CFAES
OHIO STATE UNIVERSITY EXTENSION

4-H 613

FOR USE IN 2021

EXPLORING POLAR SCIENCE

THE OHIO STATE UNIVERSITY
COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

Name ______________________________

Age (as of January 1 of current year) ______________________________

County ______________________________

Club or group name ______________________________

Project helper ______________________________

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NOTE TO THE PROJECT HELPER

Congratulations! A 4-H member or other youth has asked you to serve as a project helper. You may be a parent, relative, project leader, friend, club advisor, or another important person. Your duties begin with helping the youth create and carry out a project plan, as outlined in the Project Guide.

As a project helper, it is up to you to encourage, guide, and assist. How you choose to be involved helps to shape the learner's life skills and knowledge of the importance of polar science.

Your Role as Project Helper

Your contributions are critical to delivery of the 4-H program, which is committed to providing experiences that strengthen a young person's sense of belonging, generosity, independence, and mastery. Your interactions should support positive youth development within the framework of the Eight Essential Elements (also known as the Eight Key Elements):

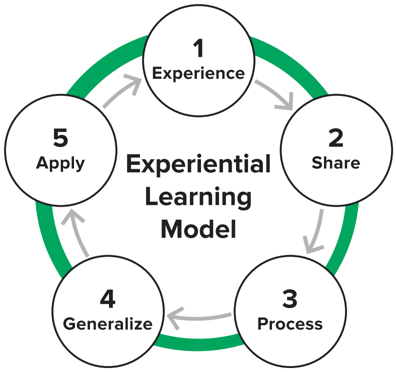
1. A positive relationship with a caring adult
2. An inclusive environment
3. A safe emotional and physical environment
4. Opportunity for mastery
5. Engagement in learning
6. Opportunity to see oneself as an active participant in the future
7. Opportunity for self-determination
8. Opportunity to value and practice service to others

For more information on the Eight Essential Elements, please refer to the *Ohio 4-H Volunteer Handbook* available online at **ohio4h.org**. On a practical level, your role as a project helper means you will strive to do the following:

- Guide the youth and provide support in setting goals and completing this project.
- Encourage the youth to apply knowledge from this project book.
- Serve as a resource person.
- Encourage the youth to go beyond the scope of this 4-H project book to learn more about natural sciences.

What You Should Know About Experiential Learning

The information and activities in this book are arranged in a unique, experiential fashion (see model). In this way, a youth is introduced to a particular practice, idea, or piece of information through an opening (1) **experience**. The results of the activity are recorded on the accompanying pages. The learner then (2) **shares** with the project helper what was done and (3) **processes** the experience through a series of questions that allow for (4) **generalizing** and (5) **applying** the new knowledge and skill.



Pfeiffer J.W., and J.E. Jones, *Reference Guide for Handbooks and Annuals*. ©1983 John Wiley & Sons, Inc. Reprinted with permission of John Wiley & Sons, Inc.

What You Can Do

- Review the Learning Outcomes (project skill, life skill, educational standard, and success indicator) for each activity to understand the learning taking place. See the inside back cover for the Summary of Learning Outcomes.
- Become familiar with each activity and the related background information. Stay ahead of the learner by trying out activities beforehand.
- Begin the project by helping the learner establish a plan. This is accomplished by reviewing the Member Project Guide.
- After each project area is completed, conduct a debriefing session that allows the learner to answer the review questions and share results. This important step improves understanding from an experiential learning perspective.
- Help the learner celebrate what was done well and see what could be done differently. Allow the learner to become better at assessing their own work.
- In the Project Guide, date and initial the activities that have been completed.

PROJECT GUIDE

Welcome to *Exploring Polar Science*! Let's take a close look at the Arctic and Antarctica to learn more about their geography, glaciers and sea ice, and plants and animals. Along the way, consider related careers and how you can help protect these beautiful and unique environments.

This project is intended for youth of any age at the intermediate level—those who already have some experience with topics in natural resources. This is a great next step. You get to be the explorer as you learn about how different—and how exciting!—Earth's North and South Poles really are.

Check your county's project guidelines (if any) for completion requirements in addition to the ones below, especially if you plan to prepare an exhibit for the fair.

The amount of time for each activity varies, but the project is easily completed within one year.

SET YOURSELF UP

Want to get organized ahead of time? Activities 2, 3, and 7 are experiments that require some special materials you might not have at home. They are listed here so you can start gathering them ahead of time. See each activity for a complete list of the materials you'll need.

Activity 2

- 1 tube-shaped, semi-waterproof container, like a Pringles can, rinsed and dried
- instant coffee
- small amounts of different natural materials like gravel, dirt, sand, and dust
- plastic insect or small plant leaf

Activity 3

- two 4-ounce bottles washable school glue, such as Elmer's
- stopwatch
- 2 to 3 tablespoons saline solution, i.e., contact lens solution
- a paint tray
- toothpicks
- sand or gravel, and small stones or pebbles

Activity 7

- permanent marker
- standard-sized loaf pan, approximately 8½ x 4½ x 2½, either a disposable aluminum one or one you already have that is okay to mark on

PROJECT GUIDELINES

Step 1: Complete **all eight** activities and **all** Talking It Over questions.

Step 2: Take part in **at least two** learning experiences.

Step 3: Become involved in **at least two** leadership/citizenship activities.

Step 4: Complete a project review.

STEP 1: PROJECT ACTIVITIES

Complete **all eight** activities and all Talking It Over questions. The More Challenges activities are optional. As you finish activities, review your work with your project helper. Then ask your project helper to initial and date your accomplishment.

Activity	Date Completed	Project Helper Initials
PROJECT AREA: Earth's North and South Poles		
1. Ends of the Earth		
2. A Layer Cake of Snow		
3. Go with the Flow		
Talking It Over		
PROJECT AREA: Life at the Poles		
4. Day in the Life		
5. Web of Life		
6. Can You Say Paleoecology?		
Talking It Over		
PROJECT AREA: The Poles Today		
7. Less Ice Equals More Water		
8. The Future Is Yours		
Talking It Over		

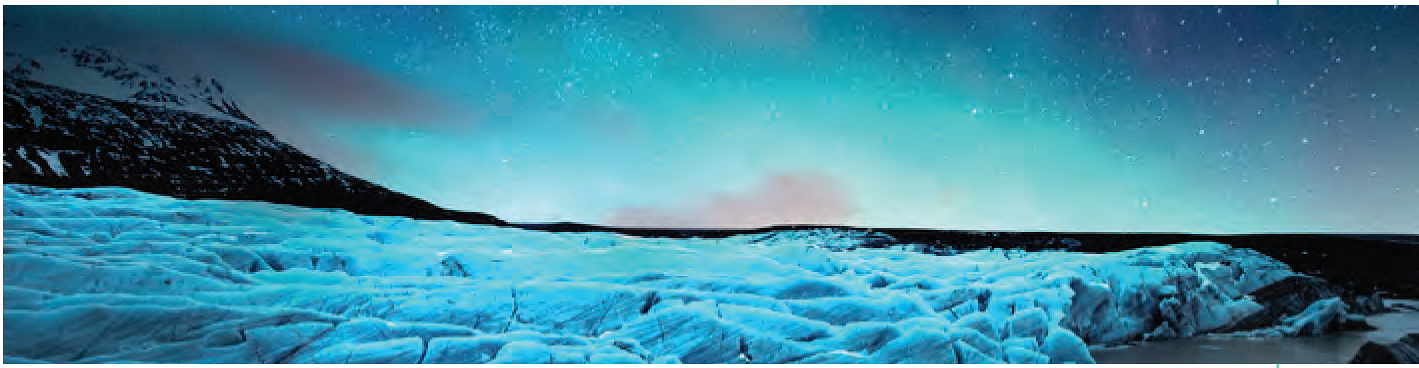
STEP 2: LEARNING EXPERIENCES

Learning experiences are meant to complement project activities, providing the opportunity for you to do more in subject areas that interest you. What are some learning experiences you could do to show the interesting things you are learning about? Here are some ideas:

- Attend a clinic, workshop, demonstration, or speech related to fossils, climate change, the environment, Earth exploration, or any other topic related to natural sciences.
- Help organize a club or group meeting based on this project.
- Go on a related field trip or tour. Consider visiting a college to explore possible areas of study.
- Prepare your own demonstration, illustrated talk, or project exhibit.
- Participate in a county fair or other judging event.
- Plan your own learning experience.

Once you have a few ideas, record them here. Complete at **least two** learning experiences. Then, describe what you did in more detail. Ask your project helper to date and initial in the appropriate spaces below.

Plan to Do	What I Did	Date Completed	Project Helper Initials
Demonstration	Showed others how ocean levels rise as glaciers melt.	5/5/YR	M.H.



STEP 3: LEADERSHIP AND CITIZENSHIP ACTIVITIES

Choose **at least two** leadership/citizenship activities from the list below (or create your own) and write them in the table below. Record your progress by asking your project helper to initial next to the date as each one is completed. You may add to or change these activities at any time. Here are some examples of leadership/citizenship activities:

- Teach someone about ice cores.
- Help another member prepare for project judging.
- Teach a lesson at camp, a club meeting, or school.
- Host a workshop to share tips about careers related to natural sciences.
- Lead a recycling campaign.
- Encourage someone to enroll in this or any natural resources project.
- Arrange for someone who has visited the North or South Pole to speak to your club or other group.
- Plan your own leadership/citizenship activity.

Leadership/Citizenship Activity	Date Completed	Project Helper Initials
Organized a club or group field trip to a natural history museum.	6/12/YR	M.H.

STEP 4: PROJECT REVIEW

All finished? Congratulations! After you have completed the activities in this book you are ready for a project review. This process will help assess your personal growth and evaluate what you have learned.

Use this space to write a summary of your project experience. Be sure to include a statement about the skills you have learned and how they may be valuable to you in the future.

Now, set up a project evaluation. You can do this with your project helper, club leader, or another knowledgeable adult. It can be part of an end-of-project meeting or something more formal such as a county fair or other judging event.

1 PROJECT AREA: EARTH'S NORTH AND SOUTH POLES
ENDS OF THE EARTH

The vast areas of the North and South Poles have attracted explorers for centuries. In the north, traders wanted to shorten the sea route between the Atlantic and the Pacific Oceans. In the south, scientists hoped to use the untouched land and water for research.

Learning Outcomes

Project skill: Making inferences about the North and South Poles based on a map **Life skill**: Processing information **Educational standard**: NGSS 3-ESS2-2. Obtain and combine information to describe climates in different regions of the world.* **Success indicator**: Identifies similarities and difference between the North Pole and the South Pole

* NOTE: The activities in this book support the learning goals for the performance indicators cited, sometimes as described in the performance indicator itself but often by laying the groundwork for learning with reinforcement of the related science and engineering practices, disciplinary core ideas, or crosscutting concepts.

Words in **bold** throughout this book are defined in the glossary.

UNDERSTANDING THE POLES

The **North Pole** is the exact northern-most point on Earth and is found within the **Arctic Ocean**. The entire North Pole region is called the **Arctic**, or the **Arctic Circle**. Its climate is very cold, with average temperatures between 32 and minus 40 degrees Fahrenheit. Despite the cold, people have lived in the Arctic for thousands of years.

The **South Pole** is the exact southern-most point on Earth and is found on a landmass—the continent of **Antarctica**. The entire South Pole region is called the **Antarctic**, or the **Antarctic Circle**. It has the coldest climate on Earth, with average temperatures between minus 18 and minus 76 degrees Fahrenheit. Although it is too cold for people to live permanently in Antarctica, scientists work at research bases there on temporary assignments of 3 to 15 months.

The Arctic Circle and the Antarctic Circle are imaginary lines that circle each polar region at a latitude of approximately 66°. They are usually represented on a globe by dotted blue lines. The areas inside these circles experience six months of daylight and six months of night!

The Arctic (North Pole region) is ocean surrounded by land.

The Antarctic (South Pole region) is land surrounded by ocean.

WHAT TO DO

Estimated time: 40 minutes

Be a better explorer by improving your map reading skills. Study the maps on these two pages and use them to answer the questions that follow.

Arctic Exploration Trivia

1. What is the name of the ocean in the Arctic Circle?

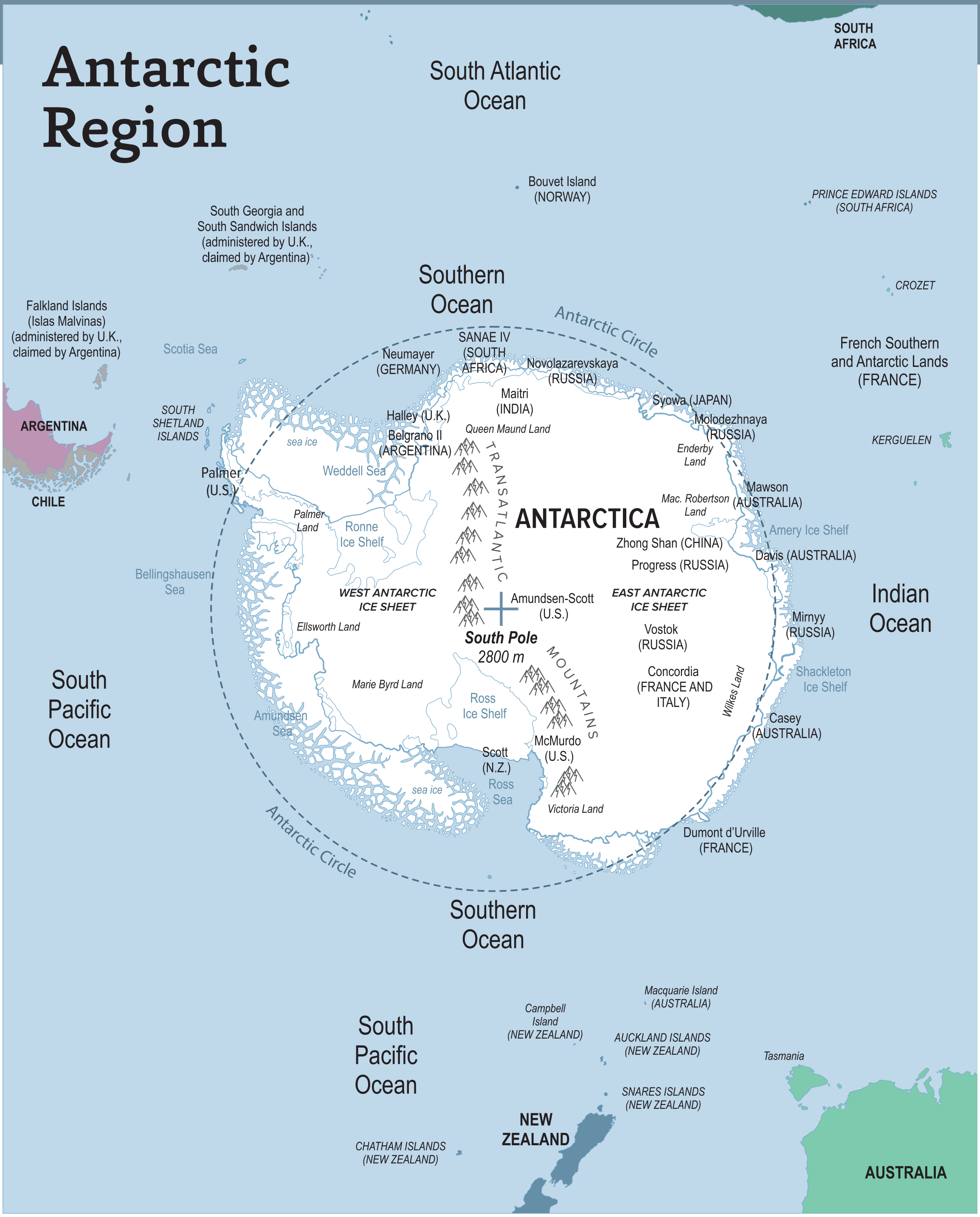
   ____

2. What is the name of one large island in the Arctic Circle?

   ____

3. Name at least four countries that have territory within the Arctic Circle.

   ____



Antarctic Exploration Trivia

1. What is the name of one mountain range in Antarctica?

___

2. What are the names of two ice sheets in Antarctica?

___

3. What other continent is closest to Antarctica?

___

You Are the Explorer

Now that you have had a good look at the maps, you are ready to explore further. What are four differences between the two polar regions you can identify? Write these differences in the spaces on the following chart. Consider land, water, animals, climate, and anything else that comes to your mind.

	The Arctic, in the Northern Hemisphere	The Antarctic, in the Southern Hemisphere
Ex.	*The North Pole is located in an ocean.*	*The South Pole is located on land.*
1.		
2.		
3.		
4.		

More Challenges

Many countries operate scientific research bases on Antarctica. The United States has three: Amundsen-Scott South Pole Station, McMurdo Station, and Palmer Station. Find all three on the map of Antarctica. Based on the geographical features you see, what challenges would you face in traveling to these bases? What stations operated by scientists from other countries are closest to the U.S. stations? If you were going to travel to one, which one would you like it to be? Share your thoughts with your project helper.

See answer key on page 48.

BACKGROUND

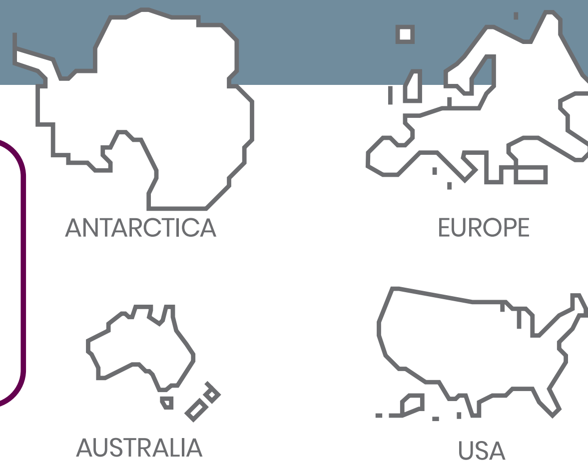
The Antarctic Treaty System, informally known as the Antarctic Treaty, contains policies for international involvement in Antarctica. Antarctica is the only continent that has never had any native people living there. The treaty sets aside Antarctica as a solely scientific preserve and bans any military bases or activity on the continent. The articles of the treaty specify that Antarctica shall be used only for peaceful purposes and that freedom of scientific investigation in Antarctica shall continue for years to come.

Originally, only 12 countries were interested in Antarctica: Argentina, Australia, Belgium, Chile, France, Japan, New Zealand, Norway, South Africa, the Soviet Union, the United Kingdom, and the United States. The treaty became effective in 1961 and is now respected by 54 countries. There are currently 40 permanent, year-round research bases on the continent. Three major ones—McMurdo Station, Amundsen-Scott South Pole Station, and Palmer Station—are run by scientists from the United States.

McMurdo Station, Antarctica during the 2012/2013 summer

Did You Know?

Antarctica is bigger than Europe, almost double the size of Australia, and about 1½ times the size of the continental United States.



Be a Diplomat

Diplomats are officials who represent their country to other countries. Many diplomats have worked together to ensure the protection of Antarctica. To become a diplomat, learn about other countries, study languages, and plan to go to college to study international relations, economics, political science, agriculture, healthcare, etc.

2

EARTH'S NORTH AND SOUTH POLES

A LAYER CAKE OF SNOW

You probably already know about tree rings, the layers of wood created each year a tree grows. They are visible in tree stumps and logs. The thickness of each ring is determined by the environmental conditions the year it was formed. How does this relate to Earth's poles? A new layer of snow falls in the Arctic and Antarctica every year, with the newest snow being on top. The weight of the added snow each year eventually changes the layers below to ice. Like tree rings, these ice layers reveal the environmental conditions the year each layer was formed.

Learning Outcomes

Project skill: Understanding how scientists learn about Earth's poles **Life skill**: Understanding systems **Educational standard**: NGSS 3-LS4-1. Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago. **Success indicator**: Makes a model of an ice core

WHAT TO DO

Estimated time: 2 hours over eight days

Ice cores are cylinders of ice pulled from ice sheets and **glaciers**. They show the horizontal layers of ice that have formed over time, sometimes over long periods. Make your own ice core to show the kinds of things scientists learn by studying them.

Materials

- 1 tube-shaped, waterproof container that can be torn apart, like a Pringles can, rinsed and dried
- liquid measuring cup
- about one quart of refrigerated water
- about one quart of refrigerated water with instant coffee added
- small amounts of gravel, dirt, sand, or dust
- plastic insect or small plant leaf
- blank sheet of paper
- pencil or pen
- rimmed cookie sheet or paint tray

Make the Ice Core

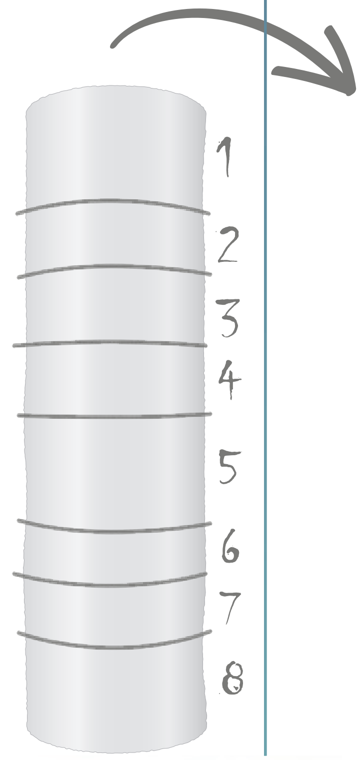
1. Pour the layers in the container, one at a time, following the layer descriptions in the chart below. You are creating an ice core with eight layers, or eight years, of evidence. ***Start with the oldest layer, which is listed at the bottom.***
2. Allow each layer to completely freeze before adding the next one. This usually takes from 12 to 24 hours. To keep track of exactly what is completed, write in the date for each layer when you pour it.
3. After you add the last (top) layer, allow it to freeze. When the core is fully frozen, remove the container by cutting the top with scissors and tearing the cardboard away from the ice. Lay your unwrapped ice core on its side on the cookie sheet or paint tray.

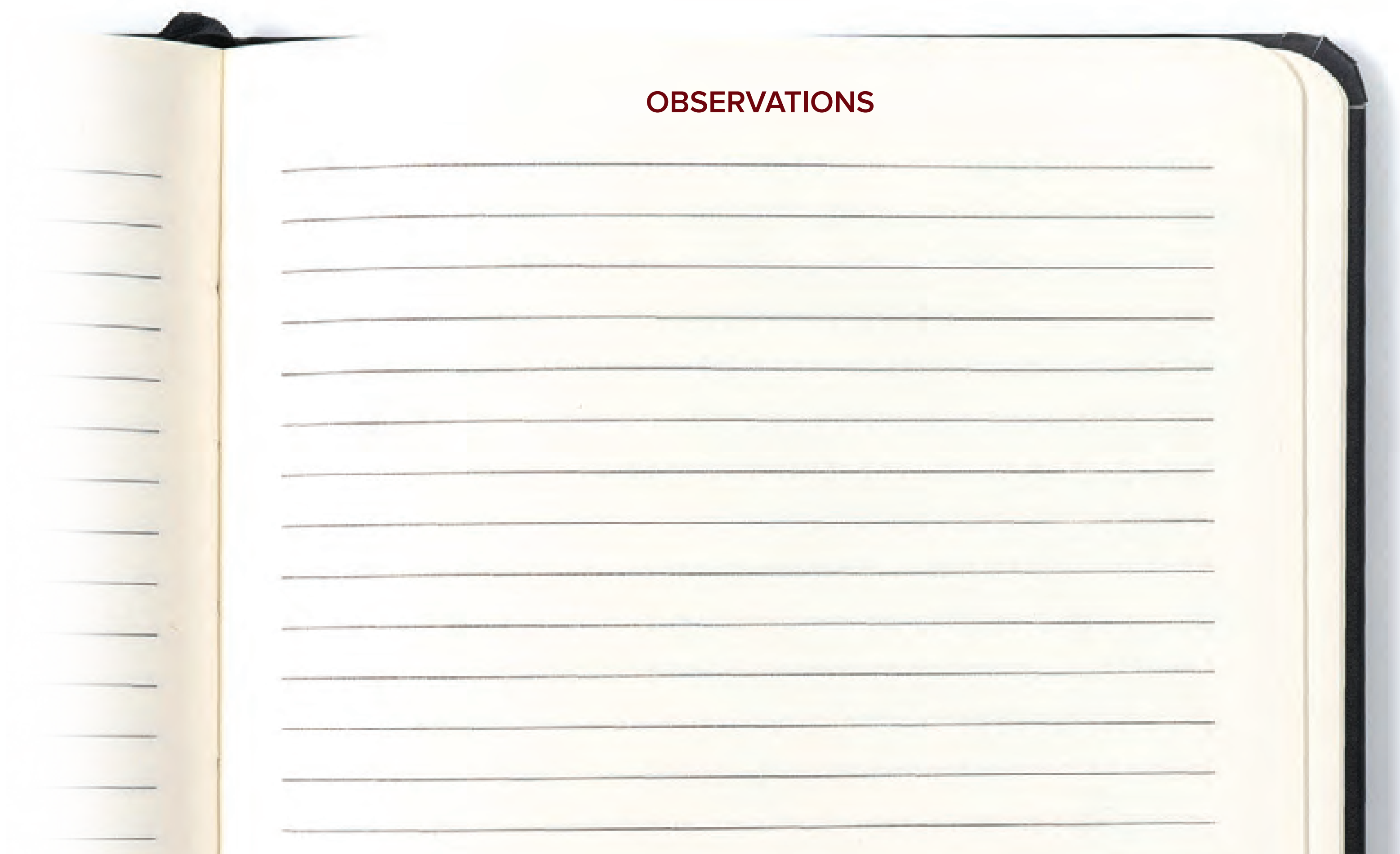
Ice Core Layer Descriptions		
Layer	Material Used to Create	Date Poured
1	½ cup water	
2	¼ cup water with dissolved instant coffee and a plastic insect or leaf	
3	⅓ cup water	
4	⅓ cup water	
5	½ cup water and a teaspoon of gravel, dirt, sand, or dust	
6	¼ cup water with dissolved instant coffee and a teaspoon of gravel, dirt, sand, or dust	
7	¼ cup water with dissolved instant coffee	
8	½ cup water	

Having trouble with your ice core? This video may help! **vimeo.com/125214592**

Examine the Ice Core

1. Use the drawing on the next page to describe your ice core. Draw and number the layers, starting with 1 at the top for the most recent layer. Use colors and labels to highlight special features, like insects, leaves, dirt, etc.
2. Closely observe each layer of ice. Imagine what each layer, if it were real, says about the history of the glacier. Here are some things to think about:
   - The thickness of the layer represents the amount of snow that year. Use the ruler to check for differences.
   - Brown layers indicate there was a lot of dust in the air and the climate was dry. A thin layer of ice that is brown is a good indication of a drought.
   - Gravel material can indicate a volcanic eruption. How many volcanic eruptions are recorded in your ice core? Label them in your drawing.
3. Use the space next to each layer to record your observations and conclusions.
4. Finally, use the space below to write at least four general observations of your ice core. To get started, use your senses. No tasting, but what do you see, hear, feel, and smell?





More Challenges

Explore the polar regions right from your home. Visit **byrd.osu.edu/educator/lessons/virtualice** to view several different expeditions. Share your favorite with your project helper.

Be a Climatologist

Climatologists are scientists who study the Earth's atmosphere and climate. They collect and analyze data from sources such as ice, soil, water, air, and even plant life. They use the data to find patterns in weather and to learn how those patterns affect the Earth and its inhabitants. To be a climatologist, plan to go to college to study environmental science, atmospheric science, geology, and geography.

BACKGROUND

When snow falls, it brings with it anything in the atmosphere at that time. Layers of snow and ice, therefore, contain more than just water. They can contain particles from forest fires and volcanoes, pollen, dust picked up by wind blowing over dry regions, bubbles of gases from the atmosphere, and **chemical tracers**. These materials in ice are rarely visible to the human eye. Scientists need special tools to observe and analyze them.

We learn about the past environment not only from the particles in the layers, but also from the layers' thickness and color. A thick layer means the glacier received a great deal of snow that year. A thin layer means the glacier received little snow. Thin layers also tend to be brown, because during a dry period, the air contains more dust, especially if it was windy.

The layers of a glacier typically are visible in **crevasses**, the places where the glacier breaks. Crevasses, however, do not allow scientists to see the layers very clearly. To see more clearly, scientists have created equipment that allows them to drill ice cores through the entire thickness of the glacier.

> Glaciers are unique records of Earth's past environment. When they melt, those records are lost forever.

Did You Know?

The average thickness of the ice on Antarctica is over a mile!

Resource

NASA's Jet Propulsion Laboratory introduces ice cores on this page: **climate.nasa.gov/news/2616/core-questions-an-introduction-to-ice-cores**.

3 EARTH'S NORTH AND SOUTH POLES
GO WITH THE FLOW

Although 71% of the earth's surface is covered in water, only a very small amount—just 2.5%—is **fresh water**. Most of that fresh water—nearly 70%—is locked in glaciers. These massive sheets of ice greatly impact global climate, local climate, the landscape, and agriculture. In other words, fresh water is a precious resource, and the water locked in glaciers is very important to humans.

Learning Outcomes

PROJECT SKILL: Understanding the significance of glaciers to humans **Life Skill**: Understanding systems **Educational standard**: NGSS 5-ESS2-1. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. **Success indicator**: Builds model of glacier that demonstrates how glaciers move and change the landscape

WHAT TO DO

Estimated time: 1 hour

Make your own glacier to demonstrate how glaciers move and how they change the surface of the Earth.

Materials

- two 4-ounce bottles washable school glue, such as Elmer's
- 1 teaspoon baking soda
- 2 to 3 tablespoons saline solution (i.e., contact lens solution)
- measuring spoons, mixing bowl, and mixing spoon
- paint tray (and small stack of books for propping it up)
- stopwatch or cell phone timer
- toothpicks
- approximately 1/4 cup sand or gravel
- small stones or pebbles

Make Glacier Material

1. Empty both bottles of glue into mixing bowl.
2. Add baking soda and stir.
3. Add 2 tablespoons of saline solution. Stir slowly. The mixture will become a little stringy then begin to harden. Continue stirring.
4. When the mixture becomes solid, pick it up and knead it until smooth. If it is too slimy, work in another ½ tablespoon of saline lens solution.

Investigate

Follow the directions below and answer each question in the space provided.

1. Place your newly created glacier on a flat surface, like a table or counter. What does it do? Real glaciers behave the same way, just much more slowly.

   ____

   ____

2. To measure how far it travels, place your glacier along the top of the paint tray. Mark a starting line at its leading edge. Allow it to travel down the paint tray for 2 minutes. Mark an ending line and measure how far it traveled.

   Distance traveled in 2 minutes: ______________________________

3. Place the glacier at the top of the paint tray again. This time place 5 toothpicks across it. Again, let the glacier travel down the paint tray for 2 minutes. What happens to the toothpicks? Do you think the glacier was traveling faster in the middle or along the sides? This is how glaciers behave in the real world.

   ____

   ____

   ____

4. Repeat step 2 above, but this time increase the steepness of the paint tray by placing some books under the end of the paint tray. Starting the glacier at the same starting line, allow it to travel down the paint tray for 2 minutes. Does it travel faster or slower than it did before? In real life, the steepness of the landscape affects the speed of the glacier.

   Distance traveled in 2 minutes: ______________________________

5. Remove the books from under the paint tray. Create a paint tray landscape with the sand or gravel and small stones by distributing them along the angled portion of the tray. These materials represent what the glacier encounters as it travels. What happens to the things the glacier encounters? Do they stay in the same place or get added to the glacier?

   ____

   ____

In real life, glaciers also pick up materials as they flow across landscapes. Dirt, sand, trees, and even boulders the size of houses get picked up and moved.

More Challenges

Look up more flubber recipes online and try them. Which is your favorite? Make some flubber for a younger friend.

BACKGROUND

Glaciers are massive sheets of ice formed over years of snow and ice buildup. Because of this buildup and the pull of gravity, glaciers flow downhill. You can see why glaciers are sometimes referred to as “rivers of ice.”

Glaciers can generally be divided into two categories: **alpine glaciers** and **continental glaciers**. Alpine glaciers, also called valley glaciers, are in mountainous regions and flow downhill. Continental glaciers, generally much larger, are domed-shaped and flow away from a central region. Due to their size, continental glaciers are typically not affected as much by **topography**.

The large amount of ice is heavy. It exerts a lot of force as it moves over an area, scraping away soil and carving **bedrock**. When the ice melts, vast volumes of water wash away material that is then deposited downstream, creating a variety of **landforms**.

Glaciers are important for humans and agriculture. Many villages in alpine glacial regions depend on their meltwater as a source of fresh water for human consumption and for hydroelectric power. Glacial deposits make excellent soils for crops.

Glacial ice has advanced and retreated many times over the history of Earth. Evidence of these advances and retreats is left behind in the landscape. **Geoscientists** use the evidence to piece together a history of what happened long ago.

Be a Glaciologist

Glaciologists are scientists who study glaciers and their impact on the landscape. To become a glaciologist, plan to attend college and study geology, climate and environmental sciences, physics, and chemistry.

Did You Know?

According to the National Park Service, approximately 20,000 years ago, most of northern North America was covered in ice. The mountains, gorges, valleys and lakes in some of the most popular national parks in the United States are a direct result of glacial action.

More Kinds of Ice

Glaciers are made from ice, but ice forms in other ways, too. An **ice shelf** is a glacier that has moved into the ocean. **Icebergs** are chunks of floating ice that have broken off from an ice shelf. **Sea ice** is ice that has formed over the ocean. **Ice cover** is a thick layer of ice that forms over large areas of both land and water. **Permafrost** is permanently frozen ground that is found under a layer of soil.

TALKING IT OVER

SHARE With the glacier activity in mind, give at least one example of how ice can shape landscapes.

REFLECT If you could travel anywhere in the world to study ice, where would you go? Why?

GENERALIZE Explain what ice cores can tell us about the past environment?

APPLY What can you do to educate others about the role of Earth's ice on humans?

4 PROJECT AREA: LIFE AT THE POLES
DAY IN THE LIFE

Life at the poles is very different from life in the United States. The conditions can be extremely dangerous, even among the beautiful landscapes. What an experience it would be to walk on one of Earth's last true wilderness areas!

Learning Outcomes

Project skill: Imagining life in the Arctic or Antarctica   Life skill: Practicing creativity   **Educational standard**: NGSS 3-ESS2-2. Obtain and combine information to describe climates in different regions of the world.   **Success indicator**: Imagines life in the Arctic or Antarctica and creatively describes it

WHAT TO DO

Estimated time: 1 hour

Pretend you are a scientist who is exploring Earth's poles. Conduct some research about a day in the life of a scientist in Antarctica or the Arctic. What would it be like? Think about the environment (weather, hours of light, etc.), food, housing, and any other aspect of life that affects day-to-day activity.

Write one journal entry or create a piece of art to represent what you experience, what you see, what you eat, what you learn, or what you do. Attach what you write or create to this page. A picture of what you write or create is fine, too.

NEED SOME HELP GETTING STARTED?

Terry Tickhill Terrell was a 19-year-old sophomore at The Ohio State University when she joined the first all-female expedition to Antarctica in 1969. Raised on an Ohio farm, Terrell said her 4-H experience helped her get a spot on the team as a cook and field assistant. She told the expedition leader "I grew up on a farm. I am a hard worker. I'm an outdoor person, and took outdoor cookery (in) 4-H."

The images on this page are actual photos from the expedition. They show what it was like to live and work in Antarctica then. Use these images to imagine yourself as an explorer in the Arctic or Antarctica and write a journal based on those thoughts.

Here are some other possible sources of inspiration:

- A 10-minute video about Antarctica, featured on the PBS Terra YouTube channel: **youtube.com/c/pbsterra?sub_confirmation=1** (search for: *What is it like to live in Antarctica?*)
- The article "'I Went Through the Ice on Day 47:' The Daily Life of a Polar Explorer" by Kathleen Ferraro, in Outside magazine. **outsideonline.com/2156481/what-its-be-polar-explorer**
- A photo journal called *A Day in the Life of Photographer and Arctic Explorer Josh Anon*, published by 500px Blog. **iso.500px.com/a-day-in-the-life-of-photographer-arctic-explorer-josh-anon**

From *The New Explorers: Women in Antarctica by Barbara Land*

"By December, 1969, Lois, Eileen, Terry, and Kay were beginning to feel at home in the unearthly landscape of the Wright Valley. They learned to cope with daily surprises. Rocks that seemed close enough to reach within minutes turned out to be boulders more than a mile away. The clearest, purest air they had ever breathed played tricks on their judgment of distances. Without dust or smoke to cloud the atmosphere, without buildings or trees to lend perspective, they could judge a mile only by walking that mile."

Source: The Ohio State University

More Challenges

Want to take it up a notch? Do a mixed media project with journal writing and an art piece. Or dress up as an explorer and give an interview that you record. Let your creative juices flow!

Be an Oceanographer

Oceanography is the study of the ocean, including the organisms that live there, the **ecosystems**, circulation of ocean water, and the chemical and physical characteristics of the ocean and sea floor. To become an oceanographer, take courses in chemistry, biology, geology, and zoology.

BACKGROUND

The North and South poles are different in many ways. One thing they have in common, however, is important scientific research.

Over 70 scientific research bases—permanent, year-round facilities and summer-only ones—established by 27 countries are present in Antarctica. One of the most prominent bases is McMurdo, which is run by the United States. It can house more than 1,000 scientists at a time, summer or winter. Researchers of varying disciplines study here, including biologists, climatologists, **paleontologists**, geologists, **oceanographers**, **meteorologists**, and **astronomers**. They study everything from climate change and meteorites to animal-human interactions and more!

The Arctic is primarily a deep ocean with a thin layer of sea ice on top that is slowly thinning over time. Therefore, the research conducted there is a little different than that done in Antarctica. The first major science expedition to the Arctic was in the 1800s. Since then, scientists from every polar nation have traveled to the Arctic Ocean to study its **oceanography**, geology, biology, and chemistry.

Did You Know?

Even though dogs are known as man's best friend, they have not been allowed in Antarctica since 1994. Along with other non-native species, they are banned so that native animal species are protected from **predation** and disease. Source: Vintage News

Resources

Learn more about Terry Tickhill Terrell's experience at **go.osu.edu/terryterrell**.

Check out the virtual polar expedition at **go.osu.edu/dryvalleysvr**. It is breathtaking!

5 PROJECT AREA: LIFE AT THE POLES

WEB OF LIFE

Arctic Cottongrass

One of the fascinating aspects of both the Arctic and Antarctica is how plants and animals thrive in extreme cold. It might seem as if very little manages to survive. Both environments, however, are home to many living **organisms**. One way to see that is to look at a **food web**.

Learning Outcomes

Project skill: Understanding polar environments and their ecosystems **Life skill**: Understanding systems **Educational standard**: NGSS 3-LS4-3. Construct an argument with evidence that in a particular habitat some organisms survive well, some survive less well, and some cannot survive at all. **Success indicator**: Designs a food web for a polar ecosystem

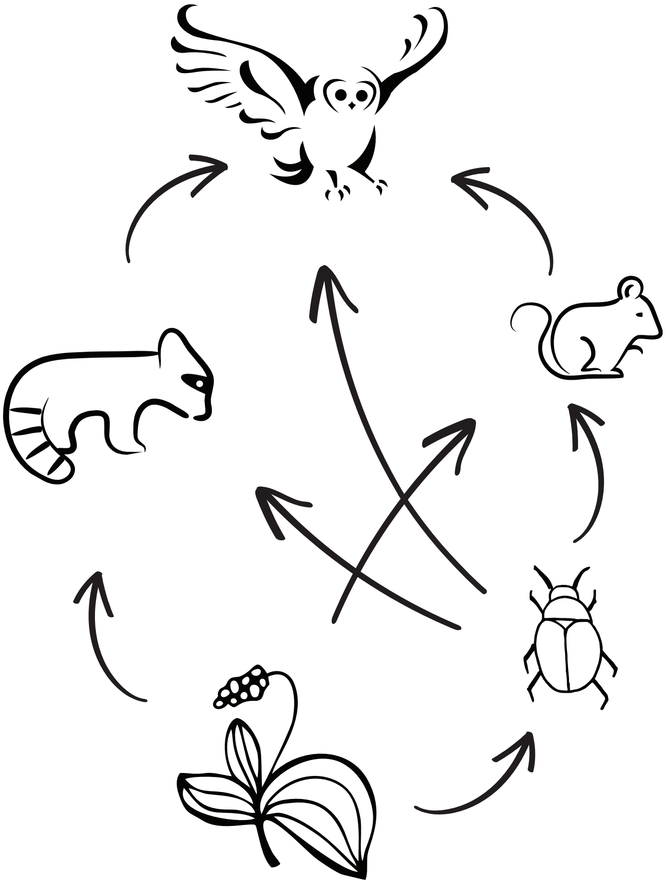
WHAT TO DO

Estimated time: 2 hours total for parts 1 and 2

Part 1: Building a Food Web

A **food web** is a description of the relationships between the plants and animals within a specific **ecosystem**. You might say it is a map of what eats what!

In the land-based food web example below, the arrows show that the mouse is eaten by the owl; the beetle is eaten by the mouse, owl and racoon; the plant is eaten by the beetle, mouse and racoon; the racoon is eaten by the owl; the owl is not eaten by anything; and the plant does not eat anything.



On the next page, make a food web of the Arctic by cutting out the accompanying squares. Place them in the food web where you think they belong. The arrows point from the food to the organism that eats it. Sometimes, multiple arrows are needed because an organism eats more than one thing or is eaten by more than one thing. To get started, check out the example and tips below.

FOOD WEB TIPS

One way to build a food web is to start with individual **food chains**. Ask yourself, who is a predator and who is prey? Multiple food chains combine to make a food web.

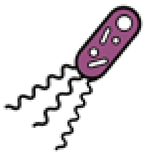
Put each organism into a likely category. Is the organism . . .

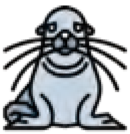
- a **producer**, or something that makes its own food, like a plant?
- an **herbivore**, or something that eats plants?
- a **predator**, or an animal that eats other animals?
- a **top predator**, or an animal that eats other animals but does not have anyone eating it?

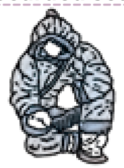
Organisms in a food web are typically arranged with producers near the bottom of the web and predators near the top.

An arrow in a food web points from the food source to the organism that eats it. It is possible for an organism to interact with more than one other organism in the ecosystem, so multiple to-and-from arrows are likely.

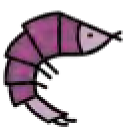

Arctic cod

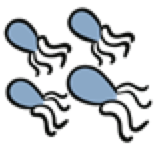

bacteria


bearded seal

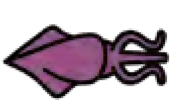

human


ice algae


krill

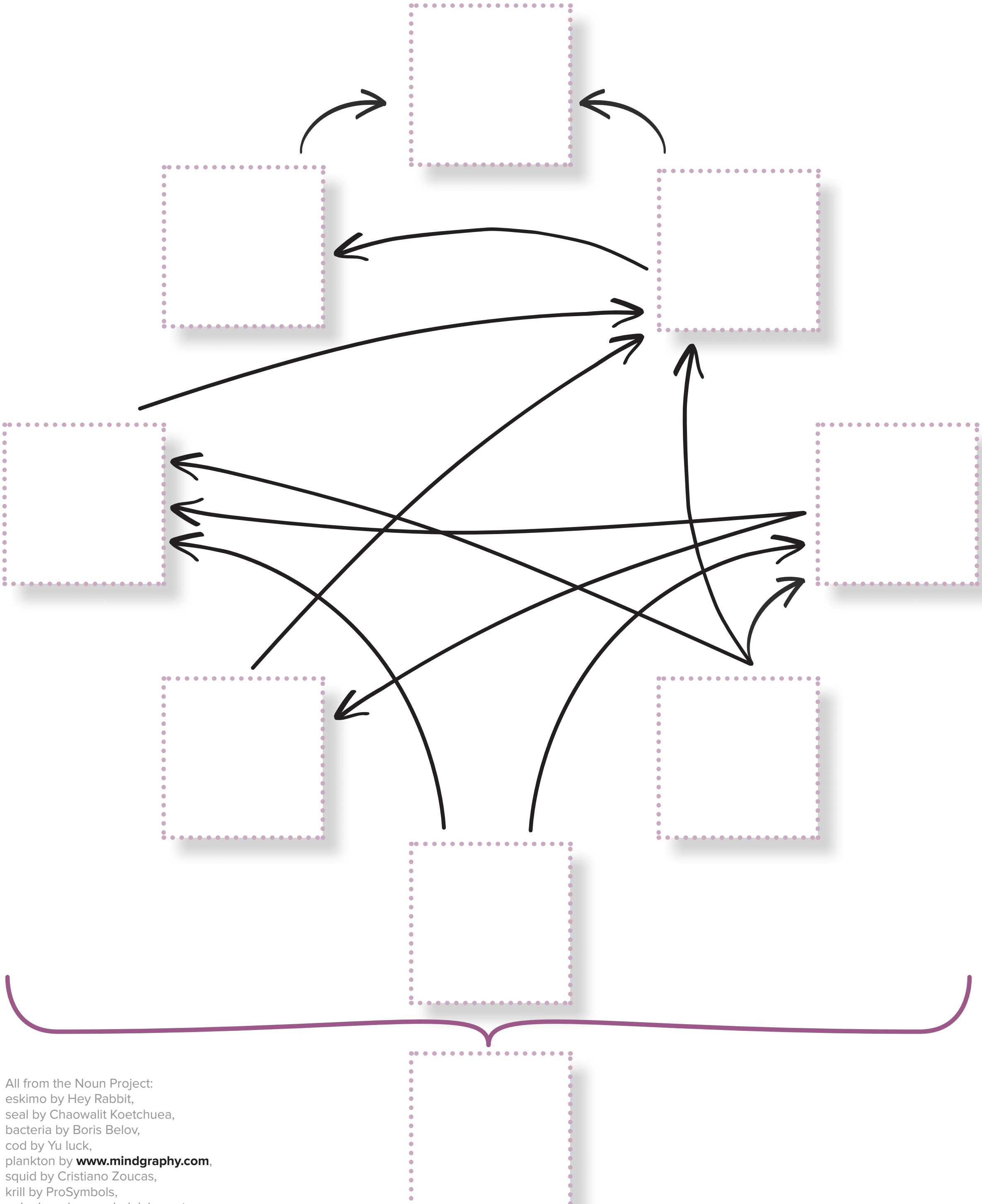

phytoplankton


polar bear


squid

ARCTIC FOOD WEB

Organisms include Arctic cod (a fish), **bacteria**, bearded seal, human, **ice algae**, **krill**, **phytoplankton**, polar bear, and squid. A good place to start is by putting bacteria at the very bottom. The bracket means everything is eventually eaten by bacteria.

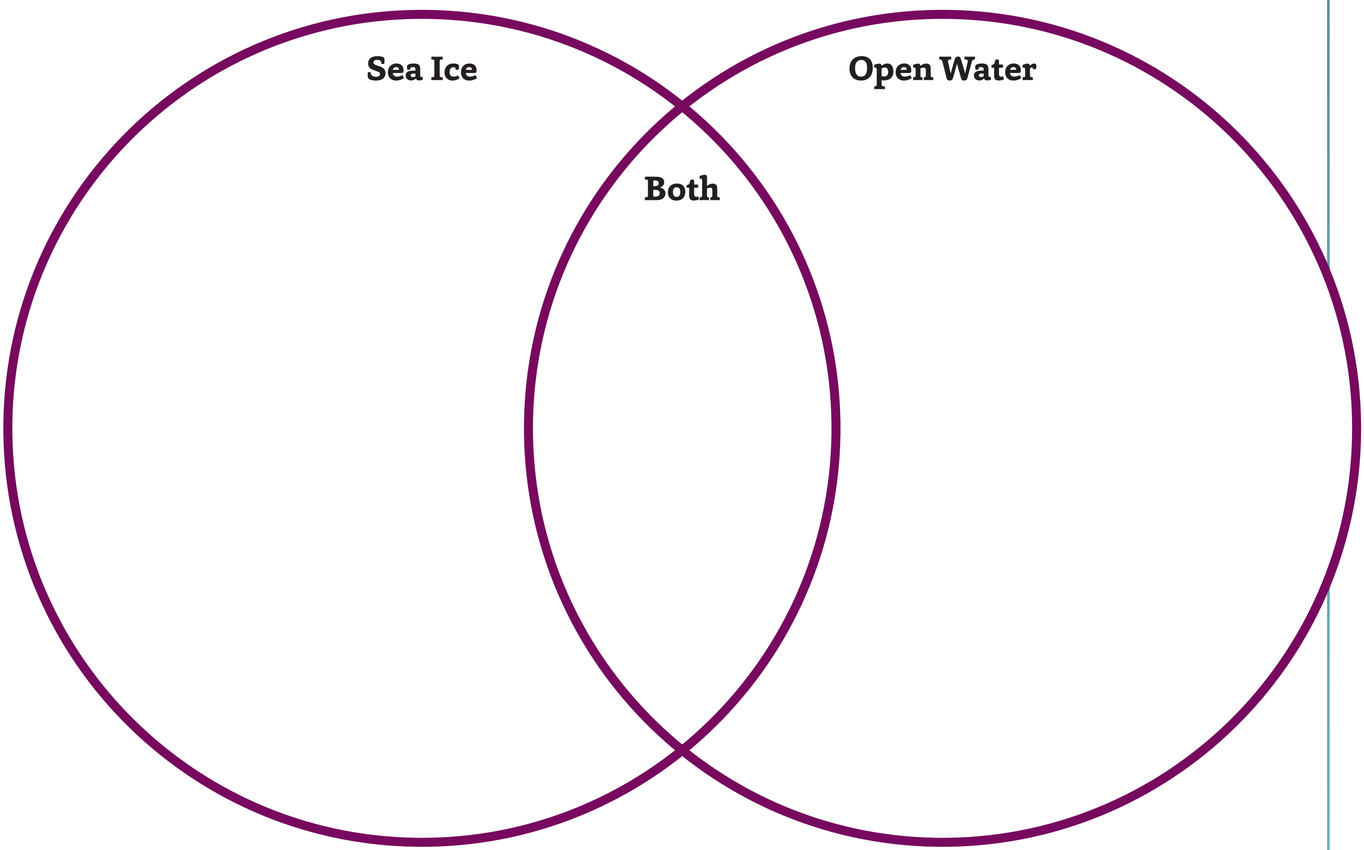


All from the Noun Project:
eskimo by Hey Rabbit,
seal by Chaowalit Koetchuea,
bacteria by Boris Belov,
cod by Yu luck,
plankton by **www.mindgraphy.com**,
squid by Cristiano Zoucas,
krill by ProSymbols,
polar bear by supalerk laipawat

See answer key on page 48.

Part 2: Creating a Venn diagram

Sea ice is ice that forms on the ocean. It is important to the Arctic food web, too. What organisms in the food web depend on sea ice for food? Which ones depend on the open water? Which rely on both sea ice AND open water? Write you answers in this **Venn diagram**.



See answer key on page 48.

More Challenges

Imagine that the Arctic Ocean warmed, and the sea ice disappeared. What living things in the food web might be affected? Would their populations increase or decrease? Why? Share your thoughts with your project helper.

BACKGROUND

Although they appear similar, there are significant differences between the Arctic and Antarctica.

The Arctic is simply a large ocean with a thin layer of ice floating on it, but there is no actual land mass beneath it. Antarctica, on the other hand, is an entire continent covered by a thick layer of ice.

Some species in the Arctic require ice cover over the ocean to survive. For instance, polar bears use the ice as a platform over the ocean and look for holes where ringed seals surface. To give birth, ringed seals make lairs in snowbanks above the ice. And ice algae grow within and on the bottom of the floating ice.

In addition to the species that live in the ocean, the Arctic is inhabited by land mammals, such as the arctic wolf, arctic fox, muskox, reindeer, ermine, and polar bear. Their special insulated fur allows them to survive and thrive. In contrast, all mammals in Antarctica depend on the ocean.

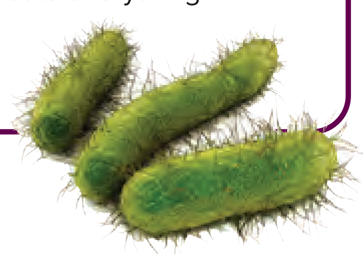
It is cold there, but no penguins live in the Arctic. All species of penguins live in the Southern Hemisphere, and many live in Antarctica. In addition to penguins, other marine birds in Antarctica include albatross, petrels, skuas, and sheathbills.

The oceans around the Arctic and Antarctica have whales, krill, plankton, and seals. For Antarctic animals to survive they have special adaptations such as blubber fat for insulation to keep them warm.

Ecosystems in the Arctic and Antarctica are very different. As a result, the organisms that live there are different too. As their environments change, some of the plants and animals are endangered. Sadly, changes in the environment are often caused by human activity.

Did You Know?

Bacteria is considered a **decomposer** and eventually eats everything!



Be an Ecologist

Ecologists study the relationships between organisms and their environments. You can become an ecologist by going to college and majoring in environmental sciences, biology, or natural resources management.

Resources

Designed by two professors of Arctic research, EcoChains: Arctic Life is an educational card game that illustrates how food chains are changing because of melting sea ice. It is available for sale at **ecochainsgame.com**.

What do all the scientists in Antartica eat? Get a fun, behind-the-scenes tour of a research station kitchen from PBS Terra in the video What Do You Eat in Antartica? at **youtube.com/watch?v=pzlA9HDNwBs**.

PROJECT AREA: LIFE AT THE POLES

6 CAN YOU SAY PALEOECOLOGY?

Who would have thought that scientists would find **fossils** of dinosaurs and other warm-climate loving animals in Antarctica? They have, though! The Earth is constantly changing its formations, temperatures, and appearance. In the **Mesozoic Era**, Antarctica looked very different.

Learning Outcomes

Project skill: Making inferences from natural evidence **Life skill**: Using scientific methods **Educational standard**: NGSS 3-LS41-1. Analyze and interpret data from fossils to provide evidence of organisms and the environments in which they lived long ago. **Success indicator**: Makes inferences from fossil records

WHAT TO DO

Estimated time: 30 minutes

Fossils are important clues to ancient life. Upon close inspection, they reveal very detailed scientific information. Review the pictures and information about each fossil below.

Fossil 1: Cryolophosaurus ellioti

The fossils that are the basis of this replica are 194,000,000 to 188,000,000 years old. The animal measured approximately 21.3 feet long, weighed 1,025 pounds, and was a **theropod** (three-toed). It lived on land in a warm climate. Based on the structure of its teeth and arms, this dinosaur was most likely a **carnivore** (meat eater).

Fossil 2: Pachypteris indica (sample PRR 21916)

This fossil is from 154,000,000 to 100,000,000 years old. A type of early fern, this plant grew on land in a warm climate. It was probably eaten by animals that were **herbivores** (plant eaters).

Fossil 3: Ammonite (sample PRR-20160)

This fossilized shell is from 154,000,000 to 66,000,000 years old and measures 18 inches across. It belonged to a squid-like animal that lived in warm water. Scientists believe these animals ate small marine creatures like shrimp.

Fossil 4: Gastropod (sample PRR-20163)

This fossil is from an animal in the **gastropod** group, which includes snails and slugs. It measures 11 inches across.

Source: The Ohio State University

For a closer look at *Cryolophosaurus ellioti*, go to **vimeo.com/388922190**. Dr. David Elliot, an earth sciences professor at The Ohio State University, describes the experience of discovering this fossil.

See the other fossils in 3D at **byrd.osu.edu/3d-polar-fossils**. It's almost as if you have them in your hands!

Now, use what you have learned to make inferences about Antarctica's past. For each statement below, use a check to indicate if the statement is true, the statement is false, or there is not enough evidence to say.

Statements	True	False	Not Enough Evidence to Say
1. At one time, Antarctica was not covered in ice and was a warm tropical area.	✓		
2. Thousands of years ago, Antarctica was a very cold place.			
3. Millions of years ago, the water at the South Pole was warm.			
4. Millions of years ago, the water at the North Pole was warm.			
5. Some fossils from Antarctica are from animals very similar to animals that live other places on Earth today.			
6. Meat-eating dinosaurs once roamed Antarctica.			
7. All sea creatures feed on small fish.			
8. Whether in the past or present, ferns live in warm environments.			
9. Fossils from Antarctica show that some creatures lived on land and some lived in water.			
10. Turtles, which have shells, are gastropods.			
11. Dinosaurs and ammonites became extinct at the same time.			
12. Paleontologists use toe bones to determine if an animal ate meat or plants.			

See answer key on page 48.

More Challenges

Obtain at least one fossil specimen and learn about the environment in which the animal lived. Make a diorama or draw a picture with the fossil in it. Explain what you learn to another person.

BACKGROUND

Paleontologists are scientists who study the biological and geological history of the earth through fossils. Fossils are any evidence of Earth's past and can include bones, shells, footprints, or plant imprints in rocks. To be considered a fossil, the evidence must be at least 10,000 years old.

One branch of paleontology is **paleoecology**. Paleoecology uses the data of fossils to reconstruct the ecosystem of the past. This includes the life, behavior, death, and environment of organisms that lived thousands and millions of years ago. Paleoecology's goal is to build the most detailed history of earth. These are called **paleoecological reconstructions**.

Did You Know?

Cryolophosaurus, shown in this activity, is the most complete dinosaur skeleton ever found in Antarctica.

Be a Paleontologist

Paleontologists are scientists who study the biological and geological history of the Earth through fossils. They often work with archaeologists, who study human artifacts and remains. Although paleontologists and archeologists sometimes work side by side, they study very different things.

PROJECT AREA: LIFE AT THE POLES

TALKING IT OVER

SHARE Would you like to visit or perhaps even live in the Arctic or Antarctica? Why or why not?

____

____

____

REFLECT If an ecosystem is disrupted—because of a change in the environment, like pollution or warmer temperatures—what do you think happens to the food web?

____

____

____

GENERALIZE How has the presence of humans changed life on Earth? Give at least two examples.

____

____

____

APPLY Do you see evidence of the work of natural scientists in your life? Identify and briefly describe at least one example.

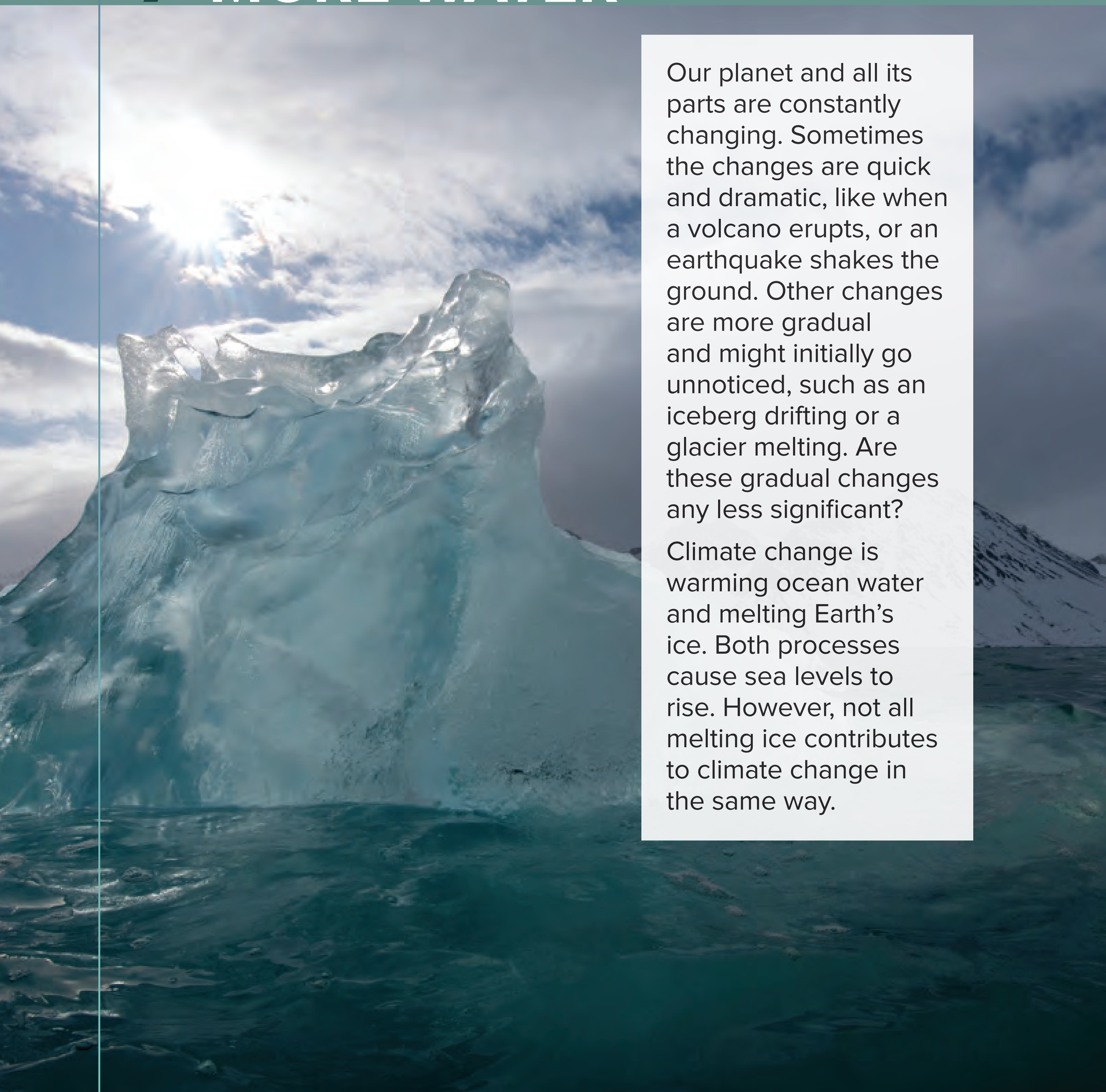
____

____

____

PROJECT AREA: THE POLES TODAY

7 LESS ICE EQUALS MORE WATER



Our planet and all its parts are constantly changing. Sometimes the changes are quick and dramatic, like when a volcano erupts, or an earthquake shakes the ground. Other changes are more gradual and might initially go unnoticed, such as an iceberg drifting or a glacier melting. Are these gradual changes any less significant?

Climate change is warming ocean water and melting Earth's ice. Both processes cause sea levels to rise. However, not all melting ice contributes to climate change in the same way.

Learning Outcomes

Project skill: Measuring effect of melting ice on water volume **Life skill**: Reasoning **Educational standard**: NGSS 5-ESS2-1. Develop a model using an example to describe the ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. **Success indicator**: Conducts experiments to show effect of melting ice on water volume

WHAT TO DO

Estimated time: 1 hour over two days

What affects sea level more—melting sea ice (ice that floats on water, like that in the Arctic) or a melting glacier (land-based ice, like that in Antarctica)? Find out by modeling each one and comparing the results.

Materials

- permanent marker
- ruler
- standard-sized loaf pan, approximately 8½ x 4½ x 2½ (either a disposable tin pan or one from around the house that it's okay to mark on)
- 24-ounce, round, plastic bowl or food storage container (like a small deli container)
- small glass or bowl at least two inches tall (It should be small enough to fit in the loaf pan.)
- water

You can cut your time in half by using 2 loaf pans, 2 plastic bowls/containers, and 2 small glasses/bowls. Melt sea ice and a glacier at the same time.

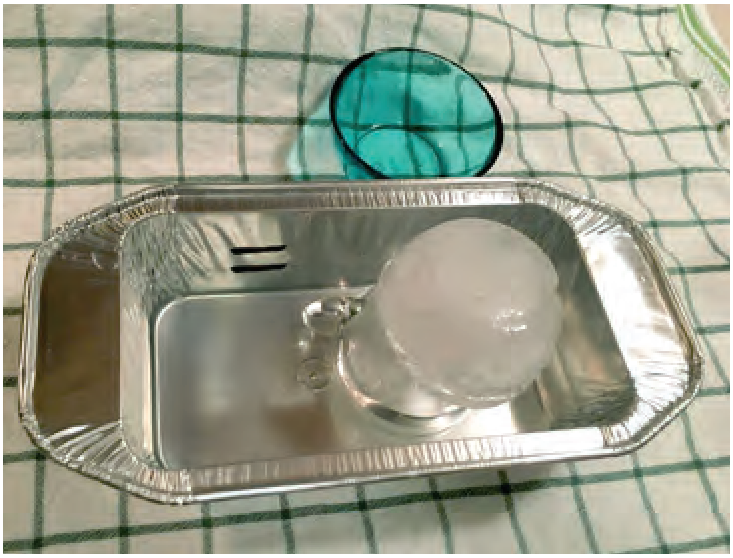
Melt Sea Ice

1. Fill the plastic container with 1 cup of water. Place it in the freezer overnight.
2. The next day, place the ruler vertically inside the pan, along any side. Measure one inch up from the bottom and, using the permanent marker, make a small mark.
3. Take the ice out of the container and place it in the pan. This represents a large piece of sea ice. Add water up to the mark you made. This is the starting water level.
4. Leave the materials at room temperature until the ice is completely melted. Mark the new water level near to the first mark. This is your ending water level for the sea ice. Pour out the water. Measure and record its distance from the bottom of the pan in the table on the next page.

This is the set-up for melting sea ice. When the ice has melted, mark the new water level.

Melt a Glacier

1. Fill the plastic container with 1 cup of water. Place it in the freezer overnight.
2. The next day, check the inside of your pan to make sure you can still see the mark for starting water level.
3. Place a small glass or bowl upside down in the middle of the pan. This represents a land mass. Add water to the 1-inch mark.
4. Take the ice out of the container and place it on top of the glass or bowl. This represents a glacier.
5. Leave the materials at room temperature until the ice is completely melted. Mark the new water level near to the first mark but away from the other previous mark. This is your ending water level for the glacier. Measure and record its distance from the bottom of the pan in the table below.



This is the set-up for melting a glacier. When the ice has melted, mark the new water level.

	Ending Water Level	Starting Water Level	Change (Ending Water Level minus Starting Water Level)
Sea Ice		1 inch	
Glacier		1 inch	

Based on your observations, which kind of melting ice affects sea level more? Explain.

____

____

____

See answer key on page 48.

More Challenges

Greenhouse gases cause warming of the Earth's atmosphere, which in turn causes more ice to melt. Help change this chain of events by modeling different behavior. Become an active participant in a reduce-reuse-recycle program, join a tree-planting effort, celebrate Earth Day, etc. Share what you do with your project helper.

BACKGROUND

Glaciers and the snow packed on mountaintops may seem permanent, but they are not. Just like an ice cube melting on a kitchen counter, if the temperature gets warm enough, they melt.

Scientists have been studying the large continental glaciers in polar regions and their surrounding landscapes for more than 100 years. They have learned that glaciers have advanced and retreated over extremely long time periods.

Sometime in Earth's past, continental glaciers grew extremely large, trapping the water that fell as snow. During these times, the water could not return to the oceans, so ocean levels dropped. At other times, the continental glaciers melted, returning water that was trapped on land into the oceans, making sea levels rise. Like a seesaw, more water trapped on land glaciers means less water in the oceans. Less water trapped on land in glaciers mean more water in the oceans.

Many of earth's glaciers are found in Greenland and Antarctica. Greenland, the world's largest island, is located northeast of the United States and lies partially within the Arctic Circle. Scientists continue to monitor continental glaciers in both Greenland in the north and Antarctica in the south. If all of Greenland's continental glaciers melted, ocean levels would rise by 25 feet, but if all of Antarctica's continental glaciers melted, ocean levels would rise over 200 feet! The impact on people around the planet would be dramatic. Cities and large regions of land located at sea level would flood.

While scientists do not think all the ice in Greenland and Antarctica will melt, there is a lot of melting occurring due to our changing climate. At its current rate, the global sea level will rise 1 to 5 feet by the year 2100. The major causes of this melting are the warming of our atmosphere and oceans, which is the result of greenhouse gases emitted from fossil fuel burning.

Be a Hydrologist

Hydrology is the study of the water on earth and other planets, including its location, movement, how it is used and how it is sustained. A **hydrologist** might predict that the level of water in a lake will continue to drop, or where snowfall will be distributed in mountainous regions. To become a hydrologist, take courses in chemistry, biology, geology, and zoology.

Did You Know?

Icebergs are pieces of glaciers or ice shelves that have broken off.

Resource

Watch this video of Bill Nye, the famous American science educator and entertainer, explaining what would happen if all the ice on earth melted! **youtube.com/watch?v=b6CPsGanO_U**

8 PROJECT AREA: THE POLES TODAY
THE FUTURE IS YOURS!

You have an incredible power to change the world around you. How can you, as a global citizen of tomorrow, alter the future of our earth? Take what you have learned in this project and use it for good. The future is yours!

Learning Outcomes

Project skill: Speaking out for a cause **Life skill**: Developing a positive view of the future **Educational standard**: NGSS 3-LS4-4. Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change. **Success indicator**: Becomes actively involved in raising awareness of polar science

WHAT TO DO

Estimated time: 2 hours

See if you can "make the best better" by producing a media story or lesson that describes what you have learned about polar science. It could be about the Arctic, Antarctica, or both. Including your own excitement makes it that much more interesting to others. Your project can be any of the following:

- newspaper article
- blog
- series of social media posts
- video
- public presentation
- poster for display in a school or other place it is likely to be seen
- lesson or activity for any age (think about camps, clubs, schools, or other groups where learning takes place)
- original children's story
- original song
- an idea of your own

When you have an idea that appeals to you, use the outline below to plan your project. Attach a copy of your plans to this page.

1. **Project description**—Provide a general overview of the project with the information you want to cover.
2. **Significance of the information**—Clearly state why the information is interesting or important.
3. **Proposed plan**—Describe who you will be working with (if anyone), the specific information you will include, how you will make it interesting, who will review it, and any other planning details.
4. **Expected outcomes**—What do you expect the response to be? How will you be able to tell?
5. **Timeframe**—Make a timeline for yourself to guide (and push!) your project along.
6. **Final product**—Describe the outcomes of your efforts. Was the final product what you hoped it would be? Would you do anything differently?

Thank you to Dr. Anne Carey and Dr. W. Berry Lyons, professors in the School of Earth Sciences at The Ohio State University, for inspiring this activity.

More Challenges

Write to a local public official and share your project experience. What did you learn about polar science and how do you want them to help take care of the Earth through community education and public policy?

Did You Know?

Greta Thunberg, a Swedish environmental **activist**, was only 15 when she started demonstrating for change. She has raised awareness of climate change and inspired many others—students like her herself and adults—to protect the Earth.

Be an Activist

An activist is someone who advocates for social, environmental, or political change. You do not need any formal training to be an activist. You just need passion, hard work, and a goal.

BACKGROUND

According to Dannee McGuire, a guest blogger and youth ambassador at ONE, young people are not just the leaders of tomorrow. They can change the world around them today! Whether it is through social media, taking part in protests, or anything in between, advocating for a cause you care about is essential to being a global citizen.

Need some ideas for how to get engaged and "be the change?" Start from where you are with Dannee's tips:

- You can volunteer. Reach out to members of your community, find the right fit for you, and get to work!
- Go a step further and write to your political representative. Elected officials want to know what interests you. It is their job! They cannot tackle poverty or climate change or any major issues singlehandedly. They really want to know what they can do.
- Use social media to reach others. You are probably already on social media. Why not use it for a good cause?
- Inspire others. The best way to get things done is to have others join you. Maybe you want to start a campaign to raise awareness. If you create a group and everyone has a role, you are encouraging others to make a change.
- Finally, think outside the box. Why do certain videos, campaigns, or pictures go viral? Sometimes a new and different way of thinking about or presenting something causes a message to be "shareable." By finding a way to make a difference in a completely unique way, you can find ways to reach entirely new audiences.

This list is adapted from Dannee McGuire's blog post at ONE (**one.org**), a global movement campaigning to end extreme poverty and preventable disease by the year 2030.

TALKING IT OVER

SHARE How did you decide what to do for your project for Activity 8?

REFLECT Is your outlook for the future of the planet a positive one? Explain.

GENERALIZE The experiment in Activity 7 demonstrated the effect of melting ice on water volume. One example of this effect in everyday life occurs when the ice in a cooler melts; the water has less volume than the ice. What is at least one more everyday example?

APPLY Name at least two things that are likely to happen as a result of melting sea ice and glaciers.

GLOSSARY

activist. Someone who advocates for social, environmental, or political change.

alpine glacier. Glacier that flows in mountainous areas, from high to low elevation.

Antarctica. A continent that surrounds the South Pole and is found within the Antarctic Circle; 98% of its surface is covered in thick ice cover.

(the) Antarctic. The region surrounding the South Pole, also known as the Antarctic Circle.

Antarctic Circle. An imaginary line that circles the southern end of the Earth at a latitude of approximately 66° 34' South; also known as "The Arctic," with the North Pole at its center.

Arctic Ocean. An ocean that surrounds the North Pole and is found within the Arctic Circle; a thin layer of sea ice covers this shallow ocean.

(the) Arctic. The region surrounding the North Pole, also known as the Arctic Circle.

Arctic Circle. An imaginary line that circles the northern end of the Earth at a latitude of approximately 66° 34' North; also known as "The Antarctic," with the South Pole at its center.

astronomer. Someone who studies the stars, planets, moons, comets, or galaxies.

bacteria. Microscopic living organisms, usually single-celled, that are found everywhere and that can be both harmful and beneficial to humans.

bedrock. The solid rock that lies underneath the looser surfaces of the Earth, such as soil; you can think of it as the uppermost crust of the Earth.

carnivore. An animal that feeds on animal tissue.

chemical tracer. An element that moves with water and that can be detected in the atmosphere, in surface waters, and in the subsurface.

climatologist. Someone who studies Earth's atmosphere and climate.

continental glacier. Glacier that is generally much larger than an alpine glacier and flows over a vast land area.

crevasse. A deep open crack, especially one on a glacier.

decomposer. Organisms whose specific role in the food chain is to eat dead and decaying plant and animals.

diplomat. A government official who represents a country to other countries.

ecologist. Someone who studies the relationships between organisms and their environments.

ecosystem. A geographic area where plants, animals, and other organisms work together to form a community in a particular physical environment.

food chain. A list of organisms in an ecosystem that shows the order of predation, or what eats what.

food web. A complex combination of plants and animals in an ecosystem or habitat that shows what eats what and what gets eaten by what; compared to a food chain, a food web is more accurate because most animals have more than one food source and are eaten by more than one predator.

fossil. The preserved remains or impression of a prehistoric organism.

fresh water. Water in ice sheets, ice gaps, glaciers, icebergs, bogs, ponds, lakes, rivers, streams and even underground; not salt water.

gastropod. A group of mollusks characterized by spiral-shaped shells (although some gastropods do not have shells) into which the body can be withdrawn; a snail or slug.

geoscientist. Someone who studies the physical aspects of Earth.

glacier. A slowly moving mass or river of ice formed by the accumulation and compaction of snow on mountains or near the poles.

glaciologist. Someone who studies and analyzes the formation, movement, and effects of different kinds of glaciers, ice caps, ice sheets, and ice shelves.

herbivore. An animal that consumes only plants.

hydrologist. Someone who studies water on Earth and other planets.

ice algae. Algae communities found in sea or terrestrial ice; on sea ice in the polar oceans, ice algae communities are primary producers.

iceberg. Floating chunks of ice that have broken off from an ice shelf.

ice core. A core sample typically extracted vertically from an ice sheet or a mountain glacier.

ice cover. A thick mass of ice that forms over large regions of both land and water.

ice sheet. A mass of glacial ice that becomes an ice shelf once it extends to the coast and over the ocean; ice sheets contain about 99% of the freshwater on Earth.

ice shelf. A glacier that has moved from land to the ocean.

inference. A conclusion based on known facts or evidence.

krill. Small crustaceans that are found in all the world's oceans; they feed on phytoplankton, and, in turn, are food for many animals.

landforms. Features on the Earth's surface that are part of the terrain, such as mountains, hills, plateaus, and plains; landforms can exist under water, too.

Mesozoic Era. A geological time-period identified as the age of dinosaurs that lasted almost 180 million years, from approximately 250 to 65 million years ago.

meteorologist. An expert in the study of weather.

North Pole. The northernmost point on Earth, located in the Arctic Ocean.

oceanographer. Someone who studies oceans, including marine life, ecosystems, circulation, the geology of the sea floor, plate tectonics and other properties.

organism. An individual living thing.

paleoecological reconstruction. A detailed description of a past ecosystem.

paleoecology. A branch of paleontology that uses the data from fossils to reconstruct ecosystems of the past.

paleontologist. Someone who studies the history of life on Earth, mainly through fossils.

permafrost. Permanently frozen ground found under a layer of soil, containing rock, sediments, ice, and the remains of plants and animals that froze before they could decompose.

phytoplankton. Tiny plants that capture the energy of the sun and turn it into food; they divide and grow very quickly during summer, when light from the sun is more intense and long lasting.

predation. The preying of one animal on others.

predator. An animal that eats other animals; if the animal eats other animals without being eaten itself, it is called a top predator.

producer. An organism that produces food, usually a green plant; plants range from microscopic algae (as in phytoplankton) to trees and use raw materials such as sunlight, carbon dioxide, and water; producers drive all food chains and food webs.

sea ice. Ice formed over the ocean.

South Pole. The southernmost point on Earth, located in Antarctica.

therapod. A carnivorous, bipedal dinosaur ranging in size from small and delicately built to large; the most well-known therapod is Tyrannosaurus rex.

top predator. An animal that eats other animals but does not have anything eating it.

topography. The physical features of land, including natural ones like mountains, rivers, lakes, and valleys and sometimes manmade ones like roads, dams, and cities.

Venn diagram. A method used to sort items into groups, presented as two or three circles overlapping each other; similar items are placed inside the overlapping section, while items that do not belong together are placed in the outer circles.

ANSWER KEY

Answers for Activities 3, 4, and 8 will vary.

Activity 1

Arctic Exploration Trivia

1. Arctic Ocean
2. Possible answers include Greenland, Baffin, Ellesmere, and Victoria.
3. Possible answers include Canada, United States, Russia, Greenland, Norway, Sweden, and Finland.

Antarctica Exploration Trivia

1. Transantarctic Mountains
2. West Antarctic Ice Sheet and East Antarctica Ice Sheet
3. South America

You Are the Explorer

Answers will vary but should be similar to those here.

	The Arctic, in the Northern Hemisphere	The Antarctic, in the Southern Hemisphere
1.	The North Pole is found in an ocean.	The South Pole is found on land.
2.	It's very cold, but warmer than the Antarctic.	It's colder than the Arctic and is the coldest place on Earth.
3.	Polar bears are only found in the Arctic.	Penguins live only in Antarctica or other parts of the southern hemisphere.
4.	It has one ocean (the Arctic).	It's surrounded by four oceans: the Southern, South Pacific, South Atlantic, and Indian.
5.	There are many landmasses inside the Arctic Circle.	There is only one landmass (Antarctica) inside the Antarctic Circle.
6.	It has less ice than Antarctica.	It has more ice than the Arctic.
7.	People have lived there in permanent settlements for thousands of years.	People live there only temporarily, working on scientific research bases.

Activity 2

Answers will vary but should be similar to those here.

Layer 1: One of the years with the most clear snow.

Layer 2: Half as much snow as the most recent year, and it's full of dust. Perhaps it was warm too, as evidenced by the insects and plant life.

Layer 3: An average amount of clear snow fell this year.

Layer 4: An average amount of clear snow fell this year.

Layer 5: A top year for snow. The presence of gravel suggests volcanic activity.

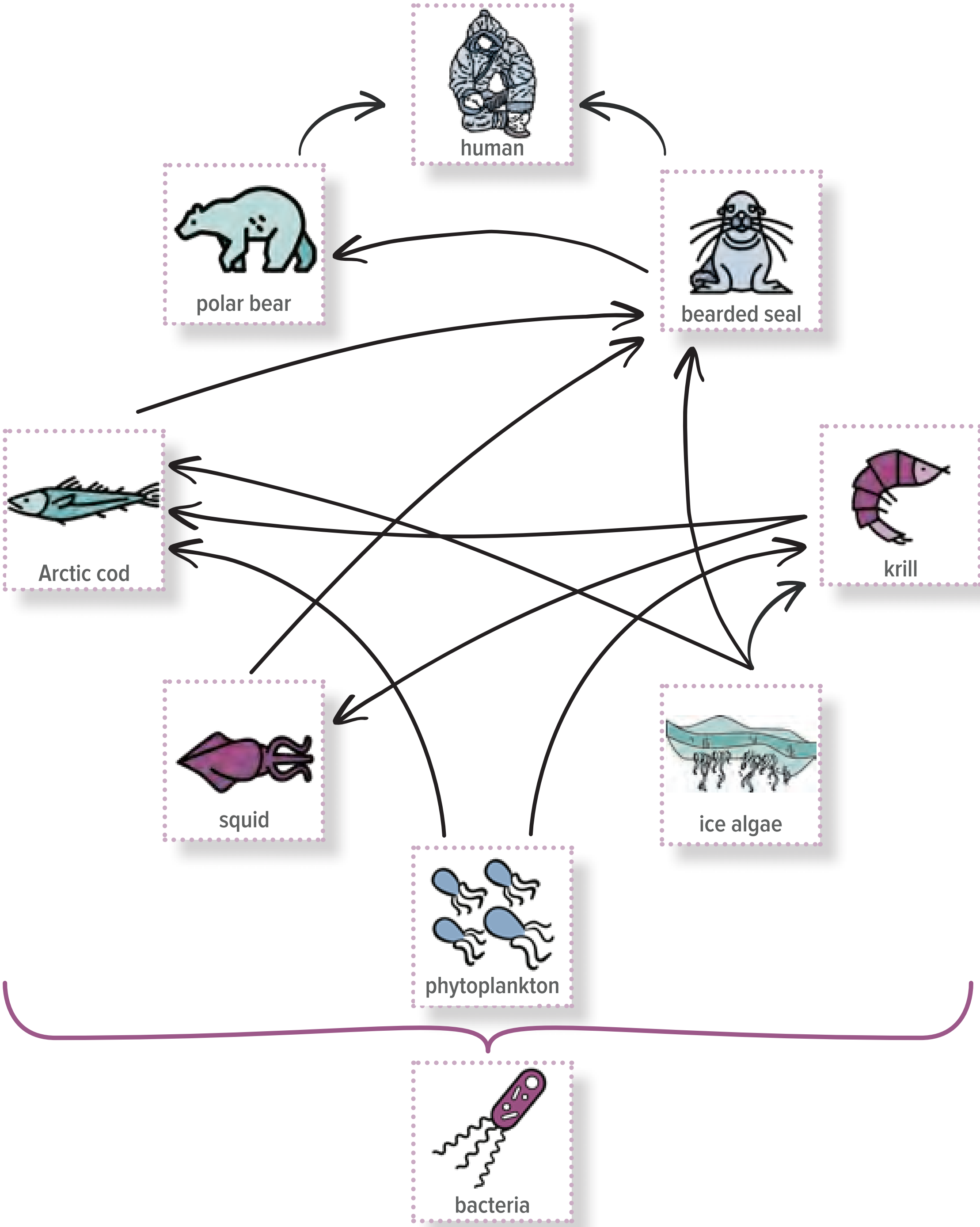
Layer 6: Dry, dust-filled snow and not much of it. The presence of gravel suggests volcanic activity.

Layer 7: Dry, dust-filled snow and not much of it.

Layer 8: One of the years with the most clear snow.

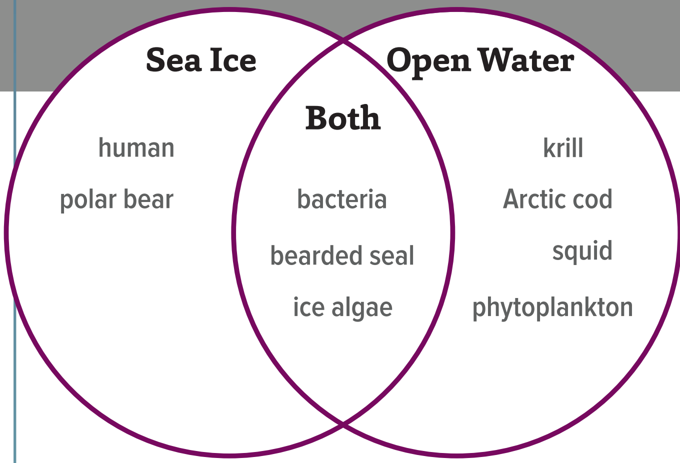
Activity 5

Answers will vary but should be similar to those here.



Further explanation

- Algae and phytoplankton are producers and do not prey on other organisms.
- Polar bears and humans are predators and very rarely serve as prey.



Further explanation about the organisms in the "Both" category:

- Bacteria are located everywhere and decompose living things that die.
- Bearded Seals feed in ocean water, but rest and care for their young on sea ice.
- Ice Algae are in the ocean water, attached to the bottom of sea ice.

Activity 6

Statements	True	False	Not Enough Evidence to Say
1. At one time, Antarctica was not covered in ice and was a warm tropical area.	✓		
2. Thousands of years ago, Antarctica was a very cold place.			✓
3. Millions of years ago, the water at the South Pole was warm.	✓		
4. Millions of years ago, the water at the North Pole was warm.			✓
5. Some fossils from Antarctica are from animals very similar to animals that live other places on Earth today.	✓		
6. Meat-eating dinosaurs once roamed Antarctica.	✓		
7. All sea creatures feed on small fish.		✓	
8. Whether in the past or present, ferns live in warm environments.	✓		
9. Fossils from Antarctica show that some creatures lived on land and some lived in water.	✓		
10. Turtles, which have shells, are gastropods.		✓	
11. Dinosaurs and ammonites became extinct at the same time.			✓
12. Paleontologists use toe bones to determine if an animal ate meat or plants.		✓	

Activity 7

Actual results will vary. Typically, however, melting glaciers cause sea level to rise more than melting sea ice. Glaciers exist on land. As they melt, they add water to Earth's oceans. Sea ice is melting, too, but it is already in the water. As an example, ice cubes in a drink melt, but do not overflow the glass.

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Activity 8

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SUMMARY OF LEARNING OUTCOMES

Activity	Project Skill	Life Skill	Educational Standard*	Success Indicator
Project Area: Earth's North and South Poles				
1. Ends of the Earth	Making inferences about the North and South Poles based on a map	Processing information	NGSS 3-ESS2-2. Obtain and combine information to describe climates in different regions of the world.	Identifies similarities and difference between the North Pole and the South Pole
2. A Layer Cake of Snow	Understanding how scientists learn about Earth's poles	Understanding systems	NGSS 3-LS4-1. Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago.	Makes a model of an ice core
3. Go with the Flow	Understanding the significance of glaciers to humans	Understanding systems	NGSS 5-ESS2-1. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.	Builds model of glacier that demonstrates how glaciers move and change the landscape
Project Area: Life at the Poles				
4. Day in the Life	Imagining life in the Arctic or Antarctica	Practicing creativity	NGSS 3-ESS2-2. Obtain and combine information to describe climates in different regions of the world.	Imagines life in the Arctic or Antarctica and creatively describes it
5. Web of Life	Understanding polar environments and their ecosystems	Understanding systems	NGSS 3-LS4-3. Construct an argument with evidence that in a particular habitat some organisms survive well, some survive less well, and some cannot survive at all.	Designs a food web for a polar ecosystem
6. Can You Say Paleoecology?	Making inferences from natural evidence	Using scientific methods	NGSS 3-LS41-1. Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago.	Makes inferences from fossil records
Project Area: The Poles Today				
7. Less Ice Equals More Water	Measuring effect of melting ice on water volume	Reasoning	NGSS 5-ESS2-1. Develop a model using an example to describe the ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.	Conducts experiments to show effect of melting ice on water volume
8. The Future Is Yours	Speaking out for a cause	Developing a positive view of the future	NGSS 3-LS4-4. Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.	Becomes actively involved in raising awareness of polar science

* The educational standards cited here are from the Next Generation Science Standards (NGSS). The activities in this book support the learning goals for the performance indicators cited, sometimes as described in the performance indicator itself but oftentimes by laying the groundwork for learning with reinforcement of the related science and engineering practices, disciplinary core ideas, and crosscutting concepts. Complete information about each performance indicator is available at **nextgenscience.org**.

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