Skull Investigation

Exploring arctic mammal adaptations through skulls

Agenda for a 60 to 90-minute activity

GRADE LEVEL: This lesson is written for 6th – 12th grade students but can be adapted into a lesson for any age, or even an adult interpretive program. For younger students, see the story *A Hairy Chase* at the end of this lesson.

GOAL: To inspire critical thinking through animal skull deduction, and to demonstrate that anatomical form dictates function and can give clues about animal ecology.

OBJECTIVES

- Students will be able to identify 1 characteristic each of carnivore, herbivore, and omnivore skulls.
- Students will be able to categorize all skulls as carnivore, herbivore, or omnivore.
- Students will be able to use clues from skull anatomy to understand species' life histories.

MATERIALS

- 10 Arctic skull boxes, printed on cardstock (ideally assembled beforehand)
- Cotton or crumpled scrap paper (for stuffing skull boxes to provide structure)
- Glue or tape
- Scissors
- Observations sheet for each student or team
- *Optional:* real skulls. Polar bear, black bear, arctic fox, or bird skulls would be good additions
- *Optional:* corresponding pelts, claws, or other parts of the animals featured
- *Optional:* stories or other materials appropriate for your students' grade level

A Note on Paper Skull Construction: While the small skull boxes are easy to assemble, the larger, multi-page boxes can be challenging even for adults. To maximize learning time, assemble skulls beforehand. Unless you are working with a large group of older students and have <1.5 hours for the lesson, students may run out of time assembling large skulls. If treated with care, paper skull boxes can be reused for years.

BACKGROUND FOR INSTRUCTORS

SKULL ADAPTATION INFORMATION

For excellent background information, see: Skulls of Alaskan Mammals: A Teacher's Guide.
https://www.pugetsound.edu/files/resources/10169_Alaskan%20skulls%20teacher%20guide.pdf

SKULL 1 (SNOWSHOE HARE)

This skull has prominent incisors for chopping plant material and flat molars for chewing plant material, both indicating that this animal is an herbivore. Its eye sockets are on the side of its head, suggesting that this is a prey animal (to see this, look at the front of the skull. Are the eye sockets clearly visible, as if the animal is looking at you? Or are the eye sockets not facing you, as if the animal is looking to the side?). It may seem like this is a rodent skull, but this skull belonged to a lagomorph. Like rodents, lagomorphs have long, ever-growing incisors. However, lagomorphs (hares, rabbits, and pikas)

have small "peg teeth" behind their incisors. When a lagomorph bites down, the lower incisors meet the peg teeth for a clean, sharp cut. This skull belonged to a snowshoe hare!

Guiding questions:

If you look straight at this skull, does it seem like the animal is looking at you? Or, is it looking to the side or behind it?

What do you notice about this animal's front teeth?

SKULL 2 (WOLVERINE)

This skull has very small incisors and large, sharp canines. Its cheek teeth (molars and premolars) are fairly pointed for chewing meat and crushing bones. The last molar is perpendicular to the other teeth, which helps this animal scavenge frozen carcasses. Plus, the eye sockets are facing forward, so this animal is a predator. Overall, this skull is also quite thick, which can indicate that this animal might grapple with its prey (or other animals). This skull also has a sagittal crest (ridge at the top). This crest gives the cheek muscles something solid to pull on for an extremely powerful bite. The larger the sagittal crest, the stronger the bite force. This is a wolverine skull! Wolverines are opportunistic: they will hunt live prey, scavenging carcasses, or steal bird eggs from nests. Their wide jaws and sagittal crest give them a powerful bite that helps them take down large prey like caribou under the right circumstances.

What do you notice about the last cheek teeth (molar)?

What's interesting about the top of this skull?

SKULL 3 (ARCTIC GROUND SQUIRREL)

Like skull 1, this skull has long incisors. Since it has no peg teeth, we know it's not a lagomorph. Note that these incisors are orange! This orange coating isn't a stain – it's made of iron, which makes the coating very strong. This is a rodent adaptation that keeps their teeth sharp. As the softer white part of their teeth wears quickly, the orange coating wears slowly and thus functions like a self-sharpening knife. Next, the cheek teeth are not pointed. This animal must be an herbivore. This skull's eye sockets are on the side, so this is a prey animal. Judging by the size, this isn't a tiny, narrow-nosed rodent like a vole or lemming, or a large rodent like a marmot or a beaver. This skull belongs to an arctic ground squirrel!

How does this skull compare to skull #1?

Why are the front teeth orange?

SKULL 4 (CANADA LYNX)

The teeth on the skull are the sharpest in this collection! The incisors are so small they are probably only used for grooming. The canines are huge, and even the cheek teeth are pointed, so this is a carnivore, not an omnivore. The eye sockets face forward (predator), and they are proportionally enormous! The nasal passage is relatively short, giving this skull an almost rounded look Note the smooth lumps near the base of the skull: those are the auditory bullae, which encase the inner ear. The larger the bullae, the stronger the sense of hearing. This skull belongs to a Canada lynx, Alaska's only wild cat. While other animals like bears or wolverines hunt by smell, lynx rely on their acute hearing and sight, even at night. Unlike opportunistic carnivores like wolverines who often scavenge, lynx almost exclusively hunt live prey and thus have very sharp, pointed teeth.

What makes this skull look different than all the others? (look at the proportions of the eye and nose)

What 'sense' might those bulbous lumps contribute to?

SKULL 5 (CARIBOU)

This large skull looks totally different than the others. It has nubbins above the eye sockets. Antlers are regrown each year and leave nubbins. Sheep and goats have horns, which are permanent. Even if the large outer sheath had fallen off, sheep/goat skulls would have a bony core. Eyes on the side indicate that this is a prey animal. The cheek teeth are flat, and the top mandible has no incisors (though the bottom mandible does – not pictured). Many herbivores, including moose,

caribou, sheep, and musk oxen, scoop soft vegetation with their lower incisors and cut it against the hard roofs of their mouths. This is a caribou skull! A moose skull would be larger. Plus, moose don't have canine teeth, while caribou have small upper canines (though they aren't always obvious or present in a cleaned skull).

Why might this animal not have upper incisors?

How do we know it's not a moose? How do we know it's not a sheep or goat?

SKULL 6 (GRIZZLY BEAR)

This is a big, broad skull. It has a long nose for a great sense of smell, and a sagittal crest for a strong bite force. You can probably guess that this is a bear, but what kind? The teeth are worn down (this animal probably lived a long life), but you can see the large, sharp canines, well-used incisors, and rounded cheek teeth. This combination of sharp and flat teeth indicates that this skull belongs to an omnivore, so it can't be a polar bear as they are carnivores and would have sharp cheek teeth. Grizzly bears are larger than black bears and have thicker skulls with more defined sagittal crests. They are more carnivorous, so their cheek teeth are still slightly pointed rather than flat. This skull belonged to a grizzly bear!

What do you know about the diets of Alaska's three bear species?

SKULL 7 (ERMINE)

Despite its small size, this skull has all the traits of a predator: sharp canines, tiny incisors, sharp cheek teeth, and eye sockets facing forward. The last molar is rotated, much like a wolverine's – perhaps they're related? The nose is long, suggesting a good sense of smell. Even the back of the skull is elongated, too, because this animal can crawl through tunnels to chase its prey. This skull belongs to the "snake of the north," the ermine! It's also known as a short-tailed weasel, or stoat. The ermine is arguably the best hunter of all the skulls we'll see today – even better than its intimidating cousin, the wolverine. Because ermines are tiny, energetic, and found in very cold climates, they have a high metabolic rate and thus must eat frequently. In Alaska they mostly hunt voles, though they also hunt shrews, mice, birds, fish, and even hares ten times their size. In winter, they locate prey in tunnels and dens under the snow (the subnivean layer) with their strong sense of smell. They kill all the prey they find, eat until they are stuffed, save the rest of their prey for later, and take over their prey's den as their new home.

What makes this skull's shape unusual?

In what kind of habitat would an animal need a narrow skull?

SKULL 8 (GRAY WOLF)

This skull isn't unlike the grizzly's skull: it has large canines, small incisors, somewhat pointed cheek teeth, forward-facing eyes, and a sagittal crest for a strong bite. This is a predator and carnivore, though it might sometimes scavenge – its teeth aren't as sharp as those of a lynx or ermine. But its nose is even longer than the grizzly's nose, so it must have an extraordinary sense of smell. This is the skull of a gray wolf! Such a strong sense of smell is especially helpful for social animals that need to be able to locate their pack members. Plus, prey animals like caribou or moose can move quickly, so wolves need to be able to track their scent.

Why might wolves need an incredible sense of smell?

SKULL 9 (COLLARED LEMMING)

This skull is dyed a bit orange, which makes it harder to notice the orange tint of its teeth. We know that means that this is a rodent! It has all the features of a herbivorous prey animal: eyes on the side, flat molars, and sharp incisors. But it also has a very stocky and boxy skull, which helps us know that this is a lemming rather than a narrow-faced vole (or a shrew – though those aren't rodents). This animal was a collared lemming and is perhaps the trickiest skull to identify! Collared lemmings eat grasses, sedges, bearberry, and cottongrass in summer. In winter they live under the snow and eat twigs and willow buds.

What do you think this animal eats in summer? In winter?

SKULL 10 (RED FOX)

This skull looks a lot like the wolf skull: eyes forward, sharp canines, somewhat pointed cheek teeth, and a long narrow snout. But it's much smaller. Some dog breeds have skulls this size, but their snouts are broader and shorter. It's smaller than a coyote, but a bit large to be an arctic fox skull, so it's more likely a red fox. However, there is size and range overlap between fox species, so it's a tough call. Remember, red foxes are more common in most parts of Alaska, so it's more likely you'll find a red fox skull in most places. Red foxes are opportunists and omnivores: they eat voles and other live prey, carrion, eggs, insects, and vegetation.

If we found this skull outside, what context clues would help us deduce its identity?

ACTIVITY SETUP (5-30 minutes)

- If students are assembling boxes, give them at least 30 minutes. Put students in groups and distribute skulls to groups by difficulty (e.g. 1 large skull vs. 3 small skulls). Distribute scissors and glue and be ready to assist students.
- Spread completed skull boxes throughout the room. Remind students to handle skull boxes gently.
- For an easier program, list all featured species in a "word bank" for students to match to skulls. For a more challenging program, do not reveal species bank. You can indicate that all species are found in the Arctic or wait for students to ask.
- If you have other animal parts, lay them out as well, and remind students to handle these items with extreme care (or not touch them at all). Demonstrate how to touch furs with the back of the hand, to avoid damaging the furs with skin oils.

PROCEDURE (30 minutes)

- Sort students into groups of 2-4. Distribute *Observations* sheet, either per student or per team.
- Ask students to make 3-4 observations per skull. Encourage them to guess each species. If needed, prompt students to consider the shape and size of the teeth, eye sockets, and skull as a whole.
- Give students 1-2 minutes to observe each skull. Rotate groups until everyone has seen each skull at least once. Allow students to return to previous skulls for comparison, if they take turns respectfully.
- Students return to their seats.

DISCUSSION (30 minutes)

Discuss student observations. Be sure to address teeth/diet and eye location/predator-prey dynamics.

CHOICES TO CONSIDER:

- Will students get a species "word bank"? Will you tell them all animals are found in the Arctic?
- Will you provide background information before students see skulls, or after they've made their guesses?
- Will you reveal each skull ID as you go, or all at the end?
- Will students get kudos for getting the species/family correct? If so, students should record final answers before the reveal.

DISCUSSION GUIDANCE:

All animals in the arctic have a place in the ecosystem and are adapted, or well-suited, to fit into their environments. By looking at an animal's body parts, we can learn about that species' place in the ecosystem. A skull alone can tell us a lot about that species.

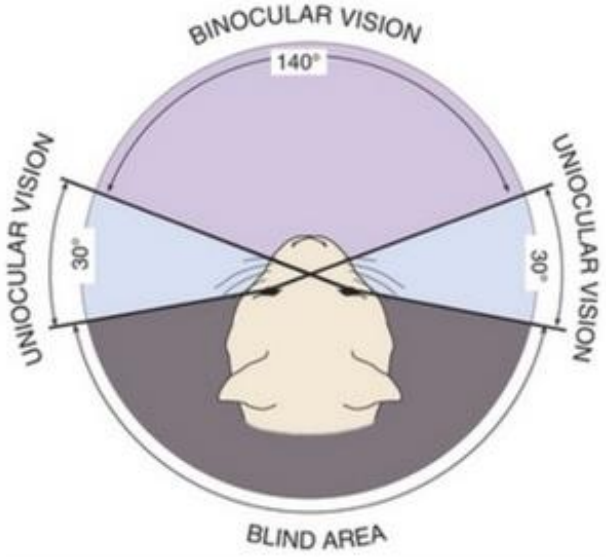
TWO VISUAL DEMONSTRATIONS:

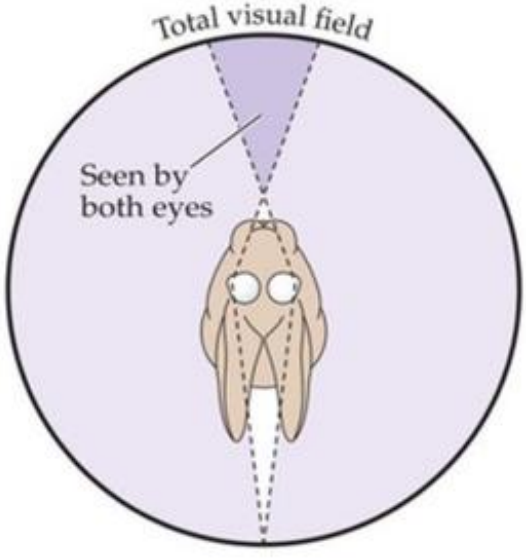
First, demonstrate the benefit of binocular vision: depth perception.

1. Hold two identical items (quarters, pencils, your index fingers) level in front of you.
2. Ask students to cover one eye.
3. Stagger quarters slightly so that one quarter is just millimeters closer to the students than the other. The one-eyed students should not be able to tell which is closer.
4. Students uncover their eyes. Now, it should be obvious which item is closer.
5. Explain: humans have binocular vision – our eyes face the same direction. This gives us great depth perception, or ability to see how close something is. Since our eyes view the world from slightly different angles, our brains can turn those two images into one image with depth perception. *What kind of animals need depth perception? (predators, tree-climbing primates)* Depth perception is valuable for animals that hunt, because they need to know how far away their prey is to be able to pounce at the right time. Animals that swing through trees (like our primate ancestors) also need to know this, so that they can swing from branch to branch without missing. *What are some arctic species that need binocular vision? (lynx, wolves, bears, wolverines, foxes, ermines)*

Next, demonstrate the limitation of binocular vision: limited peripheral vision.

1. Stand where students can see you. Students sit far enough apart that they can spread their arms wide.
2. Ask students to lock their eyes on you (or any fixed point)
3. Ask students to give you a double thumbs up with their arms outstretched.
4. While keeping their eyes locked forward, ask students to slowly swing their arms out to the sides
5. Students freeze their arms when they can no longer see their thumbs in their peripheral vision. Humans see ~170°, and only the central 70 degrees are in focus. The rest is peripheral.
6. Explain: while humans can see depth well, we can't see behind our backs. *What kinds of animals need peripheral vision? (prey animals).* Prey animals need to be able to watch out for predators approaching from behind. What are some arctic animals that need peripheral vision? *(caribou, hares, ground squirrels, other small rodents)*





Bring the discussion back to the skulls. “Eyes on the side, ready to hide. Eyes on the front, ready to hunt.” *Does this knowledge change any of your species guesses?*

But sometimes the eye trick can be deceptive: not all predators are strictly carnivores, or meat eaters. How can we learn more about an animal’s diet? Teeth! Point out canines, molars, and incisors, and ask students to hypothesize the purpose of each. *What kind of teeth would a carnivore have? Herbivore? Omnivore?* Note that most skulls have molars, because all these animals benefit from chewing their food. But meat-eating molars are pointed, while plant-eating molars are flat. Ask students questions: *How might polar bear teeth look different from grizzly bear teeth? Does this knowledge change any of your answers?*

You can go through the nuances of each skull if you have time. End by revealing the identity of each skull. You could include a friendly competition here – one point for a close guess, two points for an exact species ID (e.g. red fox vs. fox).

This story was written to demonstrate predator and prey vision (depth perception vs. peripheral vision) to younger students. Guiding questions: How did the hare know the lynx was behind it? How did the two animals use their eyes differently?

A Hairy Chase

A Canada lynx walks through the boreal forest, its large paws silent as it steps through the powdery snow. Its stomach clenches and grumbles. It has not eaten in two days. The lynx can smell that its preferred prey, the snowshoe hare, is nearby. But it cannot smell well enough to know where the hare is. Instead, the lynx hunts with its eyes and ears. It pads through the spruce trees, scanning the snow for movement. Its long ear tufts flick this way and that as it listens for a crunch of snow, or the sound of a hare chewing willow twigs. All is quiet and still. It keeps prowling.

The lynx scans the snow-covered landscape, examining each dark speck to make sure it is neither the eye nor ear tip of a hare. Its large eyes linger on a smooth dome – is it a hare, or a mound of snow? Just when the lynx is about to turn its head to move on, the wind picks up. Soft fur moves in the breeze – it *is* a hare! Had the wind not given away the hare's fluffy coat, it would have been perfectly camouflaged. The hare does not move a muscle as the lynx watches.

But there is a dense thicket of willows between the hare and the lynx. If the lynx acts now, the hare will surely get away. The lynx looks away from the hare and walks in a wide circle through the deep snow, moving between the willows to sneak up behind the hare. Perhaps the hare will think it had not been spotted. If the hare stays still, perhaps the lynx can get close enough to ambush it.

One silent step, and then another. The hare is as still as an ice sculpture. Only ten, nine, eight feet to go. The lynx crouches, its strong hind legs tensing to launch it toward the hare. But hares, like other prey animals, can see in all directions at one time. Before the lynx can pounce, the hare takes off! It runs at full speed, floating across the top of the snow like a boat skimming over the ocean.

The lynx leaps after it. Though the lynx sinks deeper into the snow than the smaller snowshoe hare, its giant paws keep it afloat enough that it can keep up. Long legs propel the lynx forward, and it starts catching up to the hare. It waits to attack until it is only inches away – one more big leap and the lynx will be able to feast at last!

Without warning, the hare leaps to the left, sprinting toward a stand of spruce trees. The lynx scrambles to change course, its paws shooting snow high into the air as it turns. It runs even faster than before, straining its muscles to catch up to the nimble hare. The lynx dodges trees and shrubs, its yellow eyes locked on the hare. With each long stride it gets closer and closer until the hare is again within reach. With a great leap the lynx springs forward, jaws open wide, sharp claws extended.

The hare sees the attack coming and leaps high, twisting in midair to change its course. Snap! The lynx's teeth lock around silky soft fur… and nothing else. The hare lands to the lynx's side and does not waste a moment as it takes off into the trees. The lynx's head bursts out of the snow, turning to search for the hare. The lynx spots the hare just before it disappears around a spruce tree, already steps ahead. The lynx does not follow. Its ribs expand with each heaving breath. It sticks out its raspy pink tongue, shaking its head to loosen the hare's fur from its mouth. The lynx relaxes into the soft snow, rolling onto its side. After a quick rest, it will search for another hare. Perhaps the next one will not be as quick or as clever.

Skull Observations

Name(s) ______________________________

Skull #: _____ Species ID guess: ____________ Observations: Final species ID: ____________	Skull #: _____ Species ID guess: ____________ Observations: Final species ID: ____________
Skull #: _____ Species ID guess: ____________ Observations: Final species ID: ____________	Skull #: _____ Species ID guess: ____________ Observations: Final species ID: ____________
Skull #: _____ Species ID guess: ____________ Observations: Final species ID: ____________	Skull #: _____ Species ID guess: ____________ Observations: Final species ID: ____________
Skull #: _____ Species ID guess: ____________ Observations: Final species ID: ____________	Skull #: _____ Species ID guess: ____________ Observations: Final species ID: ____________
Skull #: _____ Species ID guess: ____________ Observations: Final species ID: ____________	Skull #: _____ Species ID guess: ____________ Observations: Final species ID: ____________