

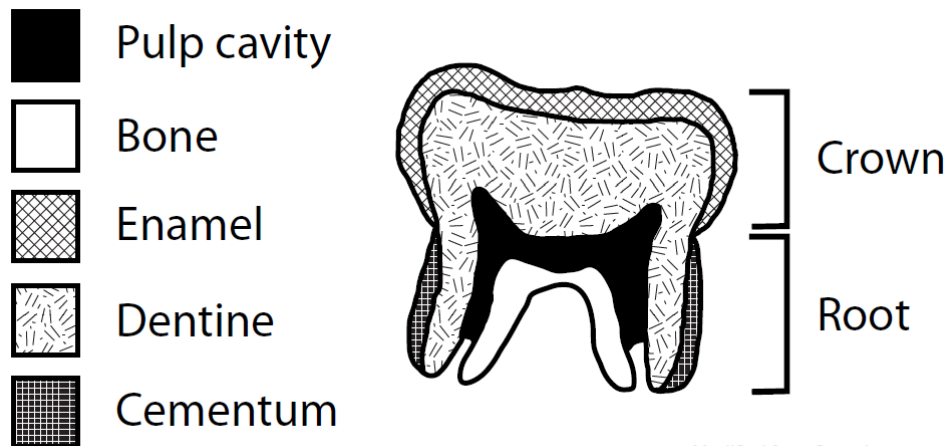
Lesson Seven

Paleoecology: Determining the Diet of Ancient Animals

Summary

Paleoecology, or the study of ancient ecosystems and how plants and animals interacted, includes many disciplines. One component of paleoecology that is easily understood by students is diet. Organisms must regularly acquire energy from their environment to support growth and development, which is in turn key to survival and reproduction. For animals, this energy comes in the form of food sources from their environment. Most vertebrates mechanically break down food in their mouth, then break it down further using enzymes and acids in their gut (stomach and small intestines), absorb the nutrients into the bloodstream, and finally transport them to the cells, where they are converted into energy that can be used. Over generations, the evolutionary process of natural selection has shaped this process, such that vertebrates efficiently acquire and process their food. Teeth are directly involved in the mechanical break down of food and thus, fossil teeth provide paleontologists a window into the diet of extinct vertebrates. The diets of vertebrates in a fossil assemblage can then be used to reconstruct the food web (what eats what) of an ecosystem, showing the ecological relationships between once-living beings.

Teeth are composed of a wear-resistant and chemical-resistant mineral called apatite (calcium fluorophosphate) with an inner pulp cavity surrounded by a softer dentine and a harder outermost layer, enamel. Teeth are affixed to the jaws of vertebrates in different ways from sitting in deep sockets in mammals to be fused to the bone. Because enamel is the hardest mineral in the body, teeth tend to fossilize more readily than other body parts. They commonly survive scavenging and stream transport that can destroy other skeletal elements. And because animals tend to have many teeth, they have a higher chance of being preserved compared to some other parts.



Modified from Strömberg, 2006

In addition, because we have modern teeth to study, we can compare the teeth of extinct fossil species with the teeth of living species and often identify the species, infer the types of foods that the extinct species ate, as well as determine the animal's size. Paleontologists may also be able to approximate the ancient food web in which the animal lived even going so far as to reconstruct

an ancient ecosystem from evidence provided by little more than fossil teeth preserved in a geologic deposit.

In this lesson, students will work with teeth from animals from the Hell Creek Formation. They will use them to better understand how paleontologists use fossils to help bring an extinct animal to life.

(This lesson adapted from ones developed by David Davies at Centenary College of Louisiana (www.beloit.edu/sepm/Fossil_Explorations/Dinosaur_Paleoecology.html) and James Westgate at Lamar University (www.beloit.edu/sepm/Fossil_Explorations/Tooth_Detectives.html)).

Objectives

Students will be able to:

1. Explain the relationship between the shape of a tooth and the animal's diet (carnivore, herbivore, etc.).
2. Show how tooth shapes are correlated with specific ways of obtaining and processing food items.
3. Recognize the dietary habits of living animal species through the examination of their teeth.
4. Hypothesize what the diets of extinct animals were through the examination of their fossil teeth.
5. Discuss how understanding an animal's diet can illustrate how it fits into an ecosystem.
6. Explain the difference between the teeth of mammals and other groups such as reptiles and amphibians.

Estimated teaching time

One class session.

Groups

Students will work in groups.

Materials

- At least one replica of teeth/jaw of each of the following animals: meat eater, insectivore, fish eater, plant eater (grinder), plant eater (scissoring)
- Photograph of tools equivalent to types of diet (five photographs in total)
- DVD with images of teeth, to be used during assessment

Teacher background

See handout on teeth.

Student background

None specifically required.

Set up

Have projector ready for PowerPoint presentation.

This activity can be done in the classroom.

Introducing the activity

1. Explain to the class that today they will be focusing on one way that paleontologists reconstruct the life (i.e. ecology) of an extinct animal.
 - Ask students if they know what a food web is?
 - Ask students how they would reconstruct a food web, or the trophic interactions between animals?
 - How would they reconstruct a food web that includes dinosaurs and/or animals that lived at the same time and in the same ecosystem as dinosaurs?
 - What evidence would they look for?
2. Now tell them that they will be focusing on teeth and what can be learned from studying teeth. First, find out what the students know.
 - What do you eat?
 - Describe the four different types of teeth that mammals (including humans) have: incisor, canine, premolar, and molar. What is the function of each tooth? How many teeth of each type do they have? What about adults (or children)?
 - Which teeth do you use for which type of food, such as meat and plants? (Humans use all of their teeth no matter what they are eating but the point here is to get students to think about how they use some teeth primarily for cutting and some primarily for grinding. Mammals are unusual in that we have different types of teeth in our mouths, whereas other groups have just one type depending on whether they are a carnivore or herbivore.)
 - Do all animals have the same type and number of teeth?
 - What are some differences/similarities?
 - Do all animals chew their food?
3. Using this information you are now going to work with a variety of teeth to try to understand the diet of the animals that lived at the end of the Cretaceous. All of the animals ate at least one of five types of food: meat; fish; insects; woody vegetation; or soft vegetation. Ask the students what they think are advantages and disadvantages of the four food types?
 - Meat is easily digested and very nutritious; prey must be caught (which may be difficult) and cut into chunks to be swallowed.
 - Fishes are also easily digested and very nutritious; however, slippery fishes live in water and are hard to grasp and swallow, typically whole.
 - Insects are nutritious, have high protein, some are squishy, others are crunchy; they are hard to find enough of at one spot for eating if you are large animal so insectivores tend to be small.
 - Woody plants are plentiful, but they have tough leaves and stems, which are difficult to chew; the high cellulose content also makes them the most difficult food to digest in the gut. They must be cut and crushed into very small pieces to be swallowed so that they can be digested.
 - Small herbs and fruit are easier to digest than woody plants or plant parts; however, they are harder to obtain in large quantities.

Also explain how plants, which some students at first might think of as being very soft, can be

very abrasive. For example, when you run a blade of grass through your hand you can get a painful cut. This cut is from the glass-like minerals (phytoliths) incorporated into blades of grass and other leaves. Horses, which eat grasses for a living, have very tall teeth that are not completely worn down or eroded by the phytoliths in their diet of grasses.

- Now show the PowerPoint (or laminated pictures) of five food and tools to see if the students can figure which type of tool works best for processing different types of food. Start by showing each food item and address the differences as described above. Examples of tools are listed below. A central point to make is to get students to think about the idea that a tooth is really a tool that breaks down food items.

FOOD	FOOD PROCESSOR	MODEL
Meat	Piercing, slashing, and cutting teeth with tall blades	Serrated knife
Fish	Pointed, piercing teeth curved toward the back of the mouth to grasp and hold slippery prey	Fish Gig
Insects	Individual teeth have multiple levels for punching through exoskeleton or cutting through grubs then for chomping	Scissors
Woody Vegetation	Battery of teeth with broad grinding surface and low cutting ridges	Washboard
Softer Vegetation	Battery of teeth with low rounded bumps (cusps) and opposing basins for crushing and grinding soft material	Mortar and Pestle

- Teeth can also provide some insights into the size of the animal. Using the different teeth provided in the box, ask the students to think about how big an animal is, based simply on its teeth. You may want them to get to think about animals that they are familiar with and how big their teeth are. However, note that this can be tricky depending on how many teeth are in the mouth.

Facilitating the activity

- Divide the students into five groups and have them analyze the teeth provided in the box.
 - Have them draw and write a description of each tooth (how are they shaped, what size are they, what fine structures, such as points, ridges, serrations, and bumps, are on the teeth).
 - Have the students decide, based on their description and what the tooth looks like, whether the tooth's owner was big or small, what the animal ate (from the five choices), and whether it was more likely to chew its food or swallow it immediately.
- Allow the students to work for five minutes or so on each tooth then pass the tooth to the next group. After each period is up have the students pass their tooth to the next group, until all groups have seen all teeth.

Assessment

Show them Powerpoint of images of teeth and ask students to state what type of diet the animals have.

Going further

Have the students choose a contemporary animal and write a short description of what teeth it is likely to have, based on its diet, and why. The students might also look at other structures or adaptations that make this animal particularly good at obtaining its meals (for example, claws to apprehend vertebrate prey). They may also want to reflect or examine animals with unusual diets or teeth (or lack thereof), such as anteaters, polar bears, baleen whales, and vampire bats, as a way to think about natural selection and evolution.

References

NA

Teaching standards

Science Content Standard 1 - Students, through the inquiry process, demonstrate the ability to design, conduct, evaluate, and communicate results and reasonable conclusions of scientific investigations.

Benchmark End of Grade 4, Number 1 - Develop the abilities necessary to safely conduct scientific inquiry, including (a step-by- step sequence is not implied): (a) asking questions about objects, events, and organisms in the environment, (b) planning and conducting simple investigations

Glossary

- Browser – An animal that feeds on leaves, buds, and green stems. These types of food are easier to digest, so that the digestive system does not need to be quite so big.
- Canine – Pointed teeth towards the front of the mouth (think Dracula fangs); usually used for piercing food or firmly holding food in order to tear it apart, and occasionally used as weapons or display
- Carnivore – An animal whose diet consists of animals (meat, fish, insects, other invertebrates)
- Grazer – An animal that feeds primarily on grasses.
- Herbivore – An animal whose diet consists of plant parts (leaves, bark, roots, fruits, seeds)
- Incisor – Simple teeth in the very front of the mouth of mammals, primarily used for nipping or cutting
- Molar – More complex teeth in rear of the mouth of mammals, used primarily for crushing and grinding (chewing)
- Premolar – Somewhat complex teeth located between canines and molars in mammals; they help in the puncturing function of the canines and the crushing function of molars