INDIANA GEOLOGICAL & WATER SURVEY
INDIANA UNIVERSITY
INDIANA UNIVERSITY
PALEONTOLOGY COLLECTION

Comparing Ice Age Mammals

Lesson Plans and Activities

By Polly R. Sturgeon and Gary J. Motz

Targeted Age:
Middle to High School

Activity Structure:
Group Activity (2 to 4 students)

Indiana Standards and Objectives:
7.ESS.2, 7.ESS.4, ES.5.5, Env.1.2

MATERIALS NEEDED

- 3-D fossil prints: mastodon, mammoth, saber-toothed cat, and dire wolf teeth (*3-D files available for download at http://igws.indiana/edu/lessonplans*)
- Magnifying glass or hand lens
- Ruler

Introduction

This activity allows students to compare the morphologies of 3-D printed teeth from Ice Age mammals. Students will manipulate 3-D prints and record observations in order to infer the diet of megafauna and discuss the role of technology in paleontological research. The 3-D prints, representative of actual fossils collected in Indiana, will be generated by students using 3-D scans from the Indiana University Paleontology Collection.

Background Information

A fossil is physical evidence of a preexisting organism through preserved remains or an indirect trace. The most common and obvious fossils are the preserved skeletal remains of animals. Shells, teeth, bones, and calcareous skeletons are all examples of hard parts that can remain unaltered or be replaced by minerals during the fossilization process. Other fossils, such as burrows, tracks and trails, and droppings, are called trace fossils because they provide a "trace" of a once-living organism rather than the remains of the organism itself. A very small fraction of the organisms that have lived on Earth are found in the fossil record. Approximately 8.7 million species live on Earth today, but only about 225,000 different animal species have been described by paleontologists! The incompleteness of the fossil record is due to preservation. Marine organisms with hard parts are generally better preserved than soft-bodied and non-marine organisms. Additionally, fossils only occur in sedimentary rocks, which account for 5 percent of the Earth's lithosphere.

Fossils of any kind are useful in interpreting the rock record. They can help us determine the geologic age and sedimentary environment in which they were deposited, and their study can help scientists better understand patterns in the evolution of life throughout Earth's history.

The fossils used in this lesson represent animals that lived in Indiana during the Ice Age. Approximately 2.6 million to 10,000 years ago, during a time known as the Pleistocene Epoch, immense glaciers spread as sheets of ice over northern North America. Normal climate fluctuations, caused by changes in the tilt of the Earth's axis and its orbit around the Sun, caused glacial ice to advance and withdraw several times. The severe climatic changes had a major effect on the flora and fauna living in Indiana. Forests dominated by deciduous trees (maple, beech, basswood, oak, and hickory) occupied Indiana during periods of glacial retreat. Glacial periods were dominated by coniferous trees such as spruce. Large mammals, such as mammoths, mastodons, saber-toothed cats, and dire wolves, roamed the land south of the glacial margin. The most recent period of glacial advance into the state occurred 30,000 to 15,000 years ago. Around 10,000 years ago, these megafaunal species disappeared during the transition from the Pleistocene to Holocene Epoch, an event geologists refer to as the Quaternary Extinction. In North America, approximately 70 percent of mammals became extinct because of climate change and human predation (including the four animals in this exercise). Today, these great beasts are only recognized by their fossil evidence.

The Indiana Geological and Water Survey and Indiana University Paleontology Collection have partnered to assist teachers in their teaching and understanding of fossils and ancient life. The 3-D prints used in this activity were scanned from a real-life fossil found in Indiana, converted into a digital model, and replicated as a 3-D printed object. The use of 3-D prints in a classroom allows for authentic, real-world learning with tangible objects that would not otherwise be readily available to teachers and students. Digitized fossil collections can be made accessible to the broader scientific community to enhance paleontological research.

Vocabulary

Browser – a herbivore that feeds on leaves, soft shoots, or fruits of woody plants, such as shrubs
Canine – pointed tooth between incisors and molars in a mammal, often enlarged in carnivores
Carnassial – blade-like cheek teeth of carnivorous mammals, which usually consists of a premolar and molar
Epoch – a subdivision of geologic time that is shorter than a period
Fossil – physical evidence of a preexisting organism through preserved remains or an indirect trace
Grazer – a herbivore that feeds on grass or other low vegetation
Megafauna – large or giant animals
Molar – grinding tooth at the back of the mouth
Morphology – the shape and structure of an organism
Paleontologist – a scientist who studies forms of preexisting life through fossils

Teacher Reference Page

Mastodon

Scientific Name: *Mammut americanum*
Lived in Indiana: 400,000–10,000 years ago
Habitat: Open spruce woodlands
Diet: Herbivore, browser, ate soft vegetation like leaves and twigs
Teeth: Short, straight tusks (up to 9 feet long). High-crowned, molar-shaped teeth (5 inches wide). Two to four cone-shaped cusps covered in enamel used to mash leaves and twigs.

Appearance: Weighed 4 to 6 tons (8,000–12,000 pounds). Flatter, more rounded forehead, lower shoulders, no fatty humps on neck or shoulders. Grew up to 10 feet tall at shoulder.

Mammoth

Scientific Name: *Mammuthus primigenius*
Lived in Indiana: 400,000–10,000 years ago
Habitat: Grassland areas
Diet: Herbivore, grazer, ate grasses
Teeth: Long, curved tusks (sometimes over 12 feet long). Large teeth (8 inches tall, 12 inches wide). Closely spaced flat-crowned ridges alternating with dentine and cement. Chewed grasses by moving lower jaw forward, down, and backward in a grinding motion.

Appearance: Weighed 4 to 6 tons (8,000–12,000 pounds). High, peaked forehead, high shoulders, fatty humps on neck or shoulders. Grew up to 14 feet tall at shoulder.

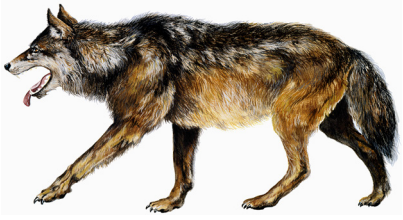
Saber-toothed Cat

Scientific Name: *Smilodon fatalis*
Lived in Indiana: 500,000–9,400 years ago
Habitat: Margins of woodlands, brush plains
Diet: Carnivore, ate slow-moving animals

Teeth: Upper canine teeth are long (7 inches), flat and daggerlike, effective for puncturing and slicing prey. Incisor teeth are conical and in a curved row. Shearing carnassial teeth, lower canines, upper and lower molars.
Appearance: Weighed 350–620 pounds, larger than lions and about the size of Siberian tigers. Front and back limbs about the same length, muscular build, short tail. Body length 5.8 feet tail to snout, grew up to 3.3 feet tall at shoulder.

Dire Wolf

Scientific Name: *Canis dirus*
Lived in Indiana: 300,000–10,000 years ago
Habitat: Woodland and plain areas
Diet: Carnivore, specializations for meat eating. Ate large prey (220–260 pounds), supplemented diet with smaller mammals, birds, and berries.
Teeth: Daggerlike canine teeth, greater bite force than modern wolves. Cutting blade on carnassial teeth, irregular bowl-shaped molars. Thickened mandible below carnassial teeth.



Appearance: Weighed 130–150 pounds, larger that the Gray wolf, Red wolf, and Coyote. Proportionally larger front legs. Shorter limbs relative to body mass, stocky build, long tail. Body length 4.1 feet tail to snout, grew up to 2.6 feet tall at shoulder.

Illustrations by Karen Carr, courtesy of the Indiana State Museum http://indianamuseum.org

Procedure

1. Distribute the fossil study sets and student data sheets to each group. Review the vocabulary terms and glacial history of Indiana prior to beginning activity.

2. Instruct students to manipulate each fossil print. Students should measure the length and width of each fossil and sketch the fossil in order to accurately report tooth morphology.

3. Instruct students to carefully record their observations on the student data sheets, making sure to include scale.

4. Once students have observed the fossils, compare and contrast tooth morphology. Ask students to contrast the fossil prints to their own teeth, emphasizing the role of each tooth's shape in their own eating habits.

5. Ask the class what clues to diet are shown in the teeth. Students should record their hypotheses on their data sheets, making sure to justify their answers with observations.

6. Allow students to review the activity through the reflection questions. Discuss how 3-D printing allowed them to make these observations.

What clues to diet are shown in teeth? Ask students to observe fossil morphology in order to infer diet.

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_____

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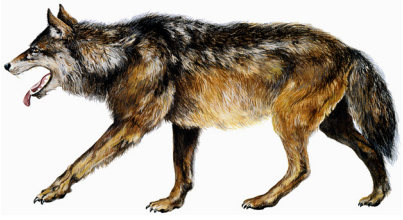

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Student Data Sheet

1. Assign a letter for each fossil print. Measure the width and length of each fossil and record your data below.

Fossil	Width (cm)	Length (cm)
A		
B		
C		
D		

2. Observe each fossil carefully and sketch its shape in the spaces below. Make detailed observations of the tooth morphology. Include scale using your measurements from above.

Fossil A	**Fossil B**
Fossil C	**Fossil D**

3. Make an inference of each animal's diet based on its tooth morphology. Complete the table below and justify your answers using observations of fossil morphology.

Fossil	Diet HB – Herbivore, browser HG – Herbivore, grazer C – Carnivore	Evidence & Observations
A		
B		
C		
D		

4. Use your Reference Sheet to identify each megafauna species based on its fossil tooth. Draw a line to match the inferred diet of each fossil tooth to the scientific name.

Fossil	Diet	Scientific Name
A	HG	*Mammut americanum*
B	C	*Mammuthus primigenius*
C	C	*Smilodon fatalis*
D	HB	*Canis dirus*

Reflection Questions

1. What type of fossil preservation is represented by the 3-D models: unaltered hard parts, mineralized hard parts, or trace fossils? Explain your answer.

2. While all megafauna fossils are rare, mastodon teeth are the most prevalent in Indiana. Why are there relatively few known fossils of Ice Age mammals?
   Hint: think about geographic diversity versus the fossilization process

Figure 1: Mastodon jawbone discovered in Rensselaer, Indiana

3. What happened to Ice Age mammals once human migration spread into North America? What other factors could have contributed to the megafaunal extinction at the end of the Pleistocene Epoch?

Figure 2: Here, a staff member is 3-D scanning the mastodon jawbone using a Creaform GoScan 50

4. What are the basic characteristics of herbivore teeth? Carnivore teeth? Give an example of a special adaptation for each.

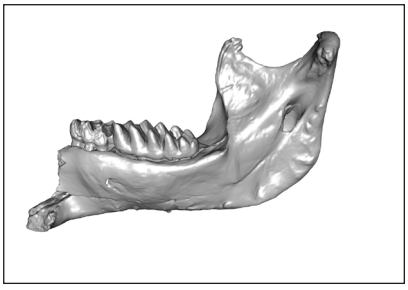

Figure 3: Complete 3-D scan of mastodon jawbone

5. How can scientists use 3-D printing to enhance paleontological research?
   Hint: think about discoverability and sharing ideas with scientists around the globe.