the filename of the photo in the Excel datasheet, or rename the photo with the unique ID of the record.

Repeat

- Place a pole with a flag in some of the spots you measured in the morning and take measurements again in the afternoon and/or evening.
- Watch the 5-day forecast. If a strong warming or cooling trend is forecast, put the measuring stick in a spot that's easy to visit and return each day to take measurements throughout the event. (Turn the power off between visits.)

Record your data

				Temperature (°F)				Location			
Student Name	Date	Time	Snow depth (in.)	Channel 1 (air)	Channel 2 (snow)	Channel 3 (snow)	Channel 4 (snow)	If photo: Filename	Latitude	Longitude	Description of location

Note: If you don't have a GPS device, you can download a free smart phone app or a desktop app for a Windows or Mac computer to view the latitude and longitude of your geotagged photos.