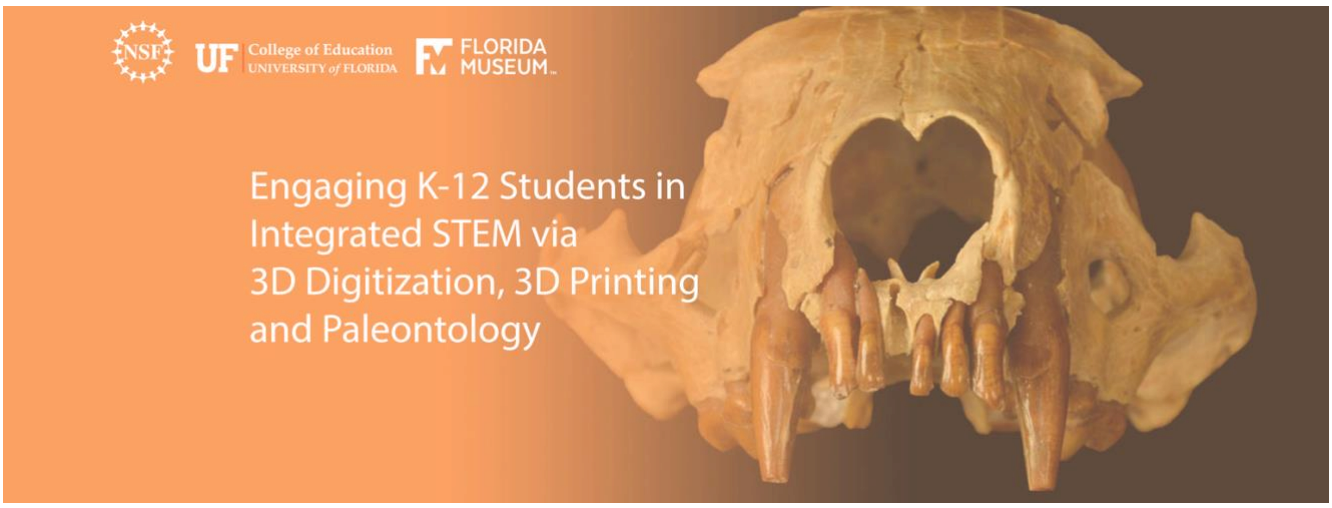

LESSON TITLE

Runner or Climber?

AUTHOR

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GRADE LEVEL

Upper elementary 4-5
Middle grades 6-7

TIME FRAME

Two 50-minutes periods

DRIVING QUESTION

How do limb dimensions relate to the locomotor habits of carnivores?

LEARNING GOALS

In this lesson, students will be able to…

- Measure different dimensions (i.e. length, diameter) of fossil bone (i.e. humerus) from different carnivores.
- Compare the length and width of humerus bone from a fossil and a modern organism.
- Hypothesize if there is a relationship between limb dimensions and their movement and hunting habits in carnivores.
- Use evidence from text to support scientific explanations.

ANCHORING EVENT

Begin the lesson by having the students focus on movement. Ask students to think about movement around them and the world. For example, clouds, animals that run, swim, fly or dig, things moved by the wind. For upper elementary level students, ask students to work in groups of 3-4 to imitate/act up some of these natural movements while other guess the movement. Show the students the two 3D printed copies of a Sabertooth humerus and a modern cat humerus and ask them (without identifying the bones) if they could tell how these carnivores moved based on their observations of their bones. Accept all answers. Some students will think that the larger bone is for running and the smaller bone is for flying.

COLLABORATIONS

In this lesson the teacher can collaborate with a paleontologist that will support the selection of fossils for the project (if a local museum is available) or finding 3D scans of fossil bones from a digital database resource like Sketchfab (https://sketchfab.com). Students will collaborate as they work in groups of 3-4 students as they complete each activity included in the lesson. Students will also collaborate while working in the 3D printing and in whole class discussions.

STEM INTEGRATION

In this lesson the students will be able to measure different dimensions of fossil bone (humerus) to determine if there is a relationship between these dimensions and their locomotion. Students will research information about the characteristics of the organisms chosen (cheetah, panthers) and an extinct species (i.e. Sabertooth). The students will also make use of the technologies of 3D scanning and 3D printing the bones of the fossils to be investigated.

ASSESSMENT

Formative assessments

Teacher may formatively assess students by circulating the room, checking for active participation in all groups, asking questions of the students, and monitoring the students' written responses as well as small group discussions and collaboration.

Summative assessments

The summative assessment may include a comparison of the initial student responses/predictions with the responses in the making Sense section of the activity (see below).

Assessment question:
Based on the information read (see Explain section), how did fossil A (large bone) and fossil B (small bone) move? Support your answer with evidence from the text.

Rubric
Constructing scientific explanations

MASTERY(4)	PROFICIENT(3)	APPROACHING PROFICIENCY(2)	BEGINNING(1)	NOT MEETING(<1)
Independently, student construct an explanation: -with a clear and accurate claim that is a complete sentence and does not begin with Yes or No. -uses two pieces of evidence (both from qualitative and quantitative data) -describes in detail the pieces of evidence -that includes a clear reasoning with appropriate scientific principles or ideas.	Independently student construct an explanation: -with a clear and accurate claim that is a complete sentence and does not begin with Yes or No. -uses one piece of evidence -describes in detail the pieces of evidence -that includes a clear reasoning with appropriate scientific principles or ideas.	Student construct an explanation: -with a clear claim that is a complete sentence and does not begin with Yes or No. -uses some basic evidence gathered in class -includes a vague reasoning with some scientific principles.	With support, Student can… -write a clear and accurate claim with no evidence.	The explanation is incorrect and no evidence is used to support the claim.

PROCEDURE

Day 1

Engage

Students will begin the lesson by completing the anchoring event described previously. Once some groups imitate their chosen natural movement, focus the discussion in carnivores. First, discuss what a carnivore is (see Key Academic and/or Scientific Language section below). The teacher may also introduce some pictures of carnivores. Then, introduce the students to the term locomotion (see Key Academic and/or Scientific Language section below). Ask students:

- Do all carnivores move the same way?
- What are some ways carnivores move? Make a list on the board of their possible responses (run, swim, walk, dig)
- What structures do carnivores have for locomotion? Focus the discussion to bones, more specifically femur and humerus.

Explore

Prior to the lesson the teacher will 3D print the bones to be used for the lesson using a 3D open source like Morphosource (see Resources and materials section for details). Give students a 3D printed copy of a Sabertooth humerus bone and a cheetah, panther, cat.

Have students make qualitative and quantitative observations of the fossil bone and compare them. Students may use a chart like the one shown below to record their observations.

Fossil	Visual Representation (Insert picture, if possible)	Observations	Fossil Measurement (cm)	
			Length	Width
1.				
2.				
3.				

Day 2

Explain

Have students compare their measurements. Ask them: How do they compare? Did they notice a pattern? Did they notice any other differences in the structure?

Then, have students answer the following questions (see below) in small groups (2-4 students). After this small group discussion engage students in a whole class discussion and push students to support their answers with evidence gathered from the measurements.

Possible prompts:

- Compare the fossils. How are they similar? How are they different?
- Do you notice a pattern on the measurements of the humerus bone)? If yes, describe the pattern.

- Based on your observations, predict how did fossil A move? Fossil B? (Hint: running, climbing, swimming, jumping, digging) Explain your thinking.

After, have students determine how these carnivores moved based on evidence from the text below. Students use the following link and read information about the different types of movement (running, climbing, flying, etc.)

https://cpb-us-e1.wpmucdn.com/blogs.cornell.edu/dist/7/3643/files/2013/09/Mammalian-Locomotion-24p1ygv.pdf

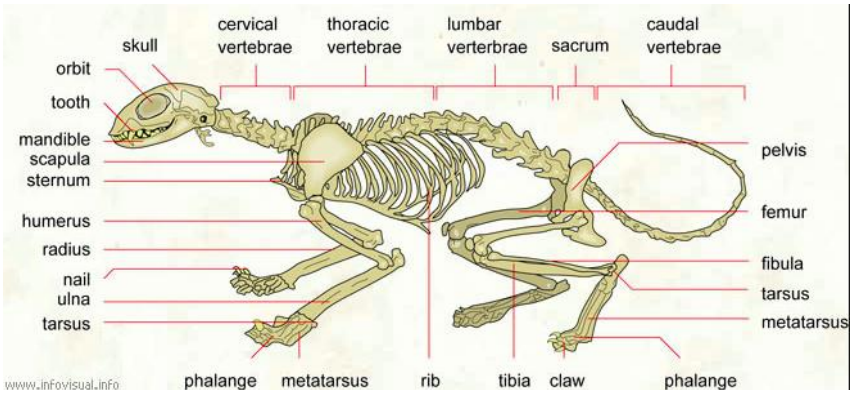
After reading, have students support their claims with evidence from the text.
Suggested prompt:

- Based on the information read, how did fossil A (large bone) and fossil B (small bone) move? Support your answer with evidence from the text.

Elaborate/Extend

If time allows, have students determine to what carnivores the 3D printed bones belong to. Have students look at the images below, read the following clues and do an online search to figure out what organisms the bones belong to.

1. Bone A (to the left) belongs to a prehistoric carnivore that lived in the Cenozoic time. The image shows the skull of this organism. Bone B (to the right) belongs to a modern carnivore that commonly lives as a pet in many households. It is much smaller in size than the organism for Bone A.



Suggested prompts:

- What organisms these bones belong to? Hint: *You may need to do a search online and look at the pictures in the previous reading.*
- Did these organisms move the same way? Support your answer with evidence from your observations.

- Can scientists predict hunting behaviors based on bone dimensions (measurements)? Explain your answer.
- Do you think that these two organisms are related? Explain your thinking.
- Are Saber-toothed cats related to modern cats? Have students use the link below to obtain information to support their answers.
  http://www.ucmp.berkeley.edu/mammal/carnivora/sabretooth.html

Students may also explore the different bones of the human skeleton using the following digital resource: https://sketchfab.com/models/ac9a7beaba8c4cd591c429d2ff70b58b .

STANDARDS

NEXT GENERATION SCIENCE STANDARDS (NGSS)

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. The materials and activities outlined in this lesson plan are just a step towards reaching the performance expectation listed above.

Science Practices	Connection to the Lesson
Developing and Using Models **Using Mathematics and Computational Thinking** **Constructing Explanations and Designing Solutions** **Obtaining, Evaluating, and Communicating Information**	In this lesson students will use 3D printed models of fossil and modern bones to understand the relationship between bone dimension and locomotion habits. Students will engage in the practice of using mathematics as they measure the dimensions (length and width) of bone sample on Day 1 in the Explore section of the lesson. Students will construct a scientific explanation as part of the summative assessment at the end of the lesson. Students will read and obtain information about different locomotion habits of carnivores on Day 2 in the Explain section.
Disciplinary Core Ideas	**Connection to the Lesson**
LS1.A Structure and Function	Students will measure the dimensions of a structure: bone and identify the function (flying, running, climbing) of different types of bones based on their dimensions in the Explain segment of the lesson (Day 2).
Crosscutting Concepts	**Connection to the Lesson**
Scale, Proportion and Quantity **Structure and Function**	In this lesson students will recognize the proportional relationship between the bone dimensions of length and width and the function of locomotion in the Explore section (Day 1).

Students will describe how the way carnivores' bones are shaped/structured determines their functions (climbing, running or flying) in the Explain section on Day 2.

CCSS STANDARDS

ELA/Literacy	Description
RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts.
RST.6.8.2	Determine the central ideas or conclusions of a text; provide accurate summary of the text distinct from prior knowledge or opinions.
RI.6.8	Trace and evaluate the argument and specific items in a text, distinguishing claims that are supported by reasons and evidence from claims that are not.
WHST.6-8.1	Write arguments focused on discipline content.
WHST.6-8.2	Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization and analysis of relevant content.
WHST.6-8.9 SL.8.5	Draw evidence from informational texts to support analysis, reflection and research.

Mathematics	Description
6.SP.B.4	Summarize numerical data sets in relation to their context.

OTHER STANDARDS

Student Standard	Description

1. Creativity and innovation	Students use models and simulations to explore complex systems and issues.
2. Communication and collaboration	Students interact, collaborate, and publish with peers, experts, or others employing a variety of digital environments and media.
3. Research and information fluency	Students locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.
4. Critical thinking, problem solving and decision making	Students plan and manage activities to develop a solution or complete a project.
5. Digital citizenship	-Students advocate and practice safe, legal, and responsible use of information and technology. -Students exhibit positive attitude toward using technology that supports collaboration, learning and productivity. -Students demonstrate personal responsibility for lifelong learning. -Students exhibit leadership for digital citizenship.
6. Technology operations and concepts	-Students understand and use technology systems. -Students select and use applications effectively and productively.

RESOURCES & MATERIALS

Materials
Digital or Manual Calipers
Magnifying Lenses
3D scans (see resources)

3D Resources:
Modern Cat: https://www.morphosource.org/MyProjects/Specimens/form/specimen_id/7598
Fossil & Modern Felids & Canids:
https://www.morphosource.org/MyProjects/Dashboard/dashboard/select_project_id/356

Fossil and Anatomy Resources:
https://www.nps.gov/joda/learn/news/carnivore-locomotion.htm
http://www.ucmp.berkeley.edu/mammal/carnivora/sabretooth.html
https://cpb-us-e1.wpmucdn.com/blogs.cornell.edu/dist/7/3643/files/2013/09/Mammalian-Locomotion-24p1ygv.pdf

KEY ACADEMIC AND/OR SCIENTIFIC LANGUAGE

Key Language	Definitions
Skeletal system	System that protects and supports the body of an organism
limb	A structure that resembles and arm and supports an organism
Femur	Upper leg bone
Humerus	Upper arm bone that extends from the elbow to the shoulder
Vertebrae	Segments of bones that are arranged into a backbone
Carnivore	An organism that gets energy by eating other animals
Homology	Similarities in structures
Structure	Parts of an organism
Function	Purpose of a structure
Locomotion	Ability to move from one place to another
Functional morphology	Science that explores the structures of organism and its features with the function.
Geologic Time Scale	System used to describe the timing and relationships of events that have occurred during Earth's history

PRIOR KNOWLEDGE

Using a caliper
Structure and function
Skeletal system

REFERENCES

Samuels, J. M. (2013). Postcranial Morphology and the Locomotor Habits of Living and Extinct Carnivorans. *Journal of Morphology, 274*, 121-146.