EDUCATOR GUIDE



BBC earth

ARCTIC

OUR FROZEN PLANET

NARRATED BY
BENEDICT CUMBERBATCH

BBC earth

An
SK Films
Release



BBC earth

ARCTIC

OUR FROZEN PLANET

EDUCATOR GUIDE

Developed By

DISCOVERY PLACE

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INTRODUCTION

The Educator Guide for *ARCTIC: Our Frozen Planet* was created by Discovery Place for use by formal and informal educators looking to inspire their kindergarten through eighth grade students. Activities are envisioned to live alongside the film and support further exploration of the major themes of the film. They are designed around the U.S. Next Generation Science Standards, but educators are encouraged to adjust them to best fit the standards or programming needs of their school board.

Experiences described by the guide encourage students to consider ways in which the changing climate of the Arctic is affecting the living things who call it home. Through observations and analytical thinking, students describe the adaptations that allow animals to survive this more extreme environment. They also learn about the way climate scientists measure and describe how the climate changes through data collection and analysis.

For millennia, life has flourished in the Arctic thanks to a steady cycle of freeze and thaw. As the planet and the region warms, this steady cycle has been significantly impacted, reducing sea ice and affecting weather patterns and life cycles. The balance of the Arctic Ocean and the solid ice that forms the foundation for so many animals has been disrupted.

ARCTIC: Our Frozen Planet, narrated by Benedict Cumberbatch, tells the stories of the Inuit people and animals in the region contending with rising temperatures. As the climate changes, the ramifications affect every living thing, including humans, like the Inuit. Scientists are working with local communities to understand what is happening and determine how all of us can combat climate change.

ARCTIC: Our Frozen Planet is an SK Films release of a BBC Earth production.

The film has a run time of 45 minutes.

LESSON 1

ARCTIC ANIMAL ADAPTATIONS

GRADE LEVEL K-2





ARCTIC: Our Frozen Planet

LESSON 1

ARCTIC ANIMAL ADAPTATIONS

GRADE LEVEL K-1

50 minute lesson

STANDARDS (NGSS):

K-ESS3-1 Use a model to represent the relationship between the needs of different plants and animals (including humans) and the places they live.

2-LS4-1. Make observations of plants and animals to compare the diversity of life in different habitats.

FROM THE FILM:

Students will see animals in the film *ARCTIC: Our Frozen Planet* that may be similar to familiar wildlife they learn about every day but have different adaptations that allow them to survive in the Arctic.

LESSON OVERVIEW:

In this activity, students will compare Arctic animals (like polar bears and wolves) to their counterparts living in warmer habitats to identify unique adaptations that enable animals to survive in freezing temperatures.

MATERIALS LIST:

- ***Arctic Animal Adaptations*** *activity pages*
  (Bears and Wolves comparisons: 2 pages)
  (Polar Bear cut-out : 1 page)
- *Art materials*
  (White and colorful paper, pencils, markers)
- *Paper glue*
- *Scissors*
- *Pads of sticky notes*
- *Chart paper or SMART board*

LESSON 1

ARCTIC ANIMAL ADAPTATIONS

EDUCATOR PREP:

Prepare one comparison sheet and polar bear template per student. Precut polar bear template for camouflage demonstration. Collect other materials listed in the materials section for students.

LESSON GUIDES:

1. As an icebreaker, ask students the following questions:

What animals did you see in the movie? Have you seen any of those animals before? If so, where?

Students may respond with various animals, but some animals featured in the movie include wolves, bison, bees, polar bears, seals, walruses, narwhals, and bowhead whales.

2. Have students pick their favorite animal from the movie and then get into groups based on their favorite animal. Ask each group to state one fact about their animal.

What color is it? Where does it live?

3. Have students consider why some animals can survive in the Arctic while others cannot.

Can you live in the Arctic? Why or Why not?

Animals that live in the Arctic can survive in cold temperatures, camouflage in the snow, and hibernate to survive the cold winters. These are called adaptations.

Humans can adapt to live in the Arctic. The Inuit people, who were featured in the movie, are the indigenous people of the Arctic. They have lived there for over 5,000 years.



A polar bear is easy to spot against a darker background.

4. Animals (and plants) are constantly working to survive by adapting to their habitat, the place an organism lives.

Ask students to reflect on their own place in their ecosystem through the following questions:

What is your habitat?

You can think of a habitat as a home. Students may list their school, their home, etc. A habitat must meet an organism's basic needs, or the organism cannot live there.

What are your basic needs to survive in your habitat?

We all need air, food, water, and shelter from extreme temperature, danger, weather, etc. to survive.

Do other animals have the same basic needs of air, food, water, and shelter? Do you think animals meet their basic needs the same ways in different habitats?

Animals develop distinct features that help them to survive better in their habitat. For example, humans developed two feet to help walk on land.

What is an adaptation?

Adaptation is a body part, feature, or behavior that helps a living thing survive and function better in its environment.

Can you think of any examples of animal adaptation?

There are many examples of animal adaptation, so students may answer with several different examples. One is camouflaging or a visual deception disguising or concealing an organism's presence by blending into or imitating surroundings.

Encourage students to explain why the adaptation gives the animal an advantage over another that does not have that adaptation.

EDUCATOR NOTES:

Ask students to brainstorm in pairs at least three adaptations that would help animals survive in Arctic habitats. As they offer ideas, one person should record the ideas on sticky notes. After a few minutes, ask each pair to share one adaptation. Instruct the students to try not to repeat any adaptations.

5. Show photos of polar bears and then brown bears. Ask students what similarities and differences they notice between the polar bears and the brown bears.

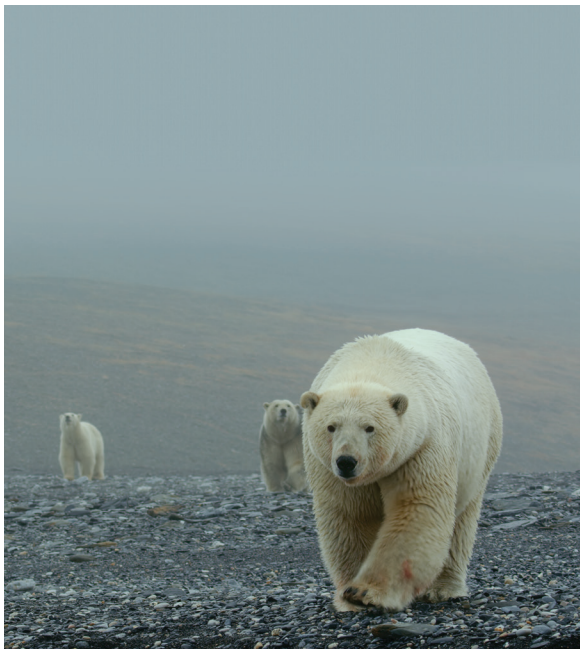
6. Draw a Venn Diagram on chart paper or a smart board and record students' answers. Add any characteristics from below that students do not suggest:

Evolution

- Polar bears diverged from brown bears only 500,000 years ago, which is actually not a long time to adapt and change.
- After migrating to colder regions, polar bears' ancestors went through a series of evolutionary changes to survive in their new Arctic habitat.

Similarities

- Both bears are large, furry, and have wide paws with sharp claws.
- Large with sharp claws because bears are powerful predators.
- Furry to provide bears warmth and protection.
- Polar bears are insulated by 2 layers of thick fur that prevent almost all heat loss. Despite below freezing Arctic temperatures, their fur keeps polar bears so warm that adult males can quickly overheat when they run.



Despite below freezing Arctic temperatures, their fur keeps polar bears so warm that they can actually become overheated.

Differences

- Polar bears appear the color of snow, but brown bears are brown, the color of tree bark and earth.
- Polar bear fur is not actually white. Each hair shaft is pigment-free (without color) and transparent, with a hollow core that scatters and reflects visible light. Their fur reflects their snowy Arctic habitat, making polar bears appear white.
- Why would brown fur be better camouflage for a brown bear's habitat? Brown bears live in forests where their brown fur helps them hard to see from the trees and soil.
- Polar bears have longer snouts and shorter claws than brown bears.
- Polar bear paws are ideally adapted for movement in the Arctic.
- Their paws are extremely large, almost a foot across! This helps them walk on thin ice without falling through. Since polar bears are quite heavy, their paws help distribute their weight over a larger area, versus having a small paw, which would break through the ice.
- Their short and sharp claws help polar bears get more traction on the ice. Polar bear paws also help them swim. Their big paws help them paddle though the water. Have you ever used flippers to help you swim? Same idea.

7. Have students talk with their partner about how unique features help different bears live in the snow.

8. Separate students into groups to create an animal that can live in the Arctic. Ask them to consider the following questions about their animals:

What would the animal look like and why? For example, what would a butterfly that lived in the Arctic look like? Would It have fur?

Would it be colorful like the butterflies we see every day?

What would it need to survive in that cold habitat? Maybe fur, blubber, camouflage?

EDUCATOR NOTES:

9. Give students about 15 minutes to draw and color their animals.

10. Once their animal is finished, ask students to turn to their neighbor and share two things about how their animal will survive in the Arctic.

11. Bring students back together as a whole group to debrief on all that they learned about Arctic animals today.

Can you name some adaptations of Arctic animals?

One very important feature of Arctic animals is that they use camouflage to blend seamlessly into their environment.

12. Inform students that as a final activity, they are going to create an environment for our friend the polar bear. Give each student a cutout polar bear and a piece of paper.

13. Show students the polar bear on colorful paper.

Does it blend in or stand out? What about the polar bear on the white paper?

14. Have students draw an Arctic environment in which the polar bear would survive on the blank piece of paper. Next, glue the polar bear into the environment so that it can survive for a long long time.

15. After students wrap up their polar bear demos, conclude by having them show a partner how they disguised their polar bear.



Polar bears can detect the scent of seals miles away!

Arctic Animal Adaptations

Activity Page

Polar Bear



Brown Bear



Look at the photos of the two bears. What is similar? What is different? Write your ideas below.

Arctic Animal Adaptations

Activity Page

Arctic Wolf



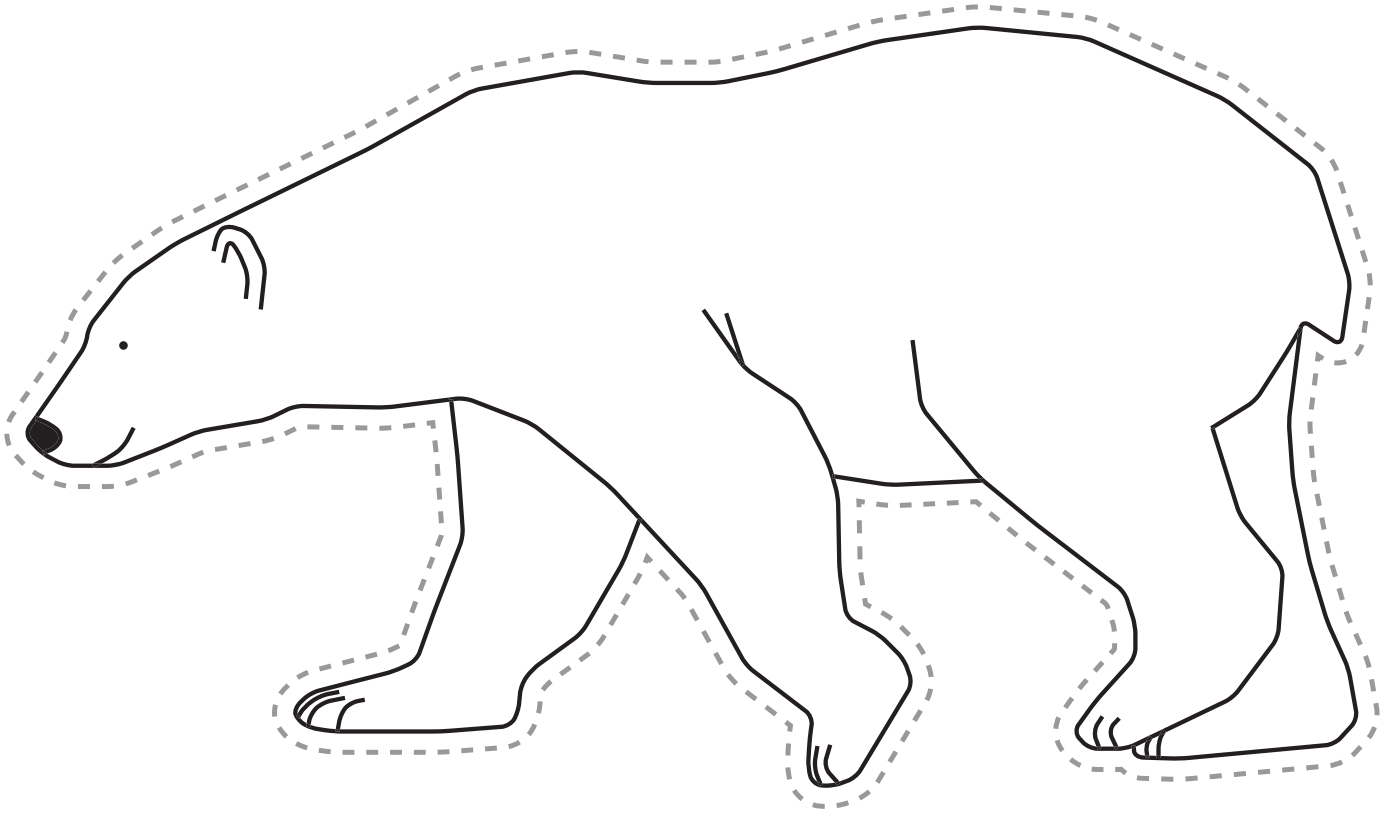
Red Wolf



Look at the photos of the two wolves. What is similar? What is different? Write your ideas below.

Arctic Animal Adaptations

Activity Page



Carefully use scissors to trim around the outline of the polar bear.

Arctic Animal Adaptations
ACTIVITY EDUCATOR KEY

Polar Bear



Brown Bear



Look at the photos of the two bears. What is similar? What is different? Write your ideas below.

Similarities

- Both bears are large, furry, and have wide paws with sharp claws.
- Both are large with sharp claws because bears are powerful predators.
- Heavy fur provide both bears warmth and protection.

Differences

- Polar bears appear the color of snow, but brown bears are brown, the color of tree bark and earth.
- Unlike brown bear fur, polar bear fur appears white. Their fur reflects their snowy Arctic habitat.
- Brown bears live in forests where their brown fur makes them hard to see from the trees and soil.
- Polar bears have longer snouts and shorter claws than brown bears.
- Polar bear paws are larger than a brown bear's paw, ideally adapted for movement in the Arctic and also help them swim.

Arctic Animal Adaptations
ACTIVITY EDUCATOR KEY

Arctic Wolf



Red Wolf



Look at the photos of the two wolves. What is similar? What is different? Write your ideas below.

Similarities

- Both wolves are important predators and keep rodent, deer or caribou populations in check.
- Both are a bit smaller than their cousin, the gray wolf.
- They live in small groups called packs.
- Both are threatened by habitat loss and human interactions.
- Both wolves mate for life.

Differences

- Red wolves have black-tipped bushy tails, a coat mostly a brown or buff color.
- Arctic wolves have a thick white or cream-colored fur, although it can also be light grey or even brown.
- Historically the red wolf ranged from southeastern Texas to central Pennsylvania. Today the only place red wolves can be found in the wild is in eastern North Carolina's Albemarle Peninsula.
- Red Wolves are endangered, Arctic wolves are not yet, but they are declining.
- The Arctic wolf is native to the Arctic regions of North America and Europe.
- Arctic foxes, wolverines, and even polar bears have been known to prey on the Arctic wolf.

LESSON 2

INUIT FOLKTALES FOR SURVIVAL

GRADE LEVEL K-2





ARCTIC: Our Frozen Planet

LESSON 2

INUIT FOLKTALES FOR SURVIVAL

GRADE LEVEL K-1

50 minute lesson

STANDARDS (NGSS):

K-ESS3-1 Use a model to represent the relationship between the needs of different plants and animals (including humans) and the places they live.

FROM THE FILM:

As portrayed in *ARCTIC: Our Frozen Planet*, Inuit are a group of culturally similar indigenous peoples inhabiting the Arctic and subarctic regions of Greenland, Siberia, Canada, and Alaska (United States). This lesson expands on the film by further exploring the cultural beliefs and practices that have helped the Inuit survive in harsh Arctic environments.

LESSON OVERVIEW:

Students will read a short story about Inuit folk lore and complete an activity to explore how their Arctic environment influences specific cultural practices and values. For example, Inuit spiritualism is animistic, characterized by belief that all things are inhabited by a spirit. Through this story and activity, students will investigate the relationship between humans and their environment through the cultural lens of Inuit peoples.

MATERIALS LIST:

- ***The Origin of Day and Night*** *by Paula Ikuutaq Rumbolt*
- ***Arctic animal*** *sorting board*
- ***Arctic animal*** *cards*
- *Inuit photographs (6)*
- *Globe or World map*
- *Technology to screen* ***Qalupalik*** *at Nunavut Animation Lab:* ***Qalupalik*** *by Ame Papatsie*

https://www.nfb.ca/film/nunavut_animation_lab_qalupalik/

LESSON 2

INUIT FOLKTALES FOR SURVIVAL

EDUCATOR PREP:

- Print Arctic Animal Activity materials for student groups. Each group will need:
    - Arctic Animal Sorting Board (1)
    - Arctic Animal Cards (12)
- Print or prepare to project Inuit photographs
- Review vocabulary and practice correct pronunciation for the following Inuktut terms featured in the lesson story and film.
    - **Tiri** (TI-ri): Arctic fox name, short for "tiriganniaq" (ti-Ri-GAN-ni-aq) which means "fox".
    - **Taaq** (TAAQ): darkness
    - **Ubluq:** day
    - **Ukaliq** (U-ka-liq): Arctic hare
    - **Siksik** (SIK-sik): Arctic squirrel
    - **Uumajurngautaviniit** (uu-ma-yurng-NGAU-ta- vi-NEET): ancient animals ("first animals") who could speak and use powerful magic, including changing forms
    - **Iglu** (IG-loo): snow house
    - **Inuksuk** (e-NOOK-sook): rock cairn used to aid hunters and indicate direction
    - **Qalupalik** (QAL-lu-PIL-look): mythological sea creatures that steal disobedient children
    - **Amautik** (a-MOW-tick): pouch in back of a woman's parka used to carry young children

Note on emic versus etic perspectives on Inuit culture

To understand cultural beliefs and practices, it is important to center the emic perspective while recognizing our inability to view indigenous life through the eyes of indigenous people. As most perspectives on indigenous culture are etic, it's important that we do not inadvertently practice ethnocentrism when learning about indigenous peoples.



Sled dogs help humans get around on the ice and snow.

LESSON GUIDES:

1. Inform students that in this activity, they will learn about how Inuit people have adapted to survive in harsh Arctic environments through cultural practices. Ask them the following questions to activate their background knowledge and assess what they already know related to the topic.

What do you know about culture?

Culture is typically defined as shared beliefs, values, and norms in a community. While students may not necessarily know this definition, they may be able to give examples of cultures or things they associate with culture.

Can you think of specific examples of classroom values and norms?

Students may provide examples of specific classroom rules (raise hand to speak, walk in line, sit in assigned seat, etc.) or general social rules (respect and avoid harming others).

Can you explain why each classroom norm or rule exists?

Student explanations will vary according to specific norm or rule, but in general rules and expectations exist to guide social interactions and ensure group functioning. For example, classroom rules about who can speak when are necessary for teachers to communicate content and address questions for optimal learning. Rules like respecting others help group members get along and effectively work together. In other words, rules outline adaptive behaviors for a specific environment, in this case the classroom.

Do you follow the same classroom rules and norms at home?

Some rules like respecting others or safety concerns are the same across contexts, but other rules like raising your hand or walking in line may differ depending on where you are (e.g., home or school). Encourage students to share something about themselves that is influenced by culture or a tradition they follow and ask if they know where the traditions came from.

2. Explain that Inuit are a group of culturally similar indigenous peoples who live in Arctic and subarctic regions of Greenland, Siberia, Canada, and Alaska (United States). Show students these locations on a globe or world map.

EDUCATOR NOTES:

3. Let students know that today, we will read a short story about Inuit folk lore and complete an activity to explore how their Arctic environment influences specific cultural practices and values. Share with them that for tens of thousands of years, oral storytelling has been a key way that parents teach children about values and behavioral norms to help them survive and thrive in their environment.

4. Tell students that many Inuit traditions and beliefs are based on animism.

What do you think animism means?

Although students may not know the definition, they should recognize the term is related to animals. Build on this familiarity by explaining that animism is the belief that all things are inhabited by a spirit.

Can you think of ways animism could influence traditional Inuit culture?

Traditional Inuit life was adapted to an extremely cold snow and icebound environment in which trees, fruit, and vegetable foods were almost nonexistent, so caribou, seals, whales, seabirds, and fish were the major food sources. Inuit observed various taboos to ensure that animal spirits were not offended.

When animals were killed for food, it was done according to certain rituals. Communal rites centered on preparation for the hunt, as this was the most important activity for survival in a hostile environment. Inuit highly valued and respected animals perhaps because their survival was closely linked with and in many ways dependent on Arctic animals.

5. Explain that they will explore animism in Inuit culture by reading a traditional folk tale. Show students the book **The Origin of Day and Night** by Paula Ikuutaq Rumbolt.

Ask the following questions as a pre-read check-in:

Has anyone read or heard the story before?

What do you think the book is about?

What do you know about book topic?

Student responses to these questions may reflect common misunderstandings of indigenous beliefs that are pervasive because the Inuit have been presented primarily from outsider (etic) rather than insider (emic) perspectives.



Aeral view of the Arctic Ocean, which is a combination of water and sea ice.

For instance, students may be familiar with and use the derogatory name Eskimo, meaning "eaters of raw flesh", without realizing its culturally negative connotation as the term perpetuated a stereotype that denigrated the Inuit. Instead, use the name they call themselves, Inuit, or "the people."

6. Tell students that this story is about Tiri and Ukaliq, an Artic fox and hare, who control the setting and rising of the sun that create the cycle of day and night. Tiri the Arctic fox is best adapted to hunt at night and wants darkness to prevail, but Ukaliq the Arctic hare thrives in daylight.

Let's read to find out what happens!

7. Slowly and clearly read story and engage with students using active reading techniques. Use distinct character voices and alter your voice and behavior as tone of story changes.

Evaluate students' engagement through attention, body language, and participation, and adapt pacing and style accordingly.

8. As you read, check in with students about how they are receiving the story through the following active reading techniques:

- Encourage students to imagine themselves in the characters' positions.
- Ask questions as story events occur, including what students see happening in illustrations, how they think characters are feeling, and what they predict will happen. What is the story about? What happened in the beginning, middle, and end?
- To reinforce this knowledge and encourage active learning, probe the source of student knowledge with questions like, "How do we know that?"
- Encourage curiosity and skepticism, even if conclusions might seem inaccurate.

EDUCATOR NOTES:

9. After you finish reading the story, explain the follow-up activity. Share with students that plants and animals, including humans, are constantly working to survive by adapting to their habitat, the place an organism lives.

What are your basic needs to survive in your habitat?

Student answers should include air, water, food, and shelter from elements, such as freezing temperatures and storms.

Can Arctic habitats support your basic needs to survive? Why or why not?

Survival is difficult because the Arctic is an extremely cold, snow and icebound environment in which trees, fruit, and vegetable foods are almost nonexistent. If students respond that humans cannot survive in harsh Arctic environments, remind them about the Inuit who live there and wrote the story. Like Arctic animals, Inuit have adapted to survive food scarcity and extreme elements that characterize Arctic habitats.

What is an adaptation?

Adaptation is a characteristic or behavior that helps a living thing survive and function better in its environment.

Can you think of examples of Arctic animal adaptations?

Student answers should reflect adaptations to provide Arctic animals warmth, including thick fur and high fat diet for insulation, as well as to provide camouflage, such as white fur.

10. Tell students that On the Origin of Night and Day is about an important behavioral adaptation, when animals are active or resting.

Nocturnal animals like Tiri the Arctic fox are most active at night, while diurnal animals like the Arctic hare Uri are most active during daylight.

Show students Arctic Animal Cards for Arctic fox and hare and ask students to identify adaptations for nocturnal and diurnal life respectively.

Why are Arctic foxes well adapted to be active at night (nocturnal)?

Special adaptations for nocturnal living include large eyes for low-light vision and heightened senses of hearing and smell to help locate prey in the dark.



Today, the Inuit people live in modern homes, and no longer in traditional igloos or tents.

Why are Arctic hares well adapted to be active during the day (diurnal)?

Special adaptations for diurnal living include white fur coats for camouflage in bright, snowy environments and claws for digging burrows for protection from predators and the elements.

11. Have students work in groups to sort Arctic Animal Cards based on when they are most active (day or night) using the Arctic Animal Sorting Board. Once all animal cards have been sorted into day or night, call out the correct answers using the color coded dots as a guide.

Were any of the Arctic animal activity times surprising?

Student responses may focus on specific animals, but others likely will point out that a few animal cards (polar bear, snowy owl, and great white shark) indicate both day and night activity. Explain that some animals' activity schedule is dictated by their environment, particularly availability of prey, and depends on the time of year (breeding, migration, feeding season), location, temperature, and weather conditions.

12. Show the Inuit photographs and remind students that many Inuit adaptations are closely related to Arctic animal adaptations.

How have Inuit adapted to survive food scarcity in Arctic habitats?

If students are unsure, ask what Arctic animals eat. Like Arctic animals, Inuit adapted to frozen environment with scarce vegetation by adopting a fat rich diet in which caribou, seals, whales, seabirds, and fish were the major food sources.

How have Inuit adapted to stay warm and protected from extreme elements that characterize Arctic habitats?

Traditional cold-weather Inuit clothing like the parka were made from thick caribou furs to protect against extreme cold. Similarly, traditional Inuit pants, mittens, and footwear were made from caribou or sealskin in numerous layers, depending on the season. Over 5,000 years, Inuit have wintered either in temporary snowblock houses, generally referred to as igloos (iglus or igluvigaqs, depending on dialect), in tents made from animal skins, or in semisubterranean houses built of stone or sod over a whalebone framework. Today, they live in houses similar to the rest of the world.

EDUCATOR NOTES:

13. To continue exploring Inuit mythology through folktales presented in a different medium, screen the short (5-minute) stop action animated film **Qalupalik** by Ame Papatsie, available at **Nunavut Animation Lab: Qalupalik** by Ame Papatsie - NFB.

Before starting the film, provide students with story context. Based on an Inuit legend told to prevent children from wandering alone to dangerous shores, Qalupalik are human-like sea creatures with green skin and long hair and fingernails. Qalupalik wear amautiit, in which they carry away disobedient children to live with them forever in the sea.

Such is the fate of Angutii, a young boy who plays by the shoreline instead of helping in his family's camp. Qalupalik seizes and drags him to the depths of the Arctic Ocean. Angutii's father, a great hunter, must then embark on a long kayak journey to rescue his son.

14. After watching the short film, discuss with students how the story reflects adaptive behaviors to survive in dangerous Arctic environments. In particular, emphasize the protective role of fear in Inuit folklore.

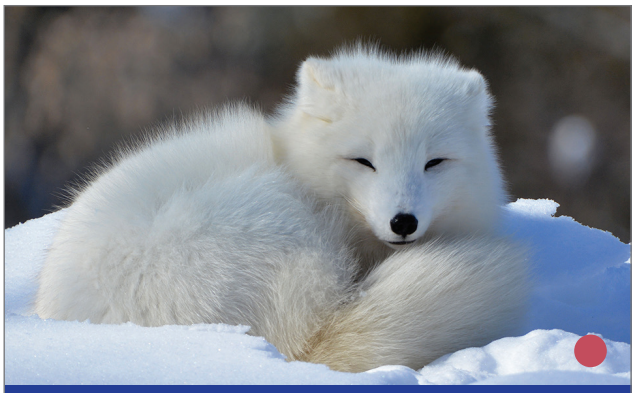


*The Inuit refer to caribou, or reindeer, as **tuktu.***

Inuit Folktales for Survival
Activity Page



Aiviq/Walrus



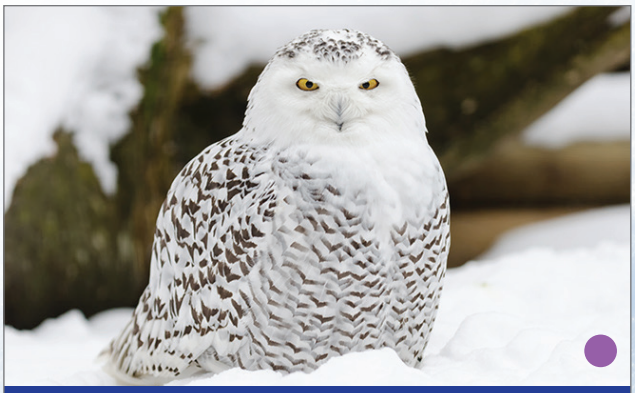
Tiriganniaq/Arctic Fox



Amaruq/Arctic Wolf



Nanuq/Polar Bear



Ukpik/Snowy Owl



Ermine/Tiriaq

Inuit Folktales for Survival
Activity Page



Ukaliq/Arctic Hare



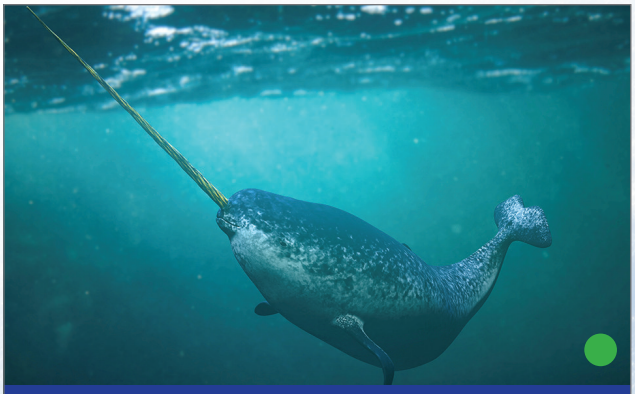
Eqalussuaq/Great White Shark



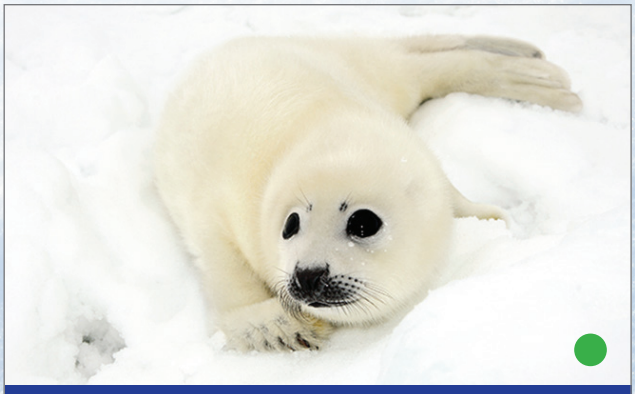
Siksik/Arctic Ground Squirrel



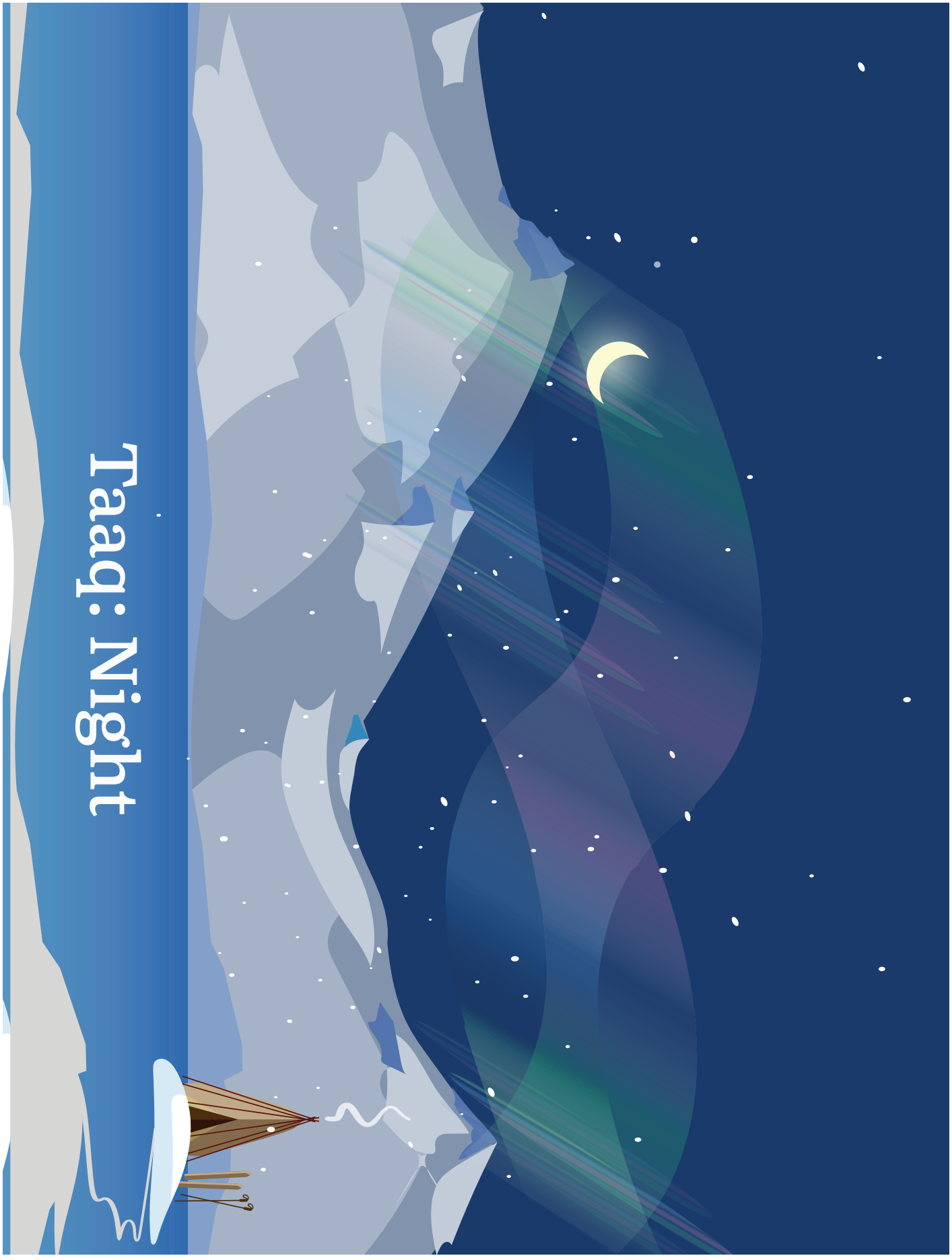
Tuktu/Caribou/Reindeer



Tuugaalik/Narwhal



Natsiq/Harp Seal

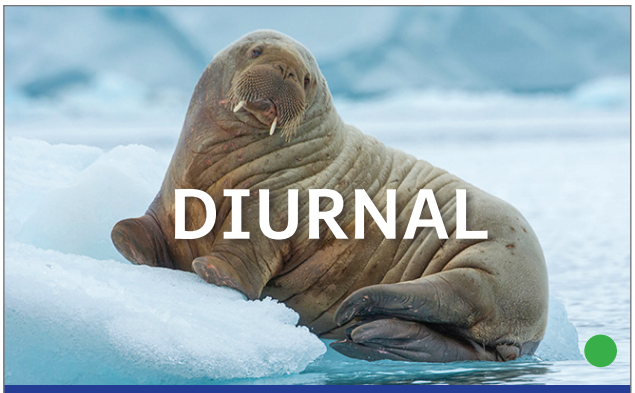

Taaq: Night

Ubluq: Day

Inuit Folktales for Survival

ACTIVITY EDUCATOR KEY

Use the color dots to identify the correct answers.



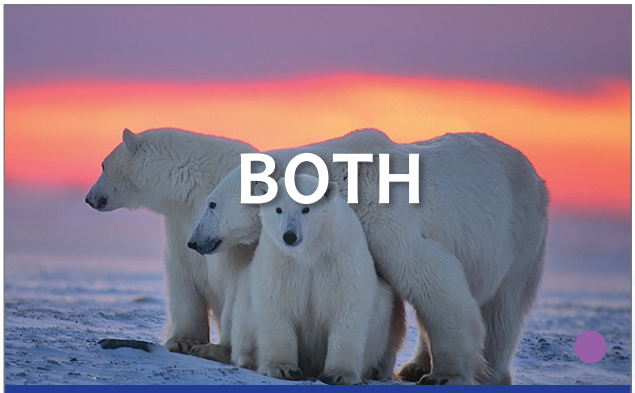
Aiviq/Walrus



Tiriganniaq/Arctic Fox



Amaruq/Arctic Wolf



Nanuq/Polar Bear



Ukpik/Snowy Owl



Ermine/Tiriaq

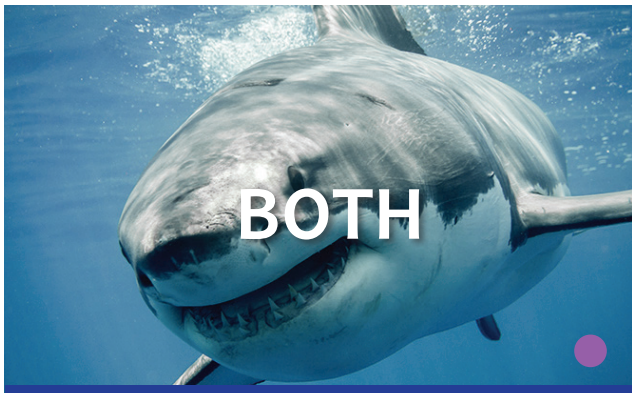
Inuit Folktales for Survival

ACTIVITY EDUCATOR KEY

Use the color dots to identify the correct answers.



Ukaliq/Arctic Hare



Eqalussuaq/Great White Shark



Siksik/Arctic Ground Squirrel



Tuktu/Caribou/Reindeer



Tuugaalik/Narwhal



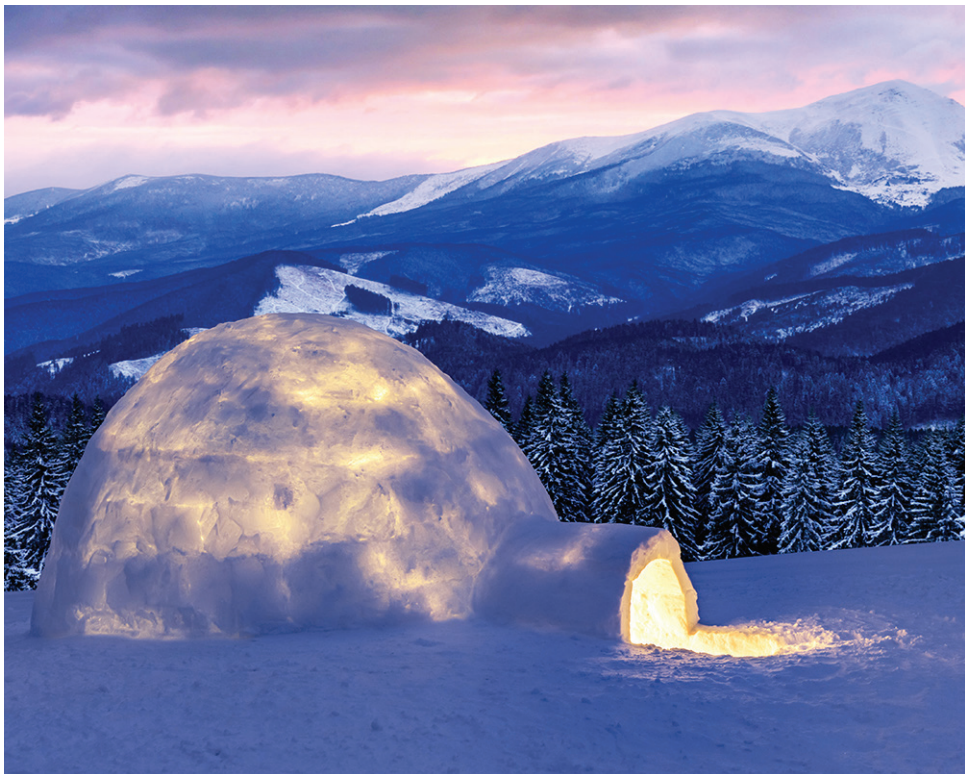
Natsiq/Harp Seal

Inuit Folktales for Survival
Inuit Photographs





Inuit Folktales for Survival
Inuit Photographs





Inuit Folktales for Survival
Inuit Photographs





LESSON 3

THE SHAPE OF ICE

GRADE LEVEL K-2





ARCTIC: Our Frozen Planet

LESSON 3

THE SHAPE OF ICE

GRADE LEVEL K-2

60 minute lesson

STANDARDS (NGSS):

2-ESS2-3: Obtain information to identify where water is found on Earth and that it can be solid or liquid.

2-PS1-1: Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.

FROM THE FILM:

In the film, *ARCTIC: Our Frozen Planet,* we learn about the critical role of water, in liquid and frozen forms, for humans and animals alike. Water provides everything from a frozen surface on which to travel for the Inuit to a place to live for narwhals and seals.

LESSON OVERVIEW:

Students will experiment with water and ice while learning about states of matter and phase changes by observing ice melt into water. They will use salt to accelerate ice melting by lowering water's freezing point and food coloring to show melting process. Finally, students will explore extraordinary and unusual ice formations in different locations and geographical formations around the world.

MATERIALS LIST:

- ***Shape of Ice*** *activity page*
- ***Strange Ice*** *cards*
- ***Ice Map*** *cards*
- *Ice trays/molds*
- *Strings or yarn (precut)*
- *Salt*
- *Food coloring*
- *Trays*
- *Medium bowls*
- *Cups (assorted shapes and sizes)*
- *Towel*

LESSON 3

THE SHAPE OF ICE

EDUCATOR PREP:

Fill ice trays and molds with water and store in freezer for several hours until fully frozen.

Prepare trays with experiment materials *(one tray per group of 4 students).*

Fill a glass with water and add a drop or two of food coloring. Mix the food coloring into the water and then divide this diluted food coloring into small cups for student trays.

Each tray should include the following materials:

- 4 distinctly shaped and sized cups
- Bowl with large ice cubes (at least 2 ice cubes per student)
- Clear cup of water
- Salt
- String (1 per student)
- Cup of dilute food coloring
- Pipettes



Sea ice is a central feature of the Arctic region, serving in some cases as a network of surfaces on which to travel.

LESSON GUIDE:

Part One: States of Matter-Solid Ice and Liquid Water

1. Tell students they will be learning about Arctic ice and water. In the film, *ARCTIC: Our Frozen Planet,* we learned about the critical role of water, in liquid and frozen forms, for humans and animals alike.

Ask students:

> Are ice and water the same thing? What (if anything) makes them different?

Student responses may include observations that ice is cold and hard, while water is warm and wet. Answers should reflect that water and ice are the same substance in different states of matter. These different states or phases of matter are caused by how the matter's molecules interact with each other.

What are molecules?

Molecules are the building blocks of matter, a bit like Lego bricks.

What is the difference between molecules in solid versus liquid states of matter?

If students are unsure, direct them to the **States of Matter** handout for helpful hints. Solid molecules are tightly packed and have a defined structure, shape, and size. Liquid molecules are less closely packed and have movement space, so liquids have no definite shape of their own.

2. Explain to students that they will conduct experiments with ice cubes and water to explore different states or phases of matter (solids, liquids) and will draw their observations on their **States of Matter** handout.

3. Have each student take one of the four empty cups out of the tray. Explain that students will work in groups to transfer an ice cube from the bowl into each container before returning it to bowl. Ask students to draw the ice in each container on their **States of Matter** handout. Give students time to transfer their ice cubes and record their observations before asking the following questions:

What state of matter is ice?

The correct answer is solid because ice has a defined structure, shape, and size.

What happens when you transfer ice into different containers? Why?

Ice cubes maintain their own shape regardless of container. Solid molecules are tightly packed without room to move around, so solids hold their shape.

4. Next, students will investigate water. Explain that students will work in groups again to transfer the water into each container and draw their observations on their States of Matter handout.

Caution students to move and pour the water slowly and carefully to keep the water inside a container and minimize spills. Students need to keep all the water together, so there should only be water in one container at a time. Sometimes students will divide the water between the containers. Remind them that sharing is wonderful, but right now we should take turns pouring all the water into each container.

After a few minutes, ask students to share their observations.

EDUCATOR NOTES:

What state of matter is water?

The correct answer is liquid. When water is a liquid it has no defined shape and can flow.

What happens when you transfer water into different containers?

Liquid molecules have some movement space, which allows them to pour and conform to shape of their container. Without a container, liquids have no defined shape (ex. spilled water). Students also may notice that some containers fill more than others (due to different shapes).

Is there more water in the containers that are filled to the top than the containers that are barely filled?

Student answers may vary depending on age, but the correct answer is no. Liquids have a set volume and will always take up the same amount of space.



A baby harp seal, resting on sea ice.

Part Two: Phase Change-Melting Fast

5. The film *ARCTIC: Our Frozen Planet* shows that Arctic ice is dramatically decreasing, endangering both land and marine animals. To explore this process, students will learn the science on how solid ice melts into liquid water, and about phase changes.

What is a phase change?

A phase change is a transition between states of matter. For example, when liquid water becomes solid ice, this phase change is called freezing. When solid ice transitions to liquid water, this phase change is called melting.

Can you think of other times you observed solids melting into liquids or liquids freezing into solids?

Student responses should provide contrasting examples between solids and liquids, as well as examples of the transition between the two. For example, many students are familiar with cold, solid ice cream melting into warm liquid.

6. Tell students to each take an ice block from the bowl. Students should have space to freely manipulate the ice and observe it melting. Instruct students to move their finger back and forth across ice block surface.

What do you notice and feel as you touch the ice?

Answers should note that ice is cold and begins to melt from solid to liquid from the heat of their touch.

7. Instruct students that they are going ice fishing: **fishing for ice!**

Ask students to sprinkle salt on their ice blocks, encouraging them to experiment with the volume and pattern of salt. Then show students how to place the end of the string on top of an ice block and sprinkle salt over it. Ask them to observe how the surface of the ice melts and refreezes around the string.

Wait about 10 seconds, the string should freeze to the ice, allowing students to "fish" for ice.

8. After students have finished ice fishing, ask them to take turns using pipettes to drip diluted food coloring over the ice blocks coated with salt. The food coloring should fill the interstices of the melted ice, tracking the pattern of the salt. Point out wherever the formation of any ice crystals becomes visible.

Part Three: Strange Ice

9. Tell students that they are going on a trip around the world to find all the most unique ice formations on Earth. Students will explore extraordinary or unusual ice formations and match them to different geographical locations using the **Strange Ice Cards** and a globe or world map.

10. Ask students to select **Strange Ice Cards,** describe selected ice formation, and imagine how it might have formed.

Students can then match the ice structure with the **Ice Map Cards** and a location on the globe to reveal more information about the environment in which the ice develops.

EDUCATOR NOTES:

11. Use this as a guide to match the ice formations with their locations:

Arctic Circle

Pancake Ice / Frost Flowers

Iceland

Diamond Ice / Needle Ice / Glacial Lagoon

Canada (Lake Abraham)

Ice Bubbles

Russia (Baikal Lake)

Ice Hummocks / Crystal Ice

Japan (Tokachi River)

Jewel Ice

United States (Maine)

Ice Circles

Chile, Argentina (Andes)

Penitentes

Antarctica

Striped Icebergs

12. If time allows or as an extension, ask students to apply what they have learned about melting and freezing water to create their own ice sculptures inspired by amazing ice formations around the world.



Baby harp seal basking in the sunshine.

The Shape of Ice

Strange Ice Cards / Front



Crystal Ice

Baikal Lake, Russia



Pancake Ice

Arctic Circle



Frost Flowers

Arctic Circle



Diamond Ice

Diamond Beach, Iceland

The Shape of Ice
Strange Ice Cards / Front



Needle Ice
Iceland



Glacial Lagoon
Iceland



Ice Bubbles
Abraham Lake, Canada



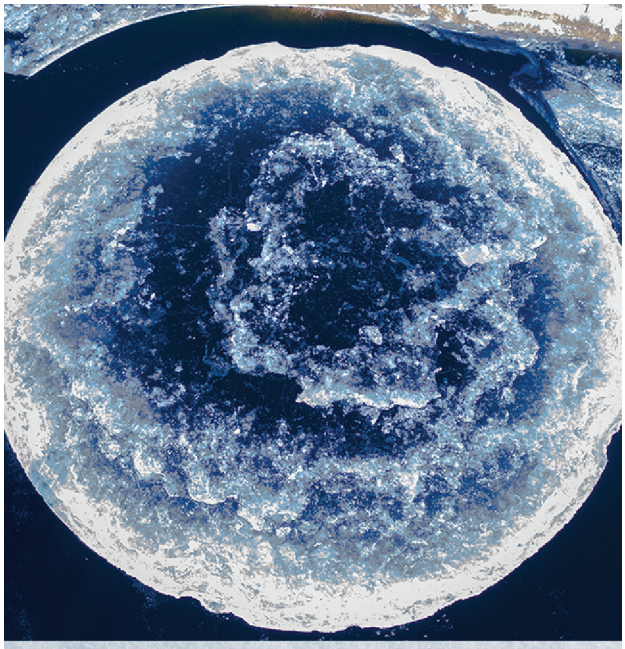
Ice Hummocks
Baikal Lake, Russia

The Shape of Ice

Strange Ice Cards / Front



Jewel Ice
Tokachi River, Japan



Ice Circles
Maine, United States



Penitentes
Andes, Chile, and Argentina



Striped Ice
Antarctica

The Shape of Ice
Strange Ice Cards / Back

Pancake Ice
Arctic Circle

Description: Ice disks that range from a foot to nearly 10 feet across. Often the discs will gather slush, or frazil ice, and become a "hanging dam," a circle of ice with high edges and a low center.

Formation: When the temperature is at freezing point but there is still moderate water movement, ice on water is broken up and spins in the eddy of a river, forming thin circles.

Crystal Ice
Lake Baikal, Russia

Description: Large shards of transparent ice that form on the lake surface, making ice appear turquoise.

Formation: Lake Baikal contains high levels of oxygen, which helps microorganisms to filter the water and keep it pristine, so it freezes into crystal clear ice.

Diamond Ice
Diamond Beach, Iceland

Description: Smooth, crystal clear blocks of ice that sparkle like diamonds against the black sand beach.

Formation: Glacial ice is formed slowly over hundreds of years by compression under a huge weight. During this process, air bubbles and impurities are pushed out of the ice, allowing light waves to travel very deep inside the ice undisturbed. The giant glacier pieces float out to the ocean where they end up breaking into polished ice blocks that wash up and sparkle on the shore.

Frost Flowers
Arctic Circle

Description: Delicate, feathery tendrils that reach two to three inches high, floating on the surface of newly frozen sea ice or lake ice.

Formation: When air is extremely dry and colder than water surface, bits of ice vaporize and make the air humid and heavy with water vapor, until crystal by crystal the vapor turns back to ice, creating delicate, feathery ice tendrils.

The Shape of Ice
Strange Ice Cards / Back

Glacial Lagoon
Iceland

Description: Glacial landscape of white, cyan-blue, and turquoise icebergs streaked with black volcanic ash and composed of ice that is over a thousand years old.

Formation: Glacial lagoons form where a melting glacier reaches sea level or a lowland plateau. As the glacier tongue slowly retreats year by year, it leaves behind a ground depression that then fills with meltwater to create a lake.

Needle Ice
Iceland

Description: Needle ice has many names including ice castles, frost columns, ice fringes, or ice filaments.

Formation: When soil temperature is above freezing but air temperature is below freezing, water in the soil is drawn up through capillary action and freezes on air contact, creating a needle-like column of ice.

Ice Hummocks
Lake Baikal, Russia

Description: Unique shard-like ice splinters as high as 32 to 39 feet above lake surface. Transparent and shining turquoise in sunlight, these masses of broken ice look like shards of glass piercing the sky.

Formation: When heavy winds push water above the lake's frozen surface, the water quickly freezes. The ice heats up during the day and cools at night. The huge swing in temperature causes the ice to crack and splinter.

Ice Bubbles
Abraham Lake, Canada

Description: Unique circular bubble patterns stacked under the ice.

Formation: Plants on lakebed release methane gas. As the methane rises to the frozen surface, it freezes as bubbles that continue to stack below one another, trapped beneath the ice.

The Shape of Ice
Strange Ice Cards / Back

Diamond Ice
Diamond Beach, Iceland

Description: Thin, round slabs of ice that rotate slowly in the water and vary in size but have been found as large as 300 feet diameter.

Formation: Ice circles, or ice discs, form in the bends of rivers. As a layer of ice is formed over the water, the current of accelerating water underneath creates a "rotational shear," breaking off a chunk of ice and twisting it until it forms a circle. There it stays, a circle of ice slowly rotating in the river bend.

Jewel Ice
Tokachi River, Japan

Description: Distinctly crystal-clear ice blocks that sparkle with orange or sapphire hue.

F**ormation:** Created by unique combination of salt-free river water, sub-zero temperatures, and ocean saltwater tides. When the mouth of the Tokachi River freezes, blocks of ice break off and drift out into the ocean before washing up with the tide. Such crystal-clear ice requires water free of contaminants and a slow freezing process, so impurities and air bubbles have time to escape before ice solidifies.

Striped Ice
Antarctica

Description: Enormous shards of ice striped in different shades of white, blue, and green.

Formation: Natural phenomenon caused by different types of water freezing together. The ice color depends on the type and amount of organic matter inside. The white color of the iceberg is caused by little snowflakes and air bubbles frozen inside the freshwater ice. When the iceberg cracks, it can fill with frozen seawater, also known as marine ice, containing algae and iron oxide that gets trapped inside the iceberg and creates beautiful jade colors.

Penitentes
Andes, Chile, and Argentina

Location: Chile, Argentina in Andes Mountains

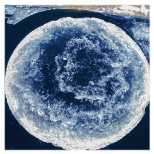
Description: Tall, jagged pinnacles of snow and ice that can range in size from an inch or two to over 16 feet tall.

Formation: Jagged structures form by sublimation, a process like melting, except that the sun turns the snow directly into water vapor without melting first. Essentially the ice goes from solid to gas and skips the liquid phase.

The Shape of Ice
Ice Map Cards

UNITED STATES

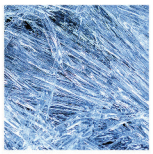




ICELAND









RUSSIA







ARCTIC CIRCLE







The Shape of Ice
Ice Map Cards

ANTARCTICA





JAPAN





ARGENTINA





CANADA





LESSON 4

EARTH WATER DELIVERY: CANCELLED!

GRADE LEVEL 3-5



ARCTIC: *Our Frozen Planet*



ARCTIC: Our Frozen Planet

LESSON 4

EARTH WATER DELIVERY: CANCELLED!

GRADE LEVEL 3-5

90 minute lesson

STANDARDS (NGSS):

5-ESS2-2 Describe and graph the amounts of salt water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.

FROM THE FILM:

In the film, The *ARCTIC: Our Frozen Planet*, we learn about the important role of both fresh and salt water in the region to support the lives of polar bears, seals, and humans. Water provides everything from a frozen surface on which to travel for the Inuit to a place to live for narwhals, polar bears, and seals. So, where does that water come from and how does it cycle around the globe?

LESSON OVERVIEW:

The Arctic contains approximately 20% of Earth's freshwater supply. In general, the water cycle is driven by Earth's gravitational pull and energy provided by the sun.

After learning about how the water cycle shows up across the globe, students will select a product (comic strip, paper slide, video, song, or poster) to present the cycling of water through Earth's systems with examples of how that looks from the perspective of the Arctic. They will share their model with each other and discuss the benefits and advantages of each.

EDUCATOR PREP:

- Collect materials
- Prepare the technology to show the video
- Print the Activity Sheet (1 sheet per pair of students)

MATERIALS LIST:

- ***Earth Water Delivery: Cancelled!*** *activity sheet*
- *Globe or image of Earth from space.*
- *Construction paper*
- *Colored pencils*
- *Card stock paper*
- *Glue sticks*
- *Assorted science or nature magazines*
- *Additional art supplies students may require or request*
- *Technology to show the video* ***How the Hydrologic Cycle Works****:*

https://www.youtube.com/watch?v=al-do-HGuIk

LESSON 4

EARTH WATER DELIVERY: CANCELLED!

LESSON GUIDE

Part I – Overview of the Water Cycle

1. Prompt students to think about planet Earth. What does it look like? If available, use the globe to spark student's thinking.

If one is not available, ask them to close their eyes and picture Earth in their minds:

What makes up planet Earth?

Students will most likely respond by describing continents or land masses along with oceans and other water.

As you look or imagine the planet, which is there more of – land or water?

Help students to understand that the earth is mostly covered in water. Even though our maps/globes often focus on landmasses, when we take the planet in consideration as a whole, we see that it's 71% or almost 3/4th is covered in water.

Where does the planet get its water?

Student responses should confirm that water is already on the planet. Their responses also may reflect confusion about the question, since this is not something that we often talk about overtly.

So if the water is already on the planet and we are not getting any water delivered to our planet, where does it come from?

This is a semi-rhetorical question intended to get young people thinking about how the water that exists on our planet is the same water that has always existed. Responses may reflect this line of thinking or may illuminate some misconceptions (we have an endless supply!) about how kids think about water.

2. Let students know what in today's activity they are going to be looking at the **water cycle** and specifically how the Arctic influences the water on Earth.

To gauge students' background knowledge on the water cycle, ask them to work in pairs to complete the first two columns of the **Arctic Water Knowledge Chart** on the activity sheet. For the first column, they should fill in what they already know about the water cycle and water in the Arctic. For the second column, they should create at least two questions that they have about water in the Arctic.



Beluga whales, seen here from above, often travel in pods, or large groups.

3. Show students the video, *The Water Cycle: How the Hydrologic Cycle Works,* and ask them to jot down three new things they have learned about the water cycle that they didn't know before, under the **What I Learned** column on their sheet.

Part II – Water Distribution across the World

4. Share with students that although water is found all over the planet, it is not distributed evenly. We are going to look at some data from the United States Geologic Survey about where water is found across the globe.

5. Direct students to complete the activity sheet, **Water in the Arctic,** with a partner, including examining the data about water distribution, drawing a bar graph to show the data visually, and writing an explanation for why water is distributed in this way.

6. Review the answers to the activity sheet with the whole group and answer any questions they may have about what they have done up to this point.

7. Have students look at the Arctic Region Map and ask the whole group about the conclusions that we can draw about how water is distributed in the Arctic knowing about how it's distributed across the planet.

Where is most of the water in the Arctic located?

Student answers should reflect their observation that similar to the rest of the planet, water in the Arctic is mostly found in the ocean and in the icecaps, glaciers, and sea ice that is around the Arctic.

As the sea ice, glaciers, and ice caps are melting, where does that water go?

The melting ice in the Arctic goes into the Arctic Ocean, which is connected to the Atlantic and Pacific Oceans as well. Since so much of the planet's water is found in this part of the world, as it melts, it increases ocean levels and reduces the ocean's salinity.

Let's talk about Salinity for a second. Salinity is the amount of salt in water. Glaciers are made up of frozen fresh water, meaning no salt, and the ocean has a lot of salt.

What happens when the glaciers melt into the water?

Student responses should reflect their understanding that mixing salt water with fresh water makes the ocean less salty, or lowers its salinity.

EDUCATOR NOTES:

Part III – Communication to the World

8. Let students know that one of the most important parts of science is communicating what you have learned to other scientists and people who aren't.

In this final activity, we will create something that will communicate what we have learned about the water cycle and how water is distributed across the globe.

9. Divide students into groups of four and then pass out the cards to assign one of four roles (listed below). Make sure that each student has a role in the group. Note, depending on your students, you may also let them select their roles once they are in groups.

Researcher - responsible for collecting the information that the group will need to complete their project, and tracking the sources from where the content originates.

Graphic Designer – responsible for creating, finding, or leading the artwork for the project.

Writer- takes the lead on writing the text, including script or copy for the project.

Project Manager – Coordinates the timeline of the project, leads the group in brainstorming, and communicates the project to other groups during the sharing process.

10. Introduce the different **Science Communication Product** options to students and explain that they will pick one product to communicate what they learned about the water cycle.

Comic Strip / Paper Slide Video / Song / Poster

11. Give students 30 minutes to work in groups to create their Science Communication Product. Remind them that they will share what they have created before the end of the period.

12. As the groups are working, float around the room to check in with the students to ensure that they stay on task and on time.

13. Once students have finished, give each group a chance to share their product depicting the water cycle and what they learned.

14. As a wrap up have students fill out the **What I Learned** section of their activity sheet and then share with their group.



The Arctic region is made up of all three: ice, water, and land.

Earth Water Delivery – CANCELLED!

Arctic Water Knowledge Chart

In this activity, we are going to examine how the water cycle occurs in the Arctic and how that leads to the distribution of water across the region. We will examine all three states of water – frozen, liquid, and water vapor.

Part I: Using the chart below, fill in the first two columns about your knowledge and curiosity as it relates to water in the Arctic region of Earth.

What I Know	What I Want to Learn	What I Learned

Earth Water Delivery – CANCELLED!

Activity Sheet

Part II: Take a look at the chart from the USGS showing the distribution of water across the globe and answer the questions below.

1. Where is most of the water on earth located?

2. Where is the second most water located?

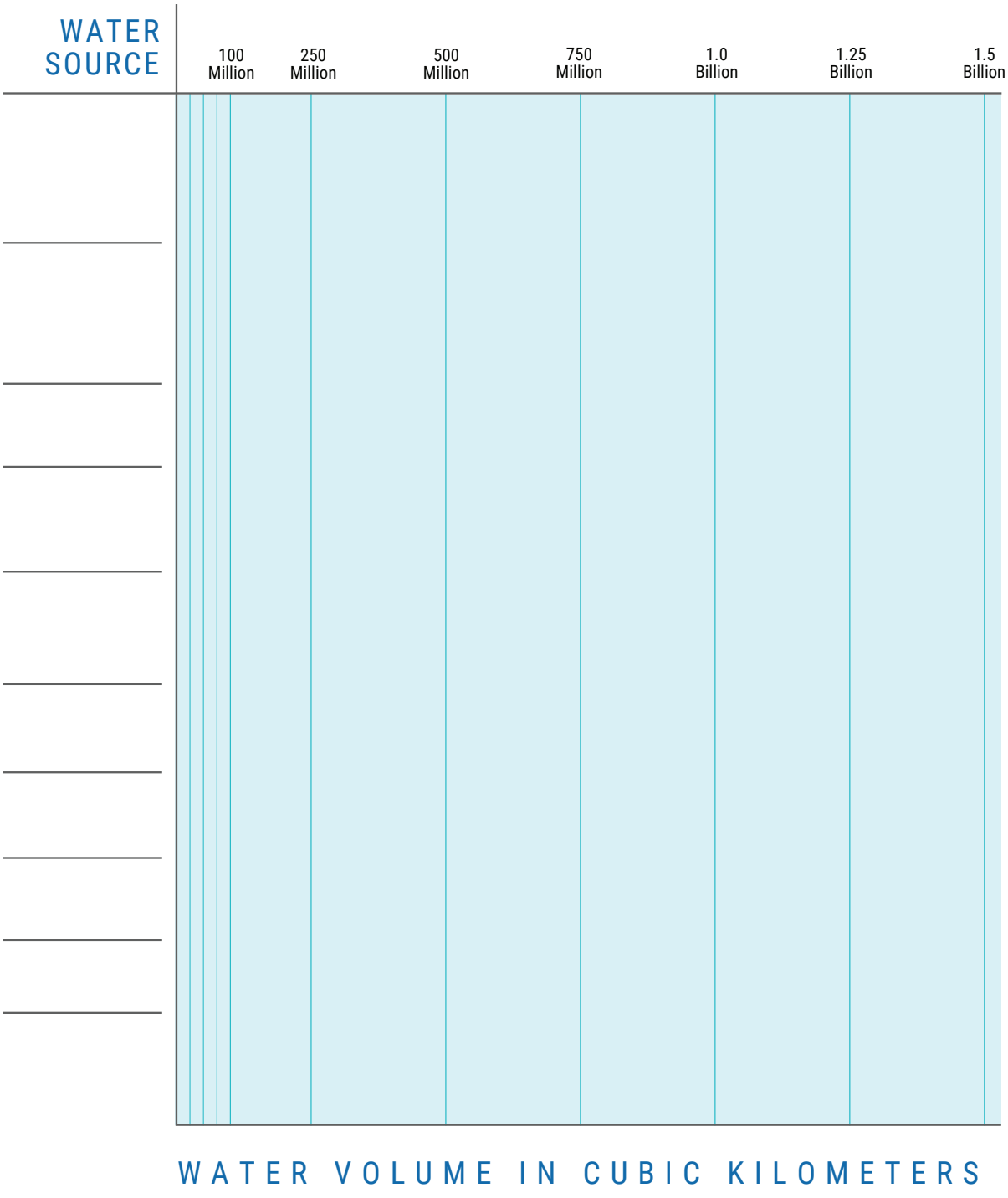
3. Do rivers or lakes contain more water?

Water Source	Water Volume in cubic kilometers	Percentage of Freshwater	Percentage of Total Water
Oceans, Seas, & Bays	1,338,000,000	0.00%	96.54%
Ice caps, Glaciers, & Permanent Snow	24,064,000	68.7%	1.74%
Groundwater *Fresh* *Saline*	23,400,000 *110,530,000* *12,870,000*	0.00% 30.1% 0.00%	96.54% 0.76% 0.93%
Soil Moisture	16,500	0.05%	0.001%
Ground Ice & Permafrost	300,000	0.86%	0.022%
Lakes *Fresh* *Saline*	176,400 *91,000* *85,400*	0.00% 0.26% 0.00%	0.013% 0.007% 0.006%
Atmosphere	12,900	0.04%	0.001%
Swamp Water	11,470	0.03%	0.0008%
Rivers	2,120	0.006%	0.0002%
Biological Water	1,120	0.003%	0.0001%
Total Water	**1,409,560,910**	**100%**	**100%**

Earth Water Delivery – CANCELLED!

Water in the Arctic

4. Using the data from the previous page, draw a bar graph below to show how water is distributed around the planet. Label each bar with the name of the source and the amount of water.



Earth Water Delivery – CANCELLED!

Activity Sheet

5. Describe in 2-3 sentences how water is distributed around the Earth, as if you were describing it to someone who has not yet seen the data above.

Communicating the Hydrosphere Project

Science Communication Product Goals: Create a product that will communicate how the water cycle works and distributes water across the planet. Be sure to describe the different parts of the water cycle as well as the locations for water across the globe. Your product can be:

Comic Strip / Paper Slide Video / Song / Poster

Roles: You will be assigned one of these roles which you will take on to ensure that the project moves forward successfully:

Researcher - responsible for collecting the information that the group will need to complete their project, and tracking the sources from where the content originates

Designer – responsible for creating, finding or leading the artwork for the project

Writer - takes the lead on writing the text, including script or copy for the project

Project Manager – Coordinates the timeline of the project, leads the group in brainstorming coordinates among the different members, and communicates the project to other groups during the sharing process.

Earth Water Delivery – CANCELLED!:

Arctic Region Map



Earth Water Delivery – CANCELLED!

Arctic Water Knowledge Chart / ACTIVITY EDUCATOR KEY

In this activity, we are going to examine how the water cycle occurs in the Arctic and how that leads to the distribution of water across the region. We will examine all three states of water – frozen, liquid, and water vapor.

Part I: Using the chart below, fill in the first **two** columns about your knowledge and curiosity as it relates to water in the Arctic region of Earth.

What I Know	What I Want to Learn	What I Learned
Answers may vary.	Answers may vary.	Answers may vary.

Earth Water Delivery – CANCELLED!

Activity Sheet / ACTIVITY EDUCATOR KEY

Part II: Take a look at the chart from the USGS showing the distribution of water across the globe and answer the questions below.

1. Where is most of the water on earth located?

   Oceans, seas, and bays.

2. Where is the second most water located?

   Ice caps, glaciers, and permanent snow.

3. Do rivers or lakes contain more water?

   Lakes contain more water.

Water Source	Water Volume in cubic kilometers	Percentage of Freshwater	Percentage of Total Water
Oceans, Seas, & Bays	1,338,000,000	0.00%	96.54%
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Atmosphere	12,900	0.04%	0.001%
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Biological Water	1,120	0.003%	0.0001%
Total Water	**1,409,560,910**	**100%**	**100%**

Earth Water Delivery – CANCELLED!

Water in the Arctic / ACTIVITY EDUCATOR KEY

4. Using the data from the previous page, draw a bar graph below to show how water is distributed around the planet. Label each bar with the name of the source and the amount of water.



Earth Water Delivery – CANCELLED!

Activity Sheet / **ACTIVITY EDUCATOR KEY**

5. Describe in 2-3 sentences how water is distributed around the Earth, as if you were describing it to someone who has not yet seen the data above.

Much of the water on Earth is found in the oceans and seas and then ice caps and glaciers, and groundwater. The water is not nearly as much in rivers, lakes, and the atmosphere.

Communicating the Hydrosphere Project

Science Communication Product Goals: Create a product that will communicate how the water cycle works and distributes water across the planet. Be sure to describe the different parts of the water cycle as well as the locations for water across the globe. Your product can be:

Comic Strip / Paper Slide Video / Song / Poster

Roles: You will be assigned one of these roles which you will take on to ensure that the project moves forward successfully:

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Designer – responsible for creating, finding or leading the artwork for the project

Writer - takes the lead on writing the text, including script or copy for the project

Project Manager – Coordinates the timeline of the project, leads the group in brainstorming coordinates among the different members, and communicates the project to other groups during the sharing process.

LESSON 5

CAN YOU SURVIVE IN THE ARCTIC?

GRADE LEVEL 3-5



ARCTIC: *Our Frozen Planet*



ARCTIC: Our Frozen Planet

LESSON 5

CAN YOU SURVIVE IN THE ARCTIC?

GRADE LEVEL 3-5

45 minute lesson

STANDARDS (NGSS):

3-LS4-3 Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.

FROM THE FILM:

In the film, *ARCTIC: Our Frozen Planet,* we see animals over a variety of habitats – this activity reinforces the idea that different animals have adapted to live in different habitats. Polar bears for example, have been living in the Arctic for hundreds of years – and have adapted to living in the cold, Arctic climate.

LESSON OVERVIEW:

In this lesson students will learn about the differences between animals that can survive in different areas of the Arctic, and what properties can help them survive.

Students will play a card game where the goal is to place animals in the correct environments. Each animal is assigned points, based on being a consumer/producer/decomposer, and a unique "ability", which enables them to thrive in different environments. The student with the most points wins.

EDUCATOR PREP:

Print and trim out one set of cards and a game board **per pair of students** and assemble kits with one coin, one game board and one set of cards.

MATERIALS LIST:

- ***Can You Survive in the Artic?*** *trimmed playing card printouts*
- ***Can You Survive in the Artic?*** *game board*
- *Coins*
- *Paper*

LESSON 5

CAN YOU SURVIVE IN THE ARCTIC?

LESSON GUIDES:

1. To begin, remind students that we saw that in the film, *ARCTIC: Our Frozen Planet*, there were many different areas within the Arctic biome where animals can survive.

2. Ask students to consider the following questions to activate their prior knowledge and what they may have learned in the film.

Allow students to pick an animal and gather in groups based on the first animal that comes to mind. What animals did they think of first?

What animals live in the ocean in the Arctic?

Answers should include the animals seen in the film, including: plankton, whales, narwhals.

What animals live on the ice in the Arctic?

Answers should include the animals seen in the film, including: seals, polar bears, walruses.

What animals live on the land in the Arctic?

Answers should include the animals seen in the film, including: wolves, bison, bees.

What are the different roles of organisms in an ecosystem to transfer energy?

Producers - convert sunlight to edible energy (sugar)

Consumers - Feed on producers and other consumers to get energy.



A lone polar bear stands out against the rocky landscape.

3. Take a moment to remind students know that there are many different animals all of whom live in various parts of the Arctic. They have adapted to enable them to survive in different areas.

Adaptions are traits that help animals thrive in their environments. There are two distinct types of adaptations, behavioral and biological.

A **biological adaptation** is a physical change in an organism that results over time from a reaction to its environment. An example would be the wolf, and their highly developed sense of smell.

A **behavioral adaptation** is the way an organism acts to survive in its environment. An example would be wolves working in packs to be more successful when hunting for prey.

4. Share with students that today, through a card game, we will demonstrate the ways in which animals work in the Arctic, and show how they can each survive in their environment.

5. Ask the students to select a playing partner, then explain to students the rules of the game:

- Students will pair off, with each pair getting one game board. They will face it towards them. Each pair of students will also get one set of cards and a coin.
- First, students will shuffle and each draw 5 cards.
- Next, they will flip a coin to see who goes first.
- Students will alternate placing a card in corresponding areas until they have played all of their cards.
- After all cards have been played, use the information on the cards to tally up the number of points earned by each person. Record the score for the round. Some cards will have special abilities, and some cards will affect how much each card is worth.
- Collect the cards, shuffle, and play again. The person with the highest score after three rounds wins.

EDUCATOR NOTES:

6. Once the game is over, have students discuss in a group what advantages the different animals have in different environments.

Would the ice animals survive in the ocean? What about on the land?

Student conversations should reflect their understanding that animals are adapted to live in their environment and would struggle to live in others. Encourage them to use specific examples to make their case as to why and examine any possible exceptions.

7. To conclude the lesson, have students reflect on what they learned about how animals are adapting to the changing environment because of climate change. Ask them to answer the following questions in a notebook or online journal:

How will polar bears survive without ice?

Student responses will vary, but should reflect something that they learned in this activity or in the film.

What changes can we make to help lesson the effects of climate change?

Student responses will vary, but should reflect something that they learned in this activity or in the film.



Perhaps surprising, but the Arctic is also home to bees and wildflowers.

Can You Survive in the Arctic?

Card Set 1

Bee
Consumer
LAND
1



Arctic Bees have special muscles that allow for them to warm up their bodies.

Bee
Consumer
LAND
1



Arctic Bees have special muscles that allow for them to warm up their bodies.

Bee
Consumer
LAND
1



Arctic Bees have special muscles that allow for them to warm up their bodies.

Bee
Consumer
LAND
1

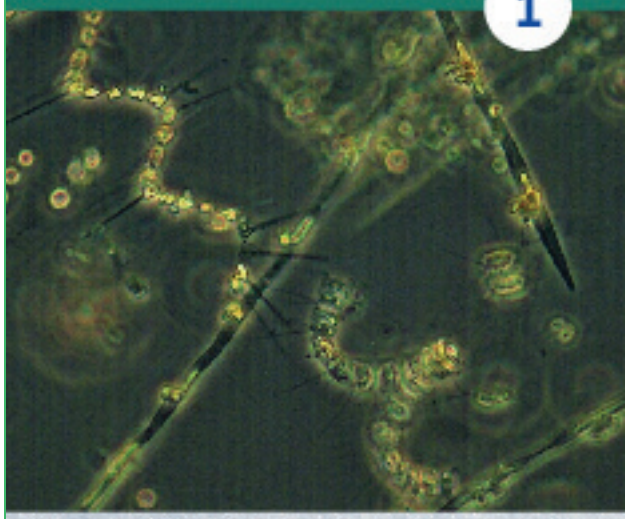


Arctic Bees have special muscles that allow for them to warm up their bodies.

Can You Survive in the Arctic?

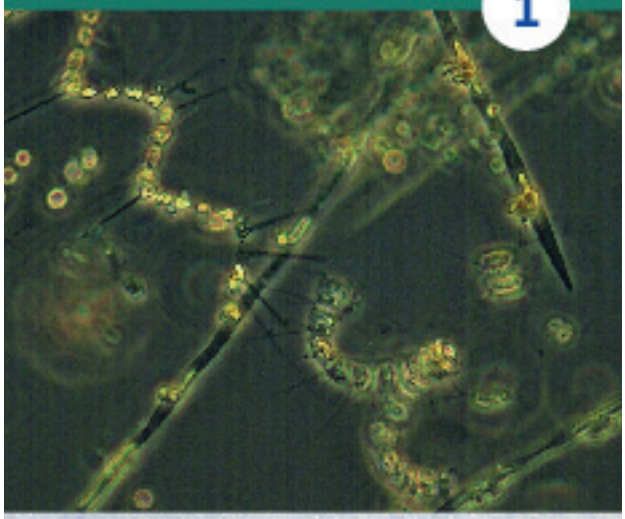
Card Set 2

Plankton
Producer
OCEAN
1



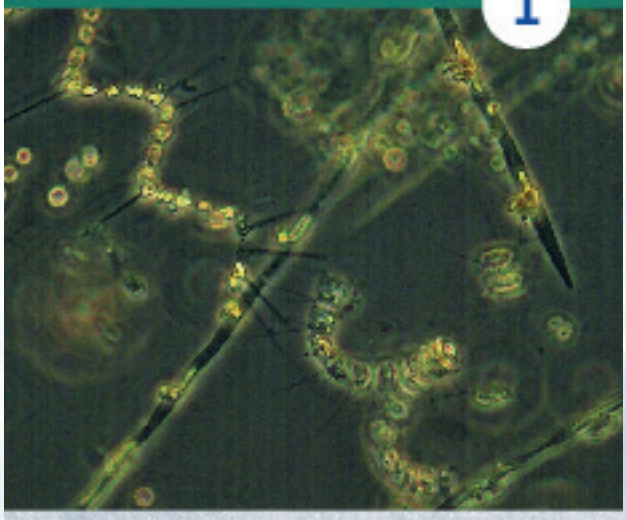
When plankton bloom in the summer, it can be seen from space!

Plankton
Producer
OCEAN
1



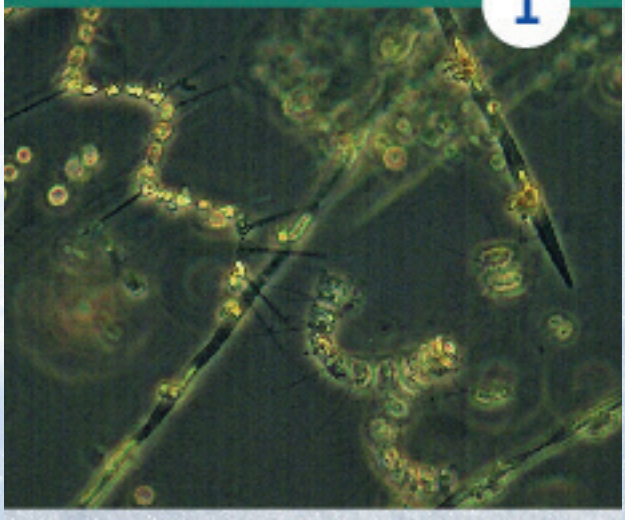
When plankton bloom in the summer, it can be seen from space!

Plankton
Producer
OCEAN
1



When plankton bloom in the summer, it can be seen from space!

Plankton
Producer
OCEAN
1



When plankton bloom in the summer, it can be seen from space!

Can You Survive in the Arctic?

Card Set 3

Wolves
Consumer
LAND
7



Arctic Wolves are carnivores. If there are 2 wolves on your board, you can take an opponent's bison.

Wolves
Consumer
LAND
7



Arctic Wolves are carnivores. If there are 2 wolves on your board, you can take an opponent's bison.

Wolves
Consumer
LAND
7



Arctic Wolves are carnivores. If there are 2 wolves on your board, you can take an opponent's bison.

Polar Bears
Consumer
ICE
10



Polar Bears are the largest bear in the world! Add 1 to your score.

Can You Survive in the Arctic?

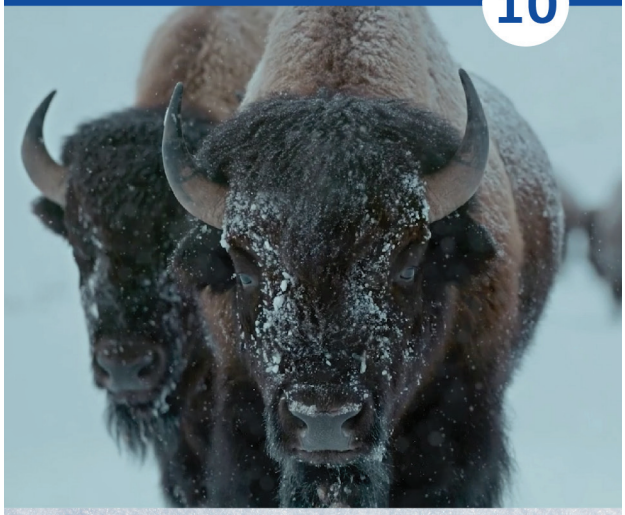
Card Set 4

Polar Bears
Consumer
ICE
10



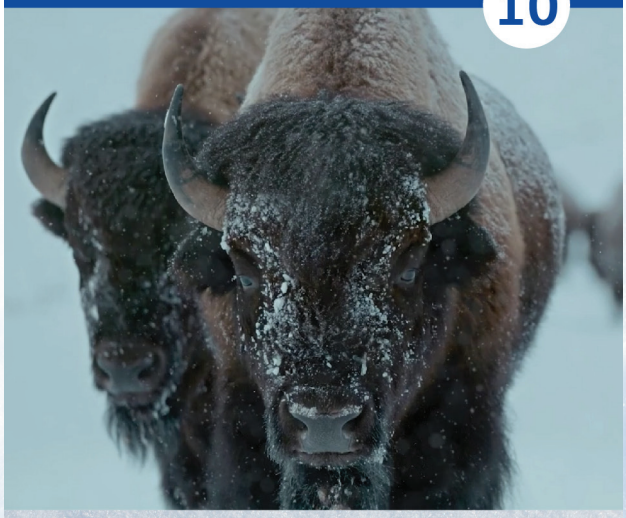
Polar Bears are the largest bear in the world! Add 1 to your score.

Bison
Consumer
LAND
10



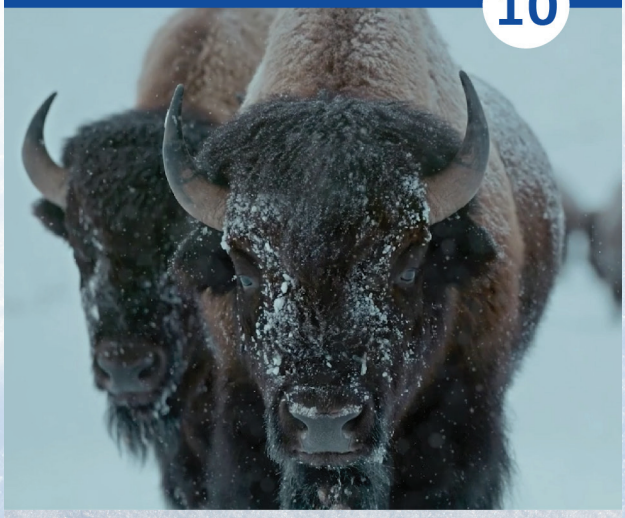
Bison can run up to 35mph, fast enough to knock the cards out of your hand. Discard 1 card after this is played.

Bison
Consumer
LAND
10



Bison can run up to 35mph, fast enough to knock the cards out of your hand. Discard 1 card after this is played.

Bison
Consumer
LAND
10



Bison can run up to 35mph, fast enough to knock the cards out of your hand. Discard 1 card after this is played.

Can You Survive in the Arctic?

Card Set 5

Bowhead Whale
Consumer
OCEAN
10



Bowhead Whales eat up to six tons of plankton a day. If there is at least 2 plankton cards in play, add 1 to this card's value.

Bowhead Whale
Consumer
OCEAN
10



Bowhead Whales eat up to six tons of plankton a day. If there is at least 2 plankton cards in play, add 1 to this card's value.

Bowhead Whale
Consumer
OCEAN
10



Bowhead Whales eat up to six tons of plankton a day. If there is at least 2 plankton cards in play, add 1 to this card's value.

Narwhals
Consumer
OCEAN
10



Narwhals' tusks is a large tooth! If there is a Walrus on the board, add a two(th) to your score.

Can You Survive in the Arctic?

Card Set 6

Narwhals

Consumer

OCEAN

10



Narwhals' tusks is a large tooth! If there is a Walrus on the board, add a two(th) to your score.

Harp Seal

Consumer

ICE

5



Seals gain about five pounds a day after they are born. Draw 2 cards after this is played.

Harp Seal

Consumer

ICE

5



Seals gain about five pounds a day after they are born. Draw 2 cards after this is played.

Climate Change



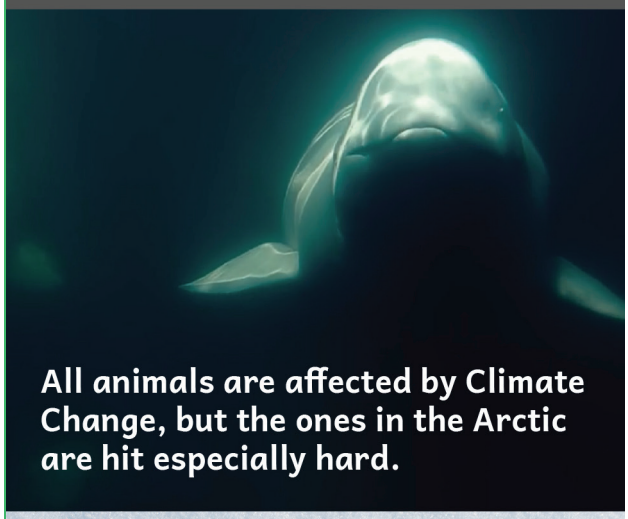
All animals are affected by Climate Change, but the ones in the Arctic are hit especially hard.

Reduce all of your opponent's cards by 1.

Can You Survive in the Arctic?

Card Set 7

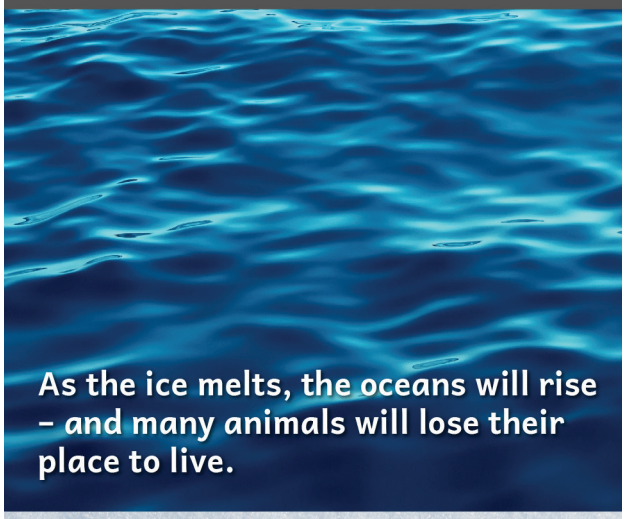
Climate Change



All animals are affected by Climate Change, but the ones in the Arctic are hit especially hard.

Reduce all of your opponent's cards by 1.

Ocean Rising



As the ice melts, the oceans will rise – and many animals will lose their place to live.

Remove 1 card from your opponent's Ice or Ocean rows.

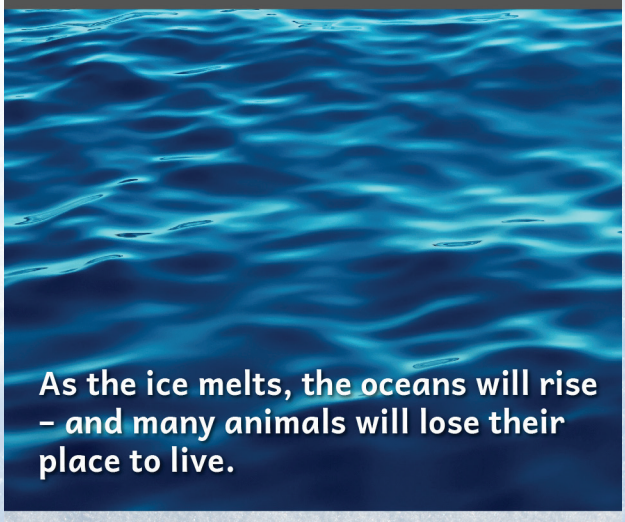
Bee
Consumer

LAND
1



Arctic Bees have special muscles that allow for them to warm up their bodies.

Ocean Rising



As the ice melts, the oceans will rise – and many animals will lose their place to live.

Remove 1 card from your opponent's Ice or Ocean rows.

Can You Survive in the Arctic?

Card Set 8

Walrus
Consumer
ICE
7



Walrus' tusks can be used to break holes in ice. Draw 1 card.

Walrus
Consumer
ICE
7



Walrus' tusks can be used to break holes in ice. Draw 1 card.

Walrus
Consumer
ICE
7



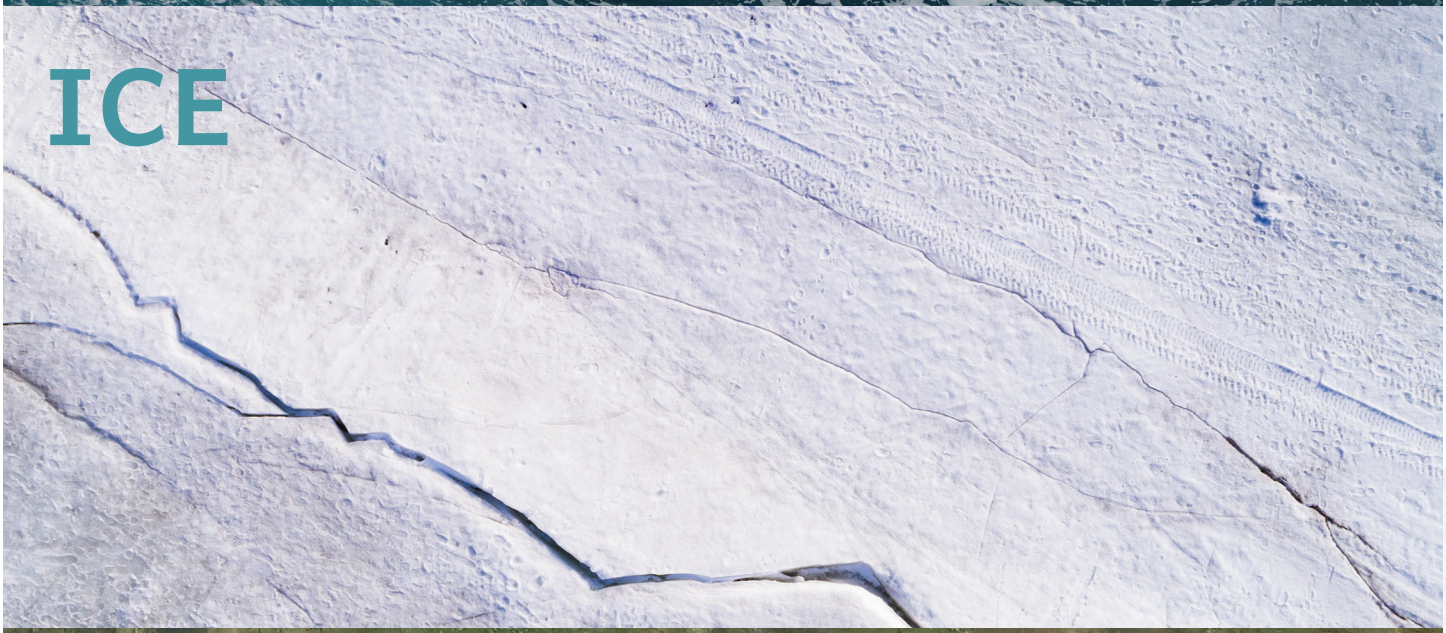
Walrus' tusks can be used to break holes in ice. Draw 1 card.

Queen Bee
Producer
LAND
10



Queen bees lay all the eggs for the hive. If there are no bee cards down, play 2.


SEA


ICE


LAND

LESSON 6

CARVING EARTH

GRADE LEVEL 3-5



ARCTIC: Our Frozen Planet



ARCTIC: Our Frozen Planet

LESSON 6

CARVING EARTH

GRADE LEVEL 3-5

45-60 minute lesson

STANDARDS (NGSS):

4-ESS2-1 Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.

FROM THE FILM:

In the film, *ARCTIC: Our Frozen Planet,* we saw how powerful a force water can be as it melts and channels through ice. In this activity, we will explore each of these forces, how they carved the Earth we know today, and make estimates of what our future Earth will look like if these same forces continue acting on our earth at the same rate they are today.

LESSON OVERVIEW:

Students will conduct a series of tests to explore geologic concepts that shape the Earth's surface, discuss signs of weathering and erosion, and generate a prediction of what our future earth might look like based on current ice movement. Students will be able to explain how the Earth's surface changes on a large scale over a period of time by the movement of water, ice, and wind.

EDUCATOR PREP:

Add sand into foil pans, providing one pan per pair or one per group. Each pan should have enough sand for teams to build a small mound or sandcastle. In advance, freeze ice cubes for students to use.

MATERIALS LIST:

- ***Carving Earth*** *activity sheet*
- *Sand / 50 lb. bag / 2-4 cups of sand per group*
- *Rocks*
- *Trays/aluminum pans (one per pair or one per group)*
- *Ice cube / One per group*
- *Water / One cup per group*
- *Paper or plastic cup / One per group*
- *Hand-held fan (preferred), or a box fan*
- *Raised globe or relief map*
- *(Optional) Samples of limestone, coquina, or other sedimentary rocks that show evidence of impact and erosion from glaciers/water/wind*

LESSON 6

CARVING EARTH

LESSON GUIDES:

1. Begin by leading a class discussion about what students learned in watching In *ARCTIC: Our Frozen Planet*. Use the following questions to focus the conversation and have students follow along on their Activity Sheet:

What were some powerful geologic or water-based forces we saw in the movie?

The film depicted several powerful forces, including ice breaking off from glaciers and crashing into the ocean, water that had melted from the glaciers carving channels through the ice, water and ice vortexes, evidence of glacier-formed landscapes.

What are forces that cause erosion?

Water, Ice, Wind, Gravity

With enough time and force, how can water, ice, wind, and gravity cause erosion?

Rocks and sediment get picked up and moved by streams, ice, or wind.

Water gets into cracks in rocks and expands as it freezes, causing rocks to break apart. A steady stream of water landing on a rock over time can create enough pressure to carve through the rock.

Glaciers can shrink and grow depending on the climate, and as they change shape, they also move across the landscape crushing the earth beneath them, carrying rocks and sediment with them, and pushing deposits off to the side.

Wind blows sediment and can alter landscapes where the sand or soil is loose. Gravity can cause rocks to break apart, especially if they are already fragile and cracked.



Huskies are well adapted to life in the Arctic.

2. Let's look at a raised globe or a relief map as a class.

What are some geologic processes that can alter the Earth?

- Volcanoes
- Shifting tectonic plates
- Erosion

Can you identify areas on the map that were created by glaciers?

Glaciers can create geological features called cirques, moraines, paternoster lakes, and kettles. The Great Lakes around Michigan were all created by glaciers.

In Montana, you can visit **Glacier National Park** and witness all the different geologic features and processes firsthand.

Why is it important to understand how glaciers shape landscapes?

Clues of glacial erosion can give us an idea of what past climates looked like. Understanding the past can help us determine what our future Earth might look like.

3. Now we are going to explore the ways in which different types of erosion shape the land that we see. Remember, land is always continuing to be shaped by erosion, so we are always seeing something in progress of being shaped, and never the finished product.

4. Pass out a tray of sand to each pair or group. Remind students that sand must stay inside the tray!

5. Ask students to build a small mountain, hill, or sandcastle with their sand.

6. Once students have finished building their sandcastle, walk around the room with a handheld fan and gently blow the sand while having students make observations.

OPTIONAL (If handheld fan is not available, groups will need to bring their tray up to a box fan one at a time for the same demonstration. *The LOW setting is recommended*).

EDUCATOR NOTES:

7. After students have had an opportunity to make observations on what happens when wind erodes their creation, pass out one small cup of water to each group.

Students will test how water erodes their landscape and record their observations.

How did the water alter your sand creation?

Water moved down the sand creation, pushing sand out of the way and creating a pathway.

How does **Force,** *(pouring a large amount of water at once vs. a slow and steady stream,)* impact erosion?

More water results in more force. When larger quantities of water are poured at once, sand was displaced at a greater scale. A slow and steady stream created a controlled pathway and appeared less destructive than a lot of water at once.

8. Give each group one or two ice cubes. Groups should set the ice cube on the top of their mountain (they may need to push it into the sand a little). Allow their ice to sit and begin melting.

Tell students we will come back to this later.

9. As a class, go outdoors and search for signs of erosion. Students should take their **Activity Sheet** with them to record their observations.

10. As students finish the scavenger hunt, have them discuss as a group the following questions:

Are there any boulders nearby? If so, what signs of erosion do they show?

Tops of boulders may appear rounded from rainfall. There may be pockets in the boulder where rain pools in larger quantities.

Are there any nearby streams to view how water erodes the landscape?

Tops of boulders may appear rounded from rainfall. There may be pockets in the boulder where rain pools in larger quantities.

Can you find any cracks in rocks caused by water?

Students may find rocks with cracks in them or rocks that have been split into pieces. This is often a sign of erosion from rainfall and multiple freeze-thaw cycles.



An Inuit hunter traverses the ice thanks to a team of sled dogs.

11. Tell students to finish up, as the class is going back inside to check on our ice.

Has the ice in the tray moved at all?

Answers may vary. (Example) The ice melted slightly and moved down that sand mound.

What has happened to the sand around the ice?

Answers may vary. (Example) The ice pushes the sand to the side as it melts.

Does the ice create a trail or an indentation in the sand?

Answers may vary. (Example) Yes, the ice creates a trail as it melts.

Has the sand been **relocated?**

Answers may vary. (Example) It appears that sand is being relocated as the ice moves down the mound. Sand is sticking to the ice cube as it moves down the pathway.

12. Have students clean up any messes they made and put away materials.

13. Time to regroup.

We now know how wind, water, ice, and gravity can affect landscapes.

Looking at our current Earth, what do we think the world will look like 15 years from now? In 100 years? In 1000 years?

Answers will vary. (Example) The heating and cooling of Earth depends greatly on whether or not humans can ease up on the amount of carbon they release into the atmosphere. At the current rate, ice at the poles will melt in the next 15 - 100 years, causing sea levels to rise. If sea levels rise too quickly, it will cause more destruction to the coastlines and waterways than it would if it rises slowly. There would be coastal erosion on a global scale with many beachfront properties falling into the ocean. Rivers that stem from the ocean would see a rise which could also cause erosion to the surrounding landscape. As ice and glaciers at the poles melt, they will carve into any earth that they come in contact with, which may result in the formation of new valleys and lakes.

The Earth has gone through many freeze and thaw cycles and animals largely adapt. Because temperature increases are happening so quickly, it makes it particularly difficult for humans and animals to adapt. Increased global temperatures will also lead to more landscape changes as well.

EDUCATOR NOTES:

How can we affect the erosion of our beaches?

Foot traffic and tourism causes a great amount of erosion on the beaches, but the biggest threat to our beaches is the global increase in temperature which is melting the poles and causing the sea level to rise.

What strategies may work to prevent melting and what can we do?

Answers may vary. (Example) We can take better care of out planet, reduce waste, and reduce our dependence on fossil fuels. .

Ask the students to come up with 2-3 solutions that we can all implement.

We can switch to renewable energy.

We can plant more trees to absorb excess CO_2 in the atmosphere.

We can greatly reduce the amount of carbon we put out into the atmosphere by buying products that are created sustainably, shopping local, and growing our own produce.

14. Have the students write letters to their political representatives describing what climate solutions they would like to see the government support. ***Be sure to check letters before sending.***



Walrus, sunning on the beach.

Carving Earth

Activity Sheet

Name: _____

Date: _____

1. Reflecting on The Arctic

What were some powerful geologic or water-based forces we saw in the movie?

2. Erosion

What are forces that cause erosion?

Over time, how do these forces cause erosion

3. Geologic Processes

What are some geologic processes that can alter the surface of the Earth?

Carving Earth
Activity Sheet



MAP OF THE MIDWESTERN UNITED STATES

Can you identify any areas of the map that may have been created by glaciers?

Why is it important to understand how geologic processes have shaped landscapes?

Carving Earth
Activity Sheet

4. Erosion Activity

You and your teammates will work together to build a sandcastle and test how the following forces effect the shape of your structure. **Please keep sand in the tray!**

Record your observations:

FORCE	OBSERVATIONS (what happens to your structure?)
WIND	
WATER	
ICE	

Carving Earth
Activity Sheet

5. Outdoor Erosion Scavenger Hunt

Are there any boulders nearby? What signs of erosion do they show?

Are there any streams nearby? How does water erode the landscape?

Can you find any rocks or boulders with cracks in them? How can water crack a rock?

Are there any paths made by humans? How does human activity cause erosion?

6. Make Connections

How have geologic processes historically altered the surface of Earth?

Carving Earth
Activity Sheet

Given our understanding of erosion, if the ice in the Arctic continues to melt, what will Earth look like in the future?

Explain your predictions. (Use extra paper for your response if necessary.)

Bonus: What are some possible solutions that humans can implement to help slow the rate at which ice is melting at the poles?

Take action and write a letter to your local congressman to express your concerns.

Carving Earth

Activity Sheet / **EDUCATOR KEY**

Name: _____

Date: _____

1. Reflecting on The Arctic

What were some powerful geologic or water-based forces we saw in the movie?

(Answers may vary depending on the students' perception of the film) The film depicted several powerful forces, including ice breaking off from glaciers and crashing into the ocean, water that melted from the glaciers carving channels through the ice, water and ice vortexes, and evidence of glacier-formed landscapes.

2. Erosion

What are forces that cause erosion?

Wind, water, ice, and gravity.

Over time, how do these forces cause erosion

(Answers may vary) • Rocks and sediment get picked up and moved by streams, ice, or wind. • Water gets into cracks in rocks and expands as it freezes, causing rocks to break apart. • A steady stream of water over time can create enough pressure to carve through the rock. • Glaciers move across the landscape crushing the earth, carrying rocks and sediment while pushing deposits off to the side. • Wind blows sediment where the sand or soil is loose. • Gravity can cause fragile or cracked rocks to break apart.

3. Geologic Processes

What are some geologic processes that can alter the surface of the Earth?

Volcanoes, shifting tectonic plates, erosion.

Carving Earth

Activity Sheet / **EDUCATOR KEY**



MAP OF THE MIDWESTERN UNITED STATES

Can you identify any areas of the map that may have been created by glaciers?

The Great Lakes of Michigan were formed by glaciers. The Glacier National Park in Montana was also formed by glaciers *(not pictured on map).*

Why is it important to understand how geologic processes have shaped landscapes?

Clues of geologic processes can give us an idea of what past climates may have looked like. Understanding the past can help us determine what our future Earth may look like.

Carving Earth

Activity Sheet / **EDUCATOR KEY**

4. Erosion Activity

You and your teammates will work together to build a sandcastle and test how the following forces effect the shape of your structure. **Please keep sand in the tray!**

Record your observations: Answers may vary.

FORCE	OBSERVATIONS (what happens to your structure?)
WIND	The wind displaced the sand and caused the surface of the sandcastle to shift. Higher winds caused more displacement.
WATER	Water altered the surface of the sandcastle differently depending on the amount of force behind the water. Slower, steady streams carved paths in the sand, while greater forces of water caused greater destruction.
ICE	The ice had a slower impact on the sandcastle, but as the ice melted, it moved down the side of the sandcastle at a faster rate, displaced sand, and formed a pathway as it melted.

Carving Earth

Activity Sheet / **EDUCATOR KEY**

5. Outdoor Erosion Scavenger Hunt

Are there any boulders nearby? What signs of erosion do they show?

Answers may vary. Signs of erosion could be manmade (from many people standing/sitting on it), or natural (such as water dimples on eroded limestone or cracks from water).

Are there any streams nearby? How does water erode the landscape?

Answers may vary. Water will erode the landscape depending on the amount of force – a faster river will carve away more of the earth than a slower river. Sometimes we can see signs where rivers are currently low/slow, but the pathway around it might suggest that occasionally the river has surges.

Can you find any rocks or boulders with cracks in them? How can water crack a rock?

Answers may vary. Water works its way into porous surfaces of rock causing it to grow weaker. When water freezes and thaws, it expands and contracts, which leads to cracks forming in the rocks.

Are there any paths made by humans? How does human activity cause erosion?

Answers may vary. Human activity can cause erosion from the weight of our bodies moving over a surface over a period of time (gravity).

6. Make Connections

How have geologic processes historically altered the surface of Earth?

Answers may vary. Examples: volcanoes erupting have created mountains and ocean trenches, glaciers have carved out valleys and created lakes, wind and water have eroded landscapes gradually over time from varying amounts of force.

Carving Earth

Activity Sheet / **EDUCATOR KEY**

Given our understanding of erosion, if the ice in the Arctic continues to melt, what will Earth look like in the future?

Explain your predictions. (Use extra paper for your response if necessary.)

Answers may vary. If ice at the poles continues to melt, the ice will slowly carve valleys into any land masses they encounter as well as form pools of water and lakes. Sea levels will rise, causing increased erosion along coastal regions. If the ice melts at a faster rate, the effects will be much more devastating than if they happened at a slow and steady rate.

Bonus: What are some possible solutions that humans can implement to help slow the rate at which ice is melting at the poles?

Answers may vary, but should reflect students thinking creatively about ways to address the challenges of high carbon emissions, greenhouse gases, or the hole in the ozone layer.

Take action and write a letter to your local congressman to express your concerns.

Please read students' letters before sending them.

LESSON 7

ARCTIC MELTDOWN

GRADE LEVEL 6-8





ARCTIC: Our Frozen Planet

LESSON 7

ARCTIC MELTDOWN

GRADE LEVEL 6-8

30 minute discussion

60 minute activity

STANDARDS (NGSS):

MS-ESS3-5 Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

FROM THE FILM:

In *ARCTIC: Our Frozen Planet,* we see how ice at the poles is dramatically decreasing, putting sea life and indigenous populations at risk of losing their habitat and livelihood. In this activity, students will explore the science and reasoning behind depleting ice at the poles and work through the engineering design process to search for solutions that might help slow down the progression of melting ice and save our Arctic ecosystem.

LESSON OVERVIEW:

Students explore the ice-albedo feedback, the impact decreased albedo has on Arctic ecosystems, and how human activities and natural processes increase the rate at which our polar ice melts. An icy planet can reflect sunlight and heat back into outer space, but as the Arctic begins melting, that heat gets absorbed into our oceans, increasing temperatures globally. Students will engage in discussion on human impact on our earth's temperatures, build something to keep their ice from melting, and be challenged to see whose ice can last the longest.

MATERIALS LIST:

- ***Arctic Meltdown*** *activity sheet*
- *Ice cubes*
- *Basic building materials:*
  - *Cardboard*
  - *Paper bowls*
  - *Foam sponges*
  - *Construction paper*
  - *Aluminum foil*
  - *Craft sticks*
  - *Pipe cleaners*
  - *Mylar thermal sheets (optional)*
  - *Fabric/stuffing (optional)*
- *Scissors*
- *Tape*
- *Desk lamp*
- *2 thermometers*
- *1 piece of black construction paper*
- *1 piece of white construction paper*
- *Chart paper or SMART Board*
- *Optional additions:*
  - *Additional thermometer*
  - *Charcoal*
  - *Soot and microplastics spread on a piece of white paper*

LESSON 7

ARCTIC MELTDOWN

EDUCATOR PREP:

Freeze ice cubes for students in advance. If you are bringing ice cubes into the classroom and do not have a freezer that you can store them in, you can wrap the ice in tin foil and hold them in a cooler to keep them solid longer.

Prep any building materials by cutting cardboard into smaller pieces. Cut fabric mylar thermal sheets into small squares if using in this activity.

Plan how you want to distribute materials. For example, will you prefer students to pick out their own materials, or will each student get a standard amount of each?



Narwhals have only one tooth which protrudes far out from their snout.

LESSON GUIDES:

1. Students should write their own personal reflection of *ARCTIC: Our Frozen Planet,* under section 1 of the Activity Sheet.

What did we learn about the Arctic?

Student responses will vary depending on what resonated for each of them from the film, but will most likely reflect the themes of the film, including the richness of life in the Arctic, the impact of climate change, and the relationship between the organisms who live there, including humans, and the changing landscape.

What is happening at the poles?

As the earth warms due to climate change, ice in the form of glaciers and sea ice is melting, changing from solid to liquid water. This reduces the amount of solid surface in the Arctic and causes the sea levels to rise.

How does melting ice affect the wildlife in the Arctic?

Those animals that rely on a solid surface, like polar bears and humans, are forced to move to look for other places to live. Organisms which live or rely heavily on the water have to adapt to warmer temperatures and reduced salinity if they are to survive in the new environment.

2. Students will follow along answering questions under Section 2 of the Activity Sheet.

What is the ice-albedo feedback?

The ice-albedo feedback is a climate process where ice reflects some of the solar energy back into space.

How does the ice-albedo feedback relate to the Arctic?

The more ice, the more reflective the surface. Surfaces that are highly reflective are considered high albedo surfaces. The ice and snow of the Arctic creates a high albedo environment.

What impact does melting ice at the poles have on the Arctic's albedo?

As ice in the Arctic begins melting, albedo decreases. Less solar energy is reflected out into space, and instead gets absorbed into our oceans. When more solar energy gets absorbed into our oceans, global temperatures increase, which in turn melts even more ice. This creates a positive feedback loop where our problem will continue to get worse unless preventative measures are taken.

3. Introduce the concept of thermal emissivity to your students.

What is thermal emissivity?

Thermal emissivity is the rate at which a specific material or surface emits thermal radiation. Thermal emissivity can be used for heating and cooling surfaces, as well as for reflecting thermal energy away from a surface.

How do we measure an object's thermal emissivity?

Thermal emissivity can be measured from zero to one. A material with zero thermal emissivity emits no thermal radiation and can reflect thermal radiation away from it. A material with Thermal emissivity of one can completely absorb the thermal radiation that touches it.

How does thermal emissivity impact the Earth?

Warm surfaces can cool themselves by emitting thermal radiation. In the past, planet Earth has maintained a balanced rate of cooling and heating on a large scale. Human activity has altered the planet's ability to cool itself naturally, and the consequence is a continued increase in global temperatures.

EDUCATOR NOTES:

4. APPLYING CONCEPTS

Let's take a look at the thermal emissivity table under Section 3 of our Activity Sheet. Students can practice looking at the table, searching for familiar materials, and learning about their thermal emissivity.

What are some materials with high thermal emissivity? What are some materials with low thermal emissivity?

Materials with high thermal emissivity include carbon (graphite), concrete, and soil.

Materials with low thermal emissivity include polished aluminum, brass, and copper.

What materials would be good to use if you wanted to design the roof of your home to be more energy efficient in the summertime? Why?

Materials that would make the roof of your home more efficient would be polished aluminum, brass, or copper. Selecting materials with low thermal emissivity helps reflect heat and sunlight away from your home, thus reducing the need for air conditioning in the summer time.

Black and White Surfaces

Place a piece of white paper and a piece of black paper under a desk lamp. ***Optional addition:*** add a third piece of paper covered in charcoal/ soot and microplastics to discuss the impact of carbon and microplastics on ice at our poles.

Set a thermometer on each piece of paper. Have students develop a hypothesis describing what will happen to the thermometers based on their understanding of albedo and thermal emissivity. Students should write down their hypotheses under section 4 of the Activity Sheet.

Leave the thermometers on the paper for the remainder of the lesson. We will come back to this at the end of the lesson.

5. Instruct your students you will be discussing greenhouse gases and have them follow along under section 5 of the Activity Sheet.

What are greenhouse gases?

Greenhouse gases are gases released into our atmosphere that emit thermal energy. Examples of greenhouse gases in our atmosphere include carbon dioxide, methane, water vapor, nitrous oxide, fluorinated gases, and ozone.



Inuit hunters sledding on the sea ice.

How are greenhouse gases formed?

Natural greenhouse gases occur from volcanic activity and other geologic processes, the respiration and decomposition of plants, and from gases released by the ocean. Greenhouse gases that occur from human activity are generated from the burning of fossil fuels, burning waste, agriculture, and deforestation.

What are the consequences of increased greenhouse gases?

Greenhouse gases that build up in the atmosphere to unsustainable levels can raise global temperatures, melt ice at the poles, and disrupt the natural pH balance in the oceans.

6. Have students explore different ways to alleviate the climate crisis by asking:

What are some ways that individuals can make changes in their everyday life to help solve the climate crisis?

Here are some potential responses:

One can reduce the amount of greenhouse gases they produce by switching to renewable energy sources, reducing food and water waste, reducing their consumption of meat and dairy, recycling, avoiding single-use plastics, using mass transit or carpooling more, and using electric or hybrid vehicles with more efficient gas milage.

Other ways to make a positive impact include improving your home's efficiency with better insulation and smart heating and cooling systems, buying locally produced goods, getting involved in community cleanup events, protecting and restoring ecosystems, supporting regenerative farming practices, and planting flowers and trees that attract pollinators.

We can support politicians who advocate for climate smart policies, we can write to our government officials, and donate to organizations invested in finding climate solutions.

There are many ways that we can make a positive impact and leave the world in better shape than we found it in. Have students respond to questions under section 6 of their Activity Sheet.

EDUCATOR NOTES:

7. Tell students you are now going to start to make connections with the ideas you have been discussing.

What are some reasons for increasing global temperatures?

Decreased albedo at the poles. High levels of greenhouse gases.

Ask students if they can think of anything else?

Deforestation decreases the earth's ability to process greenhouse gases. Pollution affects ocean acidity which can increase the rate of melting ice at the poles and throw off the albedo balance. (There are many possible answers to this question.)

8. Challenge the students to build something that can keep ice from melting. Using their understanding of thermal emissivity, students must select materials to build with that they think will help keep their ice cold for as long as possible.

Allow students to take their time selecting materials and building.

Hint: reflective materials such as aluminum foil and mylar thermal sheets are best for keeping ice cold. Students should also consider insulating their creation with other materials such as cotton, foam, or fabric.

Encourage students to get creative and think outside the box with their designs. When students are all finished building, pass out one ice cube to each student/pair. Students can be challenged to see whose ice stays frozen the longest.

Instruct students to place their creations somewhere where they can be left undisturbed. Evaluate their designs.

Most students' ice will stay cool for a few hours. Teachers may want to have students check on their ice periodically throughout the day to see which students/teams are still standing.

If leaving ice overnight (or for long periods of time), students may return to find that their ice has melted. A thermometer can be used to test the temperature of the water to see if some are still cold.

Students can be evaluated by the appearance of their design. Encourage students to share their experiences with the rest of the class.



Close-up of the frozen bumblebee queen.

Ask students what materials they used? Is their creation designed to reflect solar and thermal energy away from it? Does their creation have any insulation?

Answers may vary depending on class experience.

What materials were used and why? Was your design successful? Why or why not?

Answers may vary depending on class experience.

9. After students are finished building their ice-saver, check the thermometers from earlier.

Which thermometer has the highest temperature? The one on white paper or the one on black paper?

The black paper should have had the higher temperature.

If a third paper with carbon/soot and microplastics was added, how does this compare to the white and black papers tested?

Students' answers may vary depending on class experience. The paper with microplastics and carbon/soot will likely be around the same temperature as the black paper or hotter.

What does that say about carbon and microplastics and their effect on ice in the Arctic? Why is it important to reduce our carbon and plastic consumption?

Students' answers may vary depending on class experience. Carbon and microplastics tend to generate more heat under the sun. When they end up on icy areas in the Arctic, the result leads to faster melting ice. Cutting back out carbon and plastic consumption can help prevent the problem from worsening.

Were the students' hypotheses correct? Why or why not?

Students' answers will vary.

Ask if anyone explain why it is not a good idea to wear a black shirt on a hot summer day?

Students' answers may vary depending on class experience. A black shirt will absorb heat at a faster rate than a white shirt and the threat of overheating will be increased.

EDUCATOR NOTES:

10. Ask students to reflect on the challenges they faced when designing something that would offset the effects of climate change using a 3-2-1 summary in their notebooks. Ask them to write:

What three things did they learn from this experience?

Students' answers will vary.

What two questions do they have after finishing the design and experiment?

Students' answers will vary.

What is one thing that they would change in their design if they did it again?

Students' answers will vary.



Beluga whales are very social animals, often hunting or traveling in groups.

Arctic Meltdown
Activity Sheet

Name: _____

Date: _____

1. Reflecting on The Arctic

What are some key takeaway points from ***ARCTIC: Our Frozen Planet*** about the changing environment taking place at the poles?

2. Ice-Albedo Feedback

What is the ice-albedo feedback?

Does the Arctic have high or low albedo?

Arctic Meltdown

Activity Sheet

Is the albedo in the Arctic currently increasing or decreasing?

How does a changing albedo at the poles affect the rest of the Earth?

Arctic Meltdown
Activity Sheet

3. Thermal emissivity

Thermal emissivity is the rate at which a specific material or surface emits thermal radiation and is measured from 0 to 1. Thermal emissivity can be used for heating and cooling spaces, as well as for reflecting thermal energy away from a surface.

A material with zero thermal emissivity emits no thermal radiation and can reflect thermal radiation away from it. A material with thermal emissivity of 1 can completely absorb the thermal radiation that touches it.

MATERIAL	EMMISSIVITY VALUE (0-1)
Aluminum: Polished	**0.05**
Brass: Polished	**0.03**
Carbon: Graphite	**0.98**
Concrete	**0.92**
Copper: Polished	**0.05**
Copper: Oxidized	**0.65**
Gravel	**0.28**
Paper: Black	**0.9**
Paper: Yellow	**0.72**
Paper: White	**0.68**
Sand	**0.9**
Soil	**0.92**
Stainless Steel	**0.52**
Wood	**0.87**

Arctic Meltdown
Activity Sheet

From the Thermal Emissivity Table, what material absorbs the most thermal radiation?

What material emits the least amount of thermal radiation?

What materials would be good to use if you wanted to design the roof of your home to be more energy efficient in the summertime? Why?

4. Black & White Surfaces

In this activity, we will place a piece of black paper and a piece of white paper underneath a desk lamp and place a thermometer on top of each. (Optional: add a third piece of paper with carbon and microplastics on it.) Over a period of time, we will record the temperatures of each to find out which piece of paper is more efficient at keeping cool.

Develop a hypothesis: What do you think will happen to the temperature of each piece of paper when held under a desk lamp?

Arctic Meltdown

Activity Sheet

Observation	Time	Black Paper (temperature)	Black Paper (temperature)	Carbon/Microplastics (temperature)
Observation 1:				
Observation 2:				
Observation 3:				

Make observations: Record the temperature of each piece of paper periodically and share your observations.

Conclusion: What happened to the pieces of paper when held underneath the desk lamp for a period of time? Was your hypothesis correct? Why or why not?

5. Greenhouse gases

What are greenhouse gases?

How are greenhouse gases formed?

What are the consequences of increased greenhouse gases?

Arctic Meltdown
Activity Sheet

6. Climate Solutions

What is the climate crisis?

Take a moment to list ways that **YOU** can make changes in your everyday life to help solve the climate crisis:

1.

2.

3.

4.

5.

6.

7.

8.

9.

10.

Arctic Meltdown
Activity Sheet
EDUCATOR KEY

Name: _____

Date: _____

1. Reflecting on The Arctic

What are some key takeaway points from ***ARCTIC: Our Frozen Planet*** about the changing environment taking place at the poles?

(Answers will vary depending on the student's perception of the movie) Example: the ice in the Arctic is melting at an alarming rate, which affects habitats of animals and humans living there. Animals and indigenous populations are becoming displaced and global temperatures will continue to rise unless something changes.

2. Ice-Albedo Feedback

What is the ice-albedo feedback?

The ice-albedo feedback is a climate process where ice reflects some of the solar radiation back into space.

Does the Arctic have high or low albedo?

The Arctic has a high albedo.

Arctic Meltdown
Activity Sheet / **EDUCATOR KEY**

Is the albedo in the Arctic currently increasing or decreasing?

The albedo in the Arctic is currently decreasing because melted ice means less solar radiation is being reflected back into space.

How does a changing albedo at the poles affect the rest of the Earth?

As the albedo at the poles decreases, more solar radiation is absorbed into our oceans which simultaneously warms the planet more and makes the problem of ice melting at the poles even worse.

Arctic Meltdown
Activity Sheet

3. Thermal emissivity

Thermal emissivity is the rate at which a specific material or surface emits thermal radiation and is measured from 0 to 1. Thermal emissivity can be used for heating and cooling spaces, as well as for reflecting thermal energy away from a surface.

A material with zero thermal emissivity emits no thermal radiation and can reflect thermal radiation away from it. A material with thermal emissivity of 1 can completely absorb the thermal radiation that touches it.

MATERIAL	EMMISSIVITY VALUE (0-1)
Aluminum: Polished	**0.05**
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Gravel	**0.28**
Paper: Black	**0.9**
Paper: Yellow	**0.72**
Paper: White	**0.68**
Sand	**0.9**
Soil	**0.92**
Stainless Steel	**0.52**
Wood	**0.87**

Arctic Meltdown
Activity Sheet / EDUCATOR KEY

From the Thermal Emissivity Table, what material absorbs the most thermal radiation?

Carbon: Graphite

What material emits the least amount of thermal radiation?

Brass: Polished

What materials would be good to use if you wanted to design the roof of your home to be more energy efficient in the summertime? Why?

Brass: Polished; (2) Aluminum: Polished; (3) Copper: Polished

These materials emit the least amount of thermal radiation and are all reflective surfaces which can also reflect thermal and solar radiation away from them. During the summertime, a house with a roof made from these materials would require less air conditioning to remain cool and would therefore be more energy efficient.

4. Black & White Surfaces

In this activity, we will place a piece of black paper and a piece of white paper underneath a desk lamp and place a thermometer on top of each. (Optional: add a third piece of paper with carbon and microplastics on it.) Over a period of time, we will record the temperatures of each to find out which piece of paper is more efficient at keeping cool.

Develop a hypothesis: What do you think will happen to the temperature of each piece of paper when held under a desk lamp?

Answers may vary.

Example: I think the black paper will increase in temperature faster than the white paper because the black paper has higher thermal emissivity and will absorb more thermal radiation. I think the paper with carbon and microplastics on it will be closer in temperature to the black piece of paper because the materials absorb heat instead of reflecting it.

Arctic Meltdown

Activity Sheet / EDUCATOR KEY

Observation	Time	Black Paper (temperature)	Black Paper (temperature)	Carbon/Microplastics (temperature)
Observation 1:	3:15	70°	70°	70°
Observation 2:	3:45	74°	72°	74°
Observation 3:	4:15	76°	72°	77°

Make observations: Record the temperature of each piece of paper periodically and share your observations. Observations may vary.

Conclusion: What happened to the pieces of paper when held underneath the desk lamp for a period of time? Was your hypothesis correct? Why or why not?

The black construction paper increased in temperature faster than the white paper. The carbon/microplastic paper was around the same temperature as the black paper (if not hotter). My hypothesis was correct because I applied my understanding of thermal emissivity before testing.

5. Greenhouse gases

What are greenhouse gases?

Greenhouse gases are gases released into our atmosphere that emit thermal energy. (Bonus if they can list examples: carbon dioxide, methane, water vapor, nitrous oxide, fluorinated gases, and ozone.)

How are greenhouse gases formed?

Greenhouse gases are formed naturally through geologic processes, decomposition of plants, and gases released by the ocean. Manmade greenhouse gases occur through deforestation, the burning of fossil fuels and waste, and through agriculture practices.

What are the consequences of increased greenhouse gases?

Increased greenhouse gases to unsustainable levels are the cause for increased global temperatures, melting of the ice at the poles, and changes in pH levels in the ocean (which can have devastating effects on plants and animals living in them).

Arctic Meltdown
Activity Sheet / **EDUCATOR KEY**

6. Climate Solutions

What is the climate crisis?

The climate crisis is what our world is facing today with increased greenhouse gases, pollution, melting ice at the poles, and an increase of global temperatures. If nothing is done to alleviate the climate crisis, our Earth will suffer and become uninhabitable. The Earth cannot absorb the level of greenhouse gases that we are releasing into the atmosphere on its own, humans need to decrease their carbon consumption, seek alternative energy sources, and nurture the Earth's ecosystems.

Take a moment to list ways that **YOU** can make changes in your everyday life to help solve the climate crisis:

Answers may vary.

Carpooling, using mass transit, or walking/riding bikes more frequently

Buy groceries from locally owned and ethically sourced businesses

Avoiding single-use plastics

Growing my own vegetables and fruits

Avoiding imported goods and goods that must travel long distances to reach me

Reducing meat and dairy consumption

Investing in renewable energy sources

Turning off lights when not using them

Not wasting water (taking shorter showers, turning water off when brushing teeth, etc.)

Using less AC in the summer and less heat in the winter (making my home more energy-efficient)

Supporting/voting for politicians who support climate smart policies

Supporting regenerative farming practices

Planting flowers and trees that attract pollinators

Making updates to my home that improve its energy efficiency

LESSON 8

LIFE ON TOP

GRADE LEVEL 6-8





ARCTIC: Our Frozen Planet

LESSON 8

LIFE ON TOP

GRADE LEVEL 6-8

Two / 30 minute lessons

Additional time required outside of class

STANDARDS (NGSS):

MS-LS2-1 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations

FROM THE FILM:

The film *ARCTIC: Our Frozen Planet* introduces students to some of the unique species that live in the Arctic and the threats to their habitat and ways of life.

LESSON OVERVIEW:

Each student will assume the role of one of the animals highlighted in the film *ARCTIC: Our Frozen Planet*. Students will research the lifestyle and survival techniques unique to their species as well as the challenges facing them in the changing climate of the Arctic. Using this knowledge, students will write an autobiography as their animal, highlighting their survival techniques and adaptations as they live and die on the ice.

MATERIALS LIST:

- ***Life on Top*** *activity sheet*
- *Research materials (library, computers with internet access)*
- *Paper*
- *Writing utensils (pens or pencils)*

LESSON 8

LIFE ON TOP

EDUCATOR PREP:

Reserve research materials or space as applicable

LESSON GUIDES:

1. Welcome students to the beginning of their Arctic exploration! As a class, discuss what ideas students already have about the Arctic.

Ask students what they know about the Arctic?

Answers will vary depending on if students have already watched *ARCTIC: Our Frozen Planet* or if this content had previously been covered in class. If students have already viewed the film encourage them to think about what they saw or learned from the film. Possible answers could include:

-The Arctic is the northern most region of Earth.

-It is almost entirely covered by water, which is mostly frozen

-Only ¼ quarter of the Arctic is land

-The Arctic includes eight countries and covers parts of Scandinavia, Russia, Greenland, Canada, and the United States of America (Alaska)

-There are multiple types of habitats found within the Arctic including aquatic and terrestrial habitats

-It is home to 4 million people as well as different species of plants and animals

-There is an annual cycle of freezing and thawing

-Arctic ice is a unique habitat to the animals that live in the Arctic, many like polar bears rely heavily on the sea ice for hunting and survival.

-Arctic ice is an important part of the life and culture of the 4 million people who live in the Arctic.

-Arctic ice reflects heat and sunlight back into space.



A baby seal suns himself on the ice.

-Arctic ice helps regulate the circulation of water and nutrients in the ocean.

-Arctic ice has a major impact on stabilizing ocean and air temperatures

-Many global conditions are tied to the Arctic ice and its ability to regulate conditions worldwide.

It is important to point out that the organisms (plants, animals, people) that live in the Arctic are specially adapted to live there. These adaptations could be physical or behavioral.

We know that the Arctic is important the species that live there, but what impact does the Arctic have on us where we live?

Answers will vary depending on location, but the Arctic affects the weather everywhere as well as anything that depends on ocean currents and affected by ocean levels.

2. Divide the class into pairs or small groups and give them time to discuss their ideas about how the Arctic is impactful to their daily lives and where they live.

Float among the groups offering guidance and direction as needed. Offer these questions to guide students in their discussions:

Do you live in a coastal area that will be affected by rising sea level?

What extreme climate can we expect where we live?

How could large storms affect us and the region where we live?

3. Bring students back together to share their ideas.

What do we notice about our ideas? Are they all the same?

Student answers will vary but look for patterns or recurring issues. Supplement students' answers as needs, especially highlighting impacts to your area such as:

-Rising global temperatures
-More extreme weather events such as hurricanes, drought, blizzards
-Sea level rise
-Shifting climates affecting food supply and crop growth

EDUCATOR NOTES:

How can we adapt to these changes? What might we have to do to be able to live here once the changes take place?

Give students time to think about these questions. Student answers will vary depending on the changes they predicted for the local area, but could include:

-Needing to use more air conditioning (or putting in air conditioning) to deal with rising temperatures

-Having to move further inland to account for rising sea levels in coastal communities

-Emergency procedures to deal with weather events like hurricanes or drought

-Build a new school to better stand up to the changing conditions

What would happen if we couldn't do those things?

Allow students to reflect on this questions, but a formal answer is not needed at this time. Use this to transition into the activity.

4. Students will select an animal featured in *ARCTIC: Our Frozen Planet* (Arctic wolf, polar bear, caribou, narwal, walrus). Explain that students will be researching the animal's physical adaptations, behavioral adaptations, survival strategies, habitat, threats to their habitat, etc.

Provide students with access to the library or the internet and time to complete their research.

Possible resources for student research:

- *https://adfg.alaska.gov/*
- *https://www.pc.gc.ca/en/pn-np/nt/woodbuffalo*
- *https://www.fws.gov/refuge/arctic*
- *https://www.nationalparksofsweden.se/choose-park---list/abisko-national-park/*
- *https://national-parks.org/*

5. Have students use the **Life on Top** activity sheet to organize their research.

6. Now that students understand their animal better, they will write their animal's autobiography.

What is an autobiography?

An account of a person's life written by that person.



Arctic shoreline.

7. Provide students with the requirements for their autobiography. Each autobiography will include the life history of the species (habitat, diet, role in ecosystem, adaptations, survival strategies), how they are handling the current changes occurring in the habitat, and their plan if the trend in ecosystem continues.

8. Teachers will determine the appropriate length of the autobiography and how much time students will have to complete the assignment.

9. Once the students have completed their autobiographies, students will share excerpts from their autobiography focusing on the future of their species.

Discuss the similarities and differences between the predictions made by students who were embodying the same species.

10. In small groups discuss their thoughts and feelings after hearing these predictions of the fates of the different species. Ask students:

> How do you feel about the consequences of the changing ecosystem in the Arctic?

11. In conclusion, as a class, brainstorm ways that their actions can have a more positive impact on the environment. Think locally and focus on things students can do such as:

- Writing a letter to the local government about their wishes for a more sustainable climate future.
- Planting a school garden.
- Carpooling to school, etc.

EDUCATOR NOTES:

Life On Top

Activity Sheet

Choose one of the animals from the film, ***ARCTIC: Our Frozen Planet*** that you want to know more about:

Atlantic walrus *Odobenus rosmarus*	Beluga *Delphinapterus leucas*	Wolf *Canis lupus*
Polar bear *Ursus maritimus*	Bowhead *Balaena mysticetus*	Hooded seal *Cystophora cristata*
Pacific walrus *Obobenus rosmarus*	Lapland bumble bee *Bombus lapponicus*	Sea angel *Clione limacina*
Guillemots *Uria aalge*	Harp seal *Pagophilus groenlandicus*	Caribou *Rangifer tarandus granti*
Narwhal *Monodon monoceros*	American bison *Bison Bison*	Crested auklet *Aethia cristatella*

Use a primary resource to learn more about the animal. Be sure to answer these questions in your research:

Animal name:	
Habitat:	Life span:
Omnivore, Carnivore, or Herbivore:	
Vertebrate Class:	Live birth or Lay eggs:
Prey:	Predator(s):

Life On Top
Activity Sheet

How is this animal affected by the events in the Arctic due to climate change?

Using what you've learned about your animal, write its autobiography telling its own story as if it was reflecting on life in the Arctic:

Life On Top
Activity Sheet / **EDUCATOR KEY**

How is this animal affected by the events in the Arctic due to climate change?

Answers will vary. The students' answers should reflect what they have learned about the animal that they chose and the impacts of climate change.

Using what you've learned about your animal, write its autobiography telling its own story as if it was reflecting on life in the Arctic:

Answers will vary. The students' autobiographies should reflect what they have learned about the animal that they chose.

LESSON 9

BECOME A CLIMATE SCIENTIST

GRADE LEVEL 6-8





ARCTIC: Our Frozen Planet

LESSON 9

BECOME A CLIMATE SCIENTIST

GRADE LEVEL 6-8

60 minute lesson

STANDARDS (NGSS):

MS-ESS2-5 Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.

MS-ESS3-4 Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

FROM THE FILM:

ARCTIC: Our Frozen Planet, highlights the work of global climate scientists, in partnership with the Inuit, as they try to understand how the global climate is changing and how that will affect every single one of us. Climate scientists and meteorologists conduct observations, collect data, and perform experiments to isolate the causes and effects of the changing planet.

LESSON OVERVIEW:

Climate change is warming the Arctic three times as fast as the rest of the globe, and melting ice at record rates. Scientists are confident that there is a strong connection between changes in the Arctic and the weather patterns across the rest of the planet, as our climate continues to warm.

EDUCATOR PREP:

Educator will need to print out **NOAA sea ice extent data**, or let students access the Excel sheet or PDF online.

Educator will need to print out **Arctic Visualization activity sheet** for students.

MATERIALS LIST:

- ***Become a Climate Scientist*** *activity sheet*
- *Laptops for students*
- *Access to Google Sheets or Excel Docs*
- *NOAA Arctic Sea Ice Extent Data*

Educator can hand out printouts or give them access to Excel sheet or PDF online

- *Pens/ pencils*

LESSON 9

BECOME A CLIMATE SCIENTIST

LESSON GUIDES:

1. Begin by tapping into students' background knowledge around what they already know about what climate scientists do and how they try to understand how the world around us works, using the following questions:

What do scientists do?

Answers should reflect students' background knowledge about science, the scientific method, and different types of science-related careers. Students should be able to describe how the scientific method helps scientists go from a research question to experimentation to results. They may also be able to hint at the idea that results need to be repeated, verified, and shared with others in the field through a peer-review process. Scientists also need to communicate their findings to peers, and in climate change – the public.

What is the difference between weather and climate? How is the climate changing?

Student responses should reflect their understanding in the difference between weather and climate.

Weather is the day-to-day changes in the atmosphere and how they impact temperatures, precipitation, and other weather phenomena. Meteorologists study the weather – you see them most often on TV, but work in all sectors of business and government.

Climate is the average weather over a long period of time. Climate scientists examine trends over years and decades. Let students explain the difference in overall weather between Canada and Mexico – one is very cold and snowy, the other is very hot and humid – that is climate!

Climate overall is warming across the globe as we add more greenhouse gases that trap heat. Canada is maybe not as cold anymore, and Mexico is even hotter.



Narwhals are one of the best diving mammals, spending a lot of their time under 800 meters (2,625 feet).

Why is the work of climate scientists so important?

Answers should reflect some of the points learned in the film. The climate is changing, rapidly, and is impacting everything from Inuit people to polar bears. Scientists need to examine these trickle-down changes, like melting sea ice, to help us predict the future changes of climate so we can better come up with solutions.

2. Students will now become climate scientists themselves. They will use real data that climate scientists have gathered in the Arctic, as we saw in the film. This data will help students examine trends of sea ice loss in the Arctic.

Make sure students have access to the charts with data from NOAA, either printed or digitally. To begin, instruct the students to pick the month of their birthday.

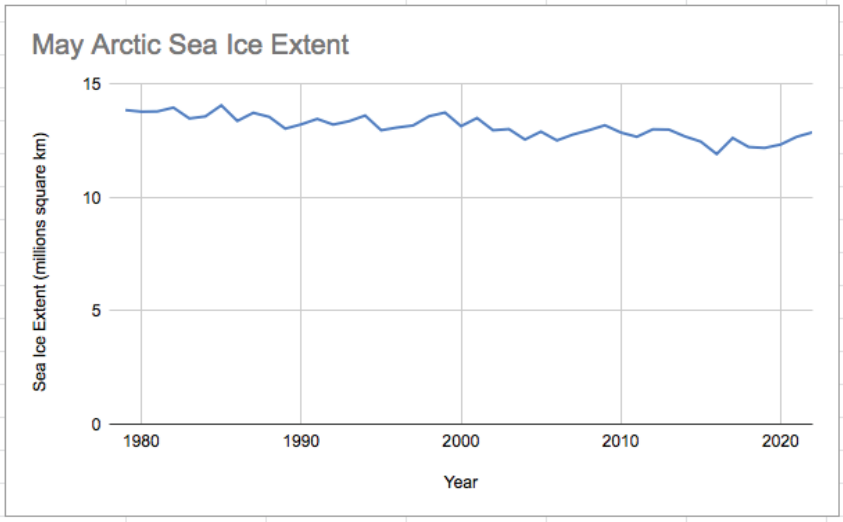
3. Open up a **Google Sheets** or **Excel document.** Paste or type in the data into columns for the month of your birthday. One column should be year; this will be your X-axis. The next column will be sea ice extent; this will be your Y-axis.

Create a line graph from the data. Check students progress to make sure they properly label and title their graph.

Below is an example for the month of May:

G19 | *fx*

	A	B	C	D	E	F	G	H	I
1	**YEAR**	**MAY**							
2	**1978**								
3	**1979**	13.86							
4	**1980**	13.79							
5	**1981**	13.8							
6	**1982**	13.97							
7	**1983**	13.49							
8	**1984**	13.58							
9	**1985**	14.07							
10	**1986**	13.38							
11	**1987**	13.74							
12	**1988**	13.56							
13	**1989**	13.04							
14	**1990**	13.23							
15	**1991**	13.47							
16	**1992**	13.22							
17	**1993**	13.37							



EDUCATOR NOTES:

To make a line graph using Google Sheets:
Insert the data for year/ sea ice extent in two columns. Highlight the columns. At the top tab click "Insert," "Chart." The chart will populate. You can edit chart titles, type, and style on the toggle menu that pops up. This will be needed for later activities in this lesson.

To make a line graph using Excel:
Insert the data for year/ sea ice extent in two columns. Highlight the columns. At the top tab click, "Chart," "Line." The chart will populate. You can edit chart titles, type, and style in the "Chart" and "Chart Layout" tabs. This will be needed for later activities in this lesson.

Hills and Valleys vs. Trends

As students examine their line graphs, make sure they understand the difference between year-to-year variation and overall trend. The little hills and valleys you see are the year-to-year ups and downs, or the weather. But if you look at the line overall…where is it headed? Is it a straight line? Is it slanted headed up or headed down? The overall trend is the climate.

Helpful analogy: When you walk your dog, your dog may swerve right and left to pick up a stick or sniff some flowers. Your dog is curving up and down like the hills and valleys. Both of you are headed in the same direction even though there is some deviation to your path.

You are walking straight ahead in one direction; you are the climate trend; while the dog is curving here and there a bit, so he is the year-to-year variation.

Let's make a prediction:

How will your birthday month sea ice continue to trend in the future?

4. Let students examine their trends and compare with each other. Discuss in small groups. Most of them will be declining trends, but some will have larger, steeper trends than others.



A "super pack" of wolves has adapted by increasing their numbers to survive in the Arctic.

Develop a Hypothesis:

Why are some trends more extreme than others?

This is because of the seasonality of Arctic sea ice. Even without climate change, Arctic sea ice has a season of growth in colder winter months, and a season of melt in warmer summer months. As our climate warms, winter growth is slowing to a halt, and summer melt is increasing at record rates. Students should see these different trends in the data.

Anyone with a winter birthday will have a slower decline. Anyone with a summer birthday will have a steeper, more extreme decline.

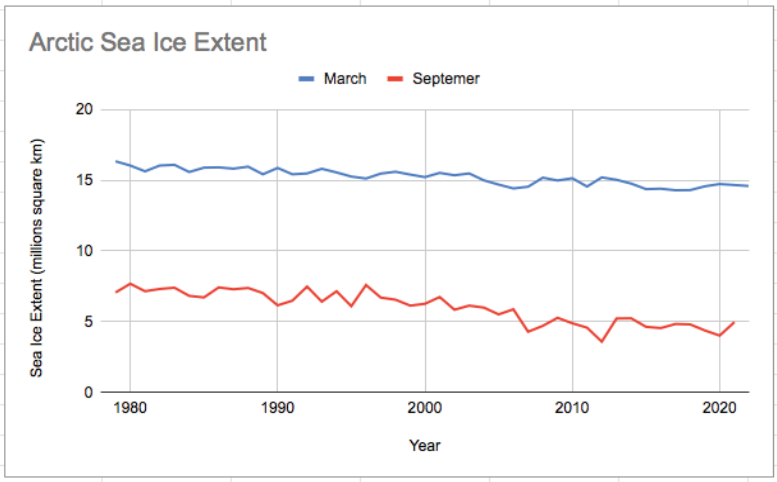
5. Let's examine this concept of seasonality more directly. Go back to your NOAA data. On your Google or Excel sheet, type in or paste the data for March and September. Make sure to include the years. Years will be your X-axis again; the sea ice extent data should be your Y-axis again.

Create a line graph, labeling titles, axis, and legend. Students should put both trend lines on one chart with a color-coded legend. See example results below.

EDUCATOR NOTES:

K13

	A	B	C
1	YEAR	MARCH	SEPTEMBER
2	1978		
3	1979	16.34	7.05
4	1980	16.04	7.67
5	1981	15.63	7.14
6	1982	16.04	7.3
7	1983	16.09	7.39
8	1984	15.58	6.81
9	1985	15.89	6.7
10	1986	15.91	7.41
11	1987	15.82	7.28
12	1988	15.96	7.37
13	1989	15.42	7.01
14	1990	15.87	6.14
15	1991	15.42	6.47
16	1992	15.48	7.47
17	1993	15.81	6.4



6. Point out that results show that September has a much steeper rate of sea ice loss than March. Ask students:

Why does September show a much steeper rate of sea ice loss than March?

September shows an even steeper trend. Why? September wraps up summer. The warmest months in the Arctic are June, July, and August. This was always slated as the natural season of melt, but what's happening over the last few decades? Arctic sea ice is melting even more than what's considered "normal," because of the warming climate.

Examination: Seasonality of Arctic Sea Ice

March wraps up the winter season of growth. The coldest months in the Arctic are December, January, and February. So, this is typically the season of sea ice growth. March should show your biggest volumes of sea ice for the year, after growing all winter. But, what is happening in March over the last few decades? Note the small decline in extent.

Make a prediction:

How will the sea ice continue to trend in the future? How will this trend vary by season?

Student answers will vary.

7. Now let's explain our findings to the public. Remember, we mentioned climate scientists are important because a lot of these changes are happening rapidly. In the Arctic, this means changes impacting the Inuit people and polar bears.

For the globe, climate change impacts all of us every day, from extreme weather to health, agriculture and ocean ecosystems.

How do we get this data and its message across in a clear, catchy way? Use the visualization activity sheet to analyze some examples from actual climate scientists doing this work today.



A seal swims just below a hole in the ice.

Color, Line and Shape:

Ask students to consider the use of colors, lines, and shapes.

Do these tools make it easier to understand the sea ice decline or temperature warming trend data? Can you spot the rapid changes more easily?

Student answers will vary.

Will someone without a science background understand these graphics? Why or why not?

Jot down notes on your activity sheet and discuss in small groups.

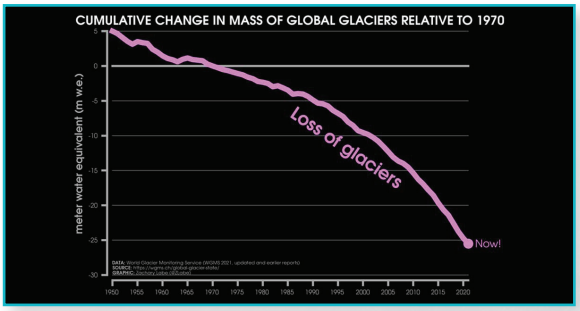
8. Ask students to look at our trend comparison for March and September again. Try different chart style and colors.

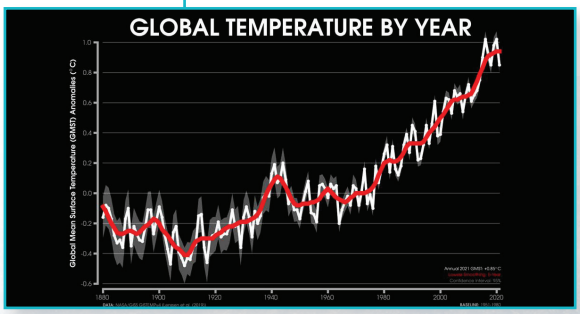
What are some other ways you can visualize this data to show the extreme melt in sea ice?

Make sure all graphs are labeled with chart and axis titles and legends.

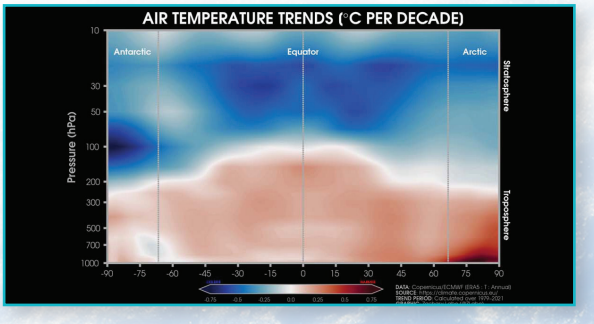
EDUCATOR NOTES:

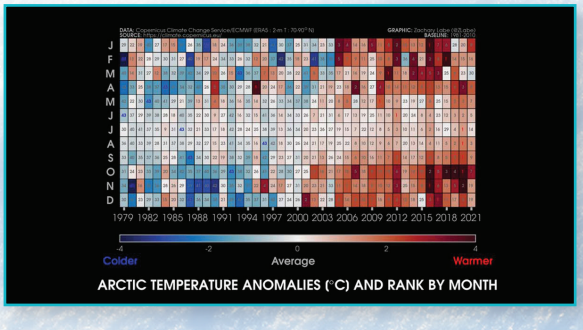
Data visualization examples:





DATA VISUALIZATION COURTESY OF ZACHARY M. LABE, PH.D.





9. Ask the students to share and present your charts with other classmates. Have them explain the reasons as to why they chose the style, and how they think it communicates your data efficiently.

Reflection on the Process:

Is it easy to clearly convey the message of this data?

This is a challenging task. Remember, not everyone has an understanding of climate science, or climate science in the Arctic, as you do now.

What are some challenges you come across in trying to present your data?

Student answers may vary.



Caribou are highly migratory, moving seasonally from place to place, and affecting the ecology of the areas they traverse.

Become *a* Climate Scientist Activity Sheet

NOAA Arctic Sea Ice Extent Data - measured in millions square km

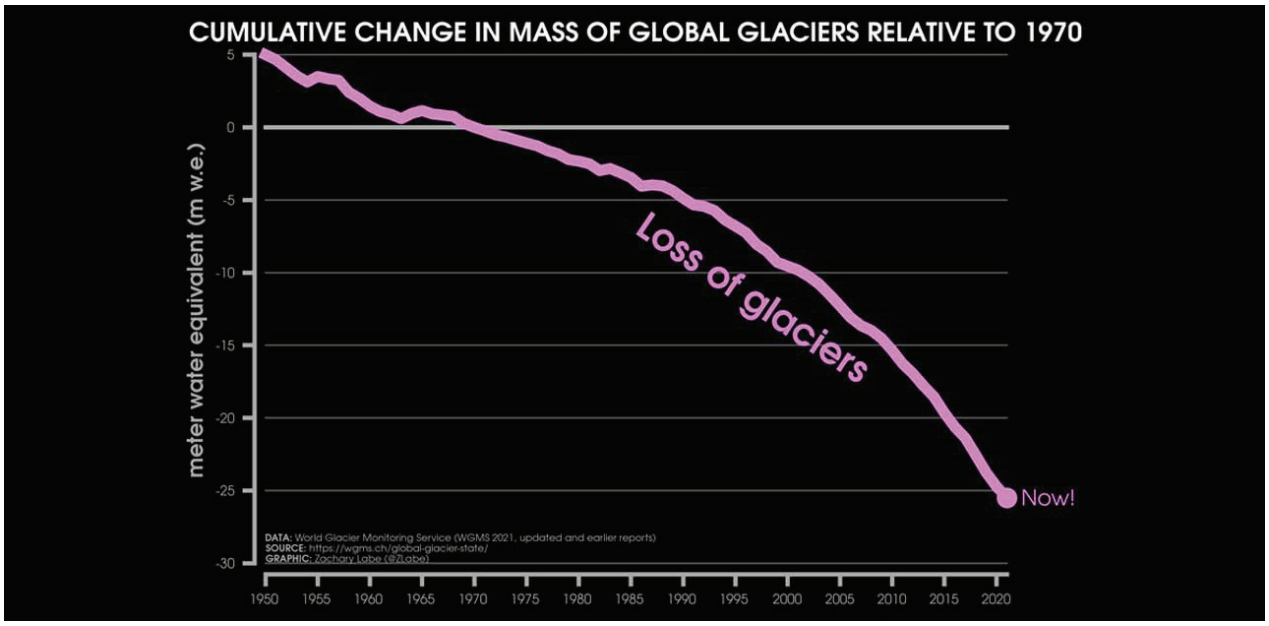
YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1978	–	–	–	–	–	–	–	–	–	–	11.65	13.67
1979	15.41	16.18	16.34	15.45	13.86	12.53	10.31	8.04	7.05	8.75	10.94	13.34
1980	14.86	15.96	16.04	15.43	13.79	12.2	10.1	7.98	7.67	9.18	11.38	13.59
1981	14.91	15.6	15.63	15.01	13.8	12.43	10.27	7.84	7.14	8.86	10.93	13.34
1982	15.18	15.97	16.04	15.47	13.97	12.48	10.37	8.14	7.3	9.42	11.63	13.64
1983	14.94	16.01	16.09	15.17	13.49	12.3	10.57	8.19	7.39	9.33	11.46	13.3
1984	14.47	15.3	15.58	15.01	13.58	12.15	9.98	7.77	6.81	8.56	10.84	12.99
1985	14.72	15.47	15.89	15.36	14.07	12.22	9.74	7.4	6.7	8.55	11.02	13.05
1986	14.89	15.78	15.91	15.06	13.38	11.98	10.15	7.98	7.41	9.48	11.45	13.22
1987	14.97	16.05	15.82	15.21	13.74	12.49	10.33	7.63	7.28	9.05	11.22	–
1988	–	15.58	15.96	15.12	13.56	11.94	9.81	7.89	7.37	9.13	11.33	13.63
1989	14.95	15.5	15.42	14.33	13.04	12.24	10.13	7.88	7.01	8.83	11.12	13.39
1990	14.78	15.58	15.87	14.65	13.23	11.64	9.25	6.8	6.14	8.48	11.08	13.11
1991	14.36	15.25	15.42	14.86	13.47	12.11	9.51	7.42	6.47	8.54	10.88	12.95
1992	14.64	15.46	15.48	14.68	13.22	12.15	10.32	7.93	7.47	9.32	11.38	13.41
1993	14.9	15.69	15.81	15.08	13.37	11.87	9.48	7.33	6.4	8.79	11.32	13.32
1994	14.73	15.56	15.55	14.89	13.62	12.02	9.93	7.64	7.14	8.92	11.12	13.27
1995	14.59	15.23	15.26	14.45	12.97	11.44	8.99	6.74	6.08	7.83	10.76	12.92
1996	14.18	15.15	15.12	14.22	13.09	12.08	10.16	8.18	7.58	9.16	10.4	12.86
1997	14.42	15.44	15.47	14.56	13.18	11.74	9.41	7.29	6.69	8.34	10.68	13.08
1998	14.72	15.75	15.6	14.89	13.59	11.71	9.42	7.51	6.54	8.45	10.44	12.76
1999	14.36	15.31	15.4	15.08	13.75	11.78	9.49	7.23	6.12	8.6	10.8	12.64
2000	14.22	15.14	15.22	14.56	13.15	11.67	9.51	7.17	6.25	8.38	10.32	12.64
2001	14.2	15.21	15.52	14.86	13.51	11.46	9.07	7.46	6.73	8.3	10.66	12.49
2002	14.27	15.34	15.35	14.3	12.97	11.58	9.27	6.6	5.83	8.16	10.34	12.61
2003	14.39	15.19	15.48	14.51	13.02	11.6	9.21	6.94	6.12	7.85	10.13	12.59
2004	14.03	14.91	14.99	13.99	12.56	11.45	9.43	6.85	5.98	7.93	10.34	12.55
2005	13.66	14.37	14.69	14.09	12.91	11.16	8.65	6.3	5.5	7.35	10.22	12.23
2006	13.47	14.32	14.42	13.91	12.52	10.92	8.46	6.5	5.86	7.54	9.66	11.95
2007	13.7	14.51	14.54	13.85	12.78	11.22	7.94	5.34	4.27	6.04	9.76	12.03
2008	13.89	14.95	15.18	14.35	12.97	11.21	8.68	5.91	4.69	7.35	10.34	12.36
2009	13.91	14.81	14.98	14.5	13.19	11.32	8.47	6.14	5.26	6.92	9.77	12.2
2010	13.74	14.58	15.14	14.66	12.87	10.59	8.07	5.87	4.87	6.98	9.61	11.83
2011	13.46	14.36	14.55	14.11	12.68	10.75	7.72	5.5	4.56	6.46	9.77	12.15
2012	13.73	14.55	15.2	14.63	13.01	10.67	7.67	4.72	3.57	5.89	9.39	12.01
2013	13.7	14.72	15.03	14.3	13	11.36	8.13	6.01	5.21	7.45	9.94	12.18
2014	13.65	14.42	14.76	14.09	12.7	11.03	8.11	6.08	5.22	7.23	10.11	12.35
2015	13.6	14.4	14.37	13.89	12.47	10.88	8.38	5.6	4.62	6.97	9.85	12.04
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2017	13.19	14.12	14.29	13.75	12.63	10.76	7.94	5.48	4.82	6.77	9.49	11.74
2018	13.08	13.97	14.3	13.7	12.23	10.78	8.27	5.61	4.79	6.13	9.82	11.86
2019	13.57	14.39	14.57	13.43	12.19	10.59	7.59	5.03	4.36	5.73	9.35	11.9
2020	13.64	14.64	14.73	13.62	12.34	10.59	7.29	5.07	4	5.33	8.99	11.73
2021	13.5	14.39	14.66	13.79	12.68	10.77	7.65	5.71	4.95	6.82	9.83	12.15
2022	13.88	14.61	14.59	14.04	12.88	–	–	–	–	–	–	–

Become A Climate Scientist

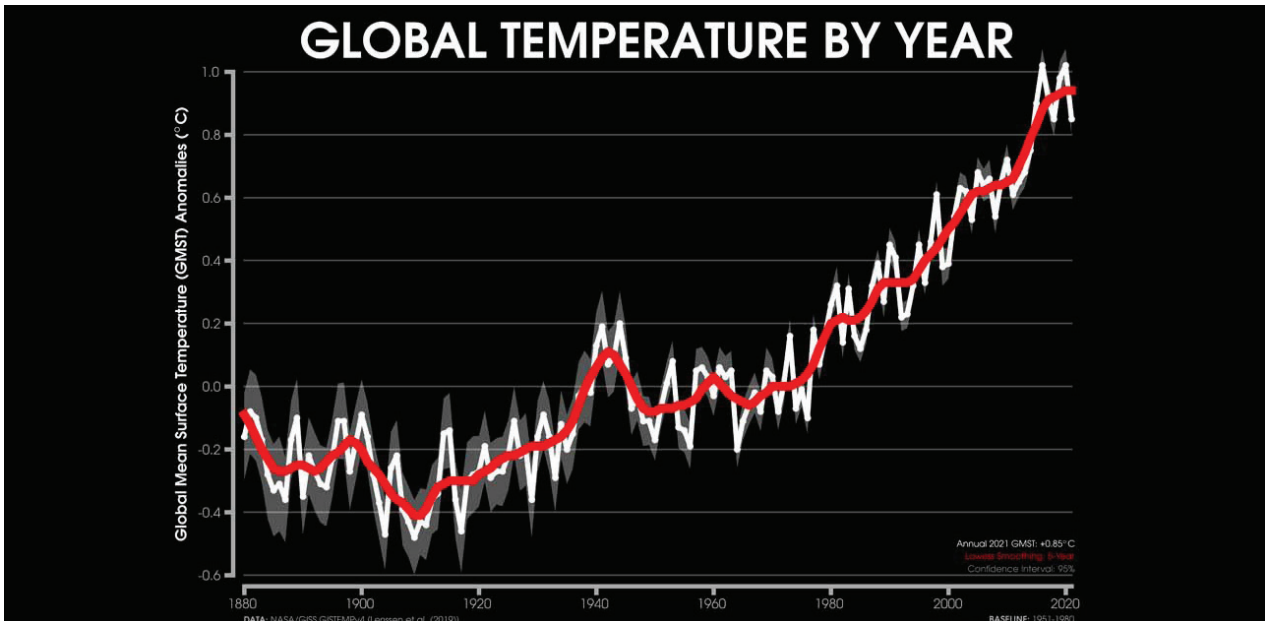
Arctic Visualization Activity Sheet

For each graph, first determine what is the variable and how is it trending.

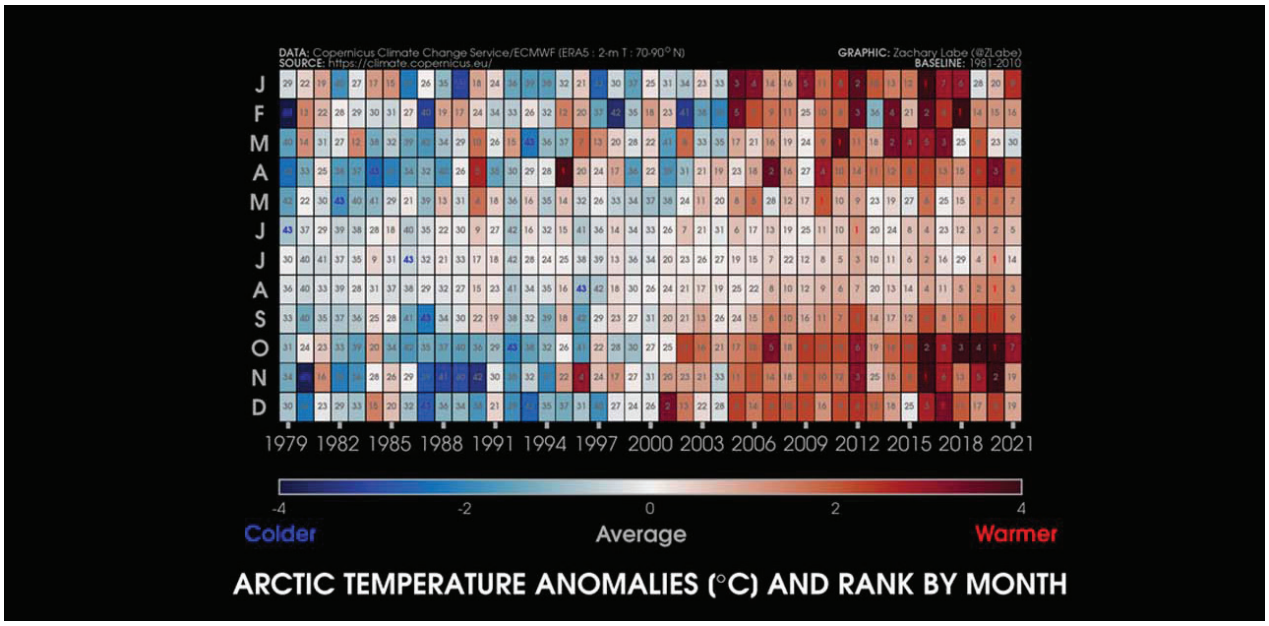
Is the trend extreme or slow and steady? Then, study the use of lines, colors, and shapes. How does this help make the trend clearer to the public? Record your notes in the space provided, and discuss in small groups.



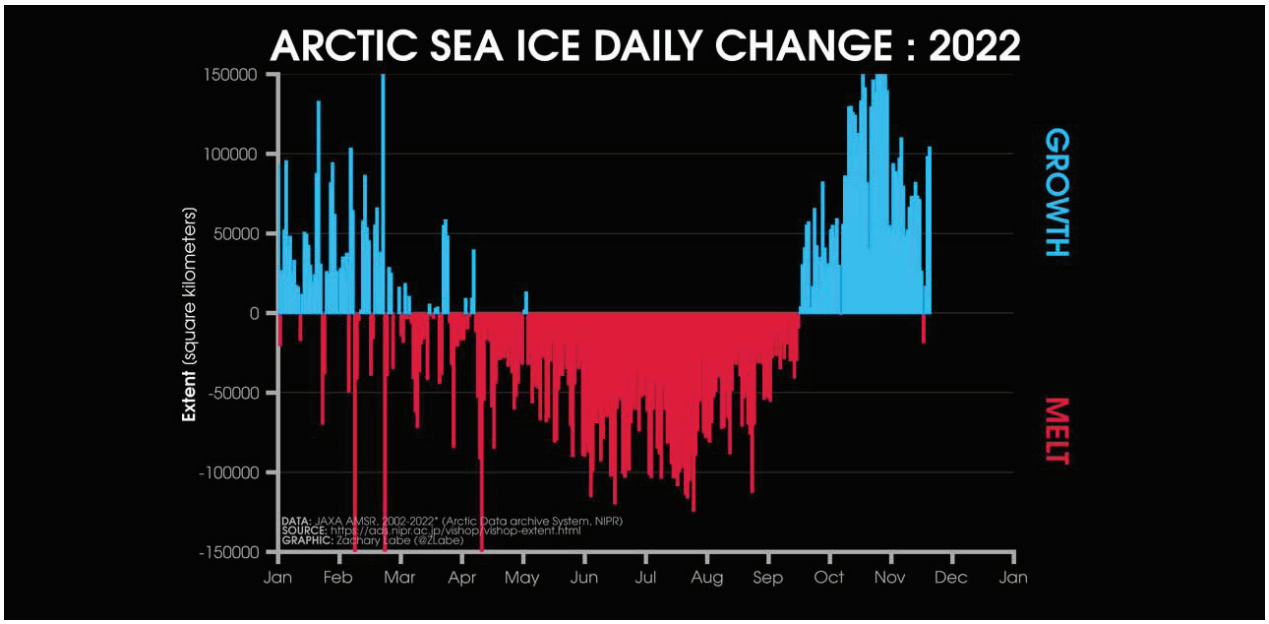
Data Visualization Courtesy of Zachary M. Labe, Ph.d.



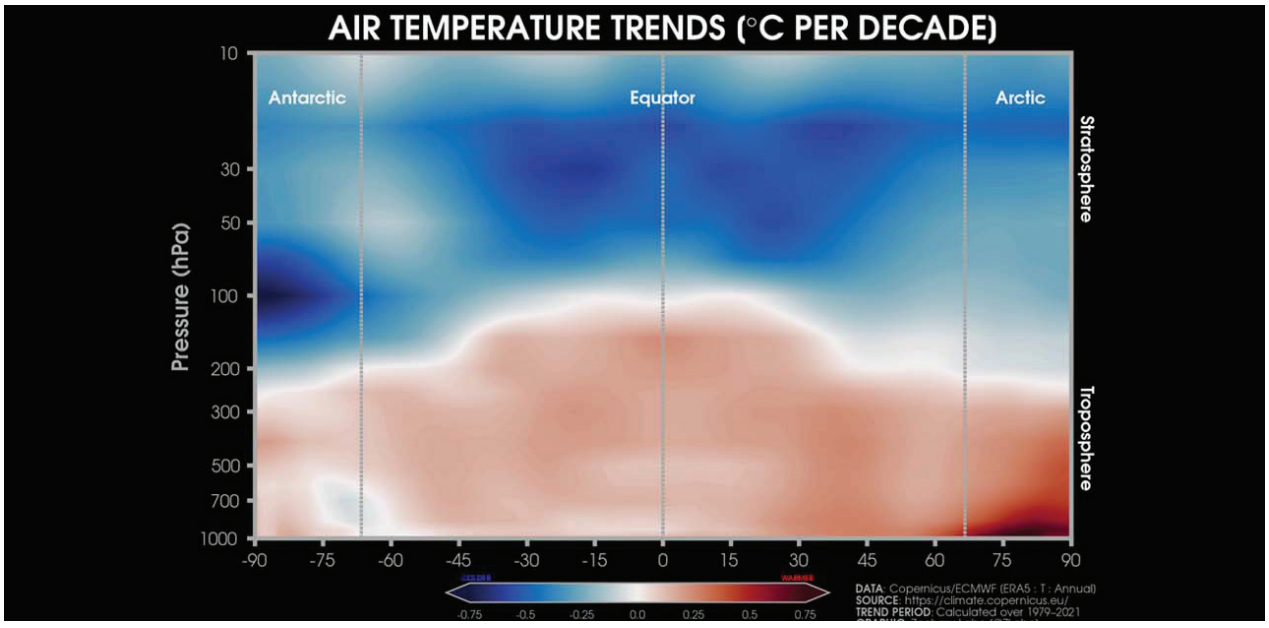
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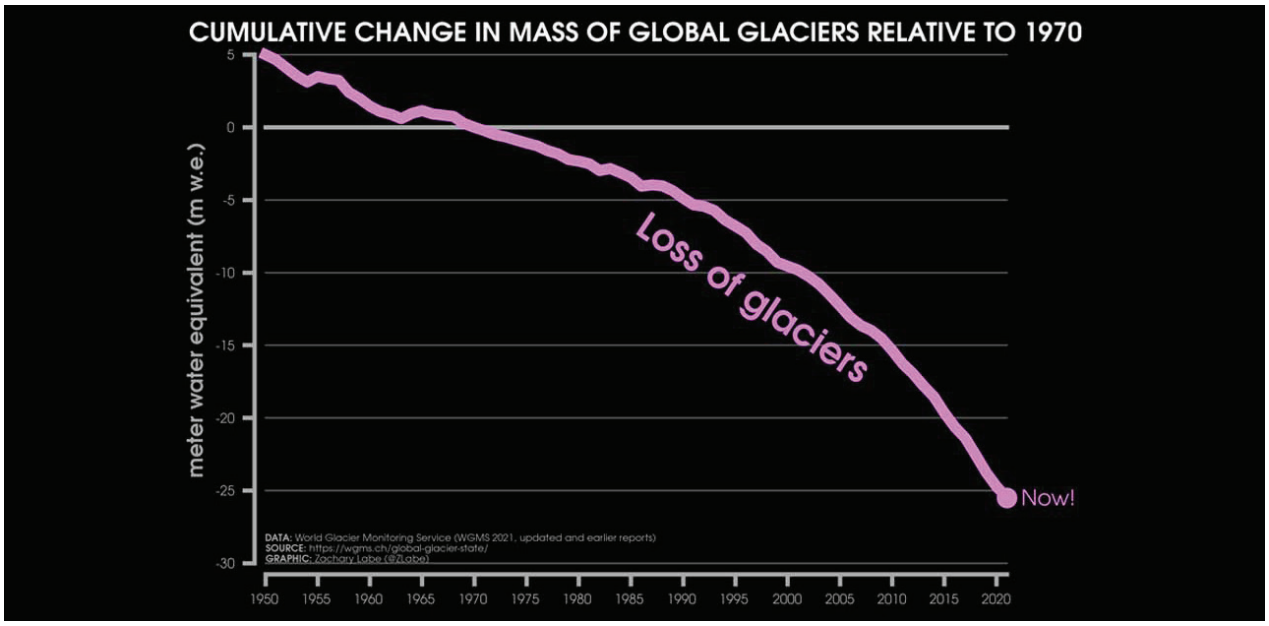
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Become A Climate Scientist

Arctic Visualization Activity Sheet / **EDUCATOR KEY**

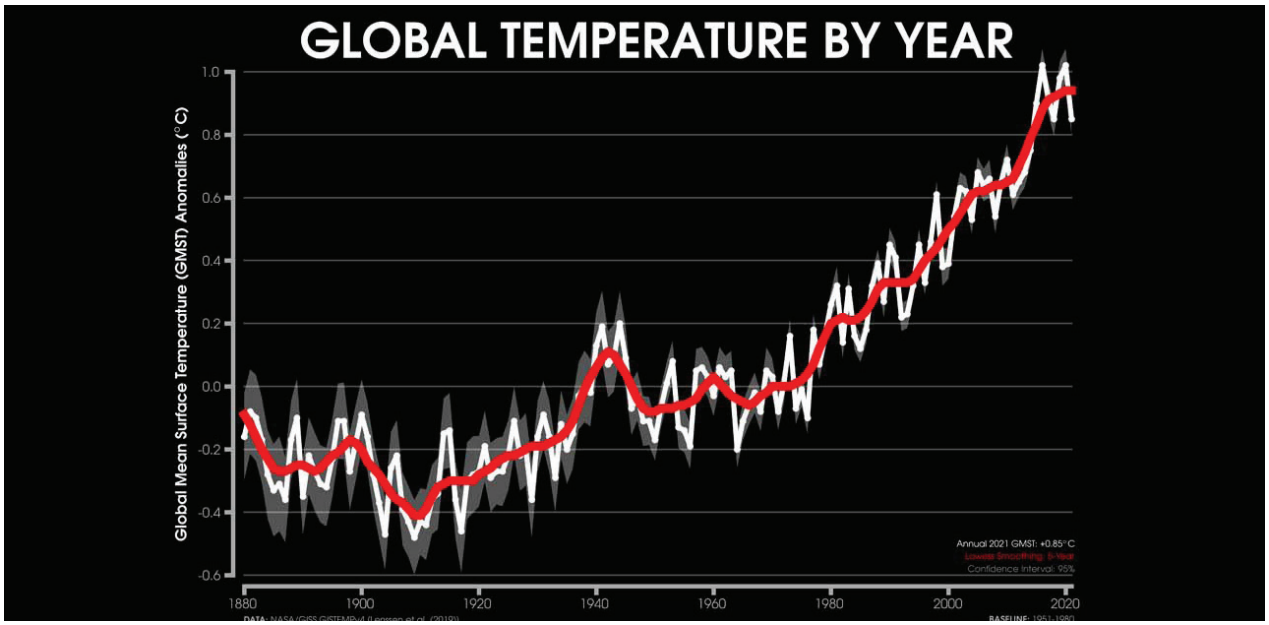
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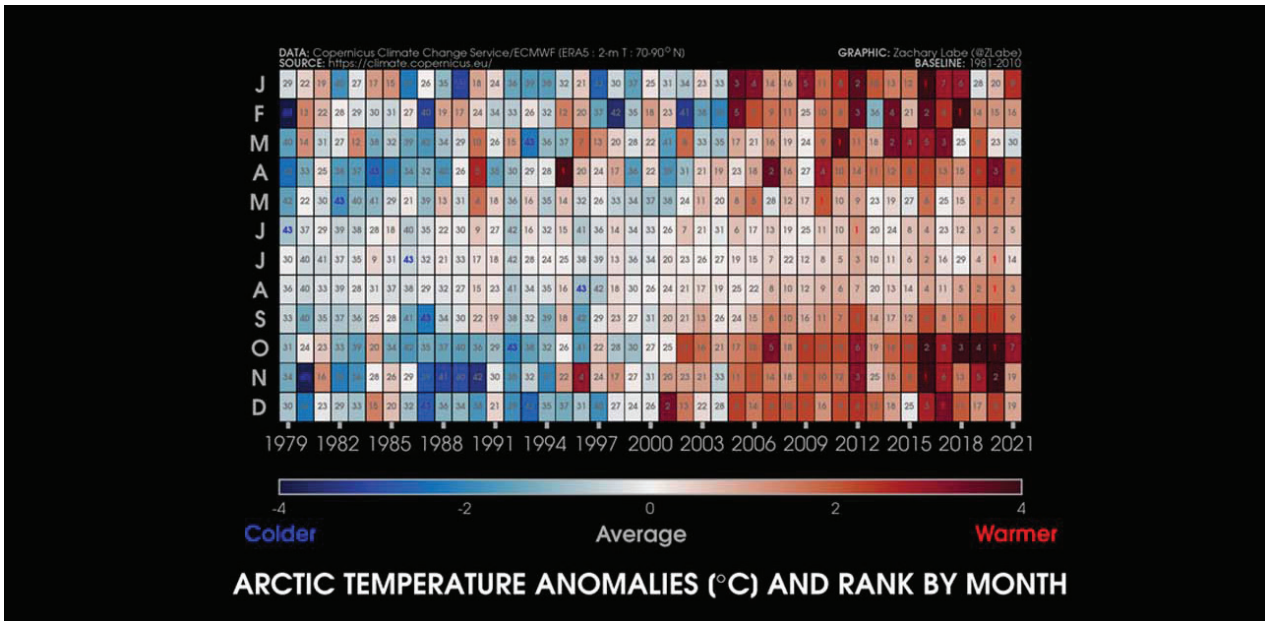
Data Visualization Courtesy of Zachary M. Labe, Ph.d.

This line graph shows the reduction in mass of global glaciers beginning in 1950 and using the amount in 1970 as a refernce point. Over the past 70 years, an obvious trend of diminished glaciers emerges.



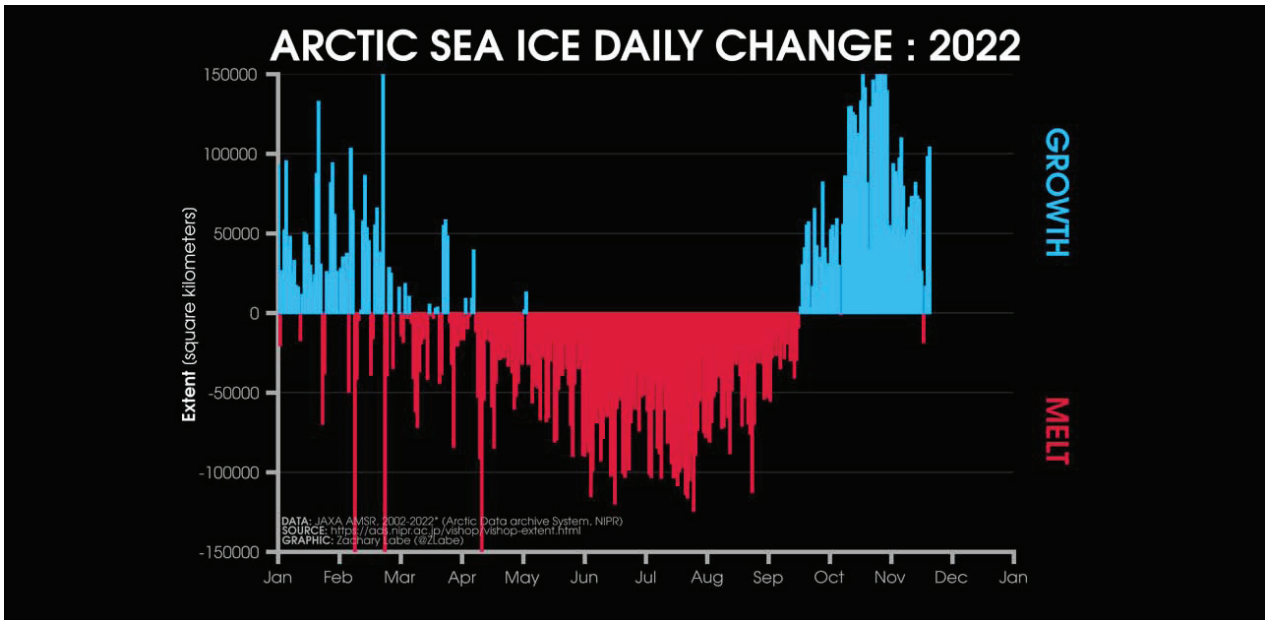
Data Visualization Courtesy of Zachary M. Labe, Ph.d.

This graph seems to show both the up and down nature of temperature over a short period of time, but then the steady upward trend of the line as a whole beginning at about 1930.



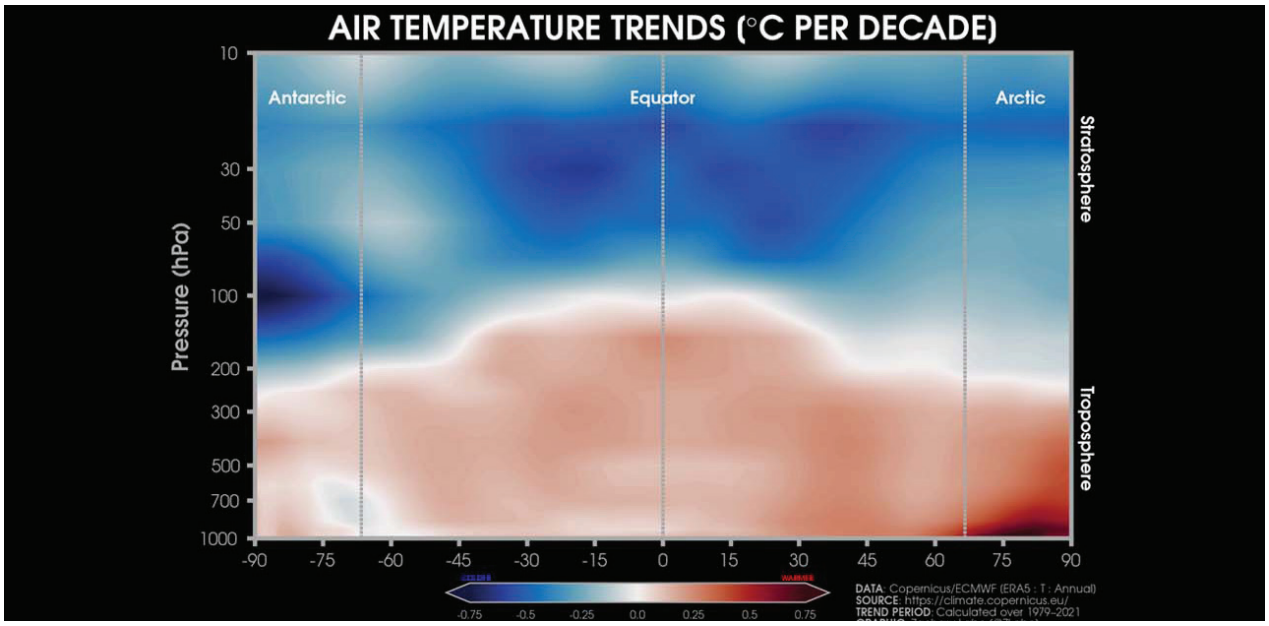
Data Visualization Courtesy of Zachary M. Labe, Ph.d.

Graphs with anomalies can help to show variation or differences in a data set over time. In this graph, we can see that around the early 1990s, the variation increased and the Arctic temperatures become increasingly warmer.



Data Visualization Courtesy of Zachary M. Labe, Ph.d.

This shows the daily change of sea ice for the year 2022 for each month. Growth refers to freezing and we can compare the amount of freezing and thawing that happens over the course of the year and see the trend that emerges: more melting, then freezing.



Data Visualization Courtesy of Zachary M. Labe, Ph.d.

This visualization shows the ways in which mean air temperature changes at different places in the atmosphere.



EDUCATOR GUIDE

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