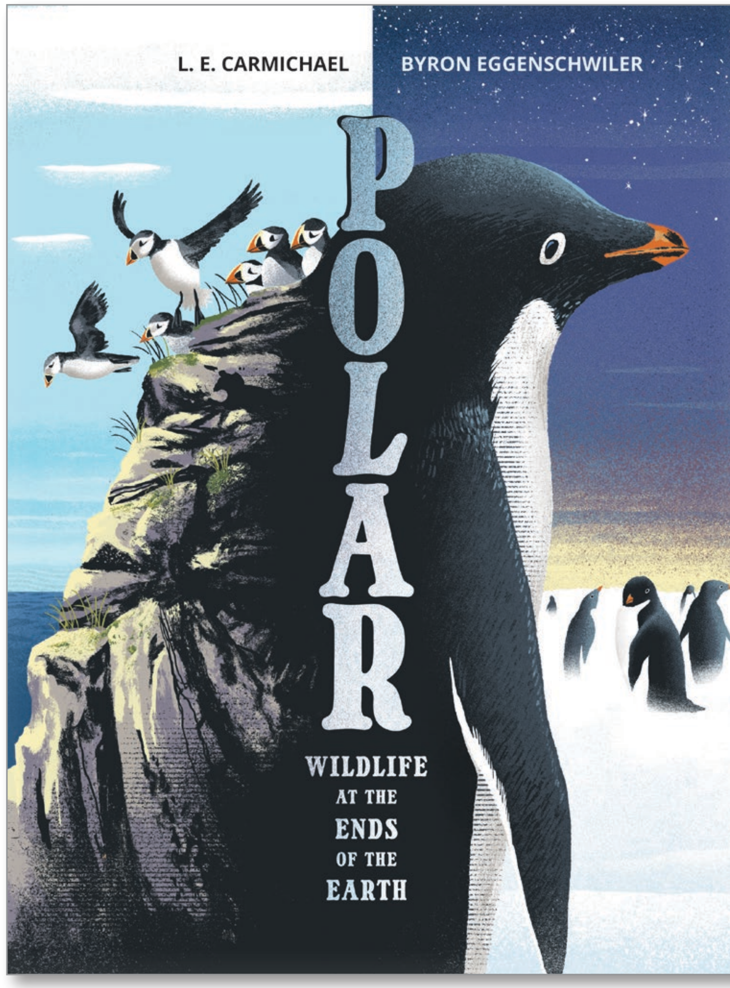
POLAR — ACTIVITY GUIDE

ABOUT THE BOOK

From the author of the critically acclaimed *The Boreal Forest*, a stunning exploration of the animals that have adapted to survive in Earth's harsh polar regions.
The Arctic and Antarctica, at opposite ends of the Earth, have much in common: bitter cold, ferocious winds and darkness lasting six months. Despite these harsh conditions, many animals have adapted to stay alive in the polar regions. This evocative and beautifully illustrated book from the award-winning team of author L. E. Carmichael and illustrator Byron Eggenschwiler explores how animals at opposite ends of the Earth survive using similar adaptations. There's the arctic fox who is protected from the ice by the fur on the soles of her feet, the emperor penguins huddling in groups around their chicks to keep everyone warm, and the narwhal using echolocation to find a crack in the surface ice to breathe. It's a fascinating journey through a year in the polar regions, where animals don't just survive — they thrive!
Each spread in the book is devoted to a month and includes a themed introduction and two stories on opposites pages, one about an animal in the Arctic and one about an animal in Antarctica. Extra spreads cover topics such as seasons, winter weather and types of ice. The book concludes with a timely description of the disruptions that climate change is causing to the polar regions, and how this will have global consequences. A glossary, further reading, author's sources, an index and ideas for what children can do to help are included.
There are strong life science curriculum applications here in animal habitats and animal adaptation, migration, hibernation and cooperation.



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ABOUT THE AUTHOR

L. E. CARMICHAEL is the author of more than twenty informational books for children, including the critically acclaimed *The Boreal Forest*. She is the winner of the Lane Anderson Award, which recognizes excellence in science writing for kids, and the Governor General's Medal for her PhD thesis about northern wolves and arctic foxes. She lives with her family in Trenton, Ontario.

ABOUT THE ILLUSTRATOR

BYRON EGGENSCHWILER is an award-winning illustrator whose recent books include *The Strangest Thing in the Sea*, *Beastly Puzzles* and *The Little Ghost Who Was a Quilt*. His work has appeared in the *New Yorker*, the *New York Times*, the *Wall Street Journal* and *GQ*. Byron lives in Calgary, Alberta, with his wife and two cats.

INDOOR ACTIVITIES

OUTDOOR ACTIVITIES

SUMMER GAMES

WINTER EXPERIMENTS

Kids Can Press

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KEEP WARM BY CUDDLING UP!

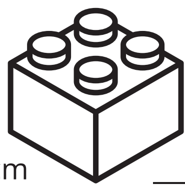
How Surface Area to Volume Ratio Helps Polar Animals Conserve Body Heat

WHAT IS SURFACE AREA TO VOLUME RATIO?

Surface area measures the outside of an object. **Volume** measures its inside. Small objects have a lot of *outside* relative to their *inside*. Bigger objects have more *inside* relative to their *outside*.

YOU CAN TEST THIS USING BUILDING BLOCKS. START SMALL:

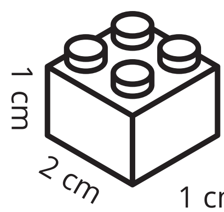
1) Measure all the edges of one block. Record your measurements on the diagram below:



__________cm

__________cm __________cm

2) Now multiply two edges to get the area of one side. For example:



1 cm × 2 cm = 2 cm^2

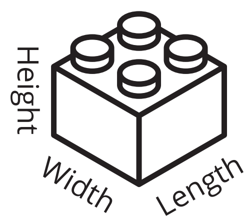
3) Repeat for every side of the block.

Side 1 _____ Side 2 _____ Side 3 _____

Side 4 _____ Side 5 _____ Side 6 _____

4) Add all six sides to get the total **surface area** for this block: ____________________________

5) To measure the **volume** of the block, multiply length × width × height = volume.



1 cm × 2 cm × 2 cm = 4 cm^2

6) For this small block, how do **surface area** and **volume** compare?

NOW LET'S SUPERSIZE IT!

Start by snapping four small blocks together to create one large rectangle.

1) Measure all the edges of the large rectangle.

____

2) Add up the surface area, and multiply the volume.

____

3) How do surface area and volume of the large rectangle compare?

____

____

4) How does the surface area to volume ratio of the large rectangle compare to that of one small block?

____

____

INDOOR ACTIVITIES

HOW DOES SURFACE AREA TO VOLUME RATIO HELP POLAR ANIMALS CONSERVE HEAT?

Birds and mammals are warm-blooded, meaning they make their own body heat. Heat leaves the body through the skin — the animal's *surface*. The more **surface area** relative to **volume**, the faster the heat loss — especially in cold environments like the polar regions.

Small animals stay warm by pretending to be big animals: they cuddle up! Called a huddle, this group of animals has less **surface area**, relative to **volume**, than a single animal: a solitary animal shivers but the huddle stays toasty warm. In Antarctica, huddles get so hot that penguins have to stop cuddling just to cool down!

Test this with your friends or siblings. Cuddle up like a pile of puppies. How soon do you start to sweat? Does changing the size of the huddle change how long you can cuddle up? What about position in the huddle — do the people in the middle get warmer than the people on the edges? Why or why not?

SURVIVE COLD WATER BY REDUCING SURFACE AREA

Mammals lose body heat 90 times faster in cold water than in cold air. The thick **blubber** of whales and seals helps keep their heat inside their bodies, even while swimming in icy polar seas.

Humans aren't so lucky! In cold water, our body temperatures can dip so low that we may die of **hypothermia**. That's why the Life Jacket Association recommends that humans huddle after a boating accident — the huddle keeps everyone warm while waiting for rescuers.

If you're waiting for rescue alone, protect yourself by changing your own **surface area to volume ratio**. Pull your knees into your chest and hug yourself. This balled-up position reduces your **surface area**, keeping you warmer longer. For extra protection, keep your hot head out of the water!

Blubber: a thick layer of body fat just below the skin

Hypothermia: losing heat faster than the body can produce it, causing a dangerous drop in body temperature

COUNTERSHADING FOR CAMOUFLAGE

In deep ocean waters, out past the coral reefs, there's nowhere to hide but in plain sight! Ocean predators use camouflage to sneak up on prey … or sneak away from larger predators.

Countershading is a common form of camouflage. Predators using countershading have pale bellies and darker backs. Seen from below, their pale bellies blend into bright sunlight. Seen from above, their backs blend into deep, dark waters that sunlight cannot penetrate.

You can build a **model** of countershading in your own kitchen! Here's how.

Model: Scientific models can be real, imaginary or mathematical. They help scientists picture and understand natural processes that can be hard to observe in real life.

YOU WILL NEED

- A plastic toy whale or shark with a pale belly and a darker back
- A clear container big enough for your toy to swim in
- Blue liquid dish soap
- A measuring cup
- Water
- A turkey baster
- White paper
- Black construction paper
- An overhead light to represent the sun
- A partner to help you

Did You Know? Sunlight travels longer distances in air than in water. At noon over tropical oceans, the light 300 m down is only as bright as a moonlit sky. At 1000 m, it's too dark for any sea animals to see.

BUILD YOUR MODEL

1) Pour liquid dish soap into the container, forming a layer 2–3 cm deep.

2) Fill the measuring cup with water.

3) Suck up some water into the turkey baster.

4) Place the tip of the baster against an inside wall of the container, just above the layer of dish soap.

5) Gently squeeze the baster to slowly release the water. The water should form a layer on top of the dish soap. If the layers start to mix, slow down even more.

6) Add water until you have a layer at least 1 cm thick.

7) Put the toy into the container and hope it floats! It's okay if it sinks into the dish soap.

Caution: When moving your model, keep the container level to avoid mixing the layers … or spilling on the floor!

INDOOR ACTIVITIES

SEEING FROM BELOW

1) Turn on the overhead light.

2) Have your partner hold your model above your head. You are now “swimming” in deep water!

3) Look up at the toy. Which parts of its body blend into the background? Which parts are most visible?

Caution: To protect your eyes, do not look directly into the overhead light.

SEEING FROM ABOVE

1) Place the white paper on your kitchen counter.

2) Place your model on the paper. Your model now represents shallow water, where some sunlight shines through.

3) Look down at the toy. Which parts of its body blend into the background? Which parts are most visible?

4) Place the black paper on your kitchen counter.

5) Place your model onto the paper. Your model now represents water so deep that sunlight cannot reach the bottom.

6) Look down at the toy. Which parts of its body blend into the background? Which parts are most visible?

7) Does the toy’s camouflage work better in shallow water or deep water? Why do you think that is?

COUNTERSHADING THROUGH COUNTERILLUMINATION

Lanternsharks live in both polar oceans. Small sharks that can be food for larger predators, lanternsharks camouflage themselves with counterillumination. “Illumination” means “lighting up.” That’s right — these sharks glow in the dark!

Special cells on the sharks’ bellies produce spots of light. The light makes their dark bellies look brighter, helping them blend into the sunlight above. And the spotted pattern confuses the eye, making the shape of the shark harder for predators — or prey! — to recognize.

MUMS AND PUPS — SEEKING WITH SOUND

Antarctic fur seals raise their young in breeding colonies that may contain thousands of individual seals. Mothers leave their pups on the beach and swim out to sea to hunt krill. They return to nurse their pups every few days.

In the seal colony on Livingston Island, up to 3000 pups are born each summer. How do returning mums find their babies in the crowd? Seal eyes don't see well in dry air, and seals can't smell each other if they're more than 15 cm apart. Instead, mums identify their pups by sound. They might recognize each other's voices, or they might use unique calls similar to human names.

Experience life in the colony by playing Mums and Pups, a variation on the game Marco Polo. Try this in the swimming pool on a hot summer day!

YOU WILL NEED

- Friends to play with
- A swimming pool or open space in a playground

RECOGNIZING VOICES

1) Choose one person to be Mum.

2) Choose another person to be Mum's Pup.

3) Everyone else is another seal pup in the same breeding colony.

4) Mum closes their eyes and calls out, "Pup?"

5) All of the pups answer "Mum!" in their regular voices.

6) Keeping their eyes closed, Mum moves towards their Pup's voice.

7) Mum can call "Pup?" as many times as needed — all pups must answer until Mum and Pup are together again!

RECOGNIZING NAMES

1) Choose one person to be Mum.

2) Choose another person to be Mum's Pup.

3) Everyone else is another seal pup in the same breeding colony.

4) Mum closes their eyes and calls out the name of their Pup.

5) All the pups answer by calling out their own names.

6) Keeping their eyes closed, Mum moves towards their Pup by listening for the correct name.

7) Mum can call their Pup's name as many times as needed — all pups must answer until Mum and Pup are together again!

TRY THIS:

- To make the game easier, all pups stand still while Mum seeks.
- To make the game harder, all pups move around the breeding colony while Mum seeks.
- For an added challenge, pick two Mums and two Pups! Both Mums seek their Pups at the same time, just like at a real colony.

MUSK OXEN AND BEARS — PROTECTING THE YOUNG

In Alaska, grizzly bears hunt both adult and baby musk oxen. Adult musk oxen can weigh more than 300 kg. At 25 kg, baby musk oxen are much easier meals … assuming bears can reach them.

To protect their young, a herd of musk oxen form a circle or crescent between their babies and the bear. The bear must break through this "wall of horns" to catch its prey.

Explore this predator-prey interaction by playing Musk Oxen and Bears — a variation of the game Red Rover.

YOU WILL NEED

- Friends to play with
- An open space in a playground

HUNTING ALONE

1) Divide into two teams, the Musk Oxen and the Bears.

2) Choose two Musk Oxen to be Babies.

3) All other Musk Oxen are Adults.

4) The Adult Musk Oxen line up and join hands, while the Babies stand behind them.

5) The Bears line up facing the Musk Oxen and choose one Bear to hunt.

6) The hunting Bear runs towards a pair of Musk Oxen, trying to break through their joined hands:

a) If the Musk Oxen stay linked, the Bears go hungry! The hunting Bear is out of the game.

b) If the hunting Bear breaks through, a Baby joins the Bears' team.

7) Bears win by capturing all of the Babies; Musk Oxen win if all of the Bears are out of the game.

WORKING TOGETHER

Sometimes, grizzlies work together to bring down large prey — like adult musk oxen! Explore the effects of teamwork by changing the game.

In each round, *two* Bears hunt at the same time:

1) If *one* Bear breaks through, a Baby joins the Bears' team.

2) If *both* Bears break through, a Baby *and* an Adult join the Bears' team.

ASK YOURSELF:

- How often do Bears win when they hunt alone?
- How often do they win when they work together?
- What advantages and disadvantages might teamwork offer to the predators of the polar regions?

WRAPPED IN WARMTH — BODY HEAT AND INSULATION

Polar birds and mammals are warm-blooded — they use energy from food to make their own body heat. Some of this heat escapes into the surrounding air. The colder the air, the more heat escapes … and the more energy an animal must burn to keep itself warm.

Fur and feathers trap body heat against the skin, reducing the amount that escapes into the air. Good **insulation** reduces the amount of energy needed to replace lost heat. That means more energy is left over for other things — like having babies or finding food.

Humans aren't as hairy as most mammals, so we insulate our bodies with clothing. In winter, we might even wear parkas stuffed with bird **down**! You can measure the impact of this insulation on your own body heat.

Insulation: a material that reduces the loss of body heat, such as fur, feathers or a whale's blubber

Down: the soft layer of feathers that's closest to a bird's skin

YOU WILL NEED

- A glass thermometer
- A long piece of string
- A clock, watch or timer
- A light spring jacket
- A warm winter jacket

INSULATING OUTSIDE

Try repeating this activity outside. But if you start to shiver, go indoors! Shivering means that your body is burning extra energy to replace lost heat.

INSULATING INDOORS

1) Use the thermometer to measure the air temperature in the room.
Record your measurement here: ________

2) Tie the string around one end of the thermometer in a big loop, so you can wear it like a necklace. Put on your spring jacket over the thermometer and fasten it up.

3) Wait five minutes, then measure the air temperature inside your jacket.
Record your measurement here: ________

4) Swap your spring jacket for your winter jacket.

5) Wait five minutes, then measure the air temperature inside your jacket.
Record your measurement here: ________

6) Take off your winter jacket before you melt!

ASK YOURSELF:

- How did the temperature in the room compare with the temperature inside your jackets?
- Which jacket kept more of your body heat close to your skin?
- Did your results change when you went outside? Why or why not?
- Did you feel uncomfortably hot while wearing your winter jacket inside? Did you feel cooler when you took your jacket off? Why?

Arctic foxes swap their winter woolies for a light summer coat. This summer fur provides much less insulation.

- If foxes could not change their coats, how hot might they feel in summer?
- Because of ongoing climate change, air temperatures in the polar regions are rising. How might this affect animals that are adapted to survive the cold?

BOOTS, SHOES AND SLEDS — EXPLORING FOOT LOAD

When an animal walks, the weight of its body presses down through each foot. The amount of weight, relative to the area of the foot, is called foot load. An animal with big feet has a lower foot load than a same-sized animal with small feet. For example:

Animal (adult female)	**Body Weight** (8 kg × 1000 g/kg)	**Area of One Foot** (length × width)	**Foot Load** (body weight ÷ area of foot)
Lynx	8000 g	275 cm^2	29 g per cm^2
Coyote	8000 g	76 cm^2	105 g per cm^2

Coyotes have a high foot load, so their feet sink deep when running through snow. In contrast, lynx can skip across the surface! Lynx burn less energy pulling their feet out of the drifts, leaving more energy for pouncing on prey.

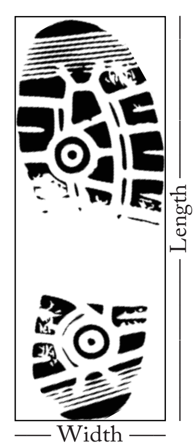
Note: Lynx live in both forest and tundra habitats, but coyotes avoid the snowy Arctic tundra. Their high foot load might be one reason why!

You can estimate your own foot load and see how it affects your travel over snow.

YOU WILL NEED

- A bathroom scale
- A ruler or measuring tape
- Winter boots
- Snowshoes
- A crazy carpet

FOOT LOAD IN BOOTS



1) Use the bathroom scale to measure your weight in kilograms and record your answer in the table below.

2) Multiply your weight in kilograms by 1000 to get your weight in grams.

3) Measure the bottom of your boot from toe to heel, and record this measurement under "length of boot." Make sure to measure at the longest point.

4) Measure the bottom of your boot from side to side, and record this measurement under "width of boot." Make sure to measure at the widest point.

5) Estimate the area of boot print by multiplying length and width.

a) In this step, you are calculating the area of the smallest rectangle that can contain the bottom of your boot. It's an *estimate* of the area of your boot print, not the *actual* area of your boot print.

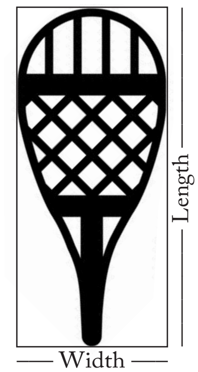
b) Does this imaginary rectangle have a bigger area, or a smaller area, than your boot print?

c) How might this estimate affect your estimate of foot load? Will your *estimated* foot load be bigger or smaller than your *actual* foot load in boots?

6) To estimate "foot load in boots", divide your weight in grams by the area of your boot print. Your answer will be in g/cm^2.

Weight in kg (from scale)	**Weight in g** (kg x 1000 g)	**Length of Boot** (centimeters)	**Width of Boot** (centimeters)	**Area of Boot Print** (length × width)	**Foot Load in Boots** (weight in g ÷ area of boot print)

FOOT LOAD IN SNOWSHOES



1) Copy your weight in grams into the table below.
2) Measure the bottom of one snowshoe from toe to heel, and record this measurement under "length of shoe." Make sure to measure at the longest point!
3) Measure the bottom of the snowshoe from side to side, and record this measurement under "width of shoe." Make sure to measure at the widest point!
4) Calculate the area of the shoe print by multiplying length and width.
- a) In this step, you are calculating the area of the smallest rectangle that can contain the bottom of your snowshoe. It's an estimate of the area of your shoe print, not the actual area of your shoe print.
- b) Does this imaginary rectangle have a bigger area, or a smaller area, than your snowshoe?
- c) How does this estimate affect your estimate of foot load? Will your estimated foot load be bigger or smaller than your actual foot load in snowshoes?

5) To estimate "foot load in snowshoes", divide your weight in grams by the area of your shoe print. Your answer will be in g/cm^2.

Weight in g (kg x 1000 g)	**Length of Shoe** (centimeters)	**Width of Shoe** (centimeters)	**Area of Shoe Print** (length × width)	**Foot Load in Snowshoes** (weight in g ÷ area of boot print)

ASK YOURSELF: Which foot load is bigger — in boots or in snowshoes?

MAKE A PREDICTION:

How deep will you sink into fresh snow while wearing boots? How deep will you sink while wearing snowshoes? Record your predictions in the table below.

Boot Prints		**Snowshoe Prints**	
Prediction	Measurement	Prediction	Measurement

PUTTING FOOT LOAD TO THE TEST

1) Wait for a day with fresh snowfall!

2) Put on your boots and walk across the snow.

3) Measure the depth of one boot print and record your measurement in the table to the left.

4) Put on your snowshoes and walk across the snow. Go in a different direction so you don't erase your boot prints.

5) Measure the depth of one snowshoe print and record your measurement in the table.

ASK YOURSELF:

- How does the measurement for each print compare to your predictions?
- How does the depth of your boot print compare to the depth of your snowshoe print?
- Explain your results using what you know about foot load!

GO FURTHER: TUMMY TOBOGGANING

Walking is just one way to get around in winter. Penguins have invented another — tobogganing on their tummies!

You can model a penguin's "tummy load" by tobogganing on a crazy carpet:

- Divide your body weight in grams by the area of your crazy carpet. How does this "tummy load" compare to your estimates of foot load?
- How much energy does it take to zip downhill?
- How much energy does it take to trudge back up?

Bonus: Visit L. E. Carmichael's blog to learn how scientists measured foot and belly load in penguins!

"Stride or Slide: How Penguins Get from Place to Place"

https://www.lecarmichael.ca/2023/04/stride-or-slide-how-penguins-get-from-place-to-place/

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