

TTCD Lesson Plan (26): Permafrost

Unit: Permafrost	Grade(s): All	Class Size: 1-30	Lesson Duration: 1 hour, 15 minutes	Location(s): Classroom
Topic(s):	Permafrost, Food storage, Climate Change			
Student Prerequisites:	N/A			
Essential Questions:	What is permafrost? How does permafrost impact buildings? How has permafrost been used for generations in Alaska for food storage? What is climate change? How is climate change impacting permafrost?			
Student Objectives:	Students will learn about climate change through the lens of changing permafrost conditions in Alaska. Students will participate in a physical and visual demonstration that compares foundations of various materials of homes with different temperatures. Students will learn how permafrost has played a role in indigenous food sovereignty. Students will learn how melting permafrost is changing building foundations and will brainstorm solutions.			
Standards:	Supports NGS Standards: 5-ESS2-1: Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact HS-ESS3-1: Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. Relevant NGS Crosscutting Concepts: Systems and System Models: A system can be described in terms of its components and their interactions. Relevant Disciplinary Core Standards: ESS2.D: Weather and Climate: Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. Cultural Standards E.1: Culturally-knowledgeable students demonstrate an awareness and appreciation of the relationships and processes of interaction of all elements in			

	the world around them by: recogniz[ing] and build[ing] upon the inter-relationships that exist among the spiritual, natural and human realms in the world around them, as reflected in their own cultural traditions and beliefs as well as those of others. E.2: Culturally-knowledgeable students demonstrate an awareness and appreciation of the relationships and processes of interaction of all elements in the world around them by: understand[ing] the ecology and geography of the bioregion they inhabit. E.5: Culturally-knowledgeable students demonstrate an awareness and appreciation of the relationships and processes of interaction of all elements in the world around them by: recogniz[ing] how and why cultures change over time.
Local Context:	Discuss how melting permafrost is impacting specific parts of the state of Alaska. Discuss how melting permafrost is threatening traditional Alaska Native food storage methods.
Vocabulary:	Permafrost: A thick subsurface layer of soil that remains frozen throughout the year, occurring chiefly in polar regions. Thaw: Ice, snow, or another frozen substance, such as food becomes liquid or soft as a result of warming. Climate Change: Climate change is a long-term shift in the average weather conditions of a region, such as temperature, rainfall, and wind. It can also refer to changes in ocean conditions, such as rising sea levels and ocean acidity. Ice Cellars: Ice cellars are a natural form of refrigeration constructed within permafrost. They are traditionally employed by indigenous Arctic peoples to store harvested wildlife.
Dena'ina language words:	
Materials:	The following materials are needed per each class: • 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 • Writing utensils • Worksheet on page 4 here – enough for each person in the class: https://cchrc.org/wp-content/uploads/media/Permafrost_Experiments_Packet.pdf
Instructor Prep:	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 plan ahead. 
Introduction:	Permafrost refers to a thick layer of underground soil that remains frozen year-round. Permafrost is found in Alaska beneath about 85% of the state, especially in the north. Many buildings in Alaska are built on top of permafrost. Heat from buildings can cause permafrost to thaw, or melt. In addition, climate change is making the weather warmer, causing additional permafrost to melt. Ask the class: What do you think are the impacts of melting permafrost on buildings? - Permafrost melting is causing foundation instability, leading to settling, cracking, tilting, and even structural collapse due to the shifting ground beneath buildings. Ask the class: What are some other things that melting permafrost might impact in Alaska? - Damaged roads and runways, slumping telephone poles, how people store their food, sinkholes, the release of greenhouse gases (warming the climate even more) Let’s talk a little bit more about storing food under permafrost, essentially creating an in-ground freezer or an ice cellar. Permafrost – the thick layer of frozen earth in cold climates has long been used as a natural freezer system by Native communities to preserve their food. In whaling communities, these ice cellars are particularly important. Read an excerpt from the beginning of this article on Alaska whaling communities and ice cellars. Consider reading from the excerpts that highlight why cold cellars work well for the particular needs of these communities: https://www.hcn.org/articles/north-climate-change-alaska-whaling-communities-pilot-a-project-to-keep-traditional-ice-cellars-frozen/

	Ask the class: What are some ways that people might be able to adapt to melting cold cellars? - Students might highlight using refrigerators or walk in freezers with enough space for something like a whale. Drying, smoking, canning meat. Finding a way to keep the ground colder. By integrating modern science and freezing technology with traditional knowledge, communities can better preserve their cultural foodways, and there is a technological solution that is being implemented in northern communities that does just that! It is called a thermosyphon, and it is basically a tube that takes heat out of the ground and releases it into the air. They are designed to stop heat from a building damaging the permafrost below. Now we are going to participate in a demonstration to see how the heat from buildings impact permafrost and what some of the different building methods are to prevent melting. Ask the students to gather around the table with their worksheets: On page 4 here: https://cchrc.org/wp-content/uploads/media/Permafrost_Experiments_Packet.pdf
Activity	 • 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. • Students should record their observations on the worksheet attached on page 4 here: https://cchrc.org/wp-content/uploads/media/Permafrost_Experiments_Packet.pdf
Wrap-Up:	Aks the students: 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? <i>Evidence of learning:</i> Ask the class: reviewing everything you have learned about permafrost, how would you design a house today that you know is built upon permafrost? What kind of refrigeration design would you include in the house? Look for reflections on the experiment and knowledge that permafrost is increasingly melting in Alaska, that the more barriers you can put between the house and the permafrost the better, that there are drawbacks to completely changing traditional methods of refrigeration.
Lesson Adaptations:	Consider conducting this experiment on page 6, which explores what happens when permafrost under buildings melt: https://cchrc.org/wp-content/uploads/media/Permafrost Experiments Packet.pdf
Extensions:	1. For older students, play this video highlighting the work of the Cold Climate Housing Research Center (CCHRC) in Fairbanks: https://imagine5.com/video/building-energy-efficient-homes-in-alaska/?fbclid=IwY2xjawHfvDtleHRuA2FibQlxMQABHVjVIMpYaH62CbzfMT2aRRYqiB_0ZXLR3FiIzn2WGPKrZ_jSsK5_3iTzQ_aem_kBvKzgBsXxVavdyaWeNKuQ 2. Reach out to someone from the CCHRC to speak to the class over zoom about adapting housing to melting permafrost. Contact info: https://cchrc.org/contact/ 3. Permafrost can also tell us about history! Play this video to show how (can be played until minute 2:50 to highlight the discovery of ancient species): https://www.youtube.com/watch?v=7VV4s4uiwLY 4. In northern Alaska communities like Utqiagvik, cold cellars are used to preserve whale meat? Ask students: what are some traditional methods of food preservation in your home/community?
Reflections:	How did it go? What did students understand most/least? What could change about instruction or lesson plan?
Resources Used:	CCHRC: Permafrost Experiments Article: Alaska whaling communities pilot a project to keep traditional ice cellars frozen CCHRC Video: https://imagine5.com/video/building-energy-efficient-homes-in-alaska/?fbclid=IwY2xjawHfvDtleHRuA2FibQlxMQABHVjVIMpYaH62CbzfMT2aRRYqi

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Permafrost Uncovering History Video:

<https://www.youtube.com/watch?v=7VV4s4uiwLY>