BBC earth

ANTARCTICA

NARRATED BY BENEDICT CUMBERBATCH

EDUCATOR GUIDE

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EDUCATOR GUIDE

Developed By

DISCOVERY PLACE

Logistical support provided by

An SK Films Release

BBC earth

NATIONAL SCIENCE FOUNDATION

WITH SUPPORT FROM THE British Antarctic Survey NATURAL ENVIRONMENT RESEARCH COUNCIL

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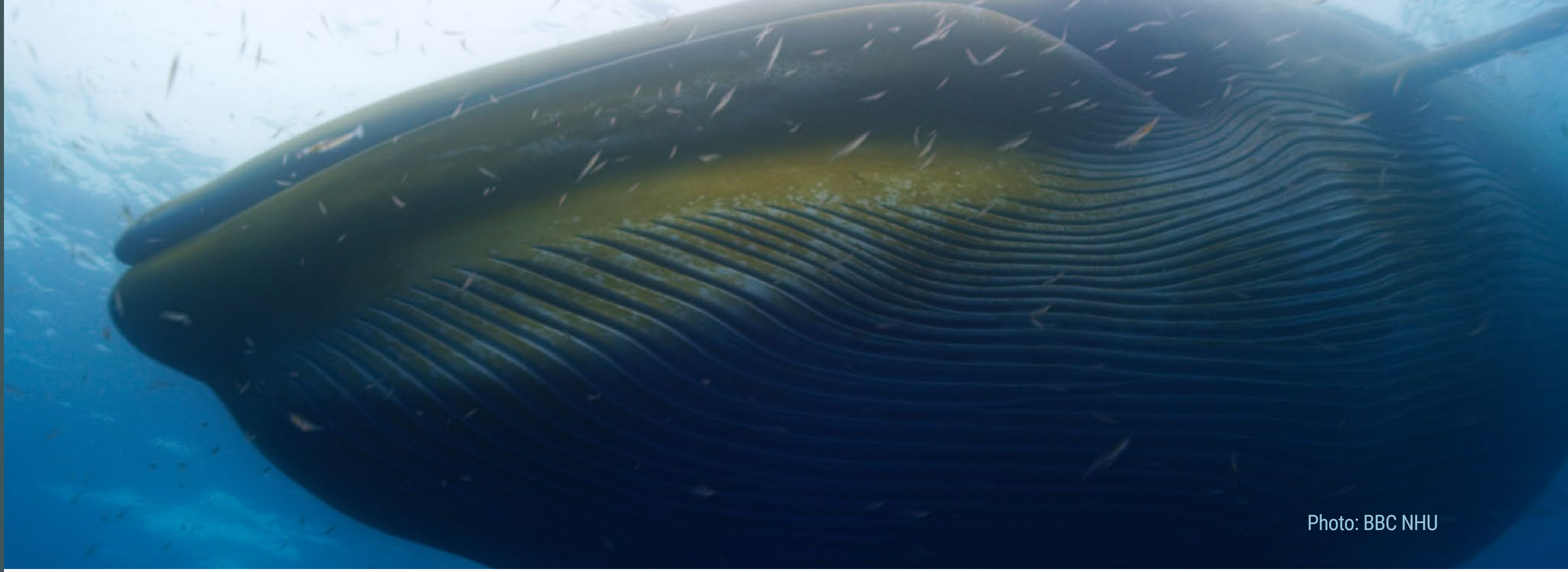
Photo: BBC NHU

INTRODUCTION TO THE GUIDE

The Educator's Guide for ***Antarctica,*** created by Discovery Place Education Studio, has been designed for use by both formal and informal educators working with students in grades Kindergarten through 8th. The guide is intended to accompany the film and support student learning of the major themes presented in ***Antarctica.*** 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. The lessons are broken out by grade bands to allow educators to select the experiences that are the most age appropriate for their students.

The lessons provide opportunities for students to create maps or models to better understand how events in Antarctica affect the rest of the world. They also help students explore the rich ecosystem of Antarctica and increase their appreciation of the biodiversity that exists in this extreme environment.

With never-before seen footage, ***Antarctica*** brings audiences to the farthest reaches of this wild and majestic continent. It is the coldest, driest, and windiest place on Earth, with the roughest oceans and weird and wonderful creatures thriving in astounding abundance.

Antarctica features the latest underwater filming techniques, allowing viewers to dive beneath 6 feet of sea ice, to experience the alien world of its seafloor - thousands of purple starfish scuttling to escape entrapment by growing ice and elaborate jellyfish performing a deadly dance. Swim alongside playful seals, soar above mountain peaks and vast penguin colonies, and witness the largest congregation of fin and humpback whales ever filmed.

Antarctica is an SK Films release of a BBC Studios Natural History Unit production, with logistical support from the National Science Foundation and British Antarctic Survey. It was directed by Fredi Devas, produced by Jonny Keeling, Jonathan Williams. Supervising producer is Myles Connolly.

The film has a run time of 45 minutes.

PENGUIN POO? FROM SPACE!?

GRADE LEVEL K-1

ANTARCTICA EDUCATOR GUIDE

PENGUIN POO? FROM SPACE!?

GRADE LEVEL K-1

(1) 60 minute Lesson or
(2) 30 minute Lessons

Standards (NGSS):

K-ESS3-1 Earth and Human Activity

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:

In the film, ***Antarctica***, we learn that scientists and researchers are using satellite imagery of penguin poo to monitor penguin populations. The color of penguin poo varies based on their diet. As an example, Adelie penguin guano varies from reddish brown if they eat a lot of krill to blue if their diet is primarily fish. This means that we can not only use this data to understand penguin counts, but also understand more about their diet and relationship with the environment.

Lesson Overview:

Penguins are flightless birds found on the continent of Antarctica. Students will learn about four different species of penguins that live in Antarctica. Then students will create their own satellite imagery of penguin poo, which scientists and researchers use to gain a better understanding of penguin population and behavior. Through this activity, students will understand that the presence of other animals, such as krill, fish, and squid, make this an ideal habitat for penguins.

Materials:

- The book:
One Day on our Blue Planet: In the Antarctic
by Ella Bailey
  https://www.amazon.com/One-Day-Blue-Planet-Antarctic/dp/1909263672
- Model Globe
- Technology to show the following video:
  www.youtube.com/watch?v=dCQVci2IXag
- Penguin identification cards - handout, pp. 10-13 (one set per group)
- Crayons or colored pencils, tempera paint in red and blue, water
- Satellite image - handout, p. 14 (one per group)
- Outline of Antarctica - p. 15
- Sheets of butcher paper, cut into 5-foot lengths (per group)
- 2 Pipettes (per group)
- 2 paper cups: small 4 oz. cups work great (per group)

PENGUIN POO? FROM SPACE!?

EDUCATOR PREP:

Prepare the video clip to be shown to the class. Print out one penguin ID sheet for each student. Prepare the guano solution using the recipe to the right. Using the map on p. 15 draw a large outline of Antarctica on each sheet of butcher paper, filling the sheet.

GUANO RECIPE:

Mix equal parts tap water and tempera paint in small cups. Provide at least 2 different colors. *(red and blue preferred)*

EDUCATOR GUIDE:

1. Inform students that today we are going to go on an adventure to Antarctica to learn about penguins. Tell them first, we need to start with what Antarctica is and where it is located.

2. Using the globe, show students first their current location, and then move towards Antarctica and the South Pole. Ask students what they think life would be like on the southern side of our planet.

3. Read aloud the book, ***One Day On Our Blue Planet: In The Antarctic,*** by Ella Bailey. Comprehension Check: Students should recognize that Antarctica is extremely cold and does not have a lot of plant life. It is surrounded by water and although it is a harsh environment, a lot of animals live here. Finish the book and ask the following questions:

What do you know about this place called Antarctica?

Students will describe the Antarctic in a lot of different ways with some focusing on the shape, others on the color, and still others on what lives on the continent.

What details do you notice about Antarctica?

Help students use descriptive words to share their observations of the continent from the clip.

What kinds of plants and animals live in Antarctica?

Student answers will reflect their recollection from the film or the clip, so they may mention penguins, seals, whales, sea stars and more.

4. Explain that as a class we are going to learn more about penguins that live in Antarctica. Pass out the penguin ID cards to each group.

5. Share with students that Antarctica is really cold and far away, which means scientists and researchers have to be creative and use interesting tools to study these animals. Today we are going to be scientists studying penguin populations.

Adult king penguins must head out to sea to collect food for their chicks. Director Fredi Devas watched this group walk to these rocks, and then hesitate getting into the cold water for ten minutes.

Eventually one was pushed in.

Photo: Fredi Devas © BBC NHU

PENGUIN POO? FROM SPACE!?

6. Students will learn more about the types of penguins found in Antarctica. Show the students each of the penguin ID cards and introduce them to the types of penguins living in Antarctica. Make note that each penguin species looks a little different and may have unique food and habitat preferences.

Note: Stop here if doing this in two lessons. If doing this in one lesson, this is a good place for a brain break – allow students to act like penguins for a few minutes – flap their wings, pretend to swim, waddle on the ice, "talk" to a friend penguin, ...etc.

PART II

7. Due to Antarctica's harsh environment, scientists have discovered new ways to study penguins. Penguin poo, known as guano, can actually be seen from space! Show students the vocabulary card with guano on it and have them say "Guano" after you say "Poo." Scientists are using satellite images or pictures to see where penguins are living and count the size of their groups called colonies. Show students the satellite images of penguin colonies from space. Penguins eat a diet of fish, squid, and krill. Scientist can also tell what kind of food the penguins are eating based on the color of their poo or guano. Penguins who eat a diet primarily of krill have a reddish brown guano, while penguins who eat a diet primarily of fish have a blueish guano.

What did you notice or what did you see in the satellite pictures taken from space?

Student answers should begin to draw connections between the patterns or "splatters" on the picture and penguins. Help the students use descriptive language to describe what they see.

8. Place the butcher paper maps of Antarctica on the floor. Tell the class that we are going to be making our own model of a penguin poo satellite image from space. Use the following prompts and questions:

So, we know the color of penguin poo is based on what?

Penguin poo is based on their diet. Guano that is primarily made up of krill are reddish brown, while penguins who eat mostly fish make guano that is mostly blueish.

What do you know about where penguins like to live?

Penguins like to live near water so that they can get to the water around the continent to get food.

Knowing all of that, where would we find blue guano?

We should see a lot of blue guano near the coast.

Educator Notes:

PENGUIN POO? FROM SPACE!?

9. Stand close to the map of Antarctica. Using a pipette, carefully drop guano or penguin poo onto the map. Each drop represents a colony of penguins. Start by adding 1 drop at a time to the map. Students should take turns one at a time.

10. Once each student has had an opportunity to add penguin poo to their group map, bring up the satellite images from the British Antarctic Survey and have the children look at the satellite image compared to their own model.

Ask the following discussion questions:

What is one thing you see that is similar about your model and the satellite photo? How is your model like the map?

Student answers will include something about the shape and the color of the patterns, and maybe even some thinking about where guano is and where it's not.

What is one thing that is different?

Student answers should reflect thinking about how the colors may be different, or the shape of their pattern may be different.

11. To close the lesson, ask students to take a few minutes and to write or draw in their notebooks what they have learned about penguins, their guano or the animals that live on/near Antarctica.

Use the sentence beginning:

"Today, I learned ________________. "

After a few minutes of writing, ask them to share something that they wrote or drew. Represent the class' learning on chart paper or make a bubble map to collect student answers.

In spring, king penguin chicks wait for days for their parents to return with food.

Photo: Fredi Devas © BBC NHU

Adelie Penguin

Size:
• 27 inches tall
• *Smallest penguin in Antarctica*

Physical Features:
• Black and white
• White ring around eye
• Peach feet

Habitat:
• Ice-free areas like rocky coasts

Diet:
• Mainly krill
• Small fish
• Squid

Photo: Shutterstock/ Simo Graells

Chinstrap Penguin

Size:
- 28 inches tall

Physical Features:
- Black band under chin
- Black beak
- Peach feet

Habitat:
- Ice-free areas like rocky coasts

Diet:
- Fish
- Squid
- Krill


Photo: Shutterstock/ Hullis

Gentoo Penguin

Size:
- 30 inches tall

Physical Features:
- Bright orange beak
- White caps over eyes
- Peach feet

Habitat:
- Ice-free areas like rocky cliffs
- Valleys
- Plains

Diet:
- Fish
- Squid
- krill

Photo: Shutterstock/ Alexey Seafarer

King Penguin

Size:
- 36 inches tall
- *Largest penguin species in the world*

Physical Features:
- Long beak with orange on lower bill
- Orange ear patches and throat
- Black feet

Habitat:
- Flat coastlines
- Valleys

Diet:
- Mainly fish
- May eat squid
- Krill and other crustaceans

Photo: Shutterstock / Anton_Ivanov

Satellite Image

Guano Tells the Story

Scientists are using satellite images to see where penguins are living and count the size of their groups called colonies.

Scientists can also tell what kind of food the penguins are eating based on the color of their poo, or guano.

Penguins who eat primarily krill have a reddish brown guano, while penguins who eat primarily fish have a blueish guano.

Photo: DigitalGlobe / British Antarctic Survey

Outline of Antarctica

Directions: Use this outline of Antarctica on each sheet of butcher paper. Do your best to fill the sheet.

AS BIG AS ANTARCTICA

GRADE LEVEL 2-3

Photo: BBC NHU

AS BIG AS ANTARCTICA

GRADE LEVEL 2-3

60 minute Lesson

Standards (NGSS):

2-ESS2-2 Earth's Systems

Develop a model to represent the shapes and kinds of land and bodies of water in an area.

From the Film:

In the film, ***Antarctica***, we learn that Antarctica is one and a half times the size of the United States and slightly over one and a half times the size of Europe. We also learn that Antarctica is a continent that holds 90% of the Earth's ice. Much like other land masses, Antarctica has a unique shape and physical features that sets it apart from other continents. In addition to being surrounded and sustained by the sea, it also has bays, mountains, and coasts.

Lesson Overview:

The class will be divided into groups of four students, with each group being responsible for creating a textured, topographic map of Antarctica. Using a provided outline of the landmass divided into 4 sections, students will label the different areas of the land mass and use various art materials to add texture and detail to their maps. When they have completed their maps, the four sections will be reassembled into one complete map of Antarctica.

Materials:

- Blue construction paper
- Outline of four parts of Antarctica, I, II, III, IV handouts - pp. 22-25
- Continent matching sheet, handout - p. 26
- Assortment of white, gray, and light blue project materials. May include:

  Yarn, paper, lace, tissue paper, crepe paper, napkins, tissues, masking tape, white or silver ribbon, markers, scissor, glue sticks or glue

- Clip from ***Antarctica*** of Globe for reference:

CLICK HERE for video

AS BIG AS ANTARCTICA

EDUCATOR PREP:

Print map and a set of four sections of the Antarctica map for each group in the class. Gather a variety of art supplies for each group.

EDUCATOR GUIDE:

1. In the film, ***Antarctica***, we learned that Antarctica is about one and a half times the size of the United States and slightly over one and a half times the size of Europe. But more importantly, we also saw that Antarctica is not just a vast range of ice, but a continent with different features and topographies.

2. Ask students in groups of three to name as many of the seven continents as they can: Asia, Africa, Antarctica, and Australia, Europe, North America, and South America. After a couple of minutes, bring the whole group together and have them collectively create a list of the seven continents. Write these on the board or chart paper.

3. Inform students that even though these landmasses are all continents, they are different in size and features. First, we are going to take a quick look at the size of these continents and compare them. Use the following questions to define a continent:

What is a continent?

Answers may include that continents are large pieces of land surrounded by water. The seven continents make up 99% of the land that is on planet earth.

Why are they different sizes and shapes?

Answers may vary depending on the background knowledge of the students. Let students know that millions of years ago, all of the continents were actually connected and were one huge continent. Scientists call this continent Pangaea. Over time, the continents separated to become seven different land masses.

4. Pass out the continent matching sheets. Ask students to talk with their elbow partner and work together to match each continent to its correct size. Project or display a map of the globe that students can reference as they consider which continents correspond with

The distinctive characteristic of a topographic map is the use of elevation contour lines to show the shape of the Earth's surface.

Photo: Shutterstock / Pongpinun Traisrisilp

AS BIG AS ANTARCTICA

which size.

5. Circulate and get a sense of how students are conceptualizing which continent is bigger or smaller and trying to match sizes.

Note: The goal here is for them to talk through the logic of matching up area measurements with size. This can be done through comparing, ordering or another approach to conceptualize what the area numbers mean.

6. After about five to seven minutes, go over the answers, asking the following questions:

Were you surprised by how small or how big any of the continents were?

Students may be surprised by any number of things related to size and depending on how they have conceptualized visual maps and compared continents on a globe. As this is a quantitative exercise, some of their previous observations may be confirmed or challenged.

Which continents are closest to being as big as Antarctica?

Antarctica is bigger than Europe and Australia, close to South America and smaller than North America, Asia, and Africa. As a fun fact, share with students that Antarctica is also about 1.5 times bigger than the United States, which is about 10.1 million km², and part of North America.

7. Continents, like people and things, are not one dimensional. Inform students that we will work together to learn more about the continent of Antarctica and create a map to gain a better understanding of different features and inhabitants of Antarctica.

8. Divide the class evenly into groups of four and give each group a set of the four sections of Antarctica and the reference map.

9. Tell students that they will work together using the information on the Overview Map to create a three-dimensional map of the continent.

10. Have students look at the blue lines on the Overview Map and explain that these lines are contour maps. The closer the lines are, the steeper the slope. The farther apart they are, the flatter the land. The blue lines will be used to model Antarctica's landscape on their maps.

11. Using various paper types and glue sticks, students will begin to "mold" or "build" their topography for their particular section. Inform students that their area of the map might consist of mountain ranges and steep cliffs.

Educator Notes:

AS BIG AS ANTARCTICA

12. Check in with groups and individual students to see how they are thinking about representing the variations in elevation on Antarctica. If they are having trouble getting started, give them some ideas on how they can fold, crumple, or layer different types of paper to add texture to their maps.

13. After about fifteen minutes, when student are feeling like they have made progress on their map sections, ask them to use a pen or marker to label three to five of the areas that are found in their section using the reference maps. This could include bodies of water, an ice shelf, a mountain range, a town or research station. Give them about five minutes to do this for their individual section.

14. Inform students that Earth is known as the Blue Planet because 70% of it is covered by water. We now need to place their map sections into their context in the South Seas before combining them into a complete map. Ask students to glue their section onto a blue piece of construction paper. Then they will use scissors to cut away construction paper to align with the flat sides of their sections.

15. Bring students together as a whole group and ask one student from each group to bring their section and tape it to the board. In this way, they can jigsaw their four sections together to create a complete map of Antarctica and attach them. Ask them to label three bodies of water around the continent.

16. In their notebook or journal, ask students to reflect on this experience of creating a model of Antarctica with their classmates using one or more of the following questions or prompts:

What are three things that you learned about Antarctica that you did not know before this activity?

Student responses will vary but should reflect some things that they learned during the lesson.

What are two questions that you have about Antarctica?

Student responses will vary but should reveal their thinking and curiosity about the continent of Antarctica.

What is one thing that you did today with a classmate today and how did it make you feel?

Student responses will vary, but should encourage awareness and labeling of different types of emotions that can emerge during a collaborative experience.

The film team spent 8 weeks on this German ice-breaker in search of the biggest aggregation of great whales that has ever been filmed.

Photo: © BBC

Overview Map

Directions: Notice the blue lines. These are contour lines. The closer together the lines are, the steeper the slope. The farther apart they are, the flatter the land. We are going to use these to model Antarctica's landscape on your map.

Key

- Ice-free rock
- Ice sheet
- Ice shelf
- Contours at 500m intervals

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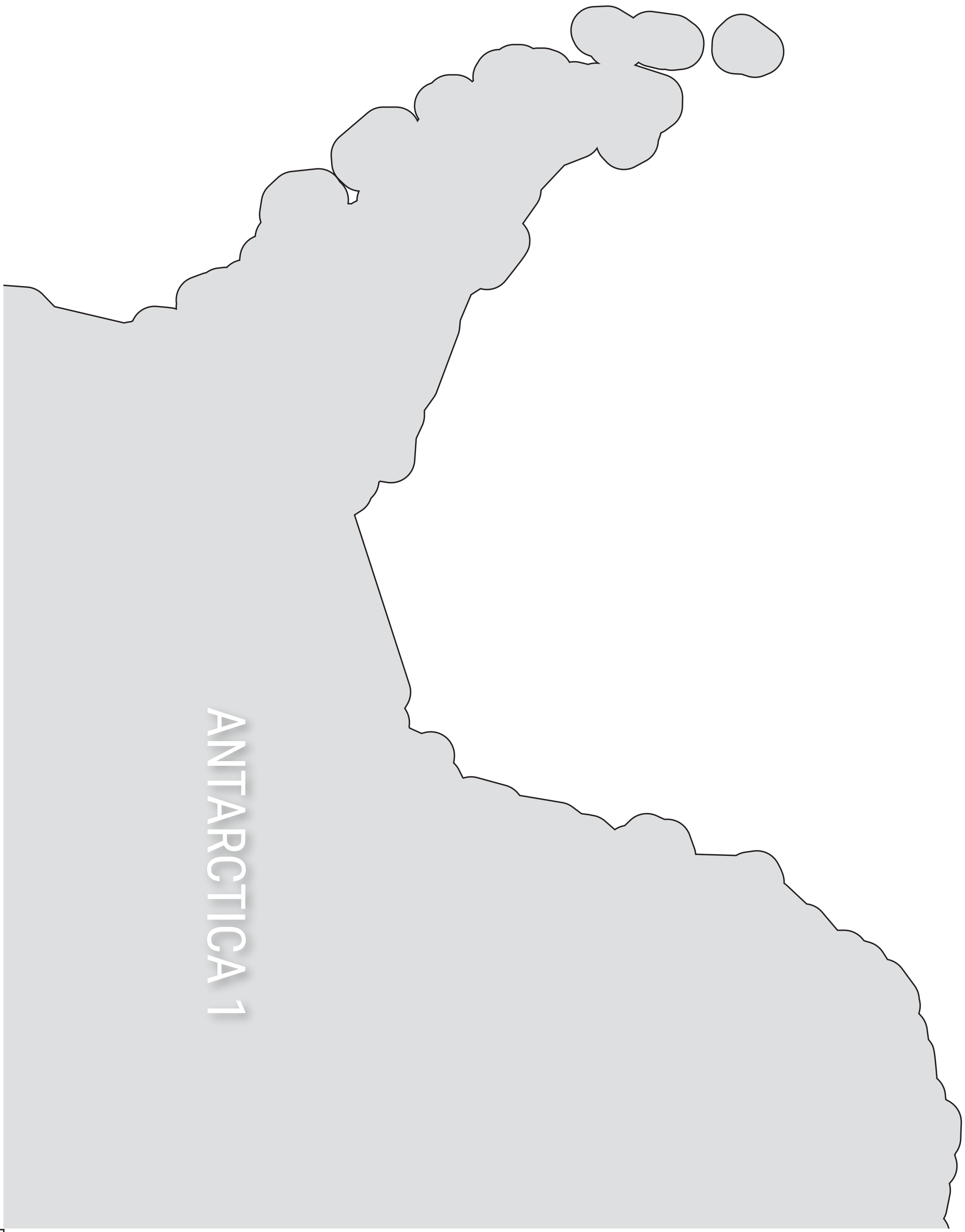
Map 1



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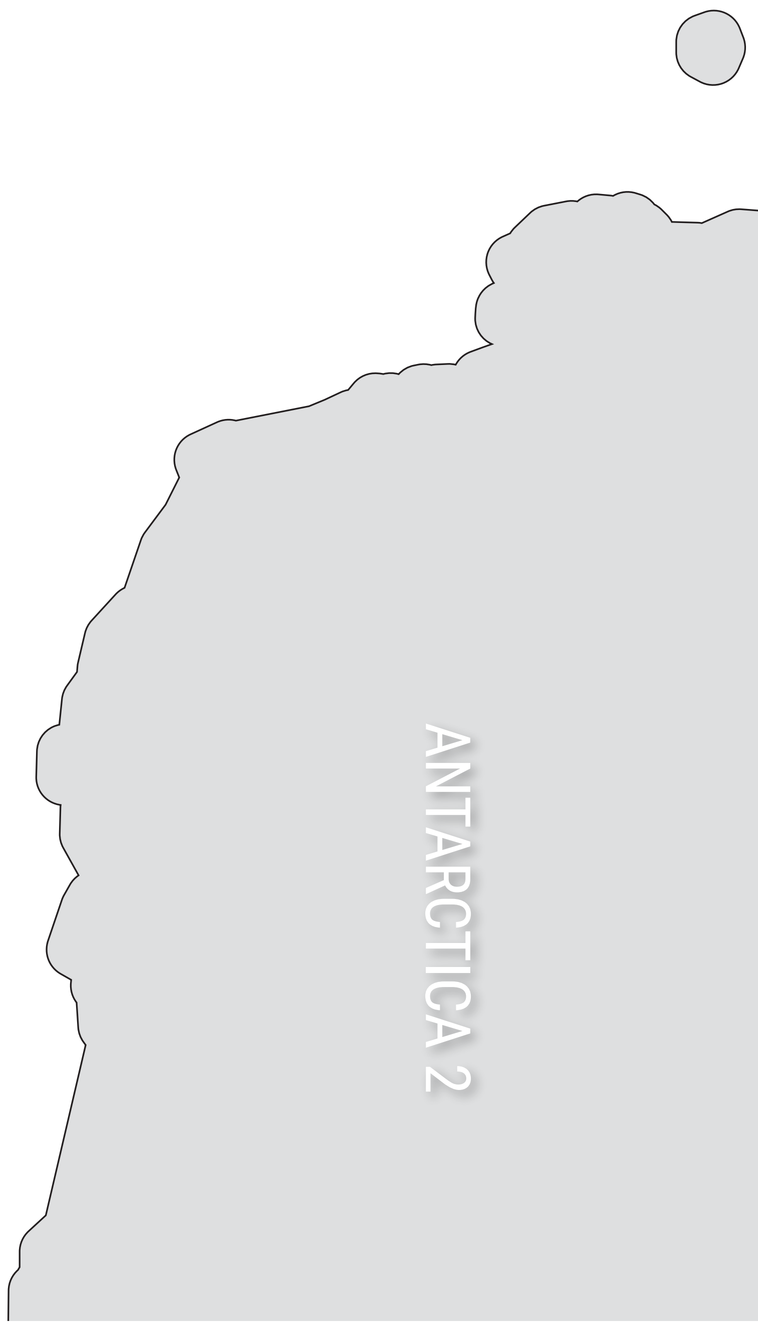
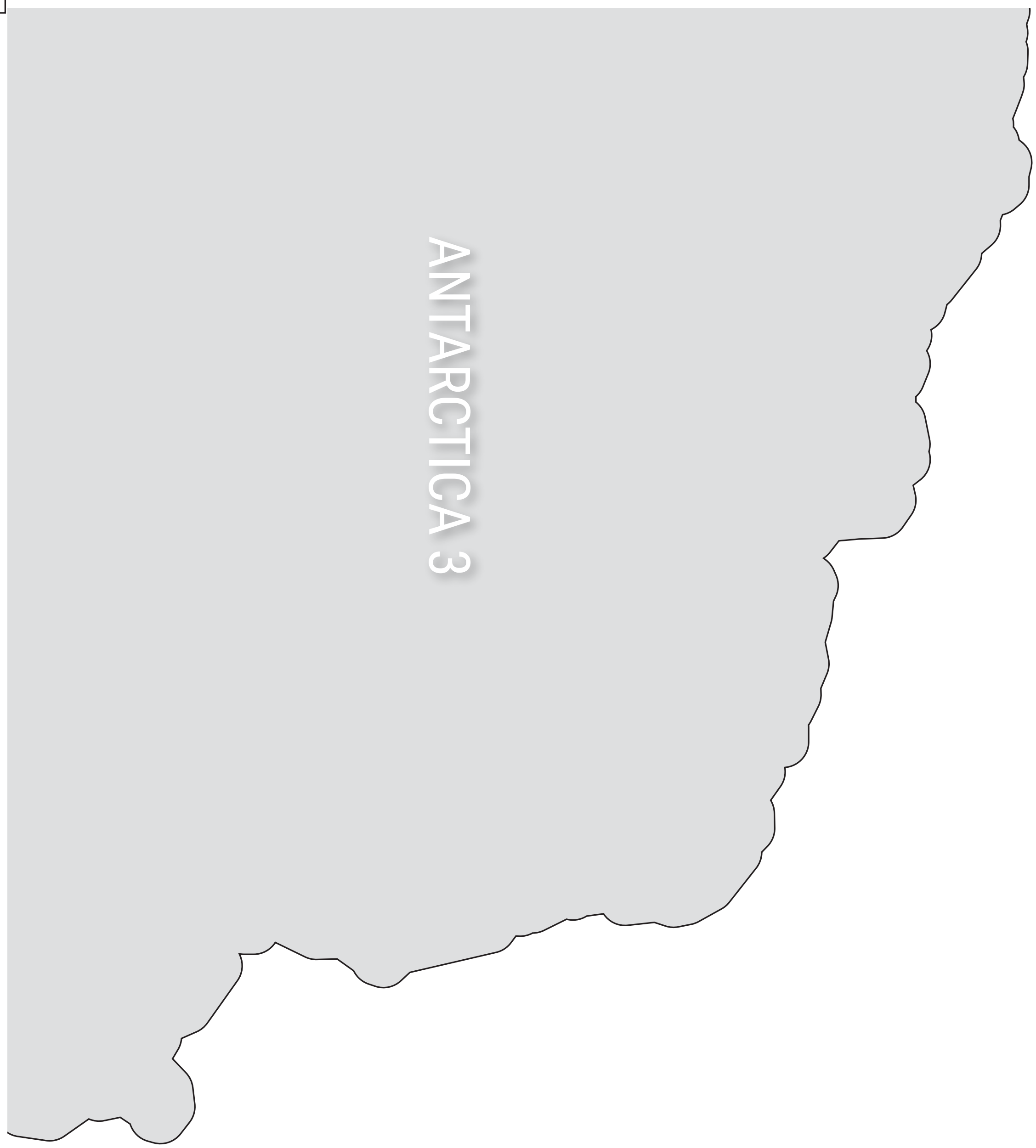
Map 2



Map 3



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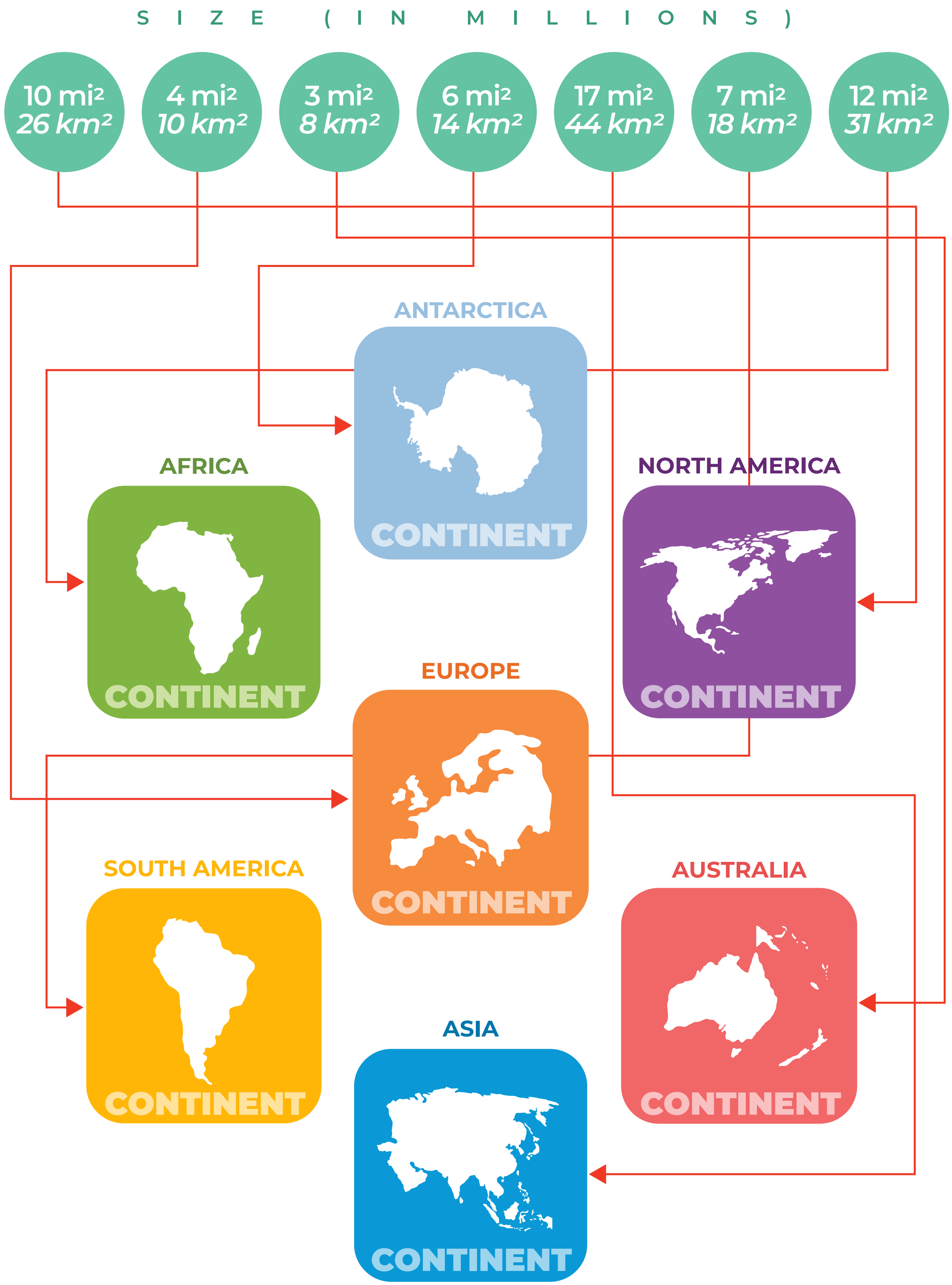
Map 4

Match the continent to its size in millions of km^2 or mi^2

S I Z E (I N M I L L I O N S)

10 mi^2 *26 km^2*	4 mi^2 *10 km^2*	3 mi^2 *8 km^2*	6 mi^2 *14 km^2*	17 mi^2 *44 km^2*	7 mi^2 *18 km^2*	12 mi^2 *31 km^2*

Match the continent to its size in millions of km^2 or mi^2



Educator Key

EXTREME SURVIVAL: ANTARCTICA!

GRADE LEVEL 2-3

EXTREME SURVIVAL: ANTARCTICA!

GRADE LEVEL 2-3
60 minute Lesson

Standards (NGSS):

3-LS4-3

Construct an argument with evidence that in particular habitats some organisms thrive, others barely survive, and others face extinction.

From the Film:

The film, ***Antarctica***, showcases a variety of animals with incredible adaptations that allow them to survive extreme conditions. We see other adaptive behaviors such as antifreeze proteins in icefish, waterproof feathers of penguins, special vocal calls by young animals, and blubber in seals. We also see behaviors such as whale feeding, ice-cutting by seals, and nesting behaviors.

Lesson Overview:

Students will discuss the examples of animal adaptations and behaviors seen in the film. They will design and create a 2D or 3D model of an animal that would survive in Antarctica and discuss the adaptations that would give the animal an advantage (ex. Antifreeze in fish, feathers, blubber, ice-cutting, teeth, feeding behaviors). The educator will demonstrate the feeding behavior of humpback whales seen in the film using a model representation.

Materials:

- My Antarctic Animal Handout, p. 34 (one per student)
- Pictures, p. 33 of Antarctic animals from the film:
  See the Antarctica film Wildlife List here
- Paper and Colored pencils or Markers for 2D Antarctic animal model
- Recycled materials for 3D model (optional) This could include cardboard, paper, fabric, plastic bottles, egg cartons, etc.
- Tape or hot glue gun (optional)
- Large container filled with water
- Small sequins or other small object that will float
- Small strainer or slotted spoon with a handle (should be easily maneuvered in container)

EXTREME SURVIVAL: ANTARCTICA!

EDUCATOR PREP:

Print ***My Antarctic Animal*** Handout. If students are making a 3D model of their Antarctic Animal, prepare enough materials for each student. Print or prepare the Antarctic Animal photos to be digitally shared with students.

EDUCATOR GUIDE:

1. In the film, ***Antarctica***, we observed many animals with special behaviors and adaptations that allow them to survive in an extreme environment. Ask students:

What is an adaptation?

An adaptation is a change or the process of change by which an organism or species becomes better suited to its environment. These changes are developed through natural selection and evolution over many generations.

What is a behavior?

A behavior is the way in which an animal or person acts in response to a particular situation or stimulus.

Can you give me an example of special adaptations or behaviors humans have?

This question has many possible answers. For example, humans have opposable thumbs, which allow them to grip objects in a way that is different from animals. It gives them an advantage by allowing them to create tools and pick up smaller objects.

What are some special adaptations you saw in the film Antarctica?

Multiple answers are possible. Examples include the Gentoo Penguins shedding their down feathers to be able to swim, or seals, who have adapted the ability to chew the ice with its teeth creating space for itself to breathe. Another example is the icefish with the antifreeze protein that allows it to swim in icy waters.

Using a feeding technique called 'bubble netting' the humpback whales blow bubbles as they rise up under a shoal of krill. The bubbles act like a net to the krill, and the whales spiral inwards to concentrate the swarm.

Photo: BBC NHU

EXTREME SURVIVAL: ANTARCTICA!

2. Instruct students that you will demonstrate a special behavior observed in the film when the humpback whale is feeding on krill. Carefully pour the sequins into the large container filled with water. Inform students that the sequins represent the krill in the ocean. Use the strainer to carefully stir inside the container, starting at the outer edges and moving in a spiraling movement into the center. This should corral the sequins in the same way that the humpback whale corrals the krill. Scoop the sequins up while the water drains out of the strainer, which is reflective of the way whales can push out water while only ingesting the krill.

Ask students:

What would happen if I just scooped the strainer in the water?

The scooper would not pick up as many krill, so you would need to exert more energy to get the same amount of sustenance.

Why do you think the whale spirals around the krill to feed?

The whale has learned that creating the spirals traps the krill in a confined space, therefore allowing it to collect and eat a lot of them very quickly.

What would happen if we used a solid spoon to scoop up the krill?

It would also end up scooping up a lot of water which would reduce the amount of krill that is caught. It would also make the spoon very heavy and more difficult to move out of the water.

How is this model similar and different to what we saw in the film?

It uses the same spiral motion to corral the sequins and the slotted spoon is like the mouth of the whale. The difference is, unlike the strainer, the whale has to create this spiral from in the water using its body and energy.

3. Show students pictures of some of the Antarctic animals they observed in the film (icefish, penguin, anemone, sea star, seal, whale). Ask students what special behavior or adaptations each of these animals have that allow them to survive in Antarctica. Record the groups answers on chart paper or white board.

4. Hand out the ***My Antarctic Animal*** handout and inform students that they will create their own animal that lives in Antarctica, able to withstand the conditions and fit into the ecosystem.

5. Give students time to brainstorm. Have students brainstorm specific adaptations that would make their animal more likely to survive in Antarctica. After ten minutes of planning, have students share their design with a small group.

Educator Notes:

EXTREME SURVIVAL: ANTARCTICA!

6. As an extension activity, if time and supplies permit, allow students to create 3D models of their animals. Students also have the option to draw and color a final 2D model of their animal.

7. Once students are finished with their model, ask them to use their notebooks and reflect on their experience. Describe the adaptations of their animals. Use the following prompts:

Which animals were your inspiration for the animal that you designed?

Why did you choose these animals?

How do the adaptations of your animal give it an advantage and allow it to survive in Antarctica?

8. If time allows, or as an extension, have students create a story about their animal where they tell about the animal, its adaptations and how that helps them survive.

Antarctic Krill. The combined weight of every single krill together is likely heavier than any other animal species on the planet.

Photo: BBC NHU

Antarctica Animal Photos

Use the photographs below to give you inspiration for the animal that you are going to design to survive in Antarctica.

Photo: Shutterstock / Paul S. Wolf

Photo: Shutterstock / Andrea Izzotti

Photo: Shutterstock / Andrea Izzotti

Photo: Shutterstock / Charles Bergman

Photo: Shutterstock / Andrea Izzotti

Photo: Shutterstock / Lua Carlos Martins

My Antarctic Animal

Directions: Use the space below to design and draw an animal that could survive in Antarctica. This does not have to be an animal that already exists.

What special adaptations does your animal have?

ANTARCTIC WEATHER MACHINE

GRADE LEVEL 4-5

ANTARCTICA EDUCATOR GUIDE


Photo: BBC NHU

ANTARCTIC WEATHER MACHINE

GRADE LEVEL 4-5
(1) 90 minute Lesson *OR*
(2) 45 minute Lessons

Standards (NGSS):
4-ESS2-2

Analyze and interpret data to describe patterns of Earth's features.

From the Film:

In the film, ***Antarctica***, we learn that ocean currents, wind patterns, and temperature shifts play a significant role in what happens across the entire planet. Due to its place on the South Pole and its unique characteristics, this continent can shift climates, affect the movement of air, and change what weather looks like in the places that we live.

Lesson Overview:

Students label and decorate a world map with ocean currents, wind patterns, and climate to represent the connections between Antarctica and their home. Students then construct an Antarctic Machine to represent how an event in Antarctica can result in an event where they live. When they are finished, they use their illustrated map to answer questions about how wind or ocean currents in Antarctica may affect other parts of the world. Emphasize that what happens here affects us all.

Materials:

- Map of the World
- Colored pencils
- Digital or printed access to:

  http://oceanmotion.org/html/impact/conveyor.htm

  http://oceanmotion.org/images/impact/global-currents.png

  https://www.youtube.com/watch?v=M0NoOtaFrEs&t=1s
- Data Sheets for students, pp. 42-45
- Global Weather Activity Sheet, p. 41
- Ping Pong balls (*one or more for each group)*
- Recycled materials like toilet paper, paper towel rolls, cardboard, plastic bottles
- Masking tape, duct tape, scotch tape
- Books *(to use as ramps)*
- String
- *If Available:*
  Toy cars, dominoes, ramps *(from car toy sets)*, small fans, pulleys.

ANTARCTIC WEATHER MACHINE

EDUCATOR PREP:

Ensure students have access to a physical or digital copy of the handout to use in creating their globes. Gather the materials for each group to be able to use in this activity.

EDUCATOR GUIDE:

1. In the film, ***Antarctica***, we learn that ocean currents, wind patterns, and temperature shifts play a significant role in what happens across the entire planet. Due to its place on the South Pole and its unique characteristics, this continent can shift climates, affect the movement of air, and change what weather looks like in the places that we live.

2. Inform students that today, we will create a model that will help to visualize and analyze how Antarctica seems so far away, but has a huge impact on what happens in our current location. This cause and effect relationship is similar to a domino effect or a Rube Goldberg Machine. Covid-19 is a great example as a virus that started in China has caused a domino effect of people getting sick, some dying, which led to closures of schools, shutting down of businesses, sports, etc.

Show students a video of a Rube Goldberg machine to show how something that happens in one place can affect things in another.

Here is a commercial for ***Goldie Blox*** toys using a Rube Goldberg device:
https://www.youtube.com/watch?v=M0NoOtaFrEs&t=1s

Ask students the following questions:

How did one single event inside the house cause something else to happen in another house down the block?

Answers will include descriptions of chain reactions as one thing causes another which causes another and so on.

How could you estimate the number of different things (or events) that happened between the first and the last?

Answers may vary, but could include: counting them, counting a set of them and then guessing based on that, or estimating using the distance from the beginning of the machine to the end.

Clouds over Mt. Erebus, McMurdo, Antarctica

Photo: Shutterstock / Michael Lodge

ANTARCTIC WEATHER MACHINE

Imagine if you could only see the first step and the last two steps and everything else was hidden behind a curtain. How could you piece together all the in-between steps?

If you are close enough to hear what was happening, you could record it and try to piece together the sequence of events. You could also use an imaging machine, like an x-ray machine that might be able to see through at least part of the curtain.

4. Inform students that the global weather patterns are like this Rube Goldberg machine, but even more interconnected and far reaching. Imagine instead of a machine, it is a house. When something occurs in one house it also has an effect on all of the houses around it. Not only that, it affects houses across the city. That's an accurate illustration of the impact Antarctica has on what happens across the globe.

5. Students will use the blank map of the earth to label the ocean currents, prevailing winds, and temperatures across the globe to try to illustrate how something that happens in Antarctica could impact where they live.

6. Pass out to students the blank map and divide them into pairs to work together.

7. Using sites like ***weather.com,*** the ***National Weather Service,*** or ***Accuweather data***, have students look up the high and low temperatures for this month, in a few major cities around the world, including the city in which they live. Label these temperatures on their map, near the cities.

a. Sydney, Australia
b. Toronto, Canada
c. Beijing, China
d. Johannesburg, South Africa
e. London, United Kingdom
f. McMurdo Station, Antarctica
g. San Francisco, United States
h. Buenos Aires, Argentina

8. Next, If using digital resources, help them navigate to the ***Ocean Currents*** data using:

http://oceanmotion.org/images/impact/global-currents.png

If using the printed format, pass out the map and help students understand what they are seeing. Ask students to look at the data and talk to their neighbor about what they notice.

9. Encourage students to draw and label the ocean currents on their own maps using a ***blue*** pencil.

Educator Notes:

ANTARCTIC WEATHER MACHINE

10. Once they finish the ocean currents in blue, direct them to use the map on their data sheets to label the prevailing wind currents in ***brown.*** Let students know that it's okay if some of their wind lines overlap with their ocean currents.

11. Inform students that their diagram shows how global currents, temperature, and wind can take something that happens in Antarctica and affect us where we live. Now, we will build a simple model of a chain reaction to show how this happens, their Antarctica Machine. Chain reactions are what caused the Rube Goldberg device at the beginning to work – one thing led to another, and then another, and then another and so on.

12. Divide the class into groups of four students. Give each group the materials that they will use to build their Antarctica Machine, including one or more ping pong balls, recycled materials like toilet paper and paper towel rolls, tape, dominoes, books, toy cars, small fans, duct tape etc. Each group should have access to the same materials.

13. Have students mark, using masking tape, on their table that their machine starts in Antarctica and finishes where they live.

14. Inform students that using the materials provided, they are to build a machine (no more than five steps) that shows effects of global warming, whaling, or pollution can travel from Antarctica to where they live.

15. Give students about 30 minutes to build their machine.

16. Once the students have a working model of the machine, do a gallery walk so that they can see what others have designed. To do this, have one person stay behind to demonstrate the machine while the rest of the group travels to other groups to hear about their model.

17. Instruct students to use their map to answer the questions on their reflection sheets and consider how something that happens in Antarctica could affect them where they live, or other places around the globe.

18. Remind students that heat is energy which cannot be destroyed. Since both water and air are able to hold and move heat around the globe ocean currents and wind patterns, in addition to direct sunlight have a big impact on temperature, precipitation, and overall climate in places.

A tropical storm comes ashore in the Caribbean.

Photo: Shutterstock / Drew McArthur

ANTARCTIC WEATHER MACHINE

19. After students have finished creating explanations for how what happens in Antarctica affects what happens where they live, go around the room and ask each pair to share some of their interpretations with the class. When responding to their explanation, focus on highlighting their thought process and analysis over whether their explanation is correct or not. For example, respond by saying"

> ***"Your connection between the ocean current around Antarctica and the one on the southern tip of South America also makes sense to me. Have you thought about...?"***

20. Wrap up the lesson by reminding students that through modeling and data analysis, scientists work hard to understand connections across seemingly disconnected events. This work is similar to the ***Rube Goldberg Machine,*** except that everything between the first and the last event is behind a curtain and scientists try to reveal or see those events. Today, they played the role of scientists and tried to peek behind the curtain and created a model of how different pieces interact across the globe.

Educator Notes:

Global Weather Activity Sheet

Directions: Use the following to collect information about weather patterns that connect Antarctica to where you live:

Where I live: ____________________

Closest Big City (*City, State, Country*): ____________________

Current Month of the Year: ____________________

City, Country	Average High Temp.	Average Low Temp.
My home		
McMurdo Station, Antarctica		
Buenos Aires, Argentina		
Beijing, China		
Johannesburg, South Africa		
London, United Kingdom		
San Francisco, United States		
Sydney, Australia		
Toronto, Canada		

Global Weather Activity Sheet

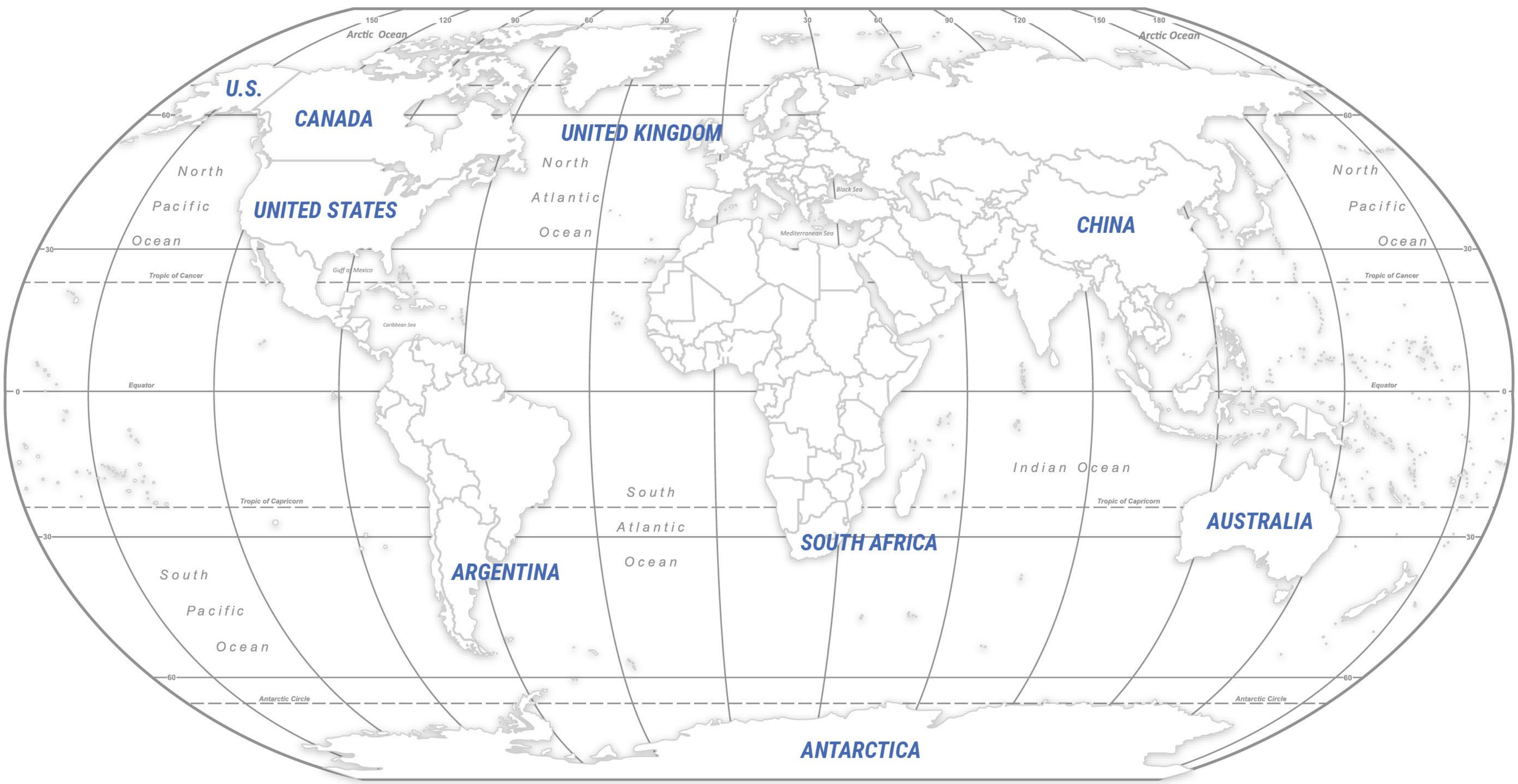
1. *Mark your hometown or closest big city on the map below.*

2. *Find the big cities and note their temperatures on the map below.*

3. *Draw the Ocean Currents in **blue** on the map below.**

4. *Draw the Prevailing Winds, in **brown**, from page #, on the map below.*

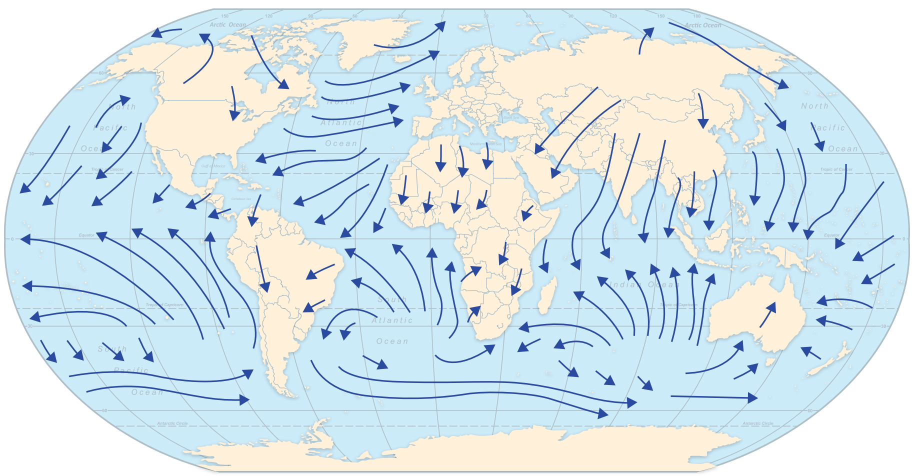
5. *Highlight a path from Antarctica to where you live, using the Ocean Currents and Prevailing Winds.*



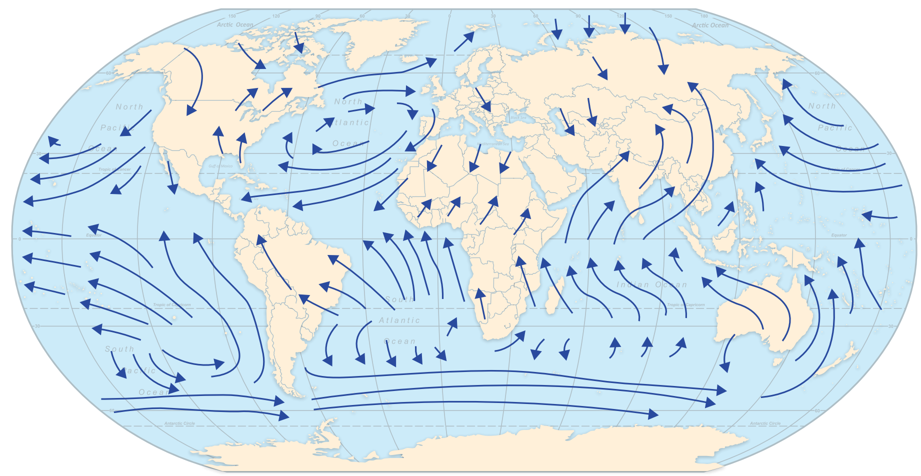
*Use http://oceanmotion.org/html/background/wind-driven-surface.htm to draw the ocean currents around the world.

Global Weather Activity Sheet

SEASONAL VARIATION OF GLOBAL WIND PATTERNS



JANUARY



JULY

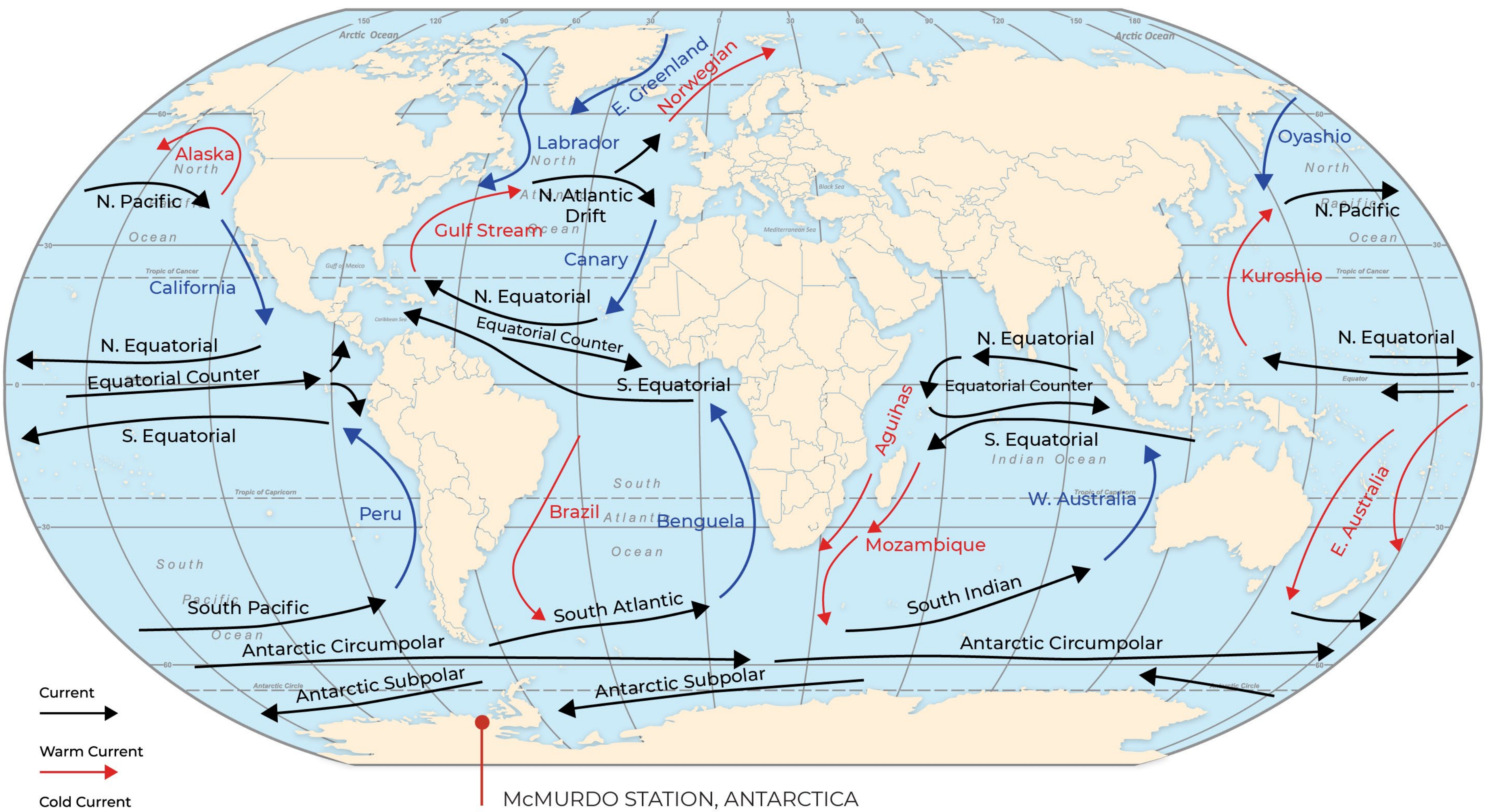
Reflection

If temperatures increase in Antarctica, causing glaciers to start melting, what impact could that have on the weather where you live? Explain using the currents, winds, and temperatures on your activity sheet.

Seasonal Variation of Global Wind Patterns courtesy of Dr. Jean-Paul Rodrigue, Department of Global Studies and Geography, Hofstra University

Ocean Currents Data

Directions: Use these data sets if students do not have access to technology to do their own research.



Temperature Data

Directions: Use these data sets if students do not have access to technology to do their own research.

LOCATION	JANUARY		APRIL		JULY		OCTOBER	
	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW
McMurdo Station, Antarctica	-1°C (31°F)	-5°C (22°F)	-17°C (0°F)	-23°C (-10°F)	-20°C (-4°F)	-27°C (-16°F)	-14°C (6°F)	-20°C (-4°F)
Sydney, Australia	°26C (79°F)	°19C (66°F)	23°C (74°F)	15°C (59°F)	18°C (64°F)	10°C (49°F)	22°C (72°F)	14°C (57°F)
Toronto, Canada	-2.5°C (28°F)	-11°C (12°F)	12°C (53°F)	1°C (33°F)	27°C (80°F)	14°C (58°F)	14°C (57°F)	4°C (39°F)
Beijing, China	2°C (35°F)	-10°C (15°F)	20°C (68°F)	7°C (45°F)	30°C (87°F)	18°C (65°F)	19°C (66°F)	7°C (45°F)
London, United Kingdom	8°C (46 °F)	2°C (36 °F)	13°C (56 °F)	5°C (41 °F)	20°C (68°F)	11°C (52°F)	15°C (59°F)	8°C (46°F)
Johannesburg, South Africa	9°C (49°F)	-3°C (26°F)	21°C (70°F)	7°C (45°F)	29°C (85°F)	17°C (63°F)	22°C (71°F)	7°C (45°F)
San Francisco, United States	14°C (57°F)	8°C (46°F)	17°C (63°F)	9°C (49°F)	19°C (67°F)	12°C (54°F)	21°C (69°F)	12°C 54(°F)
Buenos Aires, Argentina	29°C (84°F)	20°C (69°F)	22°C (71°F)	15°C (58°F)	15°C (58°F)	8°C (47°F)	21°C (70°F)	13°C (66°F)

CLOSER THAN YOU THINK

GRADE LEVEL 4-5

ANTARCTICA EDUCATOR GUIDE


Photo: BBC NHU

CLOSER THAN YOU THINK

GRADE LEVEL 4-5
60 minute Lesson

Standards (NGSS):
5-ESS2-1 Earth's Systems

Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

From the Film:

The film highlights the extremely important role that whales play in Antarctica's ecosystem and the interconnectedness of the natural systems. The presence or absence of whales directly affects the populations of phytoplankton as well as other microorganisms. We also learn the history of commercial whaling and the significant reduction in whale populations as a direct result.

Lesson Overview:

Students will understand that all things are connected and a change in one aspect of the Earth's ecosystem creates a domino like effect that can stimulate a change in another.

Select 1/5th of the class, and designate them as scientists. The remaining students will act as various parts of Antarctica's ecosystem. The Antarctica groups will create a motion rule of their system, which only they are aware of, but they all must follow as they move about the classroom. These movements should mimic living things or bodies of water in Antarctica. Their movement represents how interdependent systems can affect one another in positive ways, and the scientists must observe carefully to identify the rule. Scientists can also test different parts of the system by removing or replacing parts to see how their actions alter the system.

After the game, they will discuss their findings, systems and scientists, and recall humanity's influence on each of the variables.

Materials:

- System handouts, pp. 52-55
- Scientist Activity Sheet, p. 56
(one per student selected)

CLOSER THAN YOU THINK

EDUCATOR PREP:

Print enough copies of the ***Scientist Activity Sheets*** for 1/5th of your students to be able to use. Print the diagrams of systems and have one pack per group of four students.

EDUCATOR GUIDE:

1. Inform students that we will experience a model of Antarctica's ecosystem. Begin the lesson by surveying students' knowledge of systems by asking them the following questions:

What are some systems that you can think of?

Encourage the class to list as many as they can, including body systems (cardiovascular, digestive and respiratory), natural systems (water cycle, nutrient cycle, and rock cycle), mechanical systems (cars, factories, appliances). As students offer their answers, capture them on the whiteboard or on a piece of chart paper.

What do these systems have in common? How are they similar and different?

Consider student answers as a way to assess their background understanding of systems and how elements of systems work together.

2. Inform students that even though each of these systems are different, their basic framework is the same in that many pieces work together for the benefit of the whole.

3. Introduce the "spheres", small, interconnected systems that govern the natural world and ecosystems like Antarctica. The biosphere represents all the Earth's living things. The hydrosphere is all the water of the world, solid, liquid and gaseous. The lithosphere encompasses all the solid rock of the Earth and lastly the atmosphere, all the air on Earth. Inform students that when these spheres interact, they are called events.

4. Challenge students to identify which of the "spheres" were highlighted within the film. Ask students to give examples of systems present within Antarctica's ecosystem and encourage the students to think on the "events" that have or could occur in Antarctica when the spheres interact.

Photo of a working whaling station in Spitsbergen, Norway, 1907.

Photo: Freshwater and Marine Image Bank

CLOSER THAN YOU THINK

Why would understanding a system be important?

Use student answers to this question as a baseline assessment on how students think about or don't think about systems and why or how we can use systems in descriptive and prescriptive way. Answers may include the idea that systems help us to understand relationships or create logical steps that happen in a given order.

5. Inform students they will model Antarctica's ecosystem, and some students will be role playing as scientists. Designate 1/5th of the students as the scientists and ask them to step outside of the room.

6. The remaining students will represent the systems within Antarctica. Instruct them to come up with a motion rule that everyone within the system must follow as they move around the room. These movements should mimic living things or bodies of water in Antarctica. For example, each person within the system could identify two other people in the system to follow or remain in between them at equal distance, similar to a line of penguins. Or they could all choose different geometric shapes that their movements will follow.

7. Instruct the systems group that during the game, they should always remain moving and following the chosen motion rule, like wind moving across the landscape. If at any point an individual within the system is unable to follow the rule they should stop and remain still.

8. Allow the system students to practice for 1-2 minutes after they have identified their motion rule.

9. As the system students practice their rule, step out of the room and go over the rules for the scientists.

10. Inform the scientists that their goal is to identify the rule of the system inside the classroom. To help the scientists understand the system they may remove systems. Every 3 minutes the scientists may also pause the system to ask yes or no questions to the students within the system. Encourage students to use the ***Scientist Activity Sheet*** to record and discuss their observations with each other when the game is not paused.

11. Bring the scientists back into the classroom and start the game.

12. The game should be played until the motion rule is revealed. Scientists should use the scientist notepad to capture their thoughts while playing the game. If the scientists think they have figured out the game, they may pause the game, but may not ask any questions.

Educator Notes:

CLOSER THAN YOU THINK

13. When the scientists describe the rule, they must use their observations to substantiate their guess. Instead of telling them if they are right or wrong, encourage them to provide evidence that disproves an incorrect guess or if the scientists guess correctly, confirm with the participants. At this point, end the game and move on to class discussion.

14. Following the game, facilitate a whole group discussion about what it was like to be a part of system that could be influenced outside of their control and the intricacies of a system when observed. Ask students the following questions as a reflection first in their notebooks and then shared with the larger group to drive their discussion:

How is this game similar or different from what you know scientists do to learn about these systems?

Use student answers to these questions as a baseline or formative assessment about what students know about how scientists work and the scientific method.

What things did the scientists group do that was most helpful in revealing the pattern?

Student answers will vary, but may include something along the lines of observing different patterns that gave some ideas about what could be going on, thinking of a pattern and trying to see if it fit, changing something to see how it affected the movement of their classmates.

How did guesses that did not end up being right help the scientists get to the right answer?

Answers that are not correct, in this case, helped scientists to try different models and to tweak until they find the one that fits the movement.

15. Referring back to the film inform students the cyclic nature of how the biosphere (all the living things) influence and are influenced by the climate, the land, the air and even other living things like humans. Use student responses to highlight the complexity of the systems within the natural world. Some great examples of this are climate change, decreasing sea ice, whaling and the subsequent ban on whaling.

16. Inform students that the role of whales within Antarctica's ecosystem and the consequence of whaling affects the entire system, the same way that the removal of a person in the game affected the rest of the system.

Whales perform many ecosystemic services, not only to Antarctica but to the Earth's ecosystem. Marine organisms react as carbon sinks, whales specifically hold the equivalent of 30,000 trees worth of carbon. They acquire this carbon from eating krill, and help fertilize the photosynthetic plants, that use CO_2, with their poop.

A powerful flood destroyed this bridge in Sidi Ouaaziz, Morocco. This singular weather event is a result of the interaction of several "spheres."

Photo: Shutterstock / Migel

CLOSER THAN YOU THINK

17. Conclude the lesson by explaining to students that whaling has occurred in many different cultures dating as far back as 600 BCE. Commercial whaling began during the 11th century and from that time 1.5 million whales were processed for soap and margarine.

The whales that took a huge hit were the southern right whales, named because they were the right whales to hunt, that had their numbers decrease from 35,000 to 35. In 1986 a commercial whaling ban was instituted and since that time whale numbers have begun to increase.

18. Have students reflect on the experience in their notebooks using the following prompts:

Thinking about the game and what you learned about whales, how do scientists try to understand the effect of whaling in Antarctica?

Use student responses as a way to assess their learning from the lesson. They should explain how the scientists in the game used observations about how the students interacted to try to figure out the motion rule. In the same way, actual scientists observe not just whales, but all of the animals that interact with whales to understand the effect that whaling has on Antarctica's ecosystem.

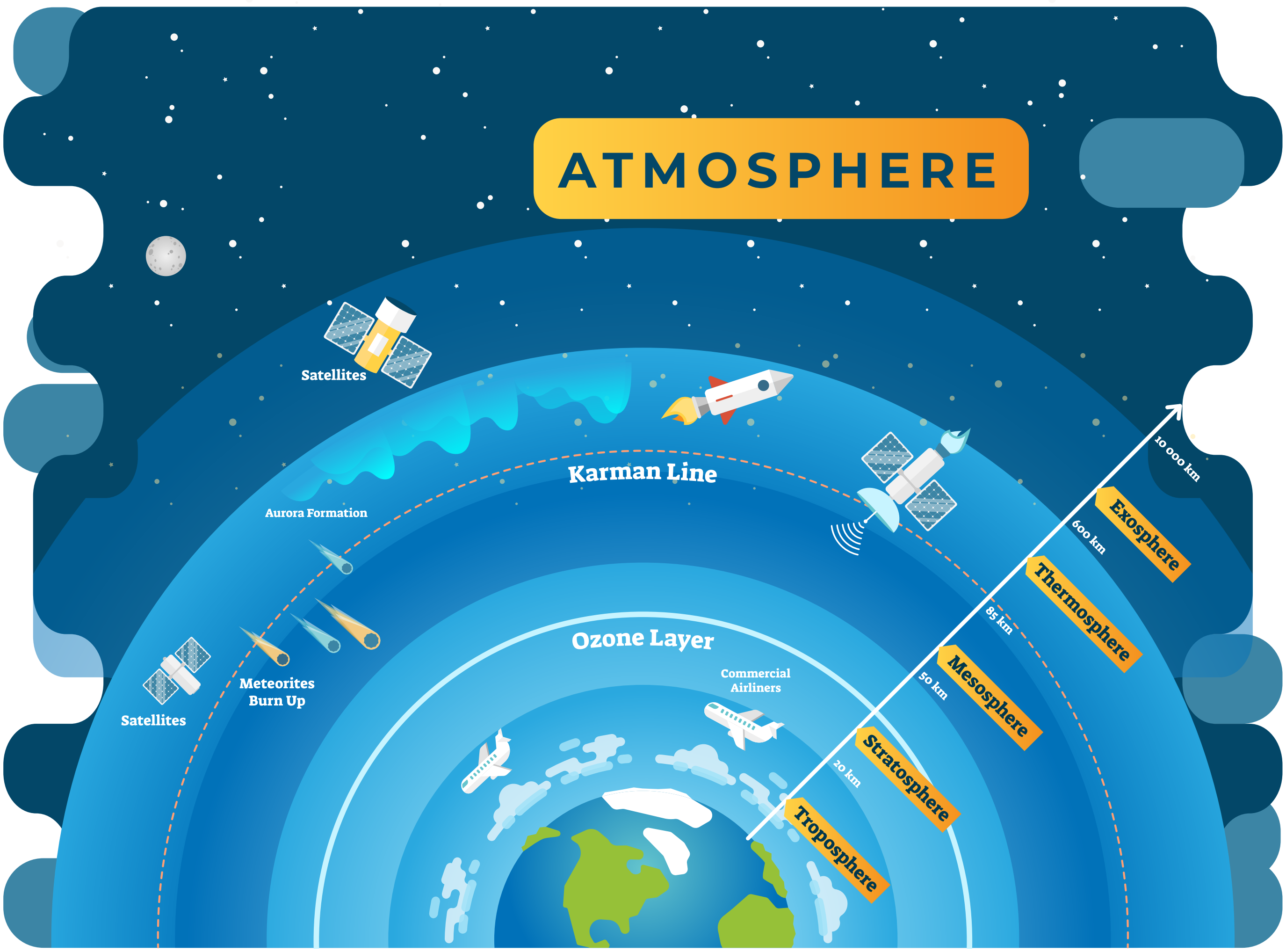
Can you think of another example where humans have done something to such an extent that it has had such a big impact on the planet?

There are limitless examples of humans harming an ecosystem through overfishing, polluting, hunting, exterminating pests...etc. Student responses should reflect an understanding that one action can cause many other things to happen.

Educator Notes:

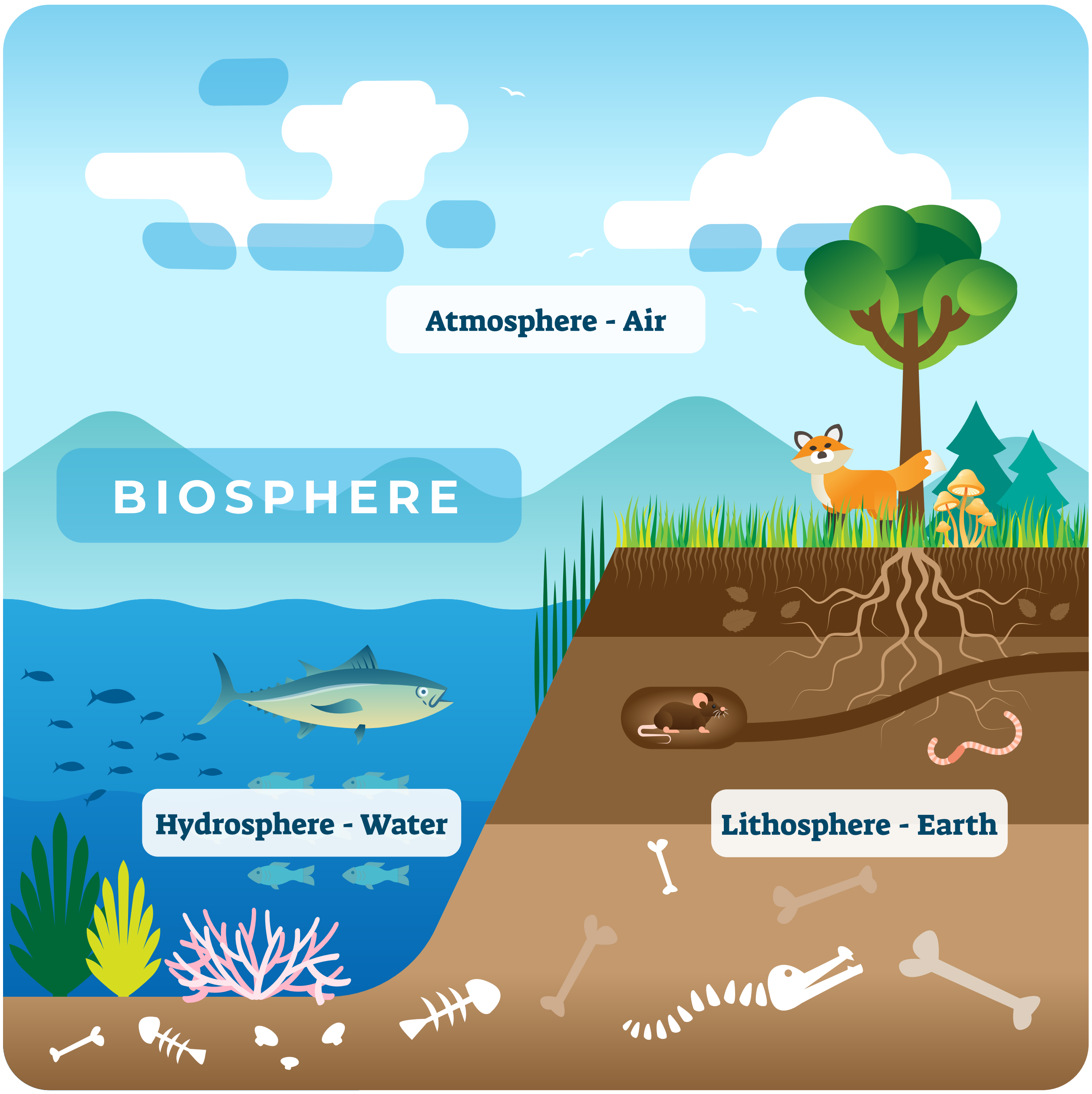
Connections: Atmosphere

Spheres are interconnected systems that describe how parts of our planet work together to make the whole. The **atmosphere** represents all the air surrounding the Earth.



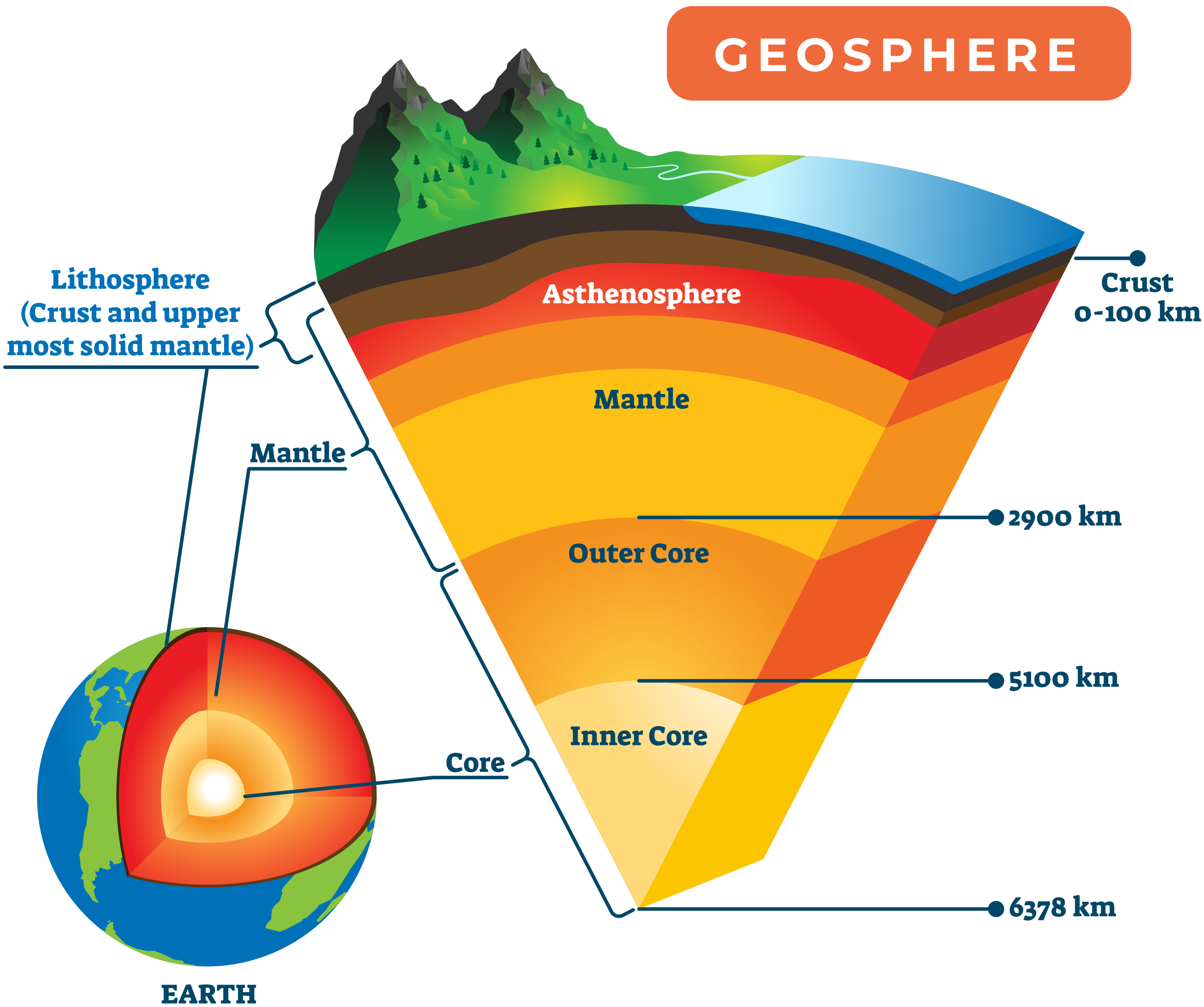
Connections: Biosphere

Spheres are interconnected systems that describe how parts of our planet work together to make the whole. The **biosphere** represents all the Earth's living things.



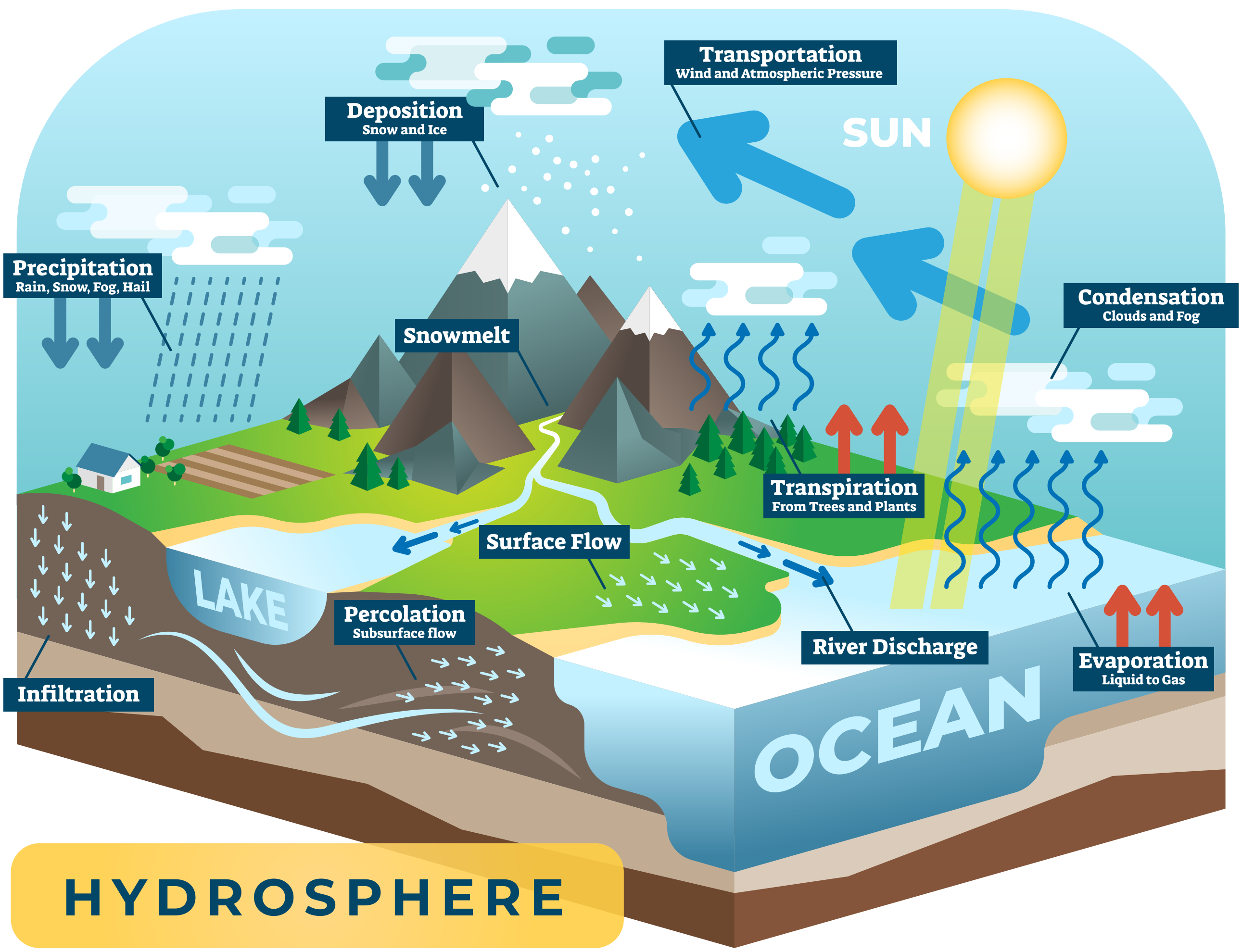
Connections: Geosphere

Spheres are interconnected systems that describe how parts of our planet work together to make the whole. The **geosphere** encompasses all the solid and molten rock of the Earth.



Connections: Hydrosphere

Spheres are interconnected systems that describe how parts of our planet work together to make the whole. The **hydrosphere** is all of the Earth's water; solid, liquid, and gaseous.



Scientist Notepad

Goal:

Attempts:

Observed Patterns:

Rules: "If this, then that." / *Example: "**If** I stand in the middle of the system, **then** Joseph stops moving.*

KRILLIN' IT: AN ANTARCTIC FOOD WEB

GRADE LEVEL 4-5

ANTARCTICA EDUCATOR GUIDE


Photo: BBC NHU

KRILLIN' IT: AN ANTARCTIC FOOD WEB

GRADE LEVEL 4-5

60 minute Lesson

Standards (NGSS):

5-PS3-1

Use models to describe energy that comes from the food animals eat (used for body repair, growth, and motion and to maintain body warmth) was once energy from the sun.

From the Film:

The film ***Antarctica*** features the relationship between various animals and their diets. One animal that is highlighted is the krill, which is a food source for a variety of animals in Antarctica. We specifically see whales and penguins feeding on krill.

Lesson Overview:

Students will discuss the various animal relationships seen in the film and create a food web model focusing on the role of krill in the Antarctic ecosystem. They will play a food web game demonstrating the flow of energy in the Antarctic ecosystem, and highlighting the importance of krill.

Materials:

- Food Web Animal Role Cards, pp. 66-67
  (can be laminated for longer lasting use)
- Food Web Map Handout, p. 63
  (one per student)
- Food Web Cards, p. 65
  (one per student)
- Candy
  (or some other energy token; math Unifix cubes also work well)
- Scissors
- Glue Sticks
- Technology to play the following video:

  http://bit.ly/AntarcticAnimalKrill

KRILLIN' IT: AN ANTARCTIC FOOD WEB

EDUCATOR PREP:

Print a copy of the ***Food Web Handout*** for each student. Print a set of the ***Animal Cards*** (per group).

EDUCATOR GUIDE:

1. In the film, ***Antarctica***, we see many animals and animal relationships highlighted. Ask students the following questions to activate their background knowledge and recollections from the film:

Which animals do you remember from the film?

Answers will vary, but may include whales, penguins, seals, sea stars, sea anemones, and elephant seals.

How did they relate to other animals?

Answers will vary, but may include that one tried to eat another, or that they fought for dominance, or that the parent penguins feed the baby penguins and more.

2. Introduce the idea of survival and share that a goal of all living things is to survive as long as possible and reproduce. Advise students that today we will be focusing on how food plays a role in the transfer of energy to animals. Ask students to turn to their neighbor and together try to answer the following question in their notebooks:

What do animals need in order to survive?

Answers may include a variety of things, including food, water, and shelter.

3. Inform students that food webs are diagrams, and a way that scientists use to understand how living things in an ecosystem relate to each other. Food webs can be as simple or complex as a spider web. They are called food webs because they are the natural intersection of food chains. A food chain is simply one strand of a more complex food web, and shows the natural relationship of predator/prey among animals.

4. Show students the six animal cards from the ***Food Web Handout***. Assign each animal to a group of four students or table groups, and ask them to create a list of what they recall from the movie for their animal. For example, what do these animals need to survive? Have each group or table share out loud with the whole class.

A ***gentoo*** penguin comes face to face with its main predator - the leopard seal.

Photo: BBC NHU

KRILLIN' IT: AN ANTARCTIC FOOD WEB

5. Ask students to consider the following questions as they watch the video ***"Animals of the Ice: Antarctic Krill".***

What food do krill need to survive?

Krill eat small plants, like phytoplankton and algae under the sea ice.

What would happen to the animals in Antarctica if all the krill disappeared?

Animals like whales, seals, and penguins would not have any source of food.

6. Hand out the ***Food Web Map.*** Inform students that a food web helps us understand how plants and animals get the energy they need in order to survive. Have students use scissors to cut out animal cards (this can also be done beforehand to save time). Students will work with a partner to place cards in the correct boxes on the sheet. Ask students to raise their hands once they are ready to check their answers. Once you have checked their food web, instruct students to glue the pictures onto their map.

7. Inform students they will be acting out their food web. Each student will be assigned an animal role to play. Inform them we will be using candy as tokens, and that they should not eat the candy until you give them permission at the end, and only if the candy is wrapped.

FOOD WEB GAME

8. Use the Animal Role Cards to randomly assign roles. Make sure to give out krill cards to ¾ of the class. Hand out at least 1 whale card, 1 seal card, and 1 penguin card for every 2-3 icefish to the rest of the class.

For example, a class of 24 would have 18 krill, 1 whale, 1 seal, 1 penguin, 3 icefish. Have students keep their animal card face down to keep secret for now.

9. Notify students that you are the sun. You will take the candy (or another token) out of a bag to hand out. Ask the students to look at their cards and have the "krill" students stand up. Give out 3 pieces of candy to every krill.

Educator Notes:

KRILLIN' IT: AN ANTARCTIC FOOD WEB

Ask the students the following question:

What do you think the candy represent? Why?

The candy represents units of energy that are transferred from the animal that is being eaten to the animal doing the eating.

10. Inform the students with krill cards that they get to store one packet of energy for themselves, but the other two pieces are available energy. Have them hold up those two pieces and sit down.

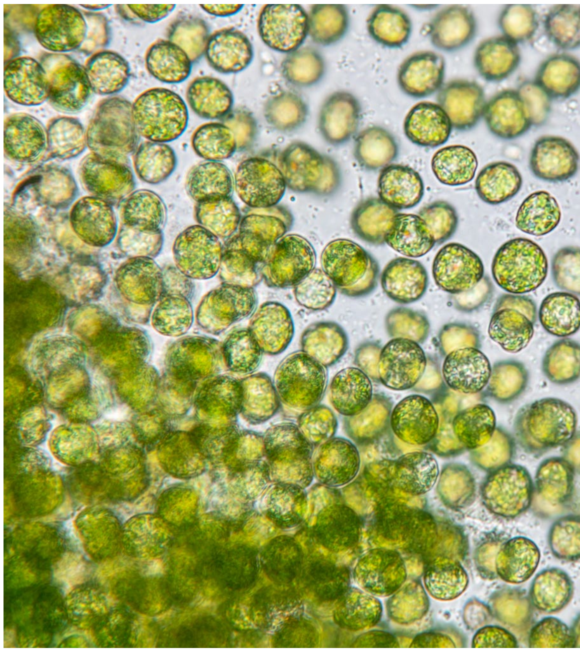
11. Ask the students with whale, seal, penguins, and icefish cards stand up. Have them go around and "eat" the krill (take their two pieces of candy available). The icefish are the smallest, so they will each eat from 1 krill. The whale is mainly dependent on krill for food so they get the most (10 krill). The seal eats 3 krill and the penguin eats 2 krill.

Note: These are guidelines, feel free to adjust the "rules" based on your class size.

12. Inform students the seal and the penguin are still hungry and need more energy so they must get their food from somewhere else, the icefish. Have the icefish store one piece of energy. Have the penguin and seal "eat" the icefish (if there's 3 icefish, have the penguin take energy from 2 icefish and the seal take 1 icefish, otherwise the icefish energy can be split evenly).

13. Inform students that the seal is still hungry. The seal can then "eat" the penguin after the penguin stores one piece of energy for itself.

14. To wrap up the game, ask students how many energy pieces they ended up with? Represent this data on a chart paper using a graph with animals on the x-axis and number of energy tokens on the y-axis.



Widespread green algae, ***Clorella***.

Photo: Shutterstock / Rattiya Thongdumhyu

KRILLIN' IT: AN ANTARCTIC FOOD WEB

15. Ask students again: what happens if there's not enough krill? Inform students this can happen due to overfishing by humans or lower levels of sea ice. Have students play the game again with only half as much krill available, graph the results again, compare, and discuss using the following questions as a group reflection:

What happens to the amount of energy available to the rest of the animals?

With only half as many krill, the other animals are not able to access the energy that is available through the phytoplankton. This means that at least some of the energy does not make it to the rest of the animals. As a result, some of the animals will die of starvation or have to find other sources of food.

Why are krill so important in Antarctica?

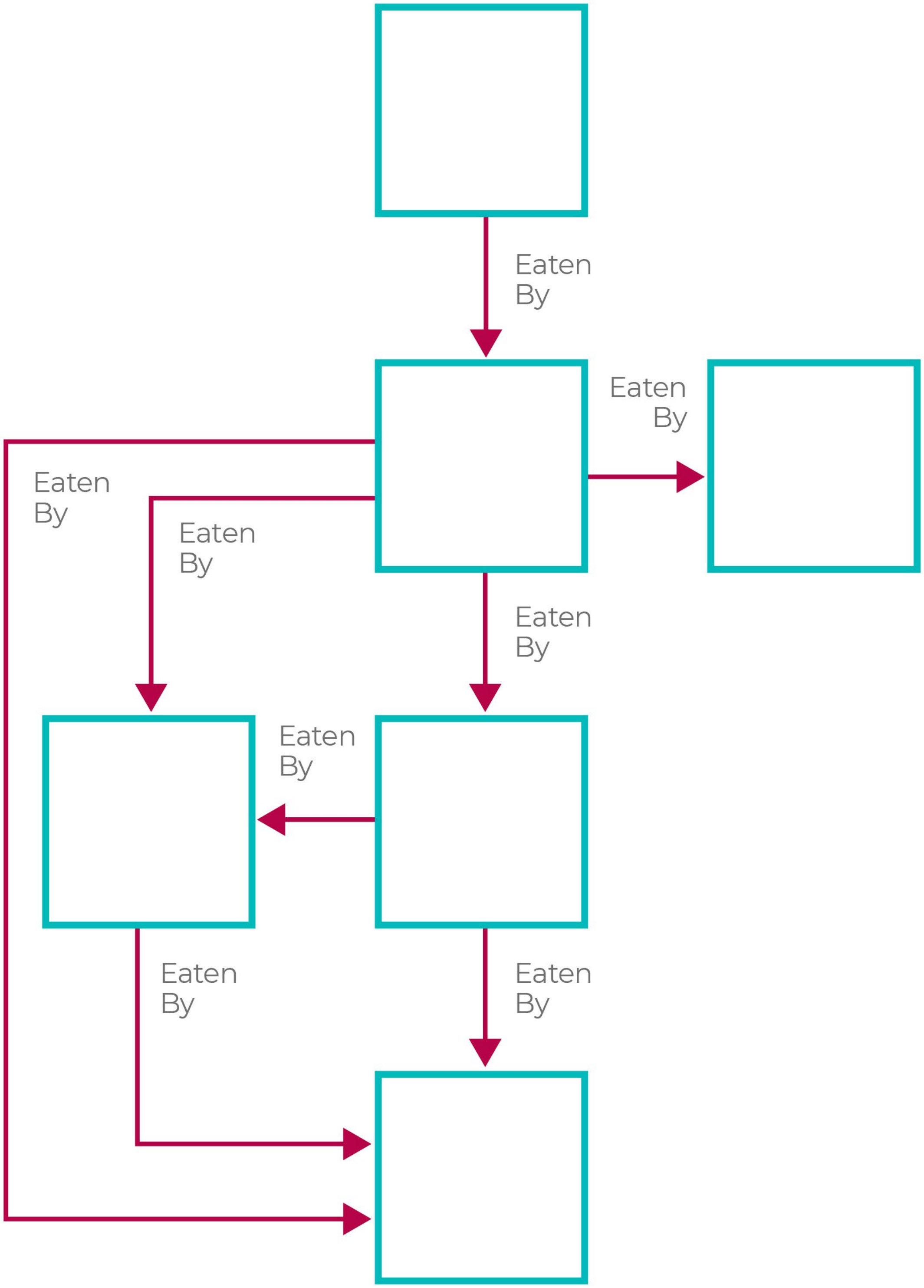
As a primary consumer, krill play a crucial role in Antarctica feeding on phytoplankton and algae so that carnivorous animals have access to the energy that is collected by phytoplankton from the sun.

16. Conclude the lesson reminding students that all biomes have food webs with different producers and consumers. These webs reflect that animals need to have certain things in order to survive and that these needs are most readily available in a healthy and balanced ecosystem.

Educator Notes:

Antarctica Food Web Map

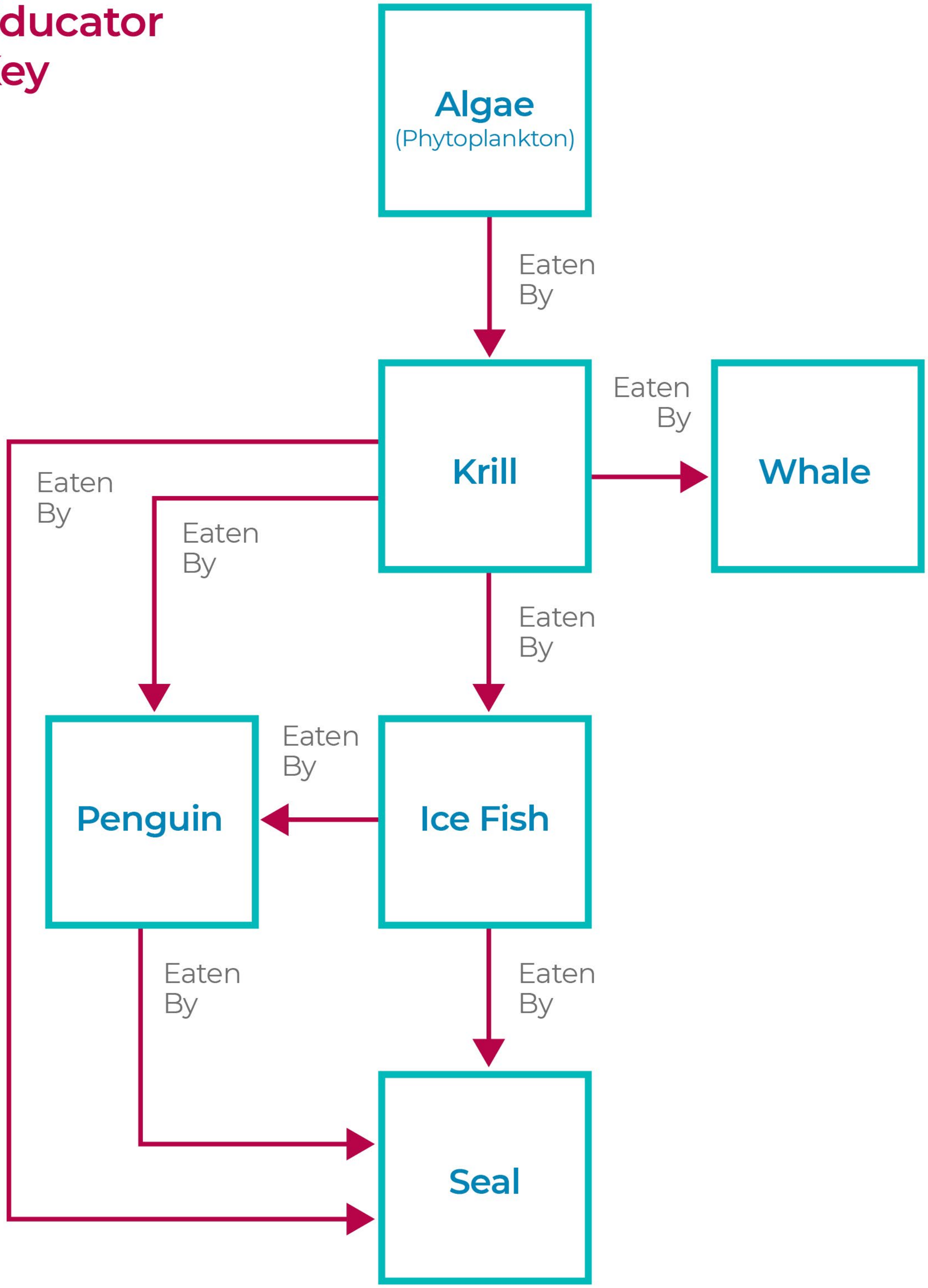
Directions: Cut out the animal cards on the following page. Paste the animals in the correct box.



Antarctica Food Web Map

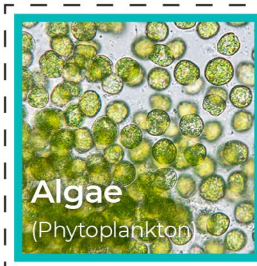
Directions: Cut out the animal cards on the following page. Paste the animals in the correct box.

Educator Key



Antarctica Food Cards

Directions: Cut out the animal cards on this page. Paste the animals in the correct box on the Food Web Activity Sheet.



Photos: Fredi Devas © BBC NHU, © Espen Rekdal, BBC NHU, Shutterstock / Rattiya Thongdumhyu, Andrea Izzotti

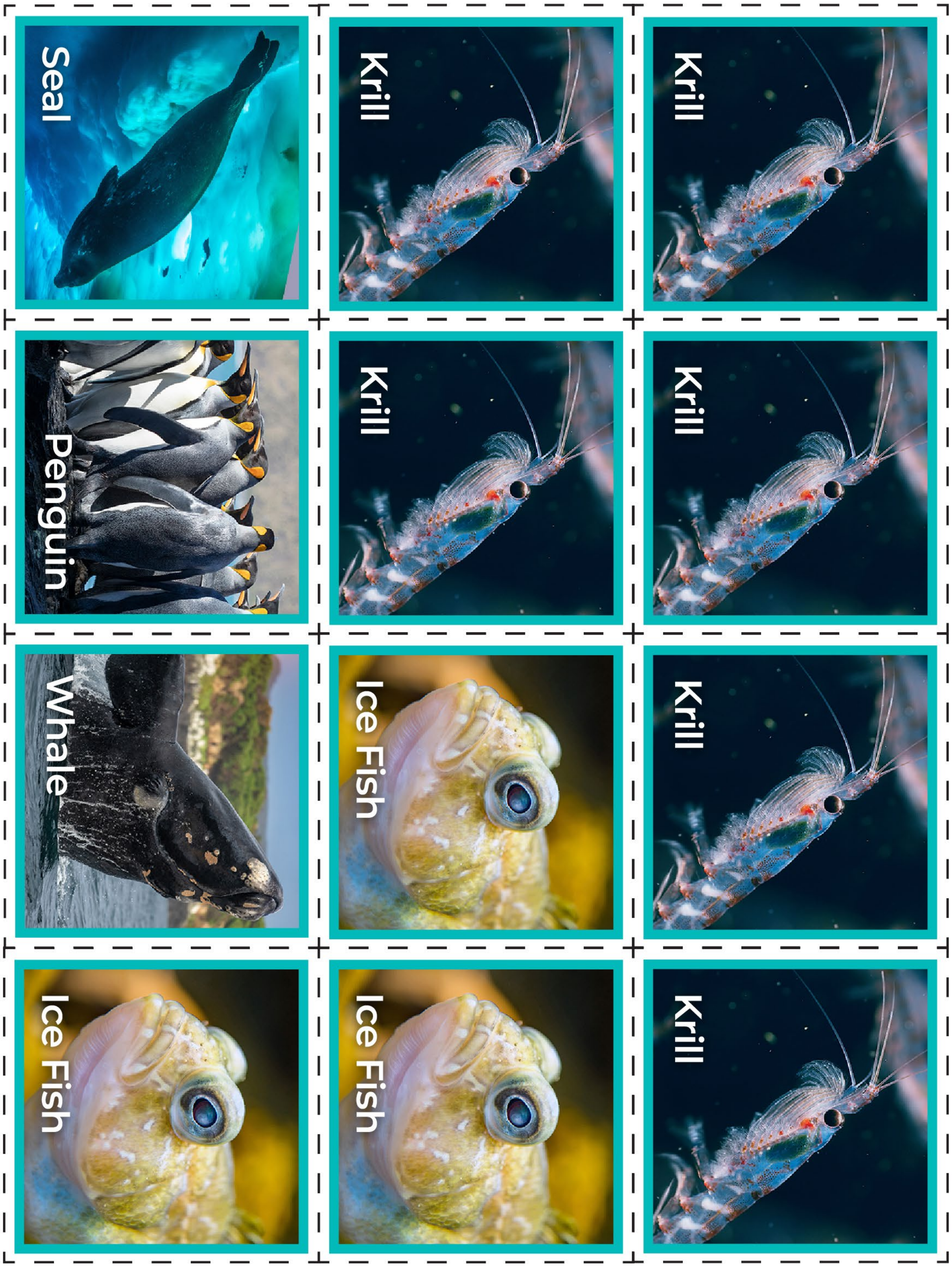
Antarctica Food Role Cards 1

Directions: Cut out the animal role cards on the this page to be used during the role playing game.

Photo: BBC NHU

Antarctica Food Role Cards 2

Directions: Cut out the animal role cards on the this page to be used during the role playing game.



Photos: Fredi Devas © BBC NHU, © Espen Rekdal, BBC NHU, Shutterstock / Rattiya Thongdumhyu, Andrea Izzotti

KEEP ANTARCTICA COLD

GRADE LEVEL 6-8

ANTARCTICA EDUCATOR GUIDE

Photo: © Espen Rekdal

KEEP ANTARCTICA COLD

GRADE LEVEL 6-8

60 minute Lesson

Standards (NGSS):

MS-ESS3-3 Earth and Human Activity

Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

From the Film:

The film focuses primarily on the ramifications of climate change on the amount of sea ice and animal behavior. It brilliantly showcases how the interconnectedness of the world's systems, no matter how far away, can affect the Antarctic ecosystem. There are many things that we as human beings can do to help mitigate human influenced climate change.

Lesson Overview:

Students will take a tour of their school observing the different operations that allow their school to run efficiently. Then, they will be split into groups and challenged to redesign a part of their school to make it more energy efficient (green) using renewable energy options or smaller, cost-effective, but impactful changes. If time allows each group could be tasked with designing the entire school. Each group will have separate building and operating budgets to consider the short term and longer-term impacts of their designs.

The goal is to design, build and write up the proposed changes to their school under the guise that they would present their recommendations to their school board.

Materials:

- Green Building Activity Sheets, pp. 72-74 *(one per student)*
- Poster board
- Scissors
- Building materials: cardboard, duct tape, glue, paper, dowel rods
- Computers (at least one per group)
- Operational & building budget handout
- LEED Building Checklist:

https://www.usgbc.org/resources/checklist-leed-v4-building-design-and-construction

- News article: *"How can we make our buildings green?"*

https://www.worldgbc.org/how-can-we-make-our-buildings-green

KEEP ANTARCTICA COLD

EDUCATOR PREP:

Prior to class, assemble presenting materials like poster board and paper and divide students into groups. Print the ***World Green Building Council*** article for each student to have a copy or provide students with access on their devices at:

https://www.worldgbc.org/how-can-we-make-our-buildings-green

EDUCATOR GUIDE:

Almere, a planned city and municipality in the Netherlands, has made a huge investment in solar energy.

Photo: Shutterstock / Pavlo Glazkov

1. Inform students that today they will respond to a Request for Proposal put forth by their school board asking for ideas to redesign a part of their school to decrease its carbon footprint. Introduce them to fossil fuels, and actions that contribute to a large carbon footprint like food waste, transportation, heating and cooling, and energy needs.

2. Have students read the article from the World Green Building Council. They will use the information provided in this article to consider possible improvements to their school.

3. With this idea in mind, break the students into groups of four or five and allow them to observe a specific section of the school for 5 minutes to understand the school's current operations. Encourage them to take note of the number of lights and type, trash and recycling access, temperature of the room, and other relevant things within their selected part of the school.

4. When they return, hand out LEED building checklist and scorecard. As you go over the checklist, show the students examples of energy efficient utilities, LEED certified building recommendations as well green alternatives. If time allows, have student research this instead of providing examples.

5. Hand out the ***Green Building/Better World*** project activity sheets and walk through the process of beginning to create a proposal.

6. Let students know that since they have been provided a finite amount of money, they will need to consider the best way to maximize their budget. Now that they have completed an initial assessment, they will need to price the upgrades to see how they can get the biggest impact for their budget.

KEEP ANTARCTICA COLD

7. Have students self-identify (or assign) into one of the four roles that will be required for this project:

Finance – responsible for having the group finalize their budget for the project)

Marketing – responsible for having the group create a Flipgrid video, including a visual aid, to share their proposal

Operations – responsible for writing up the description of what they are proposing and why

Project Manager – responsible for helping the group stay on task and meet their deadline of a written and video proposal by the end of the period.

8. Provide students with about 30 minutes to be able to complete the project sheet and record their 3-5 minute pitch on Flipgrid for why their project should be funded. They have the option to create a digital or poster-board to use in their pitch as a visual aid. This can be done with poster board, chart paper, or a digital tool like ***Google Slides*** or ***PowerPoint***. They should address all of the questions on the activity sheets as part of their Flipgrid video.

9. Once all of the proposals have been submitted, have students watch other groups' proposals and answer the following questions in their notebooks:

Which of the proposals that you did not work on was most convincing? Why?

Student answers will vary, but should include an explanation for why they found the one they choose the most compelling.

How did it feel to try to balance impact with cost?

Student choices will vary, but should include a reflection of the tension between trying to design something with some impact within the restriction of a budget.

Educator Notes:

GREEN BUILDING/BETTER WORLD

The school board of your district has allocated $250,000 for you to spend on reducing the impact of your school on the environment and have put for the an RFP (Request for Proposals). In this exercise, you will begin to develop a proposal by assessing an area in the school and considering ways that it may be modified to bring it closer to LEED Standards. Once you have made your assessment, you will put together a proposal using the price list below to consider what you will do with the budget that you have been given.

Assessment of School Area

What part of the school did you choose to modify?

Why did you choose this area?

What are the opportunities in this area to reduce your school's impact on the environment?

GREEN BUILDING/BETTER WORLD

Project Budget

Use the Price List on p. 70 to create a project budget for the $250,000 that is available to spend:

Item	Location to Install	Cost

Budget Justification

In 8-10 sentences, describe why you have selected these items with which to upfit your school. How will these upgrades help to reduce your school's impact on the environment and reduce its carbon footprint?

GREEN BUILDING/BETTER WORLD

Green Building Price List

Use the Price List below to create a budget plan for the $250,000 that is available to spend:

Item	Description	Installation Location	Cost
Solar Panels	Panels that collect sunlight that can be converted to electricity.	Solar Panels	$100,000
Recycling Wastewater System	Water is cleaned and cycled back inside the building to be used in non-potable ways.	Bathroom or Kitchens	$50,000
Windmill	Wind energy is converted to electricity used in the building.	Outside	$200,000
Windows	Replace Existing Windows with Energy Efficient Windows to reduce the amount of heat leaking in during the summer or out during the winter.	Outside	$5,000 per Window
Motion Sensors for Lights	Lights turn on when people enter the room and off when they leave.	Anywhere	$500 per light
LED Bulbs	Energy efficient bulbs reduce power usage.	Anywhere	$50 per light
Electric Car Charging Station	Allow for electric cars to recharge while parked.	Outside	$75,000
Energy Efficient Air Conditioning and Heating	Temperature control that uses less energy.	Entire Building	$100,000
Recycling Options	Stations that encourage people to reduce the amount of waste by adding items to be recycled.	Cafeteria, Classrooms	$1000 Per Station
Additional Windows for More Natural Lighting	More windows create a connection to nature and reduce the need for artificial lighting.	Anywhere	$10,000 per window
Native Plants Garden	A garden designed to contain native plants that attract and support pollinators.	Outside	$1,000
Composting Food Waste System	A system to collect food waste to reuse in the garden, and reduce garbage.	Cafeteria	$ 5,000

ON THIN ICE

GRADE LEVEL 6-8

ANTARCTICA EDUCATOR GUIDE


Photo: © Espen Rekdal

ON THIN ICE

GRADE LEVEL 6-8
60 minute Lesson

Standards (NGSS):
MS-ESS3-3 Earth and Human Activity

Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

From the Film:

The film explains how record high temperatures lead to glacial melt which often stimulates a change in feeding behavior for Antarctic wildlife. The film also examines the interrelation between sea ice melt, sea level rise, rising ocean temperatures and ocean acidification.

Lesson Overview:

Students will experience a lab demonstration in which they observe a color change when simulated sea water encounters excessive amounts of carbon dioxide. Following this activity, students will be introduced to the term ocean acidification and carbon dioxide emitters, both natural and human. Students will learn about the extra vulnerability of polar waters as carbon dioxide dissolves more in cold water than warm. They will test various acidic solutions on shells to learn, observe and record how the decreased pH affects invertebrate marine life.

Materials:

- Activity Sheets, p. 81, 83, 85, 87 *(one per student)*
- Lab Trays
- 4000 ml .04% Bromothymol Blue Solution
- Hydrochloric Acid (optional)
- Metal or paper straw or soda streamer with CO_2 canister
- Shells – one per group
- Stopwatches
- Class set of dustless chalk
- Class set of 4 oz. cups
- 50 ml glass beakers (3 per group, labeled 1, 2, 3)
- pH test strips (double class set)
- Vinegar
- Antacid tablets (class set)
- Cold, warm and hot water
- Thermometers (3 per table)
- Carbon Cycle video:

https://www.youtube.com/watch?v=vrDekmRbBVk

ON THIN ICE

EDUCATOR PREP:

Before class, make 4000 ml of a diluted Bromothymol blue solution. Pour 1000 ml of solution into each of two beakers or flasks. Warm one flask up to about 90 degrees Celsius and leave on the hot plate until ready to use. Warm up a second flask to 90 degrees and remove from the hot plate at the beginning of class. Leave the rest at room temperature.

Fill the student sets with about 100-150 ml of the solution in each beaker. Be sure that each student group set has a sample from each three temperature – one hot, one warm, and one room temperature.

Print out one activity sheet for each student.

EDUCATOR GUIDE:

1. Inform the students that today, they are going to be exploring the cause and subsequent effects of ocean acidification. Begin by showing this video of the Carbon Cycle from the EPA.

   https://www.youtube.com/watch?v=vrDekmRbBVk.

2. Just as solids like salt and sugar can dissolve in water, so can gases. One such gas is Carbon Dioxide which is produced during respiration. Encourage students to breathe in and then breathe out. Point out as they exhale: they are breathing out CO_2. This gas is also produced when organic and carbon particles are burned. While this gas is naturally occurring, with plants both above and underwater converting the CO_2 they encounter to Oxygen, it is also emitted by the burning of fossil fuels. Prior to the industrial revolution the Earth's average CO_2 was 280 parts per million (ppm). The current global average of CO_2 according to ***climate.gov*** is 407.4 ppm. About one third of atmospheric carbon dioxide is absorbed by the ocean.

3. Let students know that today, we will explore these ideas in three ways: A demonstration of Carbon Dioxide absorption, testing how temperature affects carbon absorption, and observing how acidic ocean water affects sea life.

Below the sea ice, in the Ross sea, the water is a constant -2°C (about 28°F). The sea floor is carpeted with starfish and sea spiders the size of dinner plates. This rarely seen ecosystem is perhaps one of the most pristine left on earth.

Photo: © Espen Rekdal

ON THIN ICE

CARBON ABSORPTION DEMO

4. Explain that the dark blue solution represents ocean water with an average pH of 8.1. Instruct them to pay close attention as you add something to the water

a. Using a soda streamer and purchased CO_2

i. Insert the hose into the cup or glass and spray in carbonated water.

ii. Continue to add the water until the once dark blue solution turns a bright yellow.

b. Using a reusable straw, and your own CO_2
(You may call on a volunteer, making sure that no students share the same straw)

i. Insert the straw into the cup or glass and instruct your volunteer to blow bubbles in the water.

ii. Continue to blow bubbles until the once dark blue solution turns a bright yellow.

5. Ask the students to explain what happened using these questions:

What was put into the water?

Carbon dioxide that was exhaled out of the lungs was added to the water.

What is significant about the once dark blue, now yellow water?

The color indicates how much carbon dioxide has been dissolved into the water. The color changes as more carbon dioxide is dissolved.

6. Inform students that this water has an indicator solution in it that causes it to change color based on the pH of the solution. Referencing the pH chart on their activity sheet, did the water become more alkaline or acidic?

Educator Notes:

ON THIN ICE

TEMPERATURE AND CARBON ABSORPTION

7. Inform students that next, they will test how the temperature of the water affects how quickly the carbon dioxide dissolves.

8. Ask students to confirm that the beakers are labeled #1, #2, and #3 and that each beaker contains three different temperatures of Bromothymol Blue solution.

9. Using the thermometer, have students measure and record on their activity sheets, the temperature of the Bromothymol Blue solution in the three beakers.

10. Once all the groups have recorded the temperatures of the solutions in the beakers, ask them to drop one antacid tablet into each of the beakers and start the timer on their stopwatch.

11. Let students know that once a beaker's color has changed to yellow, they should record the elapsed time from their stopwatch on their data sheet.

PART I: OCEAN ACIDIFICATION AND MARINE LIFE

Part I (Optional – if you do not feel comfortable handling hydrochloric acid safely or do not have access to it or safety equipment, please move on to Part II)

12. Give each group petri dish with a single shell in it. Let them know that now, we will observe what happens to marine life when ocean water becomes acidic. We will use hydrochloric acid, which has a pH of 0, so all students should be wearing gloves and googles.

13. Moving from group to group, using a pipette, add HCl onto the shell one drop at a time. Students do not need to touch the shell.

14. Ask the class to discuss and record their observations on their activity sheets.

PART II: OCEAN ACIDIFICATION AND MARINE LIFE

15. Provide each student with two 4 oz. cups, two small pieces of classroom chalk, two pipettes, two pH strips, and a paper towel. Inform students that the classroom chalk will represent the shell of an invertebrate, since it's made of the same materials.

16. Inform students that every two students will share a beaker of vinegar and a beaker of blue water. Instruct students to place their chalk, representing the shell of an invertebrate, in their 4 oz. cups. One cup will be our control and will only have water, with a pH of 7, while the other will be vinegar, with a pH of 2.4. Using a permanent marker, label one cup Sample 1, and the other, Sample 2.

A diver with a southern right whale. This population of around 35,000 whales was decimated by whalers and yet, amazingly, these animal remain inquisitive and gentle around humans.

Photo: BBC NHU

ON THIN ICE

17. Have students place one piece of chalk into each cup.

18. Using their pipette, add blue 'ocean' water to the cup labeled, Sample 1, just enough to submerge the chalk. After about a minute, instruct students to use the pH strip to measure the pH of solution in Sample 1 and record their observations.

19. For Sample 2, use the pipette to add vinegar to the cup, again just enough to submerge the chalk. After about a minute, instruct students to use the pH strip to measure the pH of solution in Sample 1 and record their observations.

20. Have students answer the reflection questions, comparing the two samples and explaining the significance of the findings.

CONCLUSION

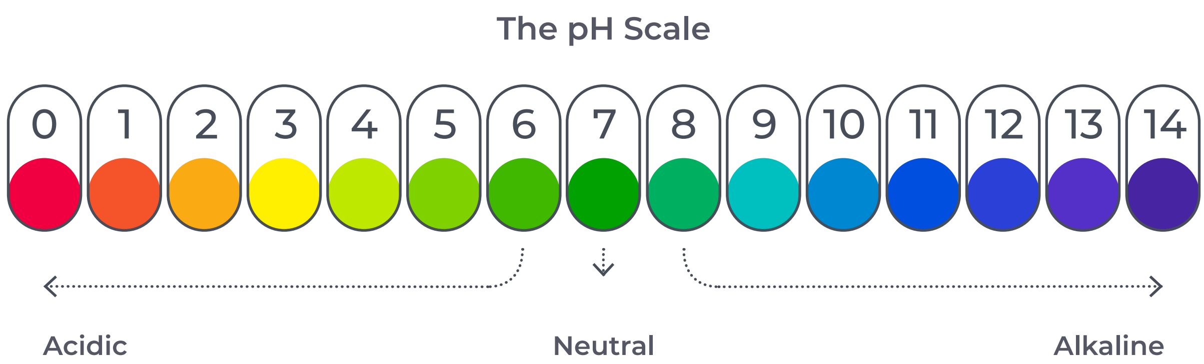
21. Wrap up the lesson by explaining to students that when carbon dioxide dissolves in the ocean some of it mixes with the water molecules to form carbonic acid. This acid can be broken down into two ions, carbonate and bicarbonate. Carbonate is incredibly helpful as it serves as the molecular foundation for marine invertebrates to construct their shells.

Normally, these four elements are balanced, however when there is an excessive amounts of CO_2 the helpful carbonate ions decrease and the not so helpful bicarbonate and carbonic acids increase, lowering the pH of the water. When this more acidic water meets marine life, it can be pretty harmful, as evidence by this experiment. This harm is not limited to animals that build shells. Fish and squid are also affected.

Due to human activities, the ocean is currently becoming more acidic at a rate that is 10x faster than any other time in Earth's history. It is the speed of this change that will make it especially difficult for many marine species to adapt. Scientists are still trying to determine how most marine life will adapt to these rapid changes to ocean chemistry.

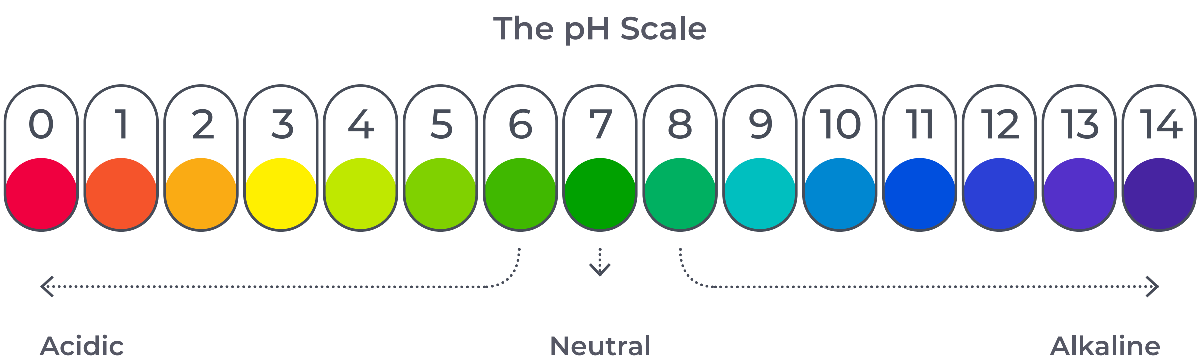
Educator Notes:

CARBON ABSORPTION DEMO



Using the chart above, did the solution become more acidic or more alkaline? How do you know?

CARBON ABSORPTION DEMO



Using the chart above, did the solution become more acidic or more alkaline? How do you know?

The solution became more acidic. I know that because the color of the solution changed from blue to yellow and the pH strip showed that it now has a pH of less than 7, which makes it acidic.

Educator Key

TEMPERATURE AND CARBON ABSORPTION

Procedure

1. Label the beakers on your tray as #1, #2, and #3.

2. Measure the temperature of the three beakers of Bromothymol Blue. Record in the table above.

3. When your educator instructs you, drop one tablet of antacid into each of the three beakers. Have one of your group members start the timer as soon as the antacids enter the water.

4. Observe the solution in the beakers as it changes color. Record in the table the amount of time in minutes it took for the solution to become yellow for each of the three beakers

Use the following table to record the data for how long it takes water to absorb carbon dioxide

	Recorded temperature	Time of Color Change (mins)
Beaker #1		
Beaker #2		
Beaker #3		

TEMPERATURE AND CARBON ABSORPTION

Procedure

1. Label the beakers on your tray as #1, #2, and #3.

2. Measure the temperature of the three beakers of Bromothymol Blue. Record in the table above.

3. When your educator instructs you, drop one tablet of antacid into each of the three beakers. Have one of your group members start the timer as soon as the antacids enter the water.

4. Observe the solution in the beakers as it changes color. Record in the table the amount of time in minutes it took for the solution to become yellow for each of the three beakers.

Use the following table to record the data for how long it takes water to absorb carbon dioxide.

	Recorded temperature	Time of Color Change (mins)
Beaker #1	Data	Data
Beaker #2	Data	Data
Beaker #3	Data	Data

Educator Key

OCEAN ACIDIFICATION AND MARINE LIFE

Part I

Describe what you observed when the hydrochloric acid was added to the shell in the petri dish.

Part II

Add your chalk to the cup. Add in your ocean water slowly, describe what happens as the water interacts with the chalk below. Using pH strips, test the ocean water by using your pipette to pick some up and place drops onto a pH strip. Set this pH strip on a napkin and label underneath it “Sample 1.” Compare the color of the strip to the scale provided on its container and write the corresponding value below.

pH of Sample 1: ________

Using a pipette add 1.5 ml of vinegar to the cup, continue to add drops until the chalk begins to dissolve. After each round of adding vinegar, record what happens to the chalk. Once it begins to dissolve, use a pH strip to test the water and record. Set your pH strip on a napkin and label it, “Sample 2.” Compare the color of the strip to the scale provided on its container and write the corresponding value below.

pH of Sample 2: ________

OCEAN ACIDIFICATION AND MARINE LIFE

Part I

Describe what you observed when the hydrochloric acid was added to the shell in the petri dish.

When the hydrochloric acid was added to the shell, it began to bubble. It looked like the shell was being slowly broken down by the hydrochloric acid.

Part II

Add your chalk to the cup. Add in your ocean water slowly, describe what happens as the water interacts with the chalk below. Using pH strips, test the ocean water by using your pipette to pick some up and place drops onto a pH strip. Set this pH strip on a napkin and label underneath it "Sample 1." Compare the color of the strip to the scale provided on its container and write the corresponding value below.

pH of Sample 1: 7

The chalk turns darker, and floats in the water before sinking to the bottom. Some bubbles seem to be coming off the chalk, but other than that, it's not doing much of anything.

Using a pipette add 1.5 ml of vinegar to the cup, continue to add drops until the chalk begins to dissolve. After each round of adding vinegar, record what happens to the chalk. Once it begins to dissolve, use a pH strip to test the water and record. Set your pH strip on a napkin and label it, "Sample 2." Compare the color of the strip to the scale provided on its container and write the corresponding value below.

pH of Sample 2: <7

The piece of chalk is fizzing and bubbling as it sits in the vinegar. I can hear it fizzing, almost like an antacid tablet when it's dropped into the water. There are also small pieces of chalk that fall off and are floating in the vinegar.

Educator Key

OCEAN ACIDIFICATION AND MARINE LIFE

How do samples 1 and 2 differ?

Based on this lab, why is it important to monitor the pH of the ocean?

OCEAN ACIDIFICATION AND MARINE LIFE

How do sample 1 and 2 differ?

The chalk in sample one seems to sit in the water and is relatively unaffected by it, while the chalk that sits in the vinegar bubbles a lot and then seems to start to slowly break apart.

Based on this lab, why is it important to keep an eye on the pH of the ocean?

If the ocean water becomes more acidic, it will slowly break down the shells of the animals that live in the water. This would mean that these animals would no longer be able to survive. Not only would many of these animals tragically become extinct, but the ecosystem that relies on them would be harmed as well.

Educator Key

WE'VE GOT LOTS OF ICE, ICE BABY!

GRADE LEVEL 6-8

ANTARCTICA EDUCATOR GUIDE

Photo: © Espen Rekdal

WE'VE GOT LOTS OF ICE, ICE BABY!

GRADE LEVEL 6-8
60 minute Lesson

Standards (NGSS):

MS-LS2-3

Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

From the Film:

In the film ***Antarctica***, students learn about the coldest region on Earth. Throughout the film we see various types of ice showcased including sea ice, glaciers, and icebergs. We also see how this ice is being affected by climate change, and how ice melting affects sea levels throughout the world.

Lesson Overview:

Let students know that they will work in groups to research the different types of ice and make a model of their designated ice type. Groups will present information to the class to the tune of an ice or cold themed song ***(ex: Ice Ice Baby, Let it Go).*** The educator will guide students to a discussion of the differences noted between the different types of ice and demonstrate the effect of Sea Ice Melting vs Ice sheets melting on sea levels.

Materials:

- Technology access for research
- Ice Features handout, p. 93 *(one per student)*
- Ice Demo and Reflection handouts, pp. 95, 97, 99 *(one per student)*
- Two identical clear food storage containers *(about 6" x 6")*
- Clay
- Tray of ice cubes

Water

Ruler

WE'VE GOT LOTS OF ICE, ICE BABY!

EDUCATOR PREP:

Print Ice Features, and Demo with Reflection Handouts (one per student)

Prepare Ice Melting Demo- Freeze ice cubes at least one day before lesson. Add enough clay to one side of each container, enough to have about 1-2 inches deep of clay.

Press clay down to create a smooth surface, it will represent the land in Antarctica. The clay should take up about a quarter of the container, the rest will be filled with water. Label one container Sea Ice and the other container Ice Sheet.

EDUCATOR GUIDE:

1. In the film, ***Antarctica,*** students were introduced to various types of ice formations. To activate their background knowledge from the movie, ask students to work in pairs to try to answer the following question. Give them about a 60-seconds to see if they can come up with all four:

What are the four types of ice formations mentioned in the film?

The narrator mentions glaciers, ice sheets, sea ice, and icebergs.

2. Bring out the Ice Melting Demonstration. Carefully place enough ice cubes on the clay in the "Ice Sheet" container. Place an equal amount of ice cubes in the "Sea Ice" container on the bottom of the container next the clay. Instruct students they will investigate the effect melting Sea Ice vs melting Ice Sheets has on sea levels.

3. Using their notebook, ask students to make a prediction about which scenario, Sea Ice or Ice Sheets, will have a greater impact on sea levels and why.

4. Add enough water to the sea ice container so that the ice cubes float, and the water level just reaches surface of the clay (it should not go onto the "land"). Do the same for the Ice Sheet container, making sure not to disturb the ice cubes on the clay (again the water should not go onto the "land").

5. Use a ruler to measure the water level in each and note the measurements on the board. Ask students what they think the difference is between ice sheets and sea ice. Inform students you will check on the water levels throughout the class period. Measure and record water levels every 15 minutes.

Antarctic iceberg in the Southern Ocean on a nearly flat sea covered by ice floes.

Some snow petrels are sitting on the top of the iceberg.

Photo: Shutterstock / Armin Rose

WE'VE GOT LOTS OF ICE, ICE BABY!

6. Inform students that while this experiment is going on, they will research the four ice formations mentioned in the film:

Ice Sheet, Sea Ice, Glacier, and Iceberg

Divide students into groups of 3-4. Hand out Ice Features Handout and assign groups to research one of the four ice features and fill out the chart as they proceed.

7. Encourage students to use websites, such as the ones below, to answer the questions for their particular ice formation:

National Science Foundation (NSF)
https://www.nsf.gov/

National Aeronautics Space Administration (NASA)
https://www.nasa.gov/

British Antarctic Survey (BAS)
https://www.bas.ac.uk/

Students they will present the information they find on their ice feature to the class and that you will give them more information on that after the next "sea level" measurement.

8. Circulate to ensure that students and groups are making progress researching the different types of ice.

9. After the next measurement, instruct students that they will share their findings with the rest of the class at the end of the period. Their presentations should be about 2-3 minutes. As a fun twist, tell them they will present it to the tune of an ice or cold themed song, such as ***Ice, Ice, Baby*** or ***Let it Go*** (almost any song from ***Frozen***).

10. Have students fill out their chart on the rest of the ice features during the presentations. Make one final measurement of water levels in the two containers. Ask students to transfer the data that is captured on the board into their notebook.

11. Instruct students to summarize their learning of the similarities and differences between the structures of ice using the reflection questions on their Ice Demo and Reflection activity sheet.

Educator Notes:

WE'VE GOT LOTS OF ICE, ICE BABY!

Ice Features

Directions: Fill out the column of your assigned ice feature as you research facts about it. Use the back of this paper if you need more space.

Guiding Questions	Ice Sheet	Glacier	Iceberg	Sea Ice
What is it?				
Where is it found?				
How is it formed?				
What are its global impacts?				
Interesting Facts?				

WE'VE GOT LOTS OF ICE, ICE BABY!

Ice Features: Educator Key

Directions: Fill out the column of your assigned ice feature as you research facts about it. Use the back of this paper if you need more space.

Guiding Questions	Ice Sheet	Glacier	Iceberg	Sea Ice
What is it?	*A layer of ice that covers land.*	*A mass of ice that covers land and is constantly moving under its own weight*	*A piece of ice that has broken off of an ice shelf or glacier, and is floating in the ocean.*	*Seawater that freezes and floats to the top of the ocean, creating chunks of ice.*
Where is it found?	*Antarctica and Greenland.*	*Mostly in the polar regions, but can also be found at the highest mountain ranges on every continent.*	*Icebergs can be found in the Arctic, Antarctic, and North Atlantic regions.*	*When ocean water freezes, the ice floats to the surface, because it is less dense than the surrounding water.*
How is it formed?	*Water flows over the surface of the earth and then freezes to create the ice sheet covering.*	*Formed as precitipitation collects on the surface. The temperature and air pressure cause it to freeze, thaw, and refreeze.*	*Icebergs break off of glaciers, falling into the ocean. They float into open water until they reach warmer waters and melt.*	*When ocean water freezes, the ice floats to the top, since ice is less dense than water.*
What are its global impacts?	*It holds much of the earth's water. As the earth warms, these ice sheets may melt, causing significant flooding.*	*Contained 90% of the world's freshwater. Due to global warming, glaciers are melting, which could lead to a rise in ocean levels.*	*Since the early 20th century, there have been various attempts to track icebergs, including aerial photos, acoustics, and satellites.*	*There are many types, shapes, and sizes of sea ice. These often melt and refreeze, creating new sea ice as the weather cools.*
Interesting Facts?	*Antarctica's ice sheets cover land that was once very lush and green with dinosaurs living on it.*	*Glaciers are classified by their shape, characteristics, and behavior.*	*When icebergs are melting, they make a whooshing sound. It was a large iceberg that the Titanic collided with, causing it to sink on April 15, 1912.*	*Sea ice can be classifed based on its age, size, whether it's attached to the shoreline, and even the speed by which its moving.*

ICE DEMO AND REFLECTION

Hypothesis:

Which one, sea ice or a sea sheet, melt more (become more liquid) by the end of the period? Why?

Data	Sea Ice (in inches)	Sea Sheet (in inches)
Level of Water at Beginning		
Level of Water after 15 mins.		
Level of Water after 30 mins.		
Level of Water after 45 mins.		

Reflection Questions:

Which container had the most water level rise?

ICE DEMO AND REFLECTION

Hypothesis:

Which one, sea ice or a sea sheet, melt more (become more liquid) by the end of the period? Why?

Student answers will vary but should include an explanation of why they think that their choice will melt more or at a higher rate.

Data	Sea Ice (in inches)	Sea Sheet (in inches)
Level of Water at Beginning	Data from student	Data from student
Level of Water after 15 mins.	Data from student	Data from student
Level of Water after 30 mins.	Data from student	Data from student
Level of Water after 45 mins.	Data from student	Data from student

Reflection Questions:

Which container had the most water level rise?

Student answers should be reflective of the data collected in the table above.

Educator Key

ICE DEMO AND REFLECTION

How do the results compare with your prediction?

Why do you think this happened?

How are glaciers and icebergs related?

ICE DEMO AND REFLECTION

How do the results compare with your prediction?

Student answers will vary but should include an evaluation of their hypotheses as it relates to the data that they collected in the table above.

Why do you think this happened?

Student answers will vary.

How are glaciers and icebergs related?

Glaciers are masses if ice and snow that cover a landmass. Icebergs are pieces of ice floating in the ocean and can be a result of a piece of glacier breaking off and floating off into the water.

Educator Key

ICE DEMO AND REFLECTION

What is the main difference between sea ice and ice sheets?

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What did you notice about how sea ice and sea sheet melted?

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What are three questions that you could ask to try to understand melting ice caused by climate change affects the planet?

1. ______________________________

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2. ______________________________

____

3. ______________________________

____

ICE DEMO AND REFLECTION

What is the main difference between sea ice and ice sheets?

Sea ice are chunks of ocean water that freeze and then float to the surface of the sea, while an ice sheet is a layer of ice that covers a landmass.

What did you notice about how sea ice and sea sheet melted?

Student answers will vary, but should include reference to student observations of how the two behaved as well as to the data chart (p. 91) that shows a difference of quantitative data between the two.

What are three questions that you could ask to try to understand melting ice caused by climate change affects the planet?

1. Student answers may vary, but could include: When Antarctic ice melts, how does it affect animals that use it for survival?
2. Student answers may vary, but could include: How much warmer will the climate of Antarctica get and how much of the ice will melt?
3. Student answers may vary, but could include: What is causing the climate of Antarctica to get warmer causing the ice to melt?

Educator Key

WHAT HAPPENS HERE AFFECTS US ALL

GRADE LEVEL 6-8

ANTARCTICA EDUCATOR GUIDE

WHAT HAPPENS HERE AFFECTS US ALL

GRADE LEVEL 6-8
60 minute Lesson

Standards (NGSS):

MS-LS2-2 Ecosystems: Interactions, Energy, and Dynamics

Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

From the Film:

In the film, we learn that things that happen in Antarctica can have a significant impact on the rest of the world. All the ecosystems on Earth are connected, so when one shifts or is thrown out of balance, it will affect the others one way or another.

Lesson Overview:

Through the classic improv game, Machine, students act out biotic and abiotic factors of the Earth's ecosystem. As they simulate the inputs and outputs of the variables, they begin to understand how things in Antarctica may affect other parts of the world. They finish the lesson by answering questions around how temperatures, biodiversity, ocean levels in Antarctica can affect them specifically in the places in which they live.

Materials:

- Ecosystem Role Cards, p. 107
(final count determined by class size)
- Activity Sheets, pp. 108, 110, 112
(one per student)
- Notebook or paper
- Technology to play the "Carbon Sink" video

Watch the video here

WHAT HAPPENS HERE AFFECTS US ALL

EDUCATOR PREP:

If you have never done improv or played the game, Machine, take a look at this video of a class playing a generic Machine game:

https://www.youtube.com/watch?v=LSVGyaZNc10

This activity will require a large open space, so students may need to move desks out of the way or take them outside or to the gym.

1. Tell students that today we are going to look at the ways in which Antarctica is connected to the rest of the planet. The ecosystem of this continent is very much tied to other ecosystems on the other six continents.

2. Inform students that an ecosystem is the way scientists describe all of the relationships between living and nonliving things in a defined community. The living things are described as biotic factors, while the non-living things are called abiotic factors and can include things like geology and weather.

3. Ask students to take a minute and using their science notebook or a piece of paper, try to name as many biotic and abiotic factors in Antarctica, using the film or their general knowledge of the continent. They can write names or sketch pictures, either is fine.

4. Inform students that these biotic and abiotic factors often interact as part of the ecosystem. These interactions are key to how well the ecosystem functions. To illustrated this concept, show students the "Carbon Sink" video and ask them to identify the biotic and abiotic factors involved in this process.

5. Tell students that today we will be playing an improv game called Machine to act out and understand the relationships between biotic and abiotic factors across multiple ecosystems.

6. Explain to students that the class will be divided to role play various ecosystems of Antarctica and from across the world. They will role play one of the following biotic or abiotic factors to explore how these affect the rest of the planet's ecological balance: phytoplankton, carbon, krill, humans, whales, glaciers in Antarctica, and abnormally massive storms and hurricanes. Each group will be influenced by an ***input (something that is acted up them)*** - and will be responsible for an ***output (something they do to, or for, another factor).***

7. Impress upon students that during this activity, they will interact with other students in the class, but that they must do so without actually touching each other. They will instead mime that connection and the transfer of energy from one to another.

A Weddell seal pup and mother.

Weddell seal pups feed on extremely rich milk and double their weight in the first two weeks of their life.

Photo: BBC NHU

WHAT HAPPENS HERE AFFECTS US ALL

Educator Notes:

8. Divide the class as evenly as possible into seven groups. Each group will play a different role in the following scenarios.

9. For Scenario 1, assign the following roles to the student groups using the cards provided:

Group 1 – Carbon

Group 2 – Phytoplankton

Group 3 – Krill

Group 4 – Whales

Group 5 – Glaciers in Antarctica

Group 6 – Hurricanes and Typhoons

Group 7 – Humans

10. Inform students that you will narrate the scenario and as each group's "character" is called out, they will move to the center of the room to act out their specific role. After the first group begins to act out their role, the next group will connect with them, acting out how they interact in the ecosystem, without touching. Assure them that there is no wrong way to do this and to collaborate with their group members to think about how to best play their role.

11. Narrate Scenario 1 using the following*; pause at points to allow students to step into the Machine:*

"One of the ways in which the Antarctic ecosystem affects the rest of the world is by capturing carbon that is in the atmosphere around the globe".

Group 1 - Carbon is part of carbon dioxide, released by animals including humans through breathing, and by emissions of cars and factories around the globe.
Group 2 - Phytoplankton in the ocean can actually capture carbon and remove it from the atmosphere.
Group 3 - Tiny marine organisms called krill eat the phytoplankton, transferring the carbon from the phytoplankton to the krill.
Group 4 - Using their signature bubble netting technique, whales eat the krill in big gulps.
Group 5 - Glaciers sit idly by and watch patiently.
Group 6 - Since the ecosystem is in balance, hurricanes and typhoons still happen across the ocean, but they are not abnormally strong.
Group 7 - Humans take shelter and weather the storm safely.

Note: after you read the scenario, encourage students to continue playing the ecosystem for another 30 seconds to a minute.

WHAT HAPPENS HERE AFFECTS US ALL

12. After completing Scenario 1, facilitate a brief reflection discussion with the group using the following questions:

What are the biotic and abiotic factors of this ecosystem?

Biotic factors are the phytoplankton, krill, whales, and humans. Abiotic factors are the hurricanes, carbon, and glaciers.

How does it feel to play your role in this version of the ecosystem in Antarctica?

No real right or wrong answer here, but it should feel pretty calm, balanced, and not very intense.

13. Ask students to return to the perimeter of the space. Once reset, Inform them that we will now begin Scenario 2, which will modify one variable to behave a little bit differently. ***Ask two students playing phytoplankton, and another playing krill to switch and become extra carbon.***

"It's sometimes a bit hard to wrap our brains around this, but in the last hundred years, humans have invented factories, cars, trains, airplanes, they have pumped more and more carbon into the atmosphere".

Groups 1, 2 - As this carbon is now floating throughout the atmosphere, not all of it can be captured by the phytoplankton, and some stay floating in the air.
Groups 1, 2, 3, 4 - Phytoplankton are still eaten by krill and krill are eaten by whales. However, the extra carbon continues to float in the atmosphere and causes the Ozone layer over the South Pole to be thinned. This is called Ozone Depletion.
Group 5 - Ozone Depletion causes the temperature to increase, which melts the glaciers of the South Seas.
Groups 6, 7 - As a result of the melting glaciers, ocean water rises and warms, causing abnormally massive storms and strong hurricanes and typhoons which destroy structures and can kill humans."

Note – again, after you read the scenario and students have jumped into the action, encourage them to keep the ecosystem going for another few minutes.

A four ton elephant bull seal defending his harem of females. This beachmaster uses his trunk like nose to boom out an almighty roar, warding off intruders.

Photo:
Fredi Devas © BBC NHU

WHAT HAPPENS HERE AFFECTS US ALL

14. After a few minutes of role-playing scenario 2, have students stop and discuss what happened in that scenario and how it's different than scenario 1, using the following questions:

How does the simple act of driving a car have such a wide-ranging effect on a planet that feels so huge to us?

It's not one car that has this impact, but the billions of cars we drive and have driven every single day for the last hundred years. Even though one car, driven by one person, one day wouldn't have this affect, the aggregate is extremely impactful.

In this scenario, we shifted a couple of people's roles to be extra carbon. Is this an accurate representation of what has happened on our planet? Why or Why not? How do we know?

The extra carbon represents the increased carbon emissions post-Industrial Revolution. Although the model is a bit simplified for our purposes, it does represent the impact that the increased carbon has on the atmosphere and the subsequent domino effect.

15. Ask students to use their notebook or journal to reflect on these two scenarios by answering the following questions:

What are the connections between the ecosystems of the six other continents and Antarctica that result in this domino effect from one to the other?

Ocean current, atmospheric currents all contribute to events in Antarctica leading to effects in other parts of the world. Similarly, when carbon is released at a high rate across the globe, that ultimately has an impact on Antarctica.

How can these connections potentially play a role in a solution to slowing down or stopping human-caused climate change?

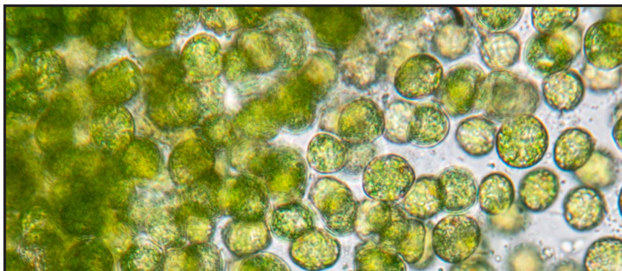
By understanding how systems interconnect, we can better understand that events don't happen in a vacuum, but instead trigger domino effects across the globe.

16. After finishing the scenarios, have students return to their workstations and complete the reflection sheet. When they finish, review the answers and discuss the implications of the ways in which Antarctica affects the rest of the world.

Educator Notes:

ECOSYSTEM ROLE CARDS

Photo: Shutterstock / Rattiya Thongdumhyu



Phytoplankton

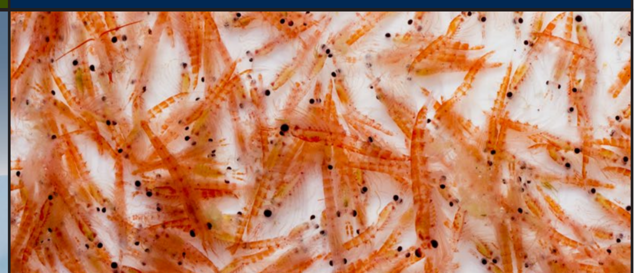
Photo: Shutterstock / Craig Lambert

Whales

Photo: BBC NHU

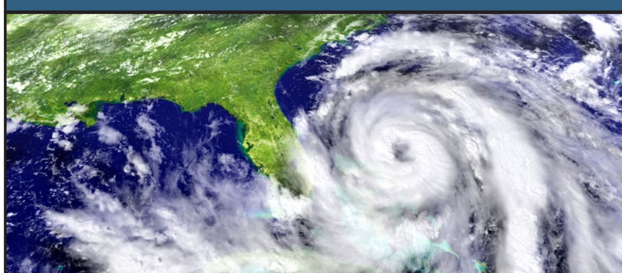
Glaciers in Antarctica

Photo: Shutterstock / I. Noyan Yilmaz



Krill

Photo: Shutterstock / Harvepino



Hurricanes and Typhoons

Photo: Shutterstock / Aleksandr Ozerov

Humans

Photo: Shutterstock / Anastasiia Tymoshenko

Carbon

Photo: Shutterstock / Anastasiia Tymoshenko

Carbon

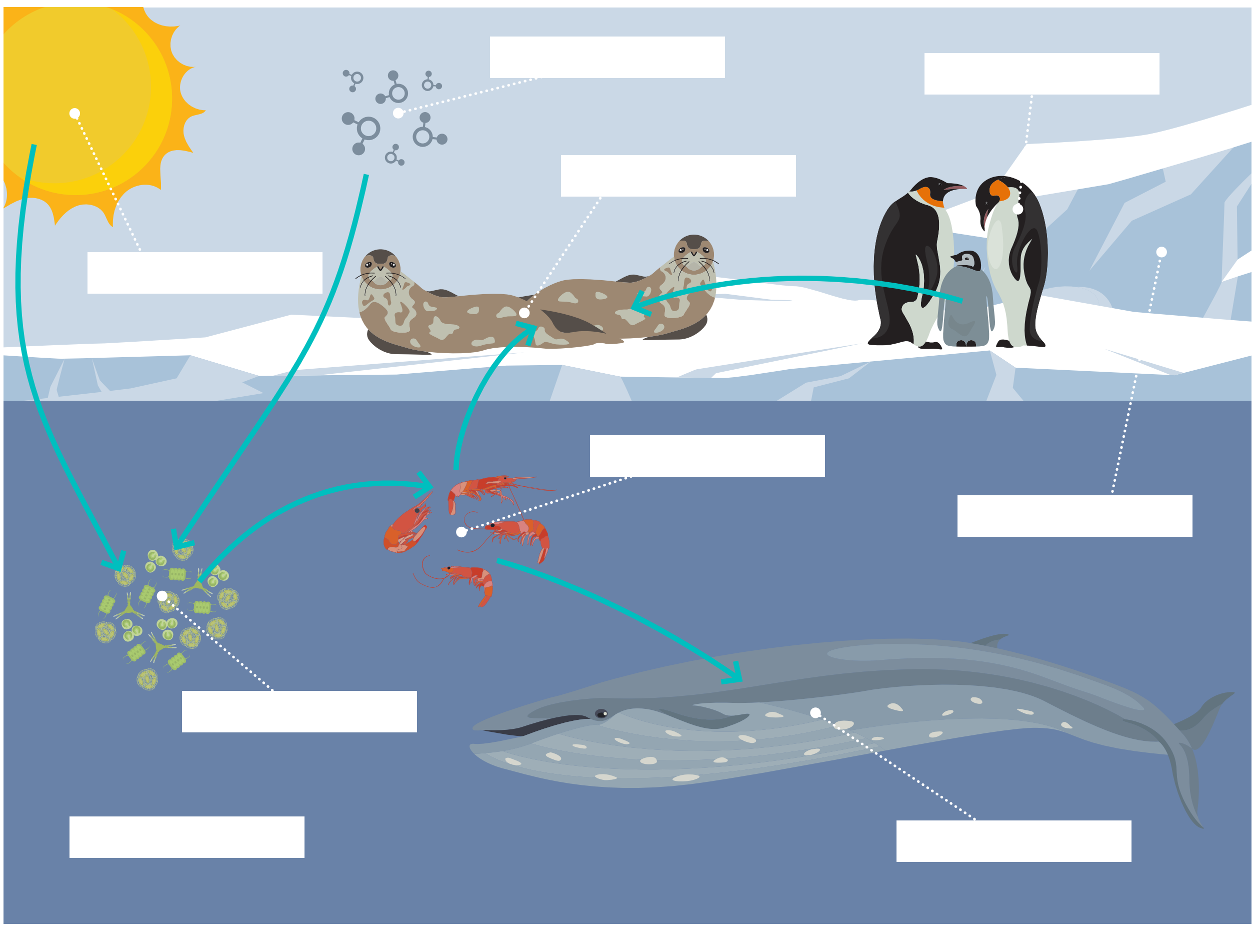
Note: Remember to produce additional carbon cards for Scenario 2.

ACTIVITY SHEET

Complete the following reflection after playing out the two scenarios for how events and conditions in Antarctica can affect places around the world:

Complete this diagram with the biotic and abiotic factors of Antarctica's ecosystem, using the terms below.

Krill	*Whale*	*Carbon*	*Ice*	*Sun*
Penguin	*Ocean*	*Phytoplankton*	*Seals*	



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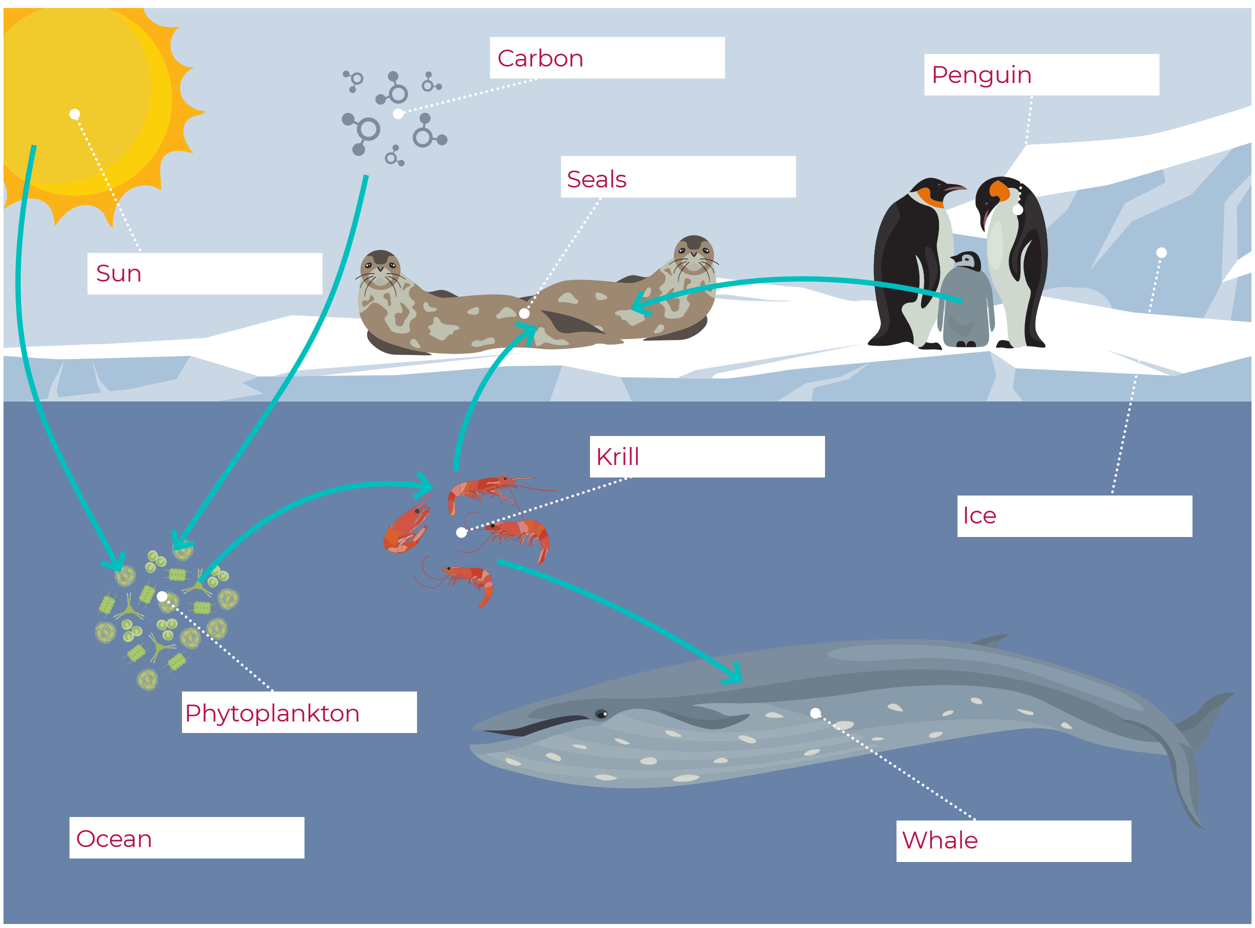

Educator Key

ACTIVITY SHEET

Match the terms with their definitions.

- KRILL
- WHALE
- CARBON
- ICE
- SOUTHERN OCEAN
- PHYTOPLANKTON
- SEALS
- PENGUIN

- Glaciers, Ice Sheets, Sea Ice
- Carnivorous, semi-aquatic mammals
- Tiny crustaceans that feed whales
- The "plants" of the ocean, can trap carbon from Carbon Dioxide
- Birds that excel at swimming instead of flying
- The largest mammals in the world
- Part of CO_2, a gas that is in the atmosphere across the globe
- The body of water around Antarctica

ACTIVITY SHEET

Match the terms with their definitions.

Terms	Definitions
KRILL	Glaciers, Ice Sheets, Sea Ice
WHALE	Carnivorous, semi-aquatic mammals
CARBON	Tiny crustaceans that feed whales
ICE	The "plants" of the ocean, can trap carbon from Carbon Dioxide
SOUTHERN OCEAN	Birds that excel at swimming instead of flying
PHYTOPLANKTON	The largest mammals in the world
SEALS	Part of CO_2, a gas that is in the atmosphere across the globe
PENGUIN	The body of water around Antarctica

Educator Key

ACTIVITY SHEET

In the scenarios that you and your classmates played out, what was the result of having additional carbon in the atmosphere that were more than what the phytoplankton were able to capture?

How did the unbalanced ecosystem on Earth affect life in Antarctica?

How did the unbalanced ecosystem on Earth affect life in other places in the world?

How does what happens in Antarctica affect life in other parts of the planet?

ACTIVITY SHEET

In the scenarios that you and your classmates played out, what was the result of having additional carbon in the atmosphere that were more than what the phytoplankton were able to capture?

When there were additional carbon in the atmosphere, it caused the atmosphere to warm up, which melts glaciers, increasing ocean levels, and creating more powerful storms. This causes an unbalanced ecosystem which threatens the wellbeing of all plants and animals, including human beings.

How did the unbalanced ecosystem on Earth affect life in Antarctica?

The unbalanced ecosystem meant that there were not enough phytoplankton to feed the krill, which meant that whales did not have anything to eat. The whale population diminished and the ecosystem as a whole struggled to stay intact.

How did the unbalanced ecosystem on Earth affect life in other places in the world?

The unbalanced ecosystem created a more powerful hurricane, causing destruction and death. Additionally, the warming of the air in Antarctica lead to warming of the ocean and the air in other parts of the world which threatened those ecosystemns as well. Finally, the unbalanced ecosystem, melted the glaciers and increased ocean levels, which threatened sealife and humans who rely on the ocean for stable weather, food, and habitat.

How does what happens in Antarctica affect life in other parts of the planet?

The ocean currents and wind patterns carry what happens in Antarctica to other places in the world. When it gets warm in Antarctica, there is a domino effect that occurs across the planet, resulting in changing temperatures, higher sea levels, more intense weather patterns, and an unbalanced ecosystem.

Educator Key

WRITERS & CONTRIBUTORS

EDUCATION GUIDE EDITOR:

Gabor Zsuppan, Discovery Place, Inc.

LESSON PLAN WRITERS:

Riana Clark, Discovery Place, Inc.
Heather Norton, Discovery Place, Inc.
Catalina Stegmann, Discovery Place, Inc.
Gabor Zsuppan, Discovery Place, Inc.

PROJECT MANAGEMENT:

Heather Norton, Discovery Place, Inc.
Gabor Zsuppan, Discovery Place, Inc.
Tory Hines, SK Films
Alex Mifflin, SK Films

GRAPHIC DESIGN:

Discovery Place, Inc.

LESSON PLAN REVIEWERS: DISCOVERY PLACE EDUCATOR ADVISORY COUNCIL

Stacie Bunn, M.Ed. in Elementary Education,
Kannapolis City Schools District

Anita Cathey, M.S. in Information Systems,
Charlotte Mecklenburg School District

Robert Leichner, M.Ed. in Curriculum & Supervision,
Charlotte Mecklenburg School District

Jill Staton, M.Ed. in Elementary Education,
Cabarrus County School District

Jill Zsuppan, M.Ed. in Curriculum and Instruction,
Mooresville Graded Schools

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ANTARCTICA

NARRATED BY BENEDICT CUMBERBATCH