UNDER THE ARCTIC:
DIGGING INTO PERMAFROST

Staff & Educator's Guide

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UNDER the ARCTIC

Digging into Permafrost

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If you have any questions about the content of the Educator Guide, exhibition, or related materials, please contact the OMSI Exhibition Tour Manager at (503) 797-4628 or travelingexhibits@omsi.edu so we can help connect you with the right people to answer your questions.

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Exhibition Overview

Under the Arctic: Digging Into Permafrost is an immersive, interactive exhibition that opens a dialog about one of the most important issues of our time: climate change. The key visitor experience is a replica of the Western Hemisphere's only permafrost research tunnel, located in Alaska. The exhibition strives to educate visitors about permafrost's unfamiliar properties, especially the impact it has on our changing climate. "It's an opportunity to make climate change tangible," said Exhibit Developer Allyson Woodard. "You get to see it, you get to touch it, you even get to smell it in the exhibit."

Permafrost, or ground that has stayed frozen for at least two years, is rapidly thawing. Not only does this harm Artic communities, but it harms all life across the globe. Permafrost holds a lot of frozen plant matter – as permafrost thaws, the plant matter decays and releases carbon dioxide and methane into the atmosphere. Carbon dioxide and methane are heat-trapping gases that cause the planet to warm even more, which causes more permafrost to melt in a feedback loop. There is an estimated two times more carbon frozen in permafrost than is currently in the air. Melting permafrost speeds up climate change, which impacts communities and places all around the Earth. By working together in our communities to use less energy, switch to renewable energy, and talk about climate change, we can slow climate change.

Under the Arctic is specially designed for students ages 9-14, school groups, and families. It was developed by the Oregon Museum of Science and Industry (OMSI) in collaboration with the Geophysical Institute at the University of Alaska Fairbanks and an Alaska Native advisory group.

Arctic Globe. Visitors are drawn into the exhibition by a glowing globe that illustrates how places all over the world are impacted by thawing permafrost. Visitors learn about the vast scale of permafrost and the surprising amount of earth's surface that is frozen year round.

Facilitation tips and supplementary information:

- Stand in front of the globe as visitors enter and welcome them to the exhibit. This allows you to engage visitors with a few questions and then transition those questions into investigation once you reveal the globe. Set up a surprising moment by asking visitors to guess how much land on earth is covered with permafrost. After everyone has guessed, reveal that it's 20%, and then invite them to find permafrost in surprising places (for example, the Rocky Mountains).
- The globe is an excellent place to emphasize three key characteristics of permafrost: it's cold, old, and huge. This sets up visitors' understanding of permafrost for the rest of the exhibit.
- Sample "welcome" questions:
  - Have you heard of permafrost before? Not many people have. *Permafrost is ground that's frozen year-round.*
  - Any guesses on how much of the Earth is covered in permafrost? (Take guesses). *About 20%.*
  - Can you find the United States on the map? *20% of the earth is equal to four of the continental United States.*
  - How old do you think permafrost is? Most *permafrost formed during the last ice age. It's not cold enough now to form new permafrost.*

  On the globe, can you find places with permafrost? Have you ever been to any of these places? If yes, what was it like?

Tunnel Experience

- *Facilitation tips and supplementary information:*
    - Researching in the permafrost tunnel is COLD! The tunnel is opened to frigid air in the winter and refrigerated to below freezing in the summer.
    - For a fun comparison, look up current temperatures and winter lows/highs in Fairbanks!

Tunnel Welcome. Maps and photographs tell the story of the Permafrost Research Tunnel in Alaska—why and how it was excavated in the 1960s. Next to the tunnel history, a permafrost researcher welcomes visitors and takes them on a video tour inside the tunnel in Alaska.

Facilitation tips and supplementary information:

- See "Tunnel Tour" demo (pg. 33)

Permafrost Research Tunnel. The key experience of the exhibition is a replica of the original Alaskan research tunnel, where visitors can discover for themselves all that's hidden inside permafrost!

Facilitation tips and supplementary information:

- See "Tunnel Tour" demo (pg. 33)

Organic Materials Smell Station. Visitors learn how and why organic material is decomposing inside the tunnel and can take a whiff of realistic funky tunnel scent.

Facilitation tips and supplementary information:

- See "Tunnel Tour" demo (pg. 33)

Tunnel Ice Structures. Visitors discover a dark, mysterious ice wedge and a complex sink hole on opposite sides of the tunnel. Visitors learn that frozen ground is full of ice structures that are ancient, complex, and beautiful.

Facilitation tips and supplementary information:

- See "Tunnel Tour" demo (pg. 33)

Tunnel Fossils. Realistic replicas of fossil bones and plants are distributed throughout the sculpted tunnel walls. Many fossils are labeled with numbers and identified on text panels—others are unlabeled to encourage discovery.

Facilitation tips and supplementary information:

- See "Tunnel Tour" demo (pg. 33)

Permafrost Field Lab

Core Sample Station. At this interactive station, visitors compare the weight and visual appearance of different permafrost core samples extracted from the tunnel and use that information to predict which site on the map will be safest for building a new structure.

Facilitation tips and supplementary information:

- This station is a natural fit for facilitation. Permafrost is made of varying amounts of ice, rocks, and soil. Ask visitors to guess which core sample contains more ice, then ask a volunteer to weigh them and report the answer (**Hint:** ice weighs less than rock and soil). This usually surprises people. Visitors can lift up the field guide flipbook to see the answers.

- Features such as ice wedges, like the ones in the permafrost research tunnel, contain the highest concentration of ice in permafrost because they're close to 100% ice. Still, silt-rich permafrost hides countless tiny "ice lenses" (named for their shape) (Sample A).

Gravelly permafrost is the best site for building, because even if the ice melts and drains away, the gravel stays relatively stable (Sample B).

Fossil Exploration Station. Visitors use a microEye magnifier to examine a tray of real fossils and rocks gathered from the tunnel. A nearby field guide flip-book contains sketches and "hand-written" notes.

Facilitation tips and supplementary information:

- You can help boost excitement for the fossils under the microscope by emphasizing their age and that researchers found them in the real permafrost tunnel. Ask visitors to find the oldest fossil, the youngest fossil, or the biggest animal.

Bison Skull Fossil. Visitors touch and examine a real bison skull discovered in Alaska's permafrost! Through this experience, they feel a sense of wonder and fun at seeing the fascinating details of a large, authentic fossil and are thrilled by interacting with an artifact that is both real and rare. Intended for all ages.

Facilitation tips and supplementary information:

- Emphasize that the skull is real and very old.
- Note that fossils found in permafrost were preserved by remaining frozen, not by becoming petrified. The skull is discolored by minerals in the permafrost—it is real bone, not stone.

Atmosphere Station. One side of this station invites visitors to feel with their hands how Earth's atmosphere acts as a heat-trapping blanket and to consider what happens as too many heat-trapping gases accumulate there. On the other side of the station, fun, touchable models of gas molecules demonstrate the properties of the different gases in our atmosphere and how they trap or release heat.

Facilitation tips and supplementary information:

- This station is an excellent place to explain the mechanisms of climate change. Use the metaphors of a heat-trapping blanket and regular vs. rampant heat-trapping gases
- See "Talking About Climate Change" (pg. 15)

Ice Age Landscape Play Station. At this fun exploration station, young children are invited to recreate a scene from the Ice Age!

Supplementary information for facilitators:

- During the last ice age, the site of the research tunnel was a grassland. The animals pictured here were adapted to grasslands. With the changing climate, as the vegetation changed from grassland to forest, some of these animals went extinct.

- Ground sloths were about 10 feet tall. They fed on tree leaves. They also lived for over 10 million years and went extinct only about 10,000 years ago, so in the grand scheme of things, they just barely disappeared.
- American lions were bigger than both modern lions and Ice Age saber-tooth cats.
- Woolly mammoths had short ears and tails to prevent frostbite. They ate grass.
- Steppe bison were bigger than today's bison. Invite visitors to touch the real steppe bison skull.
- Arctic ground squirrel: researchers are studying arctic ground squirrel hibernation to look for treatments for Alzheimer's and even aging. This is fascinating research, and is well worth an Internet search.
- Horses evolved in North America, and from here they spread across the globe, but they became extinct here at the end of the last ice age. They were reintroduced by European colonists.
- Short-faced bear: walking on all fours, this bear was tall enough to look an adult human in the eyes.
- Arctic foxes have short ears and short tails, like the woolly mammoth, to prevent frostbite and heat loss. In the winter, their fur is several inches thick. They don't start to shiver until temperatures reach -94°F.

Methane Bubble Researcher Station. Visitors are invited to take on the role of a researcher who studies ice bubbles. After counting as many ice bubbles in a frozen lake as they can while racing against the clock, visitors learn about the methane trapped in the ice. A time-lapse video of rotting food on the researcher desk serves as a metaphor for what happens to organic material inside permafrost as it thaws.

Facilitation tips and supplementary information:

- After the video game, encourage visitors to consider the aerial view of the lake and why they found more bubbles around the edges of the lake than in the middle (permafrost is thawing more quickly where there are more bubbles. Around the edges, it is warming faster).

- The large poster on the wall explains a “feedback loop” wherein climate change thaws permafrost, which in turn speeds up climate change. Humans can slow down the feedback loop if we stop burning fossil fuels. Explaining this poster is a good conversation-starter around the topic of climate change.

Build An Alaskan Village. Visitors are challenged to build roads and cabins on top of permafrost. Simulated sinkholes show what happens to structures above when permafrost thaws. Unlike real permafrost, these sinkhole can be reset.

Facilitation tips and supplementary information:

- Building on permafrost is risky and expensive, so in general it’s best to just avoid it. This activity reflects that…there’s not a great way to solve it.
- Alaskans who build houses on permafrost often have to level their foundations every few years as it thaws. This can be a fun challenge on the table as sinkholes form.

Fossil Fuel Challenge. At this highly interactive game, visitors play whack-a-mole with global fossil fuel reserves. As locations of major reserves light up on a world map, players work together to keep fossil fuels in the ground.

Facilitation tips and supplementary information:

- See “Talking About Climate Change” (pg. 15)
- Climate change messaging often targets the consumption of fossil fuels, which focuses the conversation on individual people’s actions. This activity focuses on larger, systemic solutions by addressing the production of fossil fuels. Through local, national, and

international collaboration, we can transition our global energy economy to wind, solar, and other renewable energy sources.

- This game is an excellent place to discuss with visitors the real actions they can take to support collective climate action. Research local volunteer opportunities or initiatives and offer them to visitors as signs of hope and opportunities for productive engagement. Focus on community-level actions, rather than on individual actions. For instance: instead of using the example of turning off lights when leaving a room, ask visitors what social organizations they engage with (e.g. school, workplace, church), and whether there are opportunities for acting on climate change with their peers. Steer the conversation away from doom and gloom and toward hope for the future.

Northern Stories Theater. Visitors are invited to watch a short 10-minute film that tells the story of how thawing permafrost—due to climate change—is affecting Alaska Native villages. Viewers get a glimpse into Alaska Native culture and meet people, young and old, who are working to adapt, build resilience in their communities, and mitigate climate change worldwide. Intended for all ages.

Facilitation tips and supplementary information:

- Ask visitors to share their own stories of change. What have they noticed? What climate change-related challenges are they facing or do they anticipate? What changes have they heard about that other communities are experiencing?
- A theme of this video is resilience. Ask visitors about how the speakers in the video are responding to climate change. What inspiration does this provide?

Take Action on Climate Change. Visitors take turns flipping over cards to find matching pairs. Each pair activates a message about creative ways to take community action on climate change.

Facilitation tips and supplementary information:

- This game is an excellent place to discuss with visitors the real actions they can take to address climate change. Supplement the information on the reward screens by researching local examples of collective action that addresses systemic issues. Steer the conversation away from doom and gloom and toward hope for the future.

Stories of Change Visitors learn more about what Arctic inhabitants are doing to adapt to their changing landscape and ways of life. It features maps, text, quotes, and photos.

Facilitation tips and supplementary information:

- See "Talking About Climate Change" (pg. 15)

Permafrost Researcher Photo Op. Visitors are invited to step into an Arctic landscape and take on the identity of a permafrost researcher!

Talking About Climate Change

Today's conversations about climate change will impact the health and wellbeing of future generations. Because the public has high levels of trust in museums, museum educators have a powerful opportunity to facilitate productive, friendly dialogues that focus on meaningful solutions. Yet, educators often have anxiety around talking with the public and students about climate change. What if visitors see the topic as partisan or controversial? What if climate change is too depressing? This guide is here to help.

Climate change: Recommendations to get you started

The following recommendations draw on climate interpretation techniques developed by the FrameWorks Institute, a think tank that investigates the communications aspects of social and scientific issues. FrameWorks has pioneered Strategic Frame Analysis®, an approach to science translation grounded in the cognitive and social sciences. This approach has been adopted by many museum interpreters nationwide, who have been trained to use the strategic framing process to make intentional, research tested choices about how to talk about climate change with visitors. We cite these techniques because they have proven effective, both in research and in the experience of interpreters involved in the National Network for Ocean and Climate Change Interpretation (NNOCCI).

This short guide it is not a replacement for training in Strategic Frame Analysis and support from peers. We encourage *Under the Arctic* educators to learn more:

- Access NNOCCI's resources at www.climateinterpreter.org.
- Access strategically framed "visual narratives" climate topics at vischange.org
- Read more about framing environmental issues at www.frameworksinstitute.org

You can also take a free online course designed especially for museum interpreters. To access the course free of charge:

- Visit https://frameworksacademy.org/
- Go to 'Specialized Sponsored Courses' and select 'Framing for Climate Interpreters'
- Place the course in your shopping cart (don't worry—you will not need to pay)
- 'Check out' and enter your information (no need for a code)

Once you have checked out, you will receive an email from FrameWorks Academy with instructions for accessing your course materials.

Tips for productive climate conversations

Use a reasonable tone. Avoid framing climate change as a crisis. A crisis tone can feel overwhelming and unsolvable. When talking about climate change, you will have more productive conversations when you seek to explain rather than persuade. Use matter-of-fact, optimistic language to discuss the causes, problems, and solutions associated with climate change, and avoid language that emphasizes opinion or political ideology. This allows all visitors, regardless of their political affiliation, to feel included in the conversation.

Use with caution:	Use instead:
Politicians	Civic leaders
Policies	Approaches
Laws	Programs
Regulations	Municipal codes
Government	State or city names

Start your conversation with values. Climate conversations are more effective when they appeal to widely shared values. NNOCCI research has identified two values that measurably impact people's support for addressing the root causes of climate change. They are:

- *Protection*. "It is crucial for us to protect people, and the places we all depend on, from being harmed by the issues facing our environment."
- *Responsible Management***.** "By taking practical steps to address problems facing our environment today, we are acting in the best interest of future generations."

Use tested explanatory metaphors. People are more likely to act if they understand how something works. An explanatory metaphor is a memorable comparison that quickly and effectively explains the mechanisms involved in an abstract or complex topic. Two explanatory metaphors, developed and tested extensively by FrameWorks, are a good fit for the concepts involved in *Under the Arctic*:

- *Heat-trapping blanket***. "**When we burn fossil fuels for energy, carbon dioxide is released. This excess gas builds up in our atmosphere and acts like a blanket that traps heat around the world, disrupting our climate." Similarly, "heat-trapping gases" is clearer for the public than "greenhouse gases," simply because research shows that many people don't grasp how a greenhouse works.

- *Regular vs. Rampant Co₂*. **"**Regular levels of CO_2 are created by normal life processes, but rampant levels of CO_2 are produced when we burn fossil fuels for energy. We need to reduce rampant CO_2 ; it's out of control." The word pair of "regular vs. rampant" helps the public make sense of how CO_2 can be *both* a naturally occurring and essential part of human respiration *and* a threat to nature's balance.

Focus on hope and civic action rather than doom and gloom. The effects of climate change can feel overwhelming, but when visitors hear about collective, systemic initiatives to address it, they feel more hopeful. Community-level solutions can be on the scale of a local or regional organization, such as a school, place of worship, workplace, city, or state. Children can also think about solutions on the level of the institutions they are part of: neighborhoods, classes, schools, and extracurricular organizations. You will boost your effectiveness as a facilitator if you research local initiatives and ideas for how visitors can support them. Look for initiatives that fit these themes, which FrameWorks' research has found to be effective with the public:

- *Ingenuity*. "By being resourceful and innovative, we can come up with new ways to tackle difficult problems."
- *Energy Shift*. "By using energy sources that don't add to the heat-trapping blanket effect, such as solar energy, we can get the climate system back to functioning the way it should."
- *Energy Efficiency*. "While we work towards moving away from fossil fuels for energy altogether, we can use much less of the kinds of energy that add heat-trapping gases to our atmosphere."
- *Change the Conversation*. "We all have a part to play in building support for action on climate and ocean change. By talking more often about these issues, and by joining groups, we can make a difference."

Use the exhibits. *Under the Arctic* has been designed to prompt conversations about climate change, so lean on facilitation of the exhibits to guide the conversation toward the causes, effects, and solutions to climate change. By discussing the impact of climate change on Alaskans, you can transition into a dialogue about local challenges and opportunities for civic action.

Remember, you don't need to convince visitors. Your task is to explain climate change clearly, not to win a debate. Let yourself off the hook: some visitors will leave the exhibition eager to address climate change, and some will leave believing that climate change is a hoax. This is okay. If you have explained climate change well, you have done your job.

Climate change: Questions & answers

Q. What's causing global warming and climate change today?

A. Earth's climate has changed over the millennia due to natural causes such as gases emitted by volcanic eruptions and the wobble in the Earth's orbit, which changes the amount of sunlight reaching the Earth. But right now, we are seeing change above and beyond these regular cycles – we are seeing rampant levels of the heat-trapping gas CO_2 being emitted from fossil fuels and a steep increase in temperatures as a result. In the last 130 years, the Earth's average temperature has risen more and faster than it has during the past 1,000 years. This is global warming. The global warming that we are experiencing now is driven by the use of fossil fuels for energy and other human activities, like deforestation.

When we burn fossil fuels (coal, oil, and natural gas), we add excess carbon dioxide (CO_2) gas into the air. This buildup of CO_2 acts like a blanket that traps heat. As the planet warms, our ocean warms too. The ocean acts like the heart of the climate system, pumping heat and moisture around the planet. A warming ocean disrupts this flow, which disrupts weather patterns around the world. It also directly affects the land, water and ecosystems that people, animals, and plants depend upon. By taking responsible steps to address climate disruption, we can protect the places we all depend upon now and safeguard them for future generations.

Q. Why did they stop calling it "global warming" and started calling it "climate change"?

A. Scientifically, global warming and climate change are different phenomena. Global warming is the term scientists use when they document that the average surface temperature of the Earth is rising. Climate change refers to all the effects that come from disrupting the earth's average temperature. These include problems we are seeing right now. Ice caps are melting, affecting the creatures that live in polar regions and the pace of warming, because there is less ice to reflect the sun's heat back into space. The ocean is expanding as it warms, causing water levels near our coasts to rise and adding more water to storm surges.

No matter what we call it, the key to getting things back on track is to move away from using fossil fuels for energy. The planet is warming because we are releasing excess levels of heat-trapping gases by burning coal, oil, and natural gas. The change in temperature disrupts nature's delicate balance, and we must take responsibility to do what we can to safeguard lives today and protect future generations.

Q. Is climate change just a way for scientists to get funding?

A. Keep in mind that scientists are only one voice among many who are speaking up about climate disruption caused by burning fossil fuels. For example, park rangers worldwide have seen the effects of warming temperatures: shrinking glaciers, spring flowers arriving earlier, and changes in animal behavior (where they live and when they migrate, for example). Weather forecasters report increased weather extremes. Shipping companies are plotting new routes through the Arctic Ocean as it becomes ice-free. Coastal communities are encountering more flooding as the ocean level rises, because water expands as it warms. Our military, and the military of other nations, are planning for a hotter future with more violent, more unpredictable weather caused by a changing climate.

Q. Isn't Earth's climate always changing? It's a natural cycle.

A. All ecosystems are affected by many factors, and right now, the biggest influence on our ecosystems is human activity. Natural cycles do exist, of course. For instance, natural processes took tens of millions of years to remove the heat-trapping gas of carbon dioxide from the life cycle and sequester it underground, in the form of fossil fuels. That change dropped the average temperature of the planet – but slowly! The North Pole is covered in ice today, but it was once a tropical rain forest. Of course, according to the fossil record, that was 55 million years ago!

The problem is that we clever humans figured out how to take tens of millions of years' worth of carbon dioxide out of the ground and get it back into circulation over just the last 130 years. We've extracted coal, oil, and natural gas for energy, and released rampant levels of CO_2 into our atmosphere and ocean. Heat is building up quickly around the globe, disrupting the natural systems that we depend on. This is affecting lives now – people's physical health and safety are being put at risk by extreme weather, changes in the range and longevity of disease-spreading insects, and more. To protect human health and safeguard natural habitats and creatures for the future, communities have to work together to reduce our role in warming the planet.

Q. Isn't the sun the cause of global warming?

A. The sun's energy output rises and falls by about one tenth of one percent (0.1%) in 11-year cycles. Overall, its energy output has actually decreased slightly since the 1980s. If the Sun was the main cause of global warming, the Earth's average temperature should be cooler. But out of the 17 hottest years on record, 16 have occurred since 2000 (as of 2018).

Q. How do scientists know that humans are causing the carbon dioxide (CO_2) increase in the atmosphere? A lot of CO_2 is emitted by volcanoes and other natural sources, right?

A. One thing isn't under debate – the knowledge that carbon dioxide is a heat-trapping gas, and that the amount of carbon dioxide in the atmosphere affects the temperature of the atmosphere and ocean. Even small changes in the average temperature have large effects on our ecosystems and our weather patterns.

Scientists can see a difference between "regular" CO_2 that is emitted through natural processes and "rampant" CO_2 that is released when humans burn fossil fuels. Rampant CO_2 molecules have a kind of fingerprint (isotope ratios) that allow scientists to tell the human-made from naturally emitted CO_2. Based on these CO_2 "fingerprints," we can be sure the Earth's extra CO_2 comes from fossil fuels, not volcanoes. In fact, we even know exactly how much extra. Energy companies keep accurate records of production and sales of fossil fuels (coal, oil, and natural gas). With this information, scientists can calculate how much CO_2 was produced by humans in the last 250-300 years.

To answer your question directly - volcanoes do emit carbon dioxide (CO_2), but so slowly that it would take millions of years for them to start causing global warming on their own.

Q. Warming by 3-4 degrees Celsius by the year 2100 doesn't sound like much, so should we really be worried about it?

A. 3-4 degrees Celsius is only the average increase in temperature around the world. Some places will see daily temperatures rise much more than that, particularly Polar Regions like Greenland. In Greenland, dangerous amounts of ice are already melting, causing the ocean level to rise. 3-4 degrees Celsius is a big change. During the last ice age, Earth was just 5 degrees Celsius cooler than it is now. Nearly one-third of the Earth's land area was covered by glaciers, much of North America was buried under 2 miles of ice, and the ocean level was 400 feet lower. In other words, a change of just 5 degrees Celsius brought about one of the biggest climate shifts the Earth has ever seen.

Q. Did climate change cause hurricane Harvey/Maria/Irma?

A. There's no way to show that global warming causes any individual hurricane, but it's easy to see how climate change is making hurricanes more powerful. Here's how the connection works. When we burn fossil fuels (coal, oil, and natural gas), we add rampant levels of the heat-trapping gas carbon dioxide into the air. This buildup of CO_2 acts like a blanket that traps heat. As the atmosphere warms, our ocean warms too. A warmer ocean gives hurricanes more energy, and warmer air makes them produce more rainfall. The combination results in more intense storms. This is why scientists have projected that climate change will increase the number of more powerful Category 4 and 5 hurricanes.

Climate change is connected to other extreme weather events, too – from droughts to blizzards to heat waves. It's important to remember that the ocean acts like the heart of the climate system, pumping heat and moisture around the planet. A warming ocean is putting stress on the heart of the system, so it pumps too much moisture to some places and not enough to others. This is how our use of fossil fuels is disrupting long-standing weather patterns around the world.

Q. Wind turbines and solar mirrors kill birds; isn't that a problem?

A. I share your concern for safeguarding birds and other wildlife – it's our responsibility to protect their habitats and the ecosystems they are part of. One of the most important things we can do to protect birds is to shift away from fossil fuels as our energy source. Fossil fuels emit heat-trapping gases into the atmosphere, warming the planet and disrupting our natural systems. The Audubon Society estimates that about half of all bird species in North America may be threatened by the effects of global warming over the next century.

That said, it is true that renewable energy technologies come with risks. According to estimates, wind turbines kill hundreds of thousands of birds each year in North America, and large solar farms kill tens of thousands each year in the United States. I try to put those risks into perspective, remembering that all human activities have an impact of some sort on how our ecosystems function. That's a small fraction of the hundreds of millions of bird deaths from crashing into buildings and windows, getting hit by cars, and from fossil fuel power plants. Wind turbine and solar mirror installers are trying new techniques to reduce bird deaths. With time and experience, these techniques will become more effective at keeping birds away from danger. It's important for us to keep innovating, figuring out how to move away from the very damaging effects of fossil fuels and toward safer forms of energy that won't harm the places and natural systems that all living creatures depend on.

Q. Won't it be really expensive to stop using fossil fuels and switch to renewable energy?

A. Saying we should stick to coal power because it is so cheap is like saying we should eat more junk food because it's cheap. If you did that, you would save money on your food bills for a few years, but in the long run, all that junk food would make you sick and you'd end up paying a lot more than you saved in healthcare costs. Coal is the cheapest fuel only if we don't include the price of consequences – the health of coal miners, damage to mountains, streams and forests, air and water pollution, and climate change. Include these "external costs" and the price of coal triples, making it about the same as solar and offshore wind, and more expensive than hydro, onshore wind, and geothermal. The cost of solar and wind energy is dropping every year. Soon they're going to cost less than coal.

Q. Human beings are good at adapting to changes; why do we have to worry about climate change?

A. It's true, humans are good at adapting to change. So good, in fact, that changing the ways we make and use energy is something we can do. Many individuals, businesses, and governments have already come up with solutions. All it takes is the effort of communities working together to put those solutions into practice.

Q. There was a lot of snow/it was really cold last year. Isn't that proof that climate change isn't happening?

A. Climate change has been clearly connected to all kinds of extreme weather– from droughts to severe rainfall, from blizzards to heat waves. Here's how that works. The ocean acts like the heart of the climate system, pumping heat and moisture around the planet. That's how climate is connected to the weather.

When we burn fossil fuels for energy, the heat-trapping gas carbon dioxide is released, warming both the atmosphere and the ocean. A warming ocean is putting stress on the heart of the climate system. Now, the ocean currents and winds are pumping too much moisture to some places and not enough to others. The result is that long-standing weather patterns have been disrupted, and we are seeing extreme weather of all sorts around the globe. Floods, droughts, and extreme temperatures all put human health and safety at risk.

To get our climate system back on track, and to protect people's health and safety, we need to change our energy use so that we are not releasing rampant amounts of heat-trapping gases into our climate.

Q. Climate Change is such a big problem; I can't really make a difference.

A. One drop of water won't get you wet, but a thunderstorm can drench you in seconds. It's the same with fighting climate change. Communities – tens, hundreds, thousands, or millions of people – working together is the answer. We have made larger change before, and we can do it now if we work for large-scale, systemic solutions. The important thing to remember is that joining a group and talking to others are the key ways to amplify your individual impact.

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- Hill, Liz, and Arwen Nuttall. "Is it True That Indian Languages Are Now Extinct?" 166-168.

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Glossary

Active layer: a thin layer of soil overlying permafrost that freezes in winter and thaws in summer. Plants grow in this layer, but not in the permafrost below. The thickness of the active layer varies, but around Fairbanks, where the permafrost tunnel is, it is typically around 2.5 ft. deep (permafrost in Fairbanks is typically 150 ft. deep).

Auger: a tool used to bore holes in the ground. Core sample augers pull up long cylindrical cross-sections of soil. *Under the Arctic* features a small handheld auger in the tunnel and a larger SIPRE auger at the Core Sample Station.

Carbon dioxide: CO_2, or carbon dioxide, is a heat-trapping gas released from burning fossil fuels.

Climate: Climate is average weather conditions for a region measured in time spans of 30 years or longer. Measurable air conditions include temperature, precipitation, humidity, wind, and pressure. Climate ranges in scale from regional, such as a major river valley or range of mountains, to global. The weather determines what you wear today. Your entire wardrobe is based on your local climate.

Climate change. Because of the buildup of heat-trapping gases, Earth's climate, both regionally and globally, is changing. Changes include a warming and rising ocean, shrinking ice sheets, more intense hurricanes, and ocean acidification. Ocean acidification is making the chemistry of the ocean more acidic, which makes it harder for marine animals to extract minerals from seawater to build their protective shells. Climate change refers to all the environmental changes that are happening all over our planet. Use "climate change" when talking about the overall phenomena. Use "global warming" when talking only about warming average temperatures.

Climate system. The climate system is the atmosphere, the ocean and rivers, the ice sheets, living organisms, and the soils and rocks and how they interact with each other to make regional climates around our planet. The ocean acts like the heart of the climate system. It pumps heat and moisture around our planet, which determines the climate in each region of the world.

CRREL: Rhymes with "well." The Cold Regions Research and Engineering Laboratory is a research facility maintained by the US Army Corps of Engineers. They dug the permafrost tunnel in the 1960s to test excavation techniques in permafrost, and they maintain it today as a research laboratory.

Drunken trees: Sometimes, Arctic trees tip and lean over when the permafrost below them is thawing. Alaskans call them "drunken trees."

Fossil: Fossils are traces of ancient life— anything from dinosaur tracks to an insect in amber to coprolites (fossilized poop). Many fossils are turned to stone or petrified. Fossils preserved in permafrost are frozen, not petrified.

Fossil fuels. Fossil fuels are carbon-based energy sources (coal, oil, and natural gas) formed from the remains of dead plants and animals. Most fossil fuels formed from plankton and plants that lived hundreds of millions of years ago and were buried under layers of rock and soil. We burn fossil fuels to generate electricity, heat our buildings, power our machines, and fuel our cars, trains, and planes.

Global warming. Global warming refers only to temperature. Earth's surface temperature, on average, has been rising rapidly (faster than at any time in the past 1,000 years) over the past several decades. The Earth is fueled by energy from the Sun. To maintain a constant global average temperature, any extra radiation from the Sun that is absorbed by the Earth's atmosphere must be balanced out by heat escaping back to space. If the extra heat doesn't escape, Earth will keep getting hotter and hotter. Global warming happens when the extra heat that would normally escape to space stays caught in the atmosphere by heat-trapping gases.

Greenhouse gases: see "heat-trapping gases"

Heat-trapping gases (greenhouse gases). Heat-trapping gases, or greenhouse gases, are gases that absorb heat.[1] Earth would be much colder without them. The most significant greenhouse gases are carbon dioxide (CO_2), methane (CH_4), water vapor (H_2O), and nitrous oxide (N_2O). Burning fossil fuels releases heat trapping gases. The problem is that with too many heat-trapping gases, the planet overheats. Heat-trapping gases comprise about 1% of our atmosphere, but they trap around 80% of all outgoing heat.

Ice age: also called glacial period, ice ages are characterized by cold, dry climates and glaciers that cover much of the Northern Hemisphere. The last ice age is typically just referred to as the Ice Age, although there have been many before.

Ice wedge: Ice wedges are massive ice features in permafrost named for their wedge-like shape. They formed very slowly over thousands of years during the Ice Age. The ground cracked during extreme cold each winter, and slivers of water would fill in the cracks and freeze. When an ice wedge melts, sinkholes a big as a house can open up. An ice wedge can melt in a single summer, and the change is permanent. Ice wedges are no longer forming, because our current climate is too warm.

Interglacial: interglacial periods are the warm, wet periods between ice ages (glacial periods). Earth entered a stable interglacial climate at the end of the Ice Age, around 11,700 years ago, which we call the Holocene Epoch.

Methane: CH_4, or methane, is one of the heat-trapping gases released from burning fossil fuels and from other sources (like thawing permafrost). It is less common than carbon dioxide, but is far more potent**—**it traps 25 times as much energy.

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[1] To avoid introducing new vocabulary words, unless your audience is already using the term "greenhouse gases" use the term "heat-trapping gases" instead.

Permafrost: the technical definition of permafrost is soil and/or rock that has stayed below freezing year-round for more than two years. However, since it is no longer cold enough to form new permafrost, most permafrost formed during the last ice age, over 11,700 years ago.

Silt: finer than sand, rougher than clay. The soil in the permafrost tunnel is mostly silt. The walls of the tunnel are constantly shedding silt, making things very dusty.

Taiga: Arctic forest, the largest terrestrial biome on Earth. Also called boreal forest. In Alaska, tress in the taiga are mostly pine and spruce. The permafrost tunnel is located in a taiga region.

Tundra: cold land dominated by lichens, mosses, and shrubs. Most tundra is north of the Arctic Circle, where temperatures are too cold and the growing season is too short for trees to grow.

Weather: Weather is what happens in the atmosphere at a particular place and time. Examples include rain, snow, hot temperatures, and hurricanes. Weather lasts for relatively short periods of time, on the scale of a few minutes to months, and covers small areas.

Activity Guides for Museum and Classroom Educators

The *Under the Arctic* activity guides support both formal and informal educators in communicating permafrost research and thawing permafrost's impact on Alaska and our global climate to museum visitors and students.

Exhibition Activities

Active Learning Log – pg. 29
Visitors hunt for answers as they explore the exhibition. This log is useful to hand out to students in school groups.

Permafrost Tunnel Tour – pg. 33
A facilitator acts as a tour guide as visitors enter *Under the Arctic*. The tour helps introduce visitors to the topic of permafrost and builds enthusiasm for the immersive experience of walking through the replica permafrost tunnel.

Exhibition or Classroom Activities

Permafrost Grab Bag Demonstration – pg. 40
Visitors are invited to explore what is hiding in permafrost through the tactile experience of grabbing cards out of a bag. With each card, the facilitator explains a feature of the permafrost tunnel.

Metabolizing Microbes Demonstration – pg. 47
Visitors learn about how thawing permafrost releases heat-trapping gases by observing yeast placed in warm and cold water. A facilitator places yeast with sugar in warm and cold water, and visitors observe that the yeast in the warm water fills a balloon with carbon dioxide.

Melting Foundations Demonstration – pg. 54
Visitors learn about an engineering solution Alaskans use to keep their warm houses from thawing the permafrost below. A facilitator places two warm model houses on ice; one starts to sink, while the other does not.

Classroom Activities

Melting Foundations Activity – pg. 64
Visitors learn about an engineering solution Alaskans use to keep their warm houses from thawing the permafrost below. They design creative foundations to keep model houses from melting ice in a tin.

Climate Action Poster Boards – pg. 75
Climate change is a big issue, but we can work together to address it. Students work in small groups of 3-4 to research a local climate change initiative and create a poster board with arts and craft supplies. They then present their project to the class in a poster session format.

Name____________________________________

Active Learning Log

Arctic Globe

Permafrost is cold, old, and huge. Explore the different places where you can find permafrost.

Where is a place with permafrost that surprised you?

Permafrost Tunnel

Smell the permafrost at the sniff station. What does it smell like to you?

How long does it take an ice wedge to form? How long does it take it to melt?

Draw one of the bones you see. What animal did it belong to?

Core Sample Station

Examine and weigh the core samples. Where would you build an outhouse: Site A or Site B? Why?

Fossil Station

Find the woolly mammoth tusk fragment under the microscope. How old is this bone?

Methane Bubble Station

Play the game, and after it's over, look at the map of the lake. Where are the most methane bubbles? Why do you think this is?

Atmosphere Station

Feel the two globes. Which is warmer? Why?

Take Action on Climate Change

Play the game. Give an example of how people are working together to slow climate change.

Northern Stories Theater

Watch the video. What is a ciġluaq? How is climate change affecting ciġluaqs?

Stories of Change

How many roads connect Fairbanks and the Arctic Ocean? How else do Alaskans travel?

Name_____________________________________

Active Learning Log

Arctic Globe

Permafrost is cold, old, and huge. Explore the different places where you can find permafrost.

Where is a place with permafrost that surprised you?

Example: the Rocky Mountains.

Permafrost Tunnel

Smell the permafrost at the sniff station. What does it smell like to you?

Example: funky, like a barnyard.

How long does it take an ice wedge to form? How long does it take it to melt?

Ice wedges take thousands of years to form and can melt in a single summer.

Draw one of the bones you see. What animal did it belong to? Example:

Core Sample Station

Examine and weigh the core samples. Where would you build an outhouse: Site A or Site B? Why?

Site B. It weighs more, so it contains less ice.

Fossil Station

Find the woolly mammoth tusk fragment under the microscope. How old is this bone?

12,000 years old

Methane Bubble Station

Play the game, and after it's over, look at the map of the lake. Where are the most methane bubbles? Why do you think this is?

There are more bubbles around the lake edge because the ground is warming up there, leading to permafrost thaw.

Atmosphere Station

Feel the two globes. Which is warmer? Name two gases in our atmosphere that trap Earth's heat.

The globe with an atmosphere is warmer. Carbon dioxide (CO_2) and methane (CH_4) are heat-trapping gases.

Take Action on Climate Change

Play the game. Give an example of how people are working together to slow climate change.

Example: Las Vegas runs its municipal facilities on 100% renewable energy.

Northern Stories Theater

Watch the video. What is a ciġluaq? How is climate change affecting ciġluaqs?

It is a traditional cellar dug into permafrost that keeps food frozen. Ciġluaqs are thawing. Some Alaska Natives are switching to electric freezers to store food.

Stories of Change

How many roads connect Fairbanks and the Arctic Ocean? How else do Alaskans travel?

One road. Alaskans also use airplanes, boats, and snow machines (snowmobiles) on frozen rivers.

Everyday Encounters with Science

Permafrost Tunnel Tour

Program Type: Exhibit tour	**Audience Type:** All Ages

Description: A facilitator acts as a tour guide as visitors enter *Under the Arctic*. The tour helps introduce visitors to the topic of permafrost and builds enthusiasm for the immersive experience of walking through the replica permafrost tunnel.

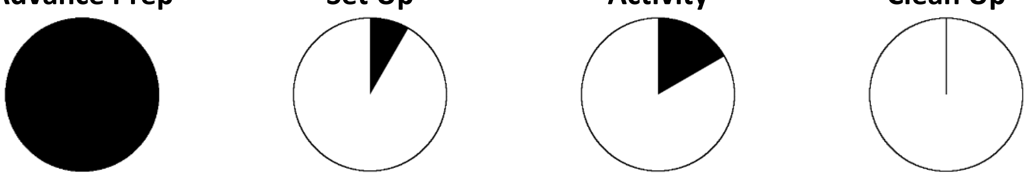
Topics: Permafrost, Microbes, Fossils, Climate change

Process Skills Focus: Inquiry, Observing

LEARNING OBJECTIVES

- Permafrost is cold, old, and huge.
- People live and depend on permafrost.
- The permafrost tunnel outside Fairbanks, Alaska is an exciting research space.

TIME REQUIRED



Advance Prep	Set Up	Activity	Clean Up
60+ minutes	5 minutes	20-25 minutes	None

SITE REQUIREMENTS

- *Under the Arctic* exhibition.

SUPPLIES

Permanent Supplies	Amount	Notes
Hard hat	1	

SET UP

Spend time exploring the *Under the Arctic* exhibition. Read the *Under the Arctic* Educator Guide. You should feel comfortable discussing the exhibition, but you don't need to have all the answers. If a visitor asks something that you don't know, be honest (and look it up for next time!). Put on the hard hat to identify yourself as a tunnel guide.

[Optional] Set up the Grab Bag demo for use inside permafrost tunnel.

[Optional but recommended]: Research a few local examples of groups working to reduce the use of fossil fuels. For example, look for civic initiatives or action taken by community groups like schools or faith communities.

INTRODUCTION

5 minutes

Suggested script is shaded. Important points or questions are in **bold**. Possible answers are shown in *italics*.

Meet visitors at the entrance to *Under the Arctic* and welcome them. If you feel comfortable playing a role, pretend that you are a permafrost researcher leading tours through the permafrost tunnel (you can even choose your area of research from those featured in the tunnel or research lab).

Ideal tour groups consist of 5-10 people. Start the tour as soon as you greet one group of visitors, but feel free to integrate newcomers that walk up as you talk outside the tunnel. Simply catch them up on what they missed and move on. Gather visitors around the globe.

Welcome to Under the Arctic! My name is ____ and this morning I'm leading tours through our permafrost research tunnel. **Are you interested?**

First off, are any of you from the Arctic? Have you visited Alaska?

Arctic residents deal with a special kind of soil. **Has anyone heard of permafrost before? What is it?**

Permafrost is ground that is frozen year-round.

One of the most surprising things for most people about permafrost is how much of it there is. It covers 20% of the Earth's land surface. You can see on this globe everywhere that has permafrost. Take a look: **does anywhere surprise you?**

Use features of the Arctic Globe to hit three key learning goals:

- **Permafrost is cold.** Permafrost is ground that is frozen year round. An "active layer" on top freezes and thaws each year with the seasons, but below that, it does not thaw.
- **Permafrost is old.** Permafrost has been frozen since the Ice Age. It doesn't get cold enough now to re-freeze permafrost, so if it thaws, it's gone for good.
- **Permafrost is huge.** Almost a quarter of the earth's land surface is underlain with permafrost. People live on permafrost; the Arctic is not an uninhabited wasteland.

TUNNEL EXTERIOR

5 minutes

In Fox, Alaska, just outside of Fairbanks, there is a research tunnel dug into the permafrost. The U.S. Army's Cold Regions Research and Engineering Laboratory (CRREL) built the tunnel to test new mining and construction methods in frozen soils. Researchers dug into a hillside near Fairbanks, Alaska during winter months in the 1960s, and it was so useful for scientists, it's still in operation.

"CRREL" rhymes with "well."

The tunnel is very cold, so researchers wear winter gear. In the summer, the tunnel is refrigerated to below freezing; in the winter, cold air from outside is blown in.

> *[Interesting side-note]:* When the Cold War began, a possible land war in Alaska was a real fear, so the US Army Corps of Engineers dug the tunnel to investigate techniques for excavation and infrastructure engineering on permafrost. Thankfully, the tunnel outlived anxiety over an Arctic land war, and today, Russian and American researchers collaborate at the permafrost research tunnel.

Ask visitors to watch the introductory video. If you're playing the role of researcher, this is a good time to introduce the topic of "your" research (but save a longer explanation for when you enter the lab area).

TUNNEL INTERIOR

10 minutes

Either use the Grab Bag Demo or the information contained in that demo to explain features of the permafrost tunnel.

During their time in the tunnel, ask visitors to find features of the tunnel rather than point them out yourself.

> *[Interesting side-note]:* the replica permafrost tunnel is a condensed version of the permafrost tunnel. Its features are accurate sculptural representations, but they are more spread out in the real tunnel. For example, fossils are only at the entrance, while most ice wedges are farther in. Exhibit designers, developers, and fabricators worked with permafrost researchers and a sculptor to bring the tunnel to life.
>
> Part of this process was the smell station. Stinky silt from the tunnel was shipped to a company that specializes in creating custom scent beads. The exhibit team sat around a table with real permafrost and a range of artificial scent options…everyone's noses were overworked after that meeting! In the end, though, the team thought that the artificial smell comes quite close to the real thing.

PERMAFROST LAB

2-5 minutes

Researchers collect samples inside the permafrost tunnel and analyze them in a lab. You will recognize a lot here that you've already seen inside the tunnel, but these stations give you the chance to poke them, prod them, question them, and learn from them. Go be a permafrost researcher yourself!

Direct visitors to the steppe bison skull, and emphasize that it is a real fossil that visitors can touch.

If you are role-playing a researcher, take visitors to a desk that relates to the research area you have chosen, and explain it in more detail.

Invite visitors to find you if they think of questions while exploring the rest of the exhibition.

OPTIONAL

20+ minutes

Tour guides can lead visitors through the entire exhibition if they wish. Use facilitation tips provided in the *Under the Arctic* Educator Guide.

BACKGROUND INFORMATION

Topic

See "Talking About Climate Change" in the *Under the Arctic* Educator Guide.

RESOURCES

Permafrost Research Tunnel:

Permafrost Research Facility. US Army Corps of Engineers, https://www.erdc.usace.army.mil/CRREL/Permafrost-Tunnel-Research-Facility/. Accessed 2 Aug. 2018.

More info on permafrost (and a great video for students):

"Permafrost – what is it?" *YouTube*, uploaded by Alfred-Wegener-Institut, Helmholtz-Zentrum für Polar- und Meeresforschung, 7 Mar. 2016. Accessed 2 Aug. 2018.

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https://climateinterpreter.org/resources

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Frameworks Academy. *Climate Reframe Cards,* https://climateinterpreter.org/sites/default/files/resources/nnocci_full_set_climate_reframe_cards.pdf. Accessed 2 Aug. 2018.

From the NNOCCI Recommendations Flyer:

"*We can teach public audiences that systemic initiatives can create wide-scale change to support both human and ecosystem health and resilience. It's uncommon for people to hear about collective, systemic initiatives, but feel more hopeful when they do learn about them. Hope supports further engagement! We're rallying around these four themes:*

- ***Ingenuity**: By being resourceful and innovative, we can come up with new ways to tackle difficult problems.*
- ***Energy Shift**: By using energy sources that don't add to the heat-trapping blanket effect, such as solar energy, we can get the climate system back to functioning the way it should.*
- ***Energy Efficiency**: While we work towards moving away from fossil fuels for energy altogether, we can use much less of the kinds of energy that add heat-trapping gases to our atmosphere.*
- ***Change the Conversation**: We all have a part to play in building support for action on climate and ocean change.*

By talking more often about these issues, and by joining groups, we can make a difference."

NEXT GENERATION SCIENCE

Practices
1. Asking questions and defining problems
4. Analyzing and interpreting data
6. Constructing explanations and designing solutions
8. Obtaining, evaluating, and communicating information

Crosscutting Concepts
1. Patterns
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter
6. Structure and function
7. Stability and change

DCIs

	Disciplinary Core Idea	K	1	2	3	4	5	MS	HS
	Physical Science								
PS1	Matter and Its Interaction	n/a	n/a		n/a	n/a			
PS2	Motion and Stability: Forces and Interactions		n/a	n/a		n/a			
PS3	Energy		n/a	n/a	n/a				
PS4	Waves and Their Applications in Technologies for Information Transfer	n/a		n/a	n/a		n/a		
	Life Science								
LS1	From molecules to organisms: Structures and processes			n/a					
LS2	Ecosystems: Interactions, Energy, and Dynamics	n/a	n/a			n/a			
LS3	Heredity: Inheritance and Variation of Traits	n/a		n/a		n/a	n/a		
LS4	Biological Evolution: Unity and Diversity	n/a	n/a	✓	✓	n/a	n/a	✓	✓
	Earth & Space Science								
ESS1	Earth's Place in the Universe	n/a			n/a				
ESS2	Earth's Systems	✓	n/a	✓	✓	✓	✓	✓	✓
ESS3	Earth and Human Activity	✓	n/a	n/a	✓	✓	✓	✓	✓
	Engineering, Technology, and Applications of Science								
ETS1	Engineering Design								

Permafrost Grab Bag

Program Type: Demo	**Audience Type:** All Ages

Description: Visitors are invited to explore what is hiding in permafrost through the tactile experience of grabbing cards out of a bag. With each card, the facilitator explains a feature of the permafrost tunnel.

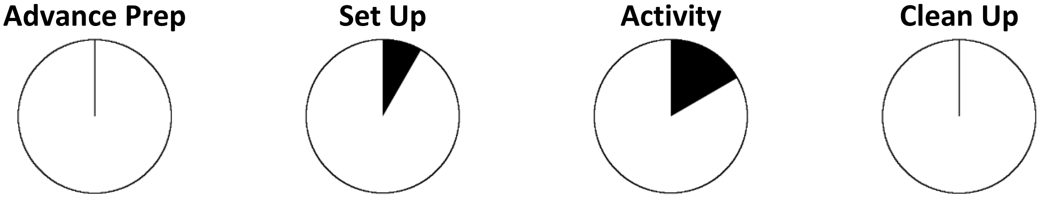
Topics: Permafrost, Microbes, Fossils, Climate change

Process Skills Focus: Inquiry, Observing

LEARNING OBJECTIVES

- Permafrost contains ice structures, fossils, microbes, and organic material.
- Permafrost offers a record of the last ice age.
- When permafrost thaws, it affects people.

TIME REQUIRED



Advance Prep	Set Up	Activity	Clean Up
None	**5 minutes**	**10 minutes**	**None**

SITE REQUIREMENTS

- None, but works well inside replica permafrost tunnel.

SUPPLIES

Permanent Supplies	Amount	Notes
Brown Fabric Bag	1	
Representational Objects	6	

SET UP

Print script. Take bag out of exhibit storage. Make sure all 6 items are in the bag.

INTRODUCTION

2 minutes

Suggested script is shaded. Important points or questions are in **bold**. Possible answers are shown in *italics*.

Would you like to try your luck with the permafrost grab bag?

This bag represents permafrost, or permanently frozen ground. Permafrost has been frozen since the Ice Age, so there are a lot of things inside it that have been preserved for thousands of years. When you dig into permafrost or when permafrost thaws, you find some unexpected things.

ACTIVITY

Grab Bag Game

5 minutes

Without looking, go ahead and grab one item out of the bag. **What does it represent?**

Read script for that card.

Grab another item!

Read script for that card then repeat until all the items have been read.

WRAP-UP

3 minutes

What did you notice about the things that thawing permafrost can release? Were there beneficial things or harmful things in the grab bag?
The fossils found in permafrost are pretty cool. Permafrost turning to water creates problems for people living on the permafrost. Because of the feedback loop, carbon dioxide and methane cause more warming, which causes more permafrost to melt.

By taking practical steps, we can protect permafrost, the global climate, and the people, plants, and animals that depend upon them for future generations.
This is an excellent time to discuss with visitors the real actions they can take to address climate change. Research local initiatives and offer them to visitors as signs of hope and opportunities for action. Steer the conversation away from doom and gloom and toward hope for the future.

CLEAN UP

- Return items to bag

BACKGROUND INFORMATION

Topic
See "Talking About Climate Change" in the *Under the Arctic* Educator Guide.

RESOURCES

Permafrost Research Tunnel:

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- ***Energy Efficiency**: While we work towards moving away from fossil fuels for energy altogether, we can use much less of the kinds of energy that add heat-trapping gases to our atmosphere.*
- ***Change the Conversation**: We all have a part to play in building support for action on climate and ocean change.*

By talking more often about these issues, and by joining groups, we can make a difference."

SCRIPT

Grab Bag Script

Microbes

Oh no! It looks like you've released a 30,000 year old bacteria that comes back to life when thawed. Although this bacteria is harmless, there are others that may thaw in the future that can make people and animals sick.

Sinkhole

Melting ice can only mean one thing: water! You have created a marshy sinkhole under an Alaskan's house. Now they will have to build a new foundation or fill the hole with gravel.

Water

As ice in permafrost melts, the ground sinks and collects water, creating lakes and marshy ground. This water eats into the ice below, leading to more and more thaw. When all the ice is gone, there is nothing to hold the water in place, and it's as if somebody pulls the plug in a bathtub. Water drains out the bottom, leading to dry soil, which can negatively impact important food sources like fish and berries.

Woolly mammoth tusk

You got lucky and unearthed a 30,000 year-old mammoth tusk! Now that it's no longer frozen in ice, better get it to a museum fast before it starts to dry out and crack.

Heat-trapping gases

Uh oh, you seem to have defrosted some frozen plants and animal remains. As they decay, they release carbon dioxide and methane into the air. When these gases rise up into the atmosphere, they work like a blanket around the Earth, trapping heat and preventing it from drifting off into space. More gases leads to higher temperatures, which thaws even more permafrost, which releases more heat-trapping gases. This is called a feedback loop.

Ice Age grass

Wow! You just discovered some fossilized grass. It's still green because the ice persevered the plant's chlorophyll. Now that that it's not frozen, it will rot just like vegetables left out of the freezer. This will smell bad and release methane and carbon dioxide, which are heat-trapping gases

NEXT GENERATION SCIENCE

Practices
1. Asking questions and defining problems
8. Obtaining, evaluating, and communicating information

Crosscutting Concepts
1. Patterns
2. Cause and effect
3. Scale, proportion, and quantity
5. Energy and matter
6. Structure and function
7. Stability and change

DCIs

	Disciplinary Core Idea	K	1	2	3	4	5	MS	HS
Physical Science									
PS1	Matter and Its Interaction	n/a	n/a		n/a	n/a			
PS2	Motion and Stability: Forces and Interactions		n/a	n/a		n/a			
PS3	Energy		n/a	n/a	n/a				
PS4	Waves and Their Applications in Technologies for Information Transfer	n/a		n/a	n/a		n/a		
Life Science									
LS1	From molecules to organisms: Structures and processes			n/a					
LS2	Ecosystems: Interactions, Energy, and Dynamics	n/a	n/a			n/a			
LS3	Heredity: Inheritance and Variation of Traits	n/a		n/a		n/a	n/a		
LS4	Biological Evolution: Unity and Diversity	n/a	n/a	✓	✓	n/a	n/a	✓	✓
Earth & Space Science									
ESS1	Earth's Place in the Universe	n/a			n/a				
ESS2	Earth's Systems		n/a	✓	✓	✓	✓	✓	✓
ESS3	Earth and Human Activity		n/a	n/a	✓	✓	✓	✓	✓
Engineering, Technology, and Applications of Science									
ETS1	Engineering Design								

Metabolizing Microbes

Program Type: Demo	**Audience Type:** All ages

Description: Visitors learn about how thawing permafrost releases heat-trapping gases by observing yeast placed in warm and cold water. A facilitator places yeast with sugar in warm and cold water, and visitors observe that the yeast in the warm water fills a balloon with carbon dioxide.

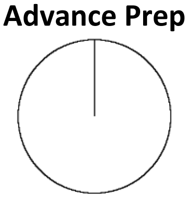
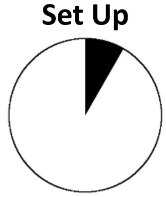
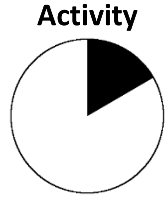
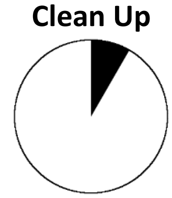
Topics: Permafrost, Heat-trapping gases, Climate change

Process Skills Focus: Inquiry, Observing

LEARNING OBJECTIVES

- When permafrost thaws, ancient microbes break down organic matter and release heat-trapping gases.
- Permafrost has the potential to significantly impact our global climate.
- We can slow permafrost thaw by working collectively to burn fewer fossil fuels.

TIME REQUIRED

Advance Prep	Set Up	Activity	Clean Up
			
None	**5 minutes**	**10 minutes**	**5 minutes**

SITE REQUIREMENTS

- None, but this activity works well in the “Permafrost Lab” area of the exhibit.
- This pocket demo works well on the same table as “Melting Foundations.” (Do this demo second.)

SUPPLIES

Permanent Supplies	Amount	Notes
Water bottles	2	
Yeast	8 tsp	Divide between bottles
Sugar	4 tsp	Divide between bottles
Hot water (~110°F)	½ C	Place in one water bottle
Ice water (ice optional)	½ C	Place in one water bottle
Balloons	2	

SET UP

Place half the yeast and sugar in one bottle with the hot water; place half the yeast and sugar in the other bottle with the cold water (adding ice to this bottle provides a nice visual, but is not necessary). Blow up and deflate the balloons once to stretch them out before placing over the nozzles of the bottle lids. Screw the lids over the bottles.

*Make sure the balloons are completely over the nozzles and are air-tight.

After a couple minutes, the balloon on the bottle with hot water will stand up straight.

[Optional but recommended]: Research a few local examples of groups working to reduce the use of fossil fuels. For example, look for civic initiatives or action taken by community groups like schools or faith communities.

INTRODUCTION

1 minute

Welcome to the permafrost lab! I'm running a science experiment. **Want to take a look?**

Have you had a chance to look around any of the exhibit?

Have you heard of permafrost before? What can you tell me about permafrost?
Permafrost is ground that's frozen year-round. It covers 20% of the Earth's land surface, mostly in the Arctic but also in some high mountain ranges and a few places in Antarctica.

ACTIVITY

Metabolizing Microbes

6 minutes

Have any of you ever baked bread? Did you put yeast in your bread? Yeast is a microbe. Microbes are living things that are so small you need a microscope to see them. The dry yeast you get at the grocery store is dormant – it's not eating, growing, or doing anything.

In this demonstration, I've put equal amounts of yeast, sugar, and water into each bottle. The only difference is the temperature of the water— **Can you guess which yeast I put in warm water, and which I put in ice water?**

Visitors almost always get it right, especially if you've added ice.

I'm using this demonstration to show what happens when permafrost thaws. Frozen in permafrost are the remains of Ice Age plants and animals. This is great food for microbes, so imagine that the sugar I've put in each bottle represents the organic material in permafrost. With cold water, you can see what happens when permafrost stays frozen: the microbes stay dormant and never eat the food. With warm water, though, they wake up. **Can anyone guess what is in the balloon?**

Invite visitors to squeeze the inflated balloon. Inside is carbon dioxide.

When you're baking, you want carbon dioxide gas because it's what makes bread rise and get fluffy. You get it by feeding sugar to yeast and waiting—essentially—for the yeast to start farting. However, this same process is why climate scientists are concerned about permafrost thaw, because when it thaws, microbes release carbon dioxide and methane. These are heat-trapping gases, the same ones we release when we burn fossil fuels. When they enter the atmosphere, they act like a blanket around the Earth, trapping heat and warming our planet.

The more our planet warms, the more permafrost thaws due to climate change. The more permafrost thaws, the more it releases heat-trapping gases into the air, which cause even more warming. This is called a "feedback loop." Thawing permafrost speeds up climate change.

Scientists are still researching how much heat-trapping gas is coming out of permafrost, but we do know that it can be a lot. Permafrost covers 20% of the Earth's land surface. If it thaws, that will have a major impact on our global climate.

Direct visitors to the permafrost tunnel, where they can smell permafrost. The decomposition you're describing is why permafrost smells like a barnyard.

Direct visitors to the "Methane Bubble Station" exhibit to learn more about how researchers are measuring methane coming out of permafrost.

WRAP-UP

3 minutes

Lead the discussion away from "doom and gloom" and toward opportunities for collective action.

If necessary, assure visitors that they do not need to stop eating bread because yeast releases carbon dioxide. Fossil fuels release *much* more gas than baking yeast.

We can't stop thawing permafrost from releasing heat-trapping gases, but we can do a lot to help keep it frozen. Some effective actions we can take are to talk about what we've learned here and work on a community level to burn fewer fossils fuels. With community initiatives, we can use less energy and switch to energy like solar and wind, which doesn't release heat-trapping gases. *[Offer a couple local examples.]*

CLEAN UP

- Wash water bottles.
- Drain water bottle bases.

BACKGROUND INFORMATION

Topic

See "Talking About Climate Change" in the *Under the Arctic* Educator Guide.

RESOURCES

Permafrost Research Tunnel:

Permafrost Research Facility. US Army Corps of Engineers, https://www.erdc.usace.army.mil/CRREL/Permafrost-Tunnel-Research-Facility/. Accessed 2 Aug. 2018.

More info on permafrost (and a great video for students):

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Frameworks Academy. *Climate Reframe Cards,* https://climateinterpreter.org/sites/default/files/resources/nnocci_full_set_climate_reframe_cards.pdf. Accessed 2 Aug. 2018.

From the NNOCCI Recommendations Flyer:

> *"We can teach public audiences that systemic initiatives can create wide-scale change to support both human and ecosystem health and resilience. It's uncommon for people to hear about collective, systemic initiatives, but feel more hopeful when*

they do learn about them. Hope supports further engagement! We're rallying around these four themes:

- ***Ingenuity**: By being resourceful and innovative, we can come up with new ways to tackle difficult problems.*
- ***Energy Shift**: By using energy sources that don't add to the heat-trapping blanket effect, such as solar energy, we can get the climate system back to functioning the way it should.*
- ***Energy Efficiency**: While we work towards moving away from fossil fuels for energy altogether, we can use much less of the kinds of energy that add heat-trapping gases to our atmosphere.*
- ***Change the Conversation**: We all have a part to play in building support for action on climate and ocean change.*

By talking more often about these issues, and by joining groups, we can make a difference."

NEXT GENERATION SCIENCE

Practices
1. Asking questions and defining problems
2. Developing and using models
4. Analyzing and interpreting data
6. Constructing explanations and designing solutions
8. Obtaining, evaluating, and communicating information

Crosscutting Concepts
2. Cause and effect
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter
7. Stability and change

DCIs

	Disciplinary Core Idea	K	1	2	3	4	5	MS	HS
Physical Science									
PS1	Matter and Its Interaction	n/a	n/a		n/a	n/a			
PS2	Motion and Stability: Forces and Interactions		n/a	n/a		n/a			
PS3	Energy		n/a	n/a	n/a				
PS4	Waves and Their Applications in Technologies for Information Transfer	n/a		n/a	n/a		n/a		
Life Science									
LS1	From molecules to organisms: Structures and processes			n/a					
LS2	Ecosystems: Interactions, Energy, and Dynamics	n/a	n/a			n/a			
LS3	Heredity: Inheritance and Variation of Traits	n/a		n/a		n/a	n/a		
LS4	Biological Evolution: Unity and Diversity	n/a	n/a			n/a	n/a		
Earth & Space Science									
ESS1	Earth's Place in the Universe	n/a			n/a				
ESS2	Earth's Systems		n/a					✓	✓
ESS3	Earth and Human Activity		n/a	n/a	✓	✓	✓	✓	✓
Engineering, Technology, and Applications of Science									
ETS1	Engineering Design								

Melting Foundations

Program Type: Demo	Audience Type: All ages

Description: Visitors learn about an engineering solution Alaskans use to keep their warm houses from thawing the permafrost below. A facilitator places two warm model houses on ice; one starts to sink, while the other does not.

Topics: Permafrost, Engineering, Climate change

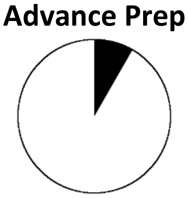
Process Skills Focus: Inquiry, Observing

LEARNING OBJECTIVES

- Warm house foundations thaw permafrost, so some Alaskans keep it frozen by building their houses on stilts.
- When permafrost thaws, it seriously impacts people living in the Arctic.
- Climate change is speeding up permafrost thaw.

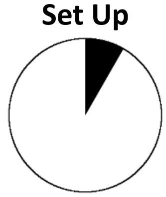
TIME REQUIRED

Advance Prep



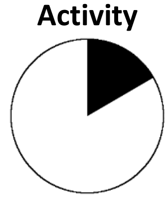
5 minutes

Set Up



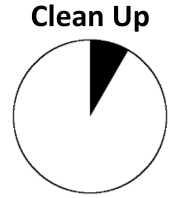
5 minutes

Activity



10 minutes

Clean Up



5 minutes

SITE REQUIREMENTS

- None, but this activity works well in the "Permafrost Lab" area of the exhibit.
- This demo works well on the same table as "Metabolizing Microbes." Do this demo first, then use the other to transition into a discussion of how thawing permafrost affects each of us by impacting our global climate.

SUPPLIES

Permanent Supplies	Amount	Notes
Model house with stilts	1	
Model house without stilts	1	
Baking pan	1	
Buckets	2	
Ice	--	Fill about 2/3 of the bucket
Soil	--	Fill about 2/3 of the bucket

SET UP

The night before, freeze two trays of ice cubes (or buy a bag of ice). Collect dirt or soil, or buy a bag of potting soil. Place ice in one bucket and soil in the other to carry to demo area.

Print photograph of house on stilts.

At demo area, tightly cover one half of each baking pan with a layer of ice. Pack soil into the other half so that both sides are at the same ground level. You can also fill in the gaps in the ice cubes with soil, but keep the ice visible for a visual cue.

Place each house in a tray. Position them so that some of the house's base is over the ice, but one edge (or two stilt legs) rests on the ice-less soil. Pour hot water into the houses. You may want to fill a thermos with hot water so that you can refresh it once it cools.

After 1-2 minutes, the house without stilts will thaw the ice below significantly more than the house on stilts. It will start to slump.

[Optional but recommended]: Research a few local examples of groups working to reduce the use of fossil fuels. For example, look for civic initiatives or action taken by community groups like schools or faith communities.

INTRODUCTION

1 minute

Suggested script is shaded. Important points or questions are in **bold**. Possible answers are shown in *italics*.

Welcome to the permafrost lab! I'm running a science experiment. **Want to take a look?**

Have you had a chance to look around the exhibit?

Have you heard of permafrost before? What can you tell me about permafrost?
Permafrost is ground that's frozen year-round. It covers 20% of the Earth's land surface, mostly in the Arctic but also in some high mountain ranges and a few places in Antarctica.

ACTIVITY

Demo

6 minutes

There is a lot of ice in permafrost, but it's not spread evenly. In each of these trays there is a massive ice wedge, and unfortunately, we've built houses on them.

Point out the ice in the trays.

Have you had a chance to explore the research tunnel? Did you see the ice wedges? Do you remember what they are? *Ice wedges are big veins of ice running through permafrost that formed during the last ice age. They are common and they turn into sinkholes when they melt.*

Direct visitors to the permafrost tunnel to see an ice wedge sculpture.

So, there's a problem with building on permafrost, which you can see with this house that's sinking. **What do you do to your house during a cold Alaskan winter?**
Heat it.

Right. I poured hot water into these houses, which has caused a bit of an issue. **What do you notice that's different between these two experiments?** *One house is raised up. More ice melted in one pan*. **What happened to the ice wedge in each pan?** *They melted. The ice wedge under the house on stilts melted less.*

If you build on permafrost and your floor heats up an ice wedge, you can end up with a sinkhole under your living room. This is why you see houses on stilts in Alaska. The stilts keep cold winter air circulating below the house, which helps keep permafrost frozen.

Show photograph of house on stilts. Direct visitors to the Engineering Challenge exhibit to build their own house on permafrost, and to the Northern Stories Theater to hear more from Alaskans living on permafrost.

WRAP-UP

3 minutes

This is an issue is becoming more and more common in Alaska and other cold places. **Any idea why?**
Different places are getting warmer. Climate change.

Alaska is warming due to climate change. This is raising the average ground temperature. In many areas, permafrost is already only slightly below freezing, so even a small rise in temperature can lead to widespread thawing, making it more and more difficult to live on permafrost. Climate change is a very visible issue for Alaskans. Putting a house on stills can prevent the house's heat from thawing permafrost, but it doesn't keep climate change from doing so.

We can work to keep permafrost frozen for future generations by slowing climate change. Some effective actions we can take are to talk about what we've learned here and work on a community level to burn fewer fossils fuels. With community initiatives, we can use less energy and switch to energy like solar and wind, which don't release heat-trapping gases. *[Offer a couple local examples.]*

Emphasize civic action and collective local initiatives. It helps to research these in advance: what steps is your local community taking to stop of reduce the burning of fossil fuels? What are some success stories? Who are some of the people involved? You can inspire hope by educating about the possibility of systemic change.

CLEAN UP

- Rinse soil from the houses and stilt foundation.
- Dump soil and ice/water from the baking trays and rinse them before putting away.

BACKGROUND INFORMATION

Topic

See "Talking About Climate Change" in the *Under the Arctic* Educator Guide.

RESOURCES

Permafrost Research Tunnel:

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NEXT GENERATION SCIENCE

Practices
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
6. Constructing explanations and designing solutions
8. Obtaining, evaluating, and communicating information

Crosscutting Concepts
1. Patterns
2. Cause and effect
5. Energy and matter
6. Structure and function
7. Stability and change

DCIs

	Disciplinary Core Idea	K	1	2	3	4	5	MS	HS
Physical Science									
PS1	Matter and Its Interaction	n/a	n/a		n/a	n/a			
PS2	Motion and Stability: Forces and Interactions		n/a	n/a		n/a			
PS3	Energy		n/a	n/a	n/a				
PS4	Waves and Their Applications in Technologies for Information Transfer	n/a		n/a	n/a		n/a		
Life Science									
LS1	From molecules to organisms: Structures and processes			n/a					
LS2	Ecosystems: Interactions, Energy, and Dynamics	n/a	n/a			n/a			
LS3	Heredity: Inheritance and Variation of Traits	n/a		n/a		n/a	n/a		
LS4	Biological Evolution: Unity and Diversity	n/a	n/a			n/a	n/a		
Earth & Space Science									
ESS1	Earth's Place in the Universe	n/a			n/a				
ESS2	Earth's Systems	✓	n/a	✓	✓	✓	✓	✓	✓
ESS3	Earth and Human Activity	✓	n/a	n/a	✓	✓	✓	✓	✓
Engineering, Technology, and Applications of Science									
ETS1	Engineering Design	✓	✓	✓	✓	✓	✓	✓	✓

Melting Foundations

Program Type: Classroom or after school program	***Audience Type:*** Grades 6-8, ages 11-14

Description: Permafrost contains large veins of ice called ice wedges, and these ice wedges can thaw and create sinkholes when people build warm houses on them. Students make permafrost out of ice and soil and design model "houses" that will keep the ice frozen.

Topics: Permafrost, Engineering, Climate change

Process Skills Focus: Engineering design, critical thinking, inquiry, observing

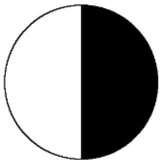
LEARNING OBJECTIVES

For Next Generation Science Standards alignment, see end of outline.

- Warm house foundations thaw permafrost.
- Alaskans engineer houses that keep permafrost frozen, including houses on stilts.
- Climate change is speeding permafrost thaw.

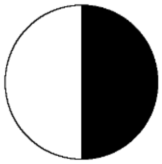
TIME REQUIRED

Advance Prep



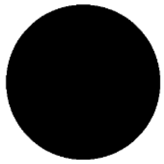
30 minutes

Set Up



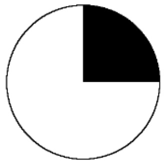
30 minutes

Activity



60+ minutes

Clean Up



15 minutes

SITE REQUIREMENTS

- Standard size classroom
- Desks or tables with chairs grouped for work in groups of 2-4
- Access to water source
- Access to at least one power outlet
- Access to freezer (overnight)

PROGRAM FORMAT

Segment	Format	Time
Introduction	Large group discussion	5 min
Make Permafrost	Demo	10 min
Engineer for Permafrost	Group Activity	30 min
Eng. for Permafrost, pt II	Group Activity	20 min
Wrap-Up	Large group discussion	10 min

SUPPLIES

Supplies	Amt	Notes
Larger baking pan	1 per group of 2-4	The deeper the better. At least 10” on the long side.
Small baking pan	1 per group	Small metal loaf pan – 8.5” x 4.5.” This will serve as the “house.”
Tables or group of desks	1 per group	For assembling houses (students can work on the floor as an alternative)
Popsicle sticks	6 per group	
Masking tape	1 arm’s-length per group	To make the activity more challenging, you can replace masking tape with rubber bands.
Tin foil	1 square sheet	
Optional supplies: rubber bands, balloons, fabric, a sponge cut into thin strips.	--	Feel free to add an additional supply if you have something fun lying around that you think could prompt creative designs. Be careful to limit the amount of supplies you offer, though, or the activity becomes too easy.

ADVANCE PREPARATION

- Freeze enough ice cubes to fill a large bowl.
- See the “Make Permafrost” demo and create a dish of “permafrost.” Then place one of the baking tins perpendicularly across the “ice wedge” portion and pour in hot water. You want one end of the dish to sink significantly more than the other as the ice melts. Play around with how tightly you pack the dirt, how much ice you use, and where you put it.

SET UP

“Make Permafrost” demo:

Gather the following supplies:

- ❑ 1 baking dish
- ❑ Dirt
- ❑ Ice cubes

“Engineer for Permafrost” Activity:

Set up the following for each station:

- ❑ 1 small baking pan
- ❑ Other supplies (refill each time you ask students to engineer a house)

Set aside for when you test the designs:

- ❑ 1 baking dish per group
- ❑ Dirt
- ❑ Ice cubes

INTRODUCTION

5 minutes

Let students speculate before offering answers to any questions. The answers given are provided primarily for the instructor’s benefit.

Suggested script is shaded. Important points or questions are in **bold**. Possible answers are shown in *italics*.

Today we’re going to be building houses for life in Alaska. Alaska has a special type of ground called permafrost. **Can anybody tell me what permafrost is?**

Permafrost is ground that’s frozen year-round. It covers 20% of the Earth’s land surface, mostly in the Arctic but also in some high mountain ranges and a few places in Antarctica.

Can anybody tell me what you need to do to your house during an Alaskan winter?

You need to heat the house. It gets really cold in the Arctic (if it's winter, try looking up current temperatures in Fairbanks or Utquaġvik).

If your warm floor was sitting on top of frozen ground, what do you imagine would happen?

Heat transfers into the ground through the floor, thawing the ground. This would make your house sink as ice turns into water and flows away.

DEMO

Make Permafrost

10 minutes

Before we get to our houses, we're going to make permafrost. I have soil in this bowl, and I have ice in this one. **How do you think I should begin?**

Fill the baking dish about halfway up with dirt. Crush up a few ice cubes and mix them in evenly. Explain that there are tiny pieces of ice frozen throughout permafrost, even though they're hard to see.

During the last ice age, over 10,000 years ago, the ground would get so cold in the winter it would crack. Cold water would fill in the crack in the spring, and re-freeze into a little sliver of ice. This would happen again and again for thousands of years, until the sliver had grown into a massive chunk of ice called an ice wedge. They can get to be as big as a house.

Draw the general shape of an ice wedge on the board. Make it as big as you can, but then invite students to imagine an ice wedge that's even *bigger*. With your hands, open up a large "crack" in the permafrost you've put in the baking dish. Fill it tightly with ice cubes, and cover with a dusting of dirt.

I mentioned that ice wedges took thousands of years to form. **Can anybody guess how long it takes them to melt?**

Ice wedges can melt in a single summer. It's also impossible to re-freeze them. It's not cold enough today to make new permafrost.

Here's a tip if you ever want to move to Alaska: **where should you build your house?**

Not on permafrost. Especially not on an ice wedge. Remember how those ice wedges are as big as a house? That melts into a giant sinkhole that your house will fall into. Around a city like Fairbanks, most people do not build on soil that contains permafrost.

Sometimes, though, it's the only ground available. Your challenge is to build a house that will keep the ice wedge frozen.

GROUP ACTIVITY

Engineer for Permafrost

30 minutes

Now that you have some background on permafrost, we're going to build houses that won't thaw it. Each group gets one of these pans (hold up baking pan), which is going to be the floor of your "house." When you're done, I will set your house on the permafrost we've made, pour hot water into it- since your house is heated in the winter, and see what happens. **How will you keep the hot water from melting the ice?**

Give students 10-20 minutes to construct a house using the baking pan, popsicle sticks, masking tape, sheet of tin foil, and any other supplies you are providing. Wander around the room to provide help where it's needed. Answer direct questions, but try to ask students about their strategy rather than leading them toward a solution that will work. It's okay for the designs to fail. Give periodic updates on time, including a 5-minute and 2-minute warning. As they near the end of their allotted time, make one tray of permafrost per house (in a large class, you can use the same tray and re-fill it between testing each house).

Let's look at what everybody did. Which group wants to share the solution they thought up?

As students share, focus on the problem-solving and creativity you see, rather than whether it looks like it will work. Ask students about the challenges they faced, and how they worked through them. This can include group dynamics.

Now it's time for the test…whose house will stay level?

Place each house perpendicularly across an ice wedge, so that any thawing will happen unevenly. Pour hot water (ideally just-boiling from an electric kettle) into the tins and wait for 10-30 seconds to see what happens.

Who thought their house was successful? Why did it work? Who thought their house *failed*? That's okay! You learned – how would you do it differently?

Again, praise students for growth and experimentation rather than success or failure. Focus on problem-solving.

Here is one example of a design that fulfils the design criteria (it keeps the hot water away from the ice and prevents melting) but can be improved (it is unstable when the water is added, and the legs sink through the loose soil):

GROUP ACTIVITY

Engineer for Permafrost Part II

20 minutes

You all designed a house and tested it. Now that we've seen what happened, we're going to do it again. As an engineer, you re-design and test all the time because you rarely design something perfectly on your first try. Testing and failure are how engineers learn to make designs that work.

I want each group to take a design you saw and improve it. Get creative!

Prepare to be flexible with this activity. Some groups will nail their designs on the first try before their time is up. When this happens, offer more difficult parameters (e.g. challenge them to design without making stilts or an insulating floor, take away a few materials due to budget cuts, or put more ice in the permafrost). Some groups will struggle to create a design that works. With them, keep praising creativity and problem-solving, ask a lot of questions about why they made the choices they did, and what they could build with different materials. If you run out of time before they make a design that works, don't frame this as a failure. Emphasize again that engineering is about trying designs until they work and finding creative solutions that point toward future designs.

WRAP-UP

10 minutes

Ask for student observations. Let students guide the discussion and present their ideas before discussing explanations.

What did you learn about living in the Arctic today?

Which designs did you think worked the best?

How would you improve your designs in the future?

If you were building a real house in Alaska, what would you do?

Some Alaskans do build their houses on stilts. This lets cold air run between the warm floor and the cold ground, to keep permafrost frozen. It's hard to keep the permafrost completely frozen, though, so they often have to level their houses every few years.

Is there anything else you can think of that might thaw permafrost?

By burning fossil fuels, people are adding heat-trapping gases to the atmosphere, which is warming the planet. This makes permafrost thaw faster and more widespread than it used to be, and it makes it harder for the people who live on it.

What can we do to help slow permafrost thaw?

Emphasize civic action and collective local initiatives. It helps to research these in advance: what steps is your local community taking to stop or reduce the burning of fossil fuels? What are some success stories? Who are some of the people involved? You can inspire hope by educating about the possibility of systemic change.

See "Talking About Climate Change" section of the Educator Guide for more resources.

CLEAN UP

- Ask students to place “permafrost” in a bucket. When it dries, you can dry this and reuse it.
- Students should place all unused materials in the center of the table for reuse.

BACKGROUND INFORMATION

Topic
See “Talking About Climate Change” in the *Under the Arctic* Educator Guide.

RESOURCES

National Network for Ocean and Climate Change Interpretation (NNOCCI)
https://climateinterpreter.org/resources

NNOCCI is an excellent resource for anyone who wants to effectively communicate about climate change. We suggest you read over the following PDFs:

Frameworks Academy. *NNOCCI Recommendations Flyer*, https://climateinterpreter.org/sites/default/files/resources/nnocci_recommendations_flyer_2016.pdf, 2016. Accessed 2 Aug. 2018.

Frameworks Academy. *Climate Reframe Cards,* https://climateinterpreter.org/sites/default/files/resources/nnocci_full_set_climate_reframe_cards.pdf. Accessed 2 Aug. 2018.

From the NNOCCI Recommendations Flyer:

> *“We can teach public audiences that systemic initiatives can create wide-scale change to support both human and ecosystem health and resilience. It’s uncommon for people to hear about collective, systemic initiatives, but feel more hopeful when they do learn about them. Hope supports further engagement! We’re rallying around these four themes:*

- ***Ingenuity****: By being resourceful and innovative, we can come up with new ways to tackle difficult problems.*
- ***Energy Shift****: By using energy sources that don't add to the heat-trapping blanket effect, such as solar energy, we can get the climate system back to functioning the way it should.*
- ***Energy Efficiency****: While we work towards moving away from fossil fuels for energy altogether, we can use much less of the kinds of energy that add heat-trapping gases to our atmosphere.*
- ***Change the Conversation****: We all have a part to play in building support for action on climate and ocean change.*

By talking more often about these issues, and by joining groups, we can make a difference."

Resource for action on climate change:

The Climate Explorer. US Climate Resiliency Toolkit, 2018, https://crt-climate-explorer.nemac.org/. Accessed 2 Aug. 2018.

More info on permafrost (and a great video for students):

"Permafrost – what is it?" *YouTube*, uploaded by Alfred-Wegener-Institut, Helmholtz-Zentrum für Polar- und Meeresforschung, 7 Mar. 2016. Accessed 2 Aug. 2018.

NEXT GENERATION SCIENCE

Practices
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
6. Constructing explanations and designing solutions
8. Obtaining, evaluating, and communicating information

Crosscutting Concepts
1. Patterns
2. Cause and effect
5. Energy and matter
6. Structure and function
7. Stability and change

DCIs

	Disciplinary Core Idea	K	1	2	3	4	5	MS	HS
Physical Science									
PS1	Matter and Its Interaction	n/a	n/a		n/a	n/a			
PS2	Motion and Stability: Forces and Interactions		n/a	n/a		n/a			
PS3	Energy		n/a	n/a	n/a				
PS4	Waves and Their Applications in Technologies for Information Transfer	n/a		n/a	n/a		n/a		
Life Science									
LS1	From molecules to organisms: Structures and processes			n/a					
LS2	Ecosystems: Interactions, Energy, and Dynamics	n/a	n/a			n/a			
LS3	Heredity: Inheritance and Variation of Traits	n/a		n/a		n/a	n/a		
LS4	Biological Evolution: Unity and Diversity	n/a	n/a			n/a	n/a		
Earth & Space Science									
ESS1	Earth's Place in the Universe	n/a			n/a				
ESS2	Earth's Systems		n/a					✓	
ESS3	Earth and Human Activity		n/a	n/a				✓	
Engineering, Technology, and Applications of Science									
ETS1	Engineering Design							✓	

Climate Action Poster Board Activity

Program Type: Classroom or after school program	***Audience Type:*** Grades 6-8, ages 11-14

Description: Climate change is a big issue, but we can work together to address it. Students work in small groups of 3-4 to research a local climate change initiative and create a poster board with arts and craft supplies. They then present their project to the class in a poster session-type format.

Topics: Climate change, collective action

Process Skills Focus: Critical thinking, research, reading, writing.

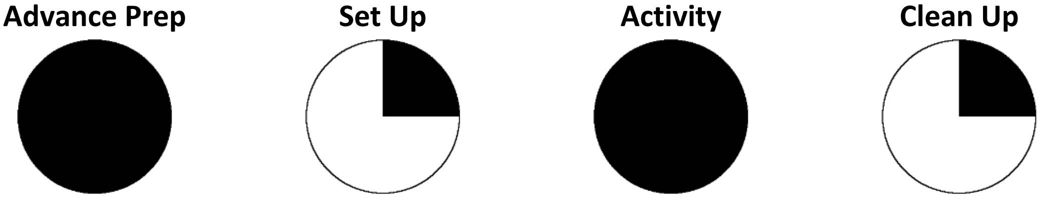
LEARNING OBJECTIVES

For Next Generation Science Standards alignment, see end of outline.

- Groups of people throughout the country are taking meaningful action on climate change.
- Students gain basic research skills by learning about climate initiatives.
- Students understand that they can contribute to local climate initiatives.

TIME REQUIRED

Advance Prep | **Set Up** | **Activity** | **Clean Up**



60 minutes | **15 minutes** | **60+ minutes** | **15 minutes**

SITE REQUIREMENTS

- Access to tables or floor space large enough for groups of 2-3 students to create poster board collages with arts and craft supplies.
- Access to a chalk or dry erase board.
- Access to computers or tablets (1 per 2-3 students) **or** printed materials on climate change projects (*see Advance Preparation for more details*).

PROGRAM FORMAT

Segment	Format	Time
Introduction	Instructor-led discussion	10 min
Creating Poster Boards	Participant-led group activity	30-40 min
Group Presentations	Participant-led group discussion	20 min

SUPPLIES

Permanent Supplies	Amt	Notes
Chalk board or dry erase board	1	Large enough for students to come up and write notes
Computers or tablets (preferable)	1 per group of 2-3 students	For researching information. Printed materials can be used as an alternative.
Printer (optional; color printer preferred)	1	For printing information and graphics for poster boards. You can also cut clippings from magazines and newspapers.
Tables or group of desks	1 per group	For assembling poster boards (students can work on the floor as an alternative)
Poster boards (around 64 cm x 64 cm or 24” x 24”)	1 per group	Cardboard could also be used
Markers	5 per group	A variety of colors
Scissors	1 per group	
Glue stick	1 per group	
Pencils	1 per student	For taking notes / making a draft

ADVANCE PREPARATION

- Review “Talking About Climate Change” section of the *Under the Arctic* Educator Guide and NNOCCI recommendation flyers (see “Resources” in this activity; NNOCCI documents are also included as an appendix to the *Under the Arctic* Educator Guide).
- If you have more time, or time in a previous class, and access to computers or tablets, students can research and find climate change initiatives themselves. Otherwise, the instructor should find one climate change initiative for each group of students to research. These can be small or large, but the key is that they involve a group of people working together to reduce the use of fossil fuels. Ideally they are local and there is a pathway for students to get involved, although this is not required.
    - Some great places to start: Has your city created a climate action plan, or is there a group proposing one? Is there another local school or youth-serving program that has instituted a practice that helps reduce fossil fuel use by using less energy (energy efficiency) or switching from fossil fuels to renewable energy like solar or wind energy? Is there a local organization that is supporting the transition to renewable energy? Try to find the personal stories behind these initiatives, so that students can see what working collectively looks like for the individuals involved.
- Instructor can select a limited amount of information on each initiative to print for each group instead of having students use computers or tablets. Printing extra-large font works well for students to read over as a group and for cutting and pasting onto poster boards.
- Each group should have at least 3-5 images printed out or cut and paste onto poster boards. Students can draw pictures as an alternative.
- Select 2-3 students who can work well together for each group.
- If students are different ages and have varying reading abilities, adjust the amount of research information assigned to the groups.

SET UP

- Give each group of students all materials needed to research a climate initiative and create a poster board:
    - Poster board
    - Computer or tablet and printer **or** pre-printed information and graphics
    - Markers
    - Scissors
    - Glue
    - Pencils

INTRODUCTION

10 minutes

Let students speculate before offering answers to any questions. The answers given are provided primarily for the instructor's benefit.

Suggested script is shaded. Important points or questions are in **bold**. Possible answers are shown in *italics*.

Today we are going to learn about what people in our community are doing to address climate change. We're going to begin by learning about the what is causing climate change.

Carbon dioxide and methane are heat-trapping gases, which you may also have heard of as "greenhouse gases." Without these gases in our atmosphere, Earth would freeze over. They surround the planet and keep heat from escaping into outer space, like a blanket holds in your body heat on a cold day.

But what happens if your blanket is too heavy or you're wearing too many layers of clothing?
You get hot and sweaty.

Regular amounts of heat-trapping gases are important, but when there are too many, the planet starts to overheat.

So where does all the extra carbon dioxide and methane come from? Can anybody tell me what a fossil fuel is?
Fossil fuels are the remains of dead plants and animals that lived hundreds of millions of years ago. We burn fossil fuels for energy. They include coal, oil, and natural gas.

When we burn fossil fuels (coal, oil, and natural gas), they release heat-trapping gases like carbon dioxide and methane. These gases enter the atmosphere and trap more and more heat, which causes Earth's climate to get warmer. As our planet gets warmer, this disrupts climates around the globe, which affects the plants, animals, and people living there. Climate change is the environmental changes that happen around the globe because the planet is warming.

This is a good time to bring up local effects of climate change and the challenges they pose for your community. Keep an explanatory, optimistic tone during this discussion. The goal is to demonstrate that climate change is relevant to students' lives while avoiding "doom and gloom."

To slow climate change, there are many things we can do to burn fewer fossil fuels.

What are some ways we can do this?

We can generate energy from sources that don't release heat-trapping gases, such as solar and wind. We can use efficient systems and technology so that we don't use as much energy. We can talk about it and get other people interested in taking action.

Climate change can feel overwhelming because it's such a large-scale issue, but we have the power to address it. When groups of people work together, they can create broad changes that benefit human health and our environment. Today, you are going to learn about a few of these groups working nearby.

Optional Enrichment

If students have the chance to visit the *Under the Arctic* exhibition, review the content in the exhibition and relate it to the conversation. Bring up challenges facing Alaskans due to climate change, and relate these to local issues.

GROUP ACTIVITY

Create Poster Boards

30-40 minutes

Assign the students to groups of 2-3 students and hand out all of the materials needed to complete the project.

You have in front of you all the materials needed to complete the project. You are going to make a poster board that tells the story of a local group working to slow climate change by burning fewer fossils fuels or respond to the effects of climate change. Here is a handout with your directions.

Provide each group with websites where they can research the initiative you selected for them **or** with materials you printed out about this group ahead of time. Encourage students to get creative and to treat the project like a storytelling session.

The poster boards can go on display in either the classroom, somewhere else in a school or ideally in a museum hosting the *Under the Arctic* exhibition. Museums can use the poster boards to supplement the exhibit and highlight climate initiatives happening in their local community.

Handout

Climate Action Poster Board Activity

Work in small groups to research a local group of people working to address climate change. After creating the poster boards, each group will present their board and talk about their project.

Directions

Create a poster board that tells a story about the group you're researching. Include the following information:

1. Do they belong to an organization? If so, what is its name?
2. Where are they working?
3. What is their work about?
4. How did these people meet or find each other?
5. What motivated them to start working on the issue?
6. What have they done, or what do they hope to do?
7. What have they done as a group that they couldn't do as individuals?

PARTIPANT-LED GROUP TALK

Group Presentations

20 minutes

Ask each group of students to make a short presentation of their poster board. Students can use their direction sheet as a guide for their presentation.

OPTIONAL EXTENSIONS

- Take a field trip to a museum hosting the *Under the Arctic* exhibition and challenge students to find examples of people responding to climate change as they move through the exhibit components. Lead a group discussion near the exhibit afterward and have students share what they learned about how Alaskans are responding to climate change and how they can help.
- Talk with museum staff about displaying the poster boards in the museum to highlight climate initiatives happening in your local community.
- Educators can involve students in an actual project addressing climate change. For example, you can help students lead an energy efficiency initiative at your school or invite community leaders to come present in the classroom about how students can volunteer to help with local projects slowing or responding to climate change.

BACKGROUND INFORMATION

Topic
See "Talking About Climate Change" in the *Under the Arctic* Educator Guide.

RESOURCES

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NEXT GENERATION SCIENCE

Practices
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Crosscutting Concepts
1. Patterns
2. Cause and effect
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter
6. Structure and function
7. Stability and change

DCIs

	Disciplinary Core Idea	K	1	2	3	4	5	MS	HS
Physical Science									
PS1	Matter and Its Interaction	n/a	n/a		n/a	n/a			
PS2	Motion and Stability: Forces and Interactions		n/a	n/a		n/a			
PS3	Energy		n/a	n/a	n/a				
PS4	Waves and Their Applications in Technologies for Information Transfer	n/a		n/a	n/a		n/a		
Life Science									
LS1	From molecules to organisms: Structures and processes			n/a					
LS2	Ecosystems: Interactions, Energy, and Dynamics	n/a	n/a			n/a			
LS3	Heredity: Inheritance and Variation of Traits	n/a		n/a		n/a	n/a		
LS4	Biological Evolution: Unity and Diversity	n/a	n/a			n/a	n/a		
Earth & Space Science									
ESS1	Earth's Place in the Universe	n/a			n/a				
ESS2	Earth's Systems		n/a						
ESS3	Earth and Human Activity		n/a	n/a	✔	✔	✔	✔	✔
Engineering, Technology, and Applications of Science									
ETS1	Engineering Design								

Guidelines for Respecting Cultural Knowledge

This section is a general introduction for educators on how to better respect and present cultural knowledge and issues pertaining to Native peoples in the United States. By no means does the following section encompass all of the ongoing and multifaceted matters related to the varied and diverse cultures of the indigenous peoples of North America and Hawaiʻi. Instead, the content is intended to address some of the most important questions and issues that educators might come across or be asked about. We strongly encourage educators to learn more by accessing the resources listed at the end of the guide and by looking for educational resources created by Native communities in their areas.

The topics included here were identified and written in collaboration with Deana Dartt, Ph.D. (*Chumash*) and project advisors and partners on OMSI's exhibition *Roots of Wisdom*. We have adapted the guidelines for the *Under the Arctic* exhibition. For more information, please download the project's legacy document here: https://omsi.edu/exhibitions/row/education-resources/

Respecting Native cultures

Valuing and respecting diverse cultures is critical for museums of all types and particularly important when hosting the *Under the Arctic* exhibition, which relies on the knowledge and experiences of Alaska Natives. Educators should be considerate of cultural differences and similarities that exist without equating value (right or wrong, good or bad) to these differences. Respecting people and cultures means recognizing that all individuals are unique and that the way they interact with their community and the larger world is affected by their language, beliefs, values, and personal experiences. Respecting cultures in this way also allows us to communicate and collaborate more effectively with diverse communities.

When hosting the *Under the Arctic* exhibition or conducting any project with Native communities, it is critical to develop a basic understanding of the key issues impacting Native communities today and historically. This understanding is particularly important because of the long history of human rights abuses Native communities have been subjected to and the lack of information most people have about contemporary Native peoples. Below, we highlight historical notes and discussions of some of these key issues.

> *"Native people often feel the term 'wild' is a pejorative term. From a Native perspective, it is thinking more about a natural order. There is no such thing as a wild river, it has an order, nature's order. The beauty has an order." —David Begay, Ph.D. (Diné [Navajo]), Vice President, IEI*

North America was not "wild" or "undiscovered" before Europeans arrived

In many Native American languages, there is no word for wild. Instead, nature is often understood as an interconnected, organic system of which the indigenous people are a part. However, because European explorers and settlers did not understand these interconnections or natural systems, they called the environments that they encountered in the Americas "wilderness." Therefore, for many Native people, using the word "wild" diminishes the value of nature's order and the long-term relationships indigenous communities have had with their homelands.

> *"European settlers who first arrived in the 'New World' wanted to believe it was just that: new not only to them but to all human kind. With their diseases preceding them, diminishing complex Native civilizations, Europeans readily assumed that the Americas were, and always have been, a barely populated wilderness. This view, which justified hundreds of years of European land theft and mistreatment of Indians, has been slow to die." —Stephanie Batencourt, NMAI (quotation from the NMAI book* Do All Indians Live in Tipis?*)*

Similarly, it is crucial to understand that the ancestors of contemporary Native American people were the original discoverers and inhabitants of North America and that they lived on this continent for thousands of years before Europeans arrived. Contact with Europeans first occurred with the arrival of Western explorers and settlers in the fifteenth century who brought with them devastating diseases that Native peoples had no immunity to, cultural conflict, and displacement on a mass scale. These disturbances changed the life-ways and futures of millions of people, and Native communities today are still recovering from the near obliteration of their populations and cultures.

> *"When talking about a name for the exhibit 'wild' was a word that rubbed people the wrong way. Native people know about managing resources from living in the same place for so long. Before Europeans showed up, they assumed things were 'wild.' They didn't know how to take care of it." —Randall Melton (CTUIR), Collection Curator, Tamástslikt Cultural Institute]*

Although Europeans perceived North America as empty space when they arrived, it was in fact populated by tens of millions of people (Batencourt 27) from an enormous diversity of Native American communities. The continent was a mosaic of sophisticated cultures with varying political systems, spiritual beliefs, languages, and forms of art. These cultures included rich knowledge of their local ecosystems and how to sustain their communities in that environment. Many tribes also had working systems of agriculture and aquaculture that dated back hundreds or thousands of years.

Refer to Native communities with the appropriate names

It is best is to refer to the specific, official tribal or National name whenever possible. Many Native people feel honored and recognized when their tribe, Nation, or community is referenced accurately. Many tribes are commonly known by names that they do not use for themselves and are sometimes offensive. Therefore, it is best to either ask a tribal member or go to an official resource (e.g. the tribe's government website) to make sure that you are using the appropriate name.

If you do need to use a generic term, *American Indian* and *Native American* are both used in the United States. The terms *Native* and *indigenous* are also acceptable. In Canada, the appropriate terms are *First People, First Nations*, and *aboriginal*. When talking about Hawai'i, use *Native Hawaiians* and, for Alaska, use *Alaska Natives*.

Native America is incredibly diverse

Native Americans do not belong to a single homogenous group—instead Native people in the United States belong to hundreds of different nations, tribes, bands, villages, Rancherias, and pueblos. As of August 2018, there are 573 federally recognized American Indian tribes and Alaska Native villages in the United States (https://www.bia.gov/about-us). Many other tribes and Native communities are not federally recognized, but are recognized by states or are seeking federal recognition. For more information on this topic, visit NMAI's website for the *Nation to Nation* exhibition (http://nmai.si.edu/nationtonation/).

Identifying "Who is Native?" is a very complex issue

Identity establishment is a complex issue in many Native American communities**.** Overall, there is no single Native American experience, and each community or tribe establishes its membership in different ways. It is especially important to know that *it is inappropriate to ask someone "how Indian" they are or make assumptions about their Native ancestry based on their appearance as it can be offensive or embarrassing for that person.* .

In general, the work of determining membership and establishing cultural identity is a complicated, ongoing issue. To learn more, please see the resources listed at the end of this guide.

Federally recognized tribes are "sovereign nations" with certain rights

Tribes that are federally recognized by the U.S. government are called "sovereign nations" and are supposed to be protected by federal law differently than other entities. This sovereign nation status is meant to require the U.S. government to engage with the tribe in a "nation-to-nation" relationship. Sovereignty also allows for the nation's independent authority and the right to govern itself.

> *"Each tribe establishes its membership in a different way. Tribes have the right--because they are governments--to decide who is and who is not a tribal member. As a result, a lot of Native people today may not 'look Indian' or fit a stereotypical image of an Indian." —Liz Hill, National Museum of the American Indian (quotation from the NMAI book* Do All Indians Live in Tipis?)

The sovereignty of federally recognized nations extends to the traditional cultural practices of these communities, including the rights to use land and resources associated with cultural traditions. The following quote from the US Bureau of Indian Affairs addresses the special rights that American Indians are entitled to:

Therefore, some Native communities have the right to hunt, fish, gather, or perform other activities in places where non-Native people are not allowed to because of these treaty agreements.

"Indigenous languages are very important—if you kill the language, you kill the culture. Raising kids to be multilingual is really important to the survival of all nations! 500 years of Hawaiian chants end up being detailed geological record. Native science describes inquiry through poetic story." —VerlieAnn Malina-Wright [Hawaiian],

It is also important to note that sovereignty and treaty rights are a very complicated and contentious issue. Many treaties have not been upheld by the U.S. government, and access to land and resources outlined in treaties is often denied by government or private entities. To learn more about these issues, please refer to the references at the end of this guide.

Native languages are critical for maintaining Native cultures and knowledge
Language maintains the strength of a person's cultural identity. Indigenous languages also contain a rich place-based knowledge. Traditionally in Native American societies, language and knowledge have been passed down orally. In recent history, many Native Americans were persecuted for using their language. Many indigenous languages are in danger of disappearing. When an indigenous language is lost, much of the cultural knowledge contained within it is also lost. Therefore, the loss of a language is also a loss of history and a culture. Now, many communities are actively working to preserve and restore their languages and therefore to preserve the traditional knowledge that is contained within them. Throughout the *Under the Arctic* exhibition, Native languages and words are prominently featured because of language's importance in sharing and passing along culture and knowledge.

"Do American Indians and Alaska Natives have special rights different from other citizens? Any 'special' rights held by federally recognized tribes and their members are generally based on treaties or other agreements between the tribes and the United States. The heavy price American Indians and Alaska Natives paid to retain certain rights of self-government was to relinquish much of their land and resources to the United States. U.S. law protects the inherent rights they did not relinquish. Among those may be hunting and fishing rights and access to sacred sites." —U.S. Bureau of Indian Affairs, http://www.bia.gov/FAQs/

"A great deal of the knowledge of a people—cultural, spiritual, medicinal, and cosmological—is carried in the language. With the loss of language comes the loss of an immense cultural knowledge, history and beliefs." —Liz Hill and Arwen Nuttall, National Museum of the American Indian (quotation from the NMAI book Do All Indians Live in Tipis?)

"For over 10,000 years, American Indians from diverse tribes have lived in the United States. Natural resource management is not a modern invention; Indians have practiced the roots of this applied discipline for millennia. Our North American landscapes, a reflection of historical processes, both natural and cultural, bear the indelible imprint of a harvested and tended the wilds for millennia."
—Traditional Ecological Knowledge: An Important Facet of Natural Resource Conservation. U.S. Department of Agriculture Natural Resource Conservation Service. n.d. (http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1045244.pdf)

Traditional Ecological Knowledge
The term Traditional Ecological Knowledge (TEK) is not explicitly used in the exhibition, but the concept is used by several academics and government agencies.

What is TEK? "Traditional Ecological Knowledge is the term used to describe the knowledge and beliefs that Indigenous peoples hold of their environments that is handed down through the generations…Drawing upon on the previous several decades of TEK-related research, the following attributes can be said to typically describe the central definition of TEK: cumulative and long-term, dynamic, historical, local, holistic, embedded, and moral and spiritual." (Menzies and Butler, 2006). Other people may refer to this type of knowledge as indigenous knowledge or Native science.

Why is TEK so important to all people? TEK offers society the opportunity to strengthen its capacity to manage environmental disturbances and local environments sustainably. Because TEK is a long-term body of accumulated locally based knowledge, it can provide both a more intimate and holistic view of the natural world. A growing number of people, including many non-Native scientists, are beginning to see how traditional knowledge and Western science can be considered two 'ways of knowing' that can be complementary rather than contradictory, especially when considering understanding ecological systems.

Speaking With and About Native People in the Museum

An important part of our roles as educators is to respectfully share the content of our exhibitions with diverse audiences. The following section contains suggestions for how to be culturally sensitive in these interactions. This information is provided because it is also important for educators to accurately and respectfully present information to all audiences.

Assume that there are Native people in your audience

> *"People are going to ask you questions, and you think that they are questions, but they are really lightning bolts of fear… People have an investment in* ***not*** *knowing in a settler nation state. This is a different kind of ignorance. This requires different levels of patience and understanding." —Darren Ranco (Penobscot), University of Maine, Coordinator of Native American Research & Associate Professor of Anthropology*

With this idea in mind, always be polite and respectful when talking about someone else's culture and recognize that you might make mistakes.

If you do not know the answer to a question, do not answer it

It is okay to say, "I don't know, but I will try to find out." There are several resources listed at the end of this guide to help answer common questions. The book written by the Smithsonian Institution's NMAI titled *Do All Indians Live in Tipis?* is especially helpful for many common questions. You are also welcome to contact OMSI or IEI (http://indigenousedu.org/), and we can reach out to project advisors and partners to answer questions.

> *" It doesn't make sense to say…'I read all about you guys before I got here,' before coming to a tribal museum. You can't really know in that way. Instead, I answer, 'this is what I've been told or taught,' to explain how I know the things that I am sharing." — Randall Melton (CTUIR), Collection Curator, Tamástslikt Cultural Institute*

Learn about what names to use

As explained previously, it is best is to refer to the specific, official tribal or national name whenever possible. Many Native people feel honored and recognized when their tribe, nation, or community is referenced accurately. Many tribes are commonly known by names that they do not use for themselves and are sometimes offensive. Try to learn how the Native communities describe themselves before identifying them. It is best to either ask a tribal member or go to an official resource (e.g. the tribe's government website) to make sure that you are using the appropriate name.

If you do need to use a generic term, *American Indian* and *Native American* are both used in the United States. The terms *Native* and *indigenous* are also acceptable. In Canada, the appropriate terms are *First People, First Nations*, and *aboriginal*. When talking about Hawai'i, use *Native Hawaiians* and, for Alaska, use *Alaska Natives*.

> *"Well-meaning people assume traditional knowledge is like a legend or myth. Actually, it is a form of real empirical knowledge that can be used. It is real knowledge based on doing something over and over again." —Charles Menzies (Tlingit/Gitxaała), Professor, Department of Anthropology, University of British Columbia*

Recognize that "Native America" actually represents an enormous diversity of nations, people, cultures, and communities

> *"It has been reported that at the end of the 15th century, over 300 American Indian and Alaska Native languages were spoken." —U.S. Bureau of Indian Affairs, http://www.bia.gov/FAQs/*

Native American cultures are commonly lumped together, and many people assume that all American Indians are the same. This idea is not true. Native Americans come from thousands of different communities with a multitude of diverse cultures, separate histories, and unique languages. No general characteristics apply to all Native American people, tribes, or communities. Although some tribes may share similarities in their stories, language, or cultural practices, all North American tribes are unique in and of themselves.

Avoid using the past tense to talk about Native peoples, cultures, knowledge, and life-ways

> *"When you say, 'This is how they used to do it,' you are teaching students that we are dead." —Wenix Red Elk (CTUIR), Public Outreach and Education Specialist, Department of Natural Resources, CTUIR*

Non-Native people often assume that if current Native people do not live traditionally, then they do not exist. This idea is not true. There are many Native communities that are actively working to protect and restore their cultural traditions in a modern context.

To acknowledge the continuing existence of Native peoples and cultures, it is more respectful and accurate to use the terms "art" or "object" instead of "artifact" when referencing an object from a Native culture. Similarly, use "pre-contact" instead of "prehistory" when talking about Native cultures before Europeans arrived. Change has always been happening in North America, before and after contact with European and other cultures, and Native communities have a variety of ways of tracking and recording these changes over time.

Be respectful of Native worldviews and knowledge

Origin stories and traditional knowledge are not "myths" or "legends." Instead, they are a critical part of many people's worldviews. Traditional stories and knowledge are also rooted in a deep understanding of the local environment and history of the places where indigenous people have lived for generations.

Avoid “exoticizing” or “romanticizing” Native people and cultures

Exoticizing means to portray Native people and cultures as exotic or unusual. Romanticizing means to glamorize or idealize Native cultures or people. It is particularly common for non-Native people to exoticize or romanticize Native cultures or people in regards to their spiritual or environmental practices. Therefore, it is important to recognize that there are many Native people with strong connections with the environment or spirituality, but not everyone and not all in the same way.

Avoid reinforcing negative stereotypes

Here are some common examples:

- *Not all Native people live on reservations.* Just like most U.S. populations, the largest Native communities are found in urban areas. According to the 2010 U.S. Census, 78% of people who identified as Native American lived outside of American Indian or Alaska Native areas. Many Native people live in urban centers because of relocation policies.
- *Not all Native people are “traditional” or “spiritual,” but that does not mean that they are not still Native people.* Like any diverse category of people, each person and community has their own spiritual and religious understanding and identity.
- *Do not assume that Native people look a certain way* (e.g. high cheekbones, dark straight hair, and other physical characteristics). Individuals have their own unique and diverse ancestry, set of physical attributes, and personal preferences that influence how they look, but this physical appearance does not confirm or negate their identity as a Native person.
- *Not all Native people live in teepees, nor did their ancestors.* There are thousands of different Native communities throughout what is now the United States with a wide variety of housing used to best fit their cultures, environments, and climates. Such housing can include teepees, pueblos, longhouses, or high-rise apartments.
- *Not all Native communities have casinos that pay for schooling and other community needs.* Many Native communities do not have casinos or other tribal enterprises that provide payments to individuals or fund community needs. Other Native individuals are not enrolled members of a federally recognized tribe or nation, therefore making it impossible for them benefit from tribal enterprises. People in this situation are also denied services reserved for tribal members under federal law. Therefore, it is not appropriate to assume that all Native American and Alaska Native people have special financial or support services available to them.

Cultural knowledge: Important Considerations for Science Museums

Respecting intellectual property

Museums and similar institutions must respect the intellectual property rights of Native knowledge holders, which means respectfully working with the knowledge holders to identify what information should be shared, how it should be shared, and how it should be credited. Just like any expert in their field, the knowledge holders should also be compensated appropriately for their time and expertise. Unlike with many other types of scientific or historical knowledge, it is rarely appropriate to simply reprint or share Native knowledge without the explicit permission of the knowledge holder. For example, it would be inappropriate to retell a cultural story or share photos of a cultural ceremony without first consulting with the knowledge holders who maintain and understand those traditions. It is also important to know that one individual does not speak or represent his or her tribal nation or community. If you are looking for this type of credit or authority on an area, then you must approach the tribal council, and they will lead you to the appropriate individuals.

To learn more about how to respectfully work with Native knowledge holders and include cultural information in educational environments, please refer the references at the end of this guide including the documents created by the Alaska Native Knowledge Network.