New Jersey School of Conservation
One Wapalanne Road • Branchville, NJ 07826-5115
http://friendsofnjsoc.org • info@friendsofnjsoc.org

Wildlife Skull Stories

Although skulls are common to all vertebrates, they vary from species to species, and even among individuals of the same taxonomic group. Knowing what to look for—both the similarities and the differences—can provide a fascinating perspective on how animals are related, what they eat, how they avoid being eaten, how they're responding to ecological change, and where our own species fits into the evolutionary picture.

OBJECTIVES:

1. Students will describe animal skulls using eye placement and size, tooth structure, nasal passage size, and size of auditory bullae.
2. Students will use these traits to determine whether the skull belongs to a predator, prey animal, or both.
3. Students will understand how the morphology of an animal can help it to survive in its natural habitat.
4. Students will hypothesize how the traits of these skulls are used by scientists to understand more about the natural world

BACKGROUND:

Looking at animal skulls can allow us to learn many things about how that animal lived in their natural environment. By observing certain parts of the skull, we can determine the way that the animal used its senses to aid in its survival.

Teeth
An animal's teeth can tell us a lot about what they eat and how they eat it. The four main types of teeth are incisors, canines, pre-molars, and molars. The number and shape of these teeth an animal possesses are directly related to the food the animal eats. Incisors and canines are front teeth used for biting and ripping. Molars and pre-molars are used for chewing and grinding.

Herbivore
Herbivores generally have flat canine teeth that resemble incisors. Since they only eat plants, they have no need for large sharp canines. In the front of their mouth, they have incisors only on the bottom jaw. The top jaw consists of a hard, bony plate that is used to brace plant stems against while the incisors tear them. Further back in the mouth, molars and pre-molars are wide with sharp crowns meant to break down plant material. Teeth do not fit together but are meant to grind together to most effectively break down their food. Unlike carnivores, herbivores are able to move their jaws side to side in order to chew, and as a result their teeth tend to wear down with age.

Carnivore
Carnivores have small, less developed incisors, which play only a minor role in activities such as grooming. Their canines are large, long, and sharp, used for biting into prey. Their molars and pre-molars are also sharp and pointed, meant for cutting and tearing through flesh. These teeth can sometimes overlap to provide scissor-like cutting action. As a result, carnivores are not able to move their jaws side to side, and carnivores gulp down their food without chewing.

Omnivore
Omnivores – unsurprisingly – have a combination of the traits of carnivores and herbivores, due to their varied diets. Their incisors are well developed for cutting through plant material, and they have large sharp canines for ripping meat. Cheek teeth further back are a mixture between the scissor-like teeth of carnivores and lower, more rounded teeth for grinding plants. Most omnivores do not have the ability to chew side to side. Instead, they do a combination of sheering and crushing their food. Most omnivores are either primarily meat eaters or primarily plant eaters, which we can learn from the variation in the shape of their cheek teeth – whether they have mostly scissor-like sharp molars, or flat rounded ones.

Beaks
Birds' beaks can also be a good indicator of the type of food they eat. Birds of prey tend to have sharp, curved beaks for ripping flesh; while seed eaters have shorter, blunter beaks made to crack open seeds. Show students the hummingbird and Red-Tailed Hawk skulls as examples of how we can observe the type of food a bird eats by the shape of its beak, just like we can use a mammal's teeth.

Eyesight
The size of an animal's eye sockets – orbits – is directly proportional to the quality and sharpness of the animal's eyesight. The large orbits of cats for example indicates their sharp vision, as well as their excellent night vision. The location of eye sockets in the skull is one of the best indicators of whether an animal plays the role of pursuer or pursued. Prey animals, such as deer or rabbits, tend to have eyes on opposite sides of their heads. This provides a nearly 360-degree field of view at all times, a tremendous advantage when spotting predators. Predators, such as bobcats and coyotes, tend to have forward-facing eyes. While this limits their field of view, it allows the view that each eye sees to overlap with the other. This heightens the animal's ability to pick up on fine visual details. More importantly, each eye's similar, but slightly different, view allows the brain to more accurately perceive depth and distances, which is helpful when pursuing prey.

Nasal Passage
An animal's nasal passage size is an indication of its sense of smell. Thin bony structures inside the nasal passage provide a framework for the membranes that sense odor. The larger these structures are, the better the animal's sense of smell. Both the size of the opening of the passage and the length of the nose itself contribute to this.

Auditory Bullae
The auditory bullae are the bony structures behind the jaw that encases the structures of the inner and middle ear. The larger and more inflated these structures are, the better the animal's sense of hearing. Cats for example have excellent hearing and large auditory bullae, whereas deer (although they have much better hearing than humans) have relatively poor hearing and small auditory bullae.

Predator and Prey
The way an animal uses its senses can also tell us whether it is primarily a predator or prey. Predators will always be either a carnivore or omnivore and have the corresponding teeth, herbivores by definition can *only* be prey animals. An animal could be both predator and prey in

different situations. When a cat eats a mouse it is acting as a predator, while when that same cat is eaten by a coyote it is filling the role of prey. Position of the eye sockets is also an extremely helpful trait when determining whether an animal is predator or prey. Predators will have their eyes on the front of their head. This allows them to have depth perception, which is key when hunting prey. Herbivores and prey animals on the other hand, have their eyes on the side of their heads. This gives them a wide range of peripheral vision. Each eye can see almost 180^o around their head, and using both, they can see almost completely around. A wider field of vision is advantageous to herbivores because it gives them the ability to locate predators around them. *"Eyes in front are for the hunt - Eyes on side must run and hide."*

Case Studies

Scientists in California were able to use skulls to determine a species' response to ecological conditions. Ecologists noticed a coastal population of coyotes feeding on seal meat, which is not a usual food source for these animals. Using chemical analysis of older skulls kept by the California Academy of Sciences, the scientists were able to determine that the coyotes did not begin consuming seal meat until the California grizzly bear was hunted to extinction. This allowed for an ecological shift in the area, and allowed the coyotes to make use of this rich food source.

A study of California song sparrow skulls showed that there was a positive correlation between beak size and temperature. It was found that birds of this species that lived along cooler coasts tended to have smaller beaks, while those of the same species living on warmer coasts tended to have larger beaks. Scientists aren't yet sure how this will be impacted by a changing climate, but skulls will certainly continue to be important to our study of the changing world.
We can also use skulls to track evolution, and one of the most notable examples of this is human skulls throughout history. Looking at skeletal records, we are able track humans by their skulls from our first upright ancestor *Australopithecus sp.* all the way to *Homo sapiens*. Looking at skulls we can clearly see our brain getting larger, as well as changes in the human diet, and how we got our food over time.

MATERIALS:

- Animal skulls (indoor and outdoor sets)
- Mystery skull worksheets to be filled out by each group
- Pencils
- Skull morphology diagram sheets
- Skull poster
- Animal fact sheets (optional)
- Animal pelts (optional)

PROCEDURE:

1. Begin class with a discussion on the three basic classifications of animals by food source – herbivore, omnivore, and carnivore. Ask students how they think an animal's food source can impact the way it looks, and which traits might be affected.

2. Discuss how an animal might have different traits based on whether it is primarily a predator or prey. How would their senses be used differently in each situation?

3. Introduce students to the idea of studying skull morphology. Explain how scientists can use skulls to learn more about animals and the way they live. Why are skulls so useful for this?

4. Using the skull poster, have students compare and contrast a skull from a herbivore, omnivore, and carnivore. Parts they should be looking at include: different types of teeth, size of orbital cavity, size of the nasal passage, eye placement forward or to the side, and size of auditory bullae. Highlight the way these traits are different in each type of animal and how different morphologies would be advantageous in different situations.

5. Break students into small groups and distribute one Mystery Skull worksheet to each group. Having each group begin at a different skull, have them rotate around the room observing the different traits on each skull. Filling out the worksheet, have the students describe the animal as an herbivore, omnivore, or carnivore; a predator, prey or both; and guess what type of animal the skull belongs to.

6. End the indoor session by discussing the students' findings and observations. Why might skull morphology be an important tool for scientists?
    - Changing food resources over time --> food webs/energy flow
    - Geographic distribution
    - Genetics
    - Evolution
    - Animal relationships/ taxonomy

Optional Indoor Extension (rainy day):

Give students the animal fact sheets that correspond with their last skull and have them present their findings. Along with what animal the skull belongs to, students should also consider any defining characteristics (how did they know it was that animal versus another). Using the fact sheet provided, students can connect what the animal eats and how it gets that food to the traits they have already identified on the skull. Encourage them not to simply read off the worksheet, but to connect that information to that animal's ecological role.

Outdoor Extension:

Hide real skulls along Wapalanne Road in strategic habitat locations that correspond to animal type and habitat use. Ask students to identify skulls based on what they learned in the indoor portion and guess why the skull may be found in the location that it is. Students might find it challenging to identify the skulls if they are broken or degraded but this illustrates the point that scientists and naturalists must use all available clues to gather information when studying wildlife and must sometimes make inferences based on what they know.

For example:
1. Groundhog skull might be hidden near Kittatinny Hall and students might conclude that groundhogs dig burrows beneath buildings to seek shelter over the winter.
2. Beaver skull might be hidden near trees on the left side of the road that are wrapped in wire and students might conclude that trees were wrapped to protect them from beaver chew.
3. Fox and bobcat skulls might be hidden in rock piles and students might conclude that these animals may utilize this habitat to hunt for small rodents.
4. Raccoon skull might be hidden near culvert pipe and students might conclude that raccoons could hunt for frogs or crayfish in this aquatic habitat.
5. Opossum skull might be hidden near a tree and students might conclude that opossums climb trees.

Bibliography
Sullivan, Lawrence M. "Wildlife Skull Activities." *University of Arizona Cooperative Extension,* University of Arizona College of Agriculture, Oct. 1999.

"Skull Stories." *California Academy of Sciences*, California Academy of Sciences, www.calacademy.org/skull-stories.

Skulls Sources
https://boneclones.com/
https://www.acornnaturalists.com/
https://www.skullsunlimited.com/

Lesson plan adapted for use by the NJSOC By Katie Tharrett and Tanya Sulikowski.
Last update 11/2019

NJ Student Learning Standards

This field lesson touches upon the following NJ Science Performance Expectations and can be tailored to focus on any of the following standards

MS-LS1: From Molecules to Organisms: Structures and Processes

- MS-LS1-1 Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.
- MS-LS1-3 Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
- MS-LS1-4 Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.
- MS-LS1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

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

Students who demonstrate understanding can:

- MS-LS2-1 Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
- MS-LS2-2 Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
- MS-LS2-3 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
- MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

• MS-LS2-5 Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

MS-LS4: Biological Evolution: Unity and Diversity

• MS-LS4-2 Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.

• MS-LS4-4 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

Climate Change

• MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Comprehensive Health and Physical Education

• 2.2.8.MSC.7 Effectively manage emotions during physical activity (e.g., anger, frustration, excitement) in a safe manner to self and others.

• 2.3.8.PS.1 Assess the degree of risk in a variety of situations, and identify strategies needed to reduce deliberate and non-deliberate injuries to self and others

Scientific and Engineering Practices / NGSS

This field lesson can be tailored to have students directly involved with

- Asking Questions and Defining Problems
- Planning and Carrying Out Investigations
- Analyzing and Interpreting Data
- Constructing Explanations and Designing Solutions
- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information

Social and Emotional Learning

All of our field lessons integrate the concepts of self-awareness, self-management, social awareness, responsible decision-making, and relationship skills found in the New Jersey's Core Social and Emotional Learning (SEL) Competencies.