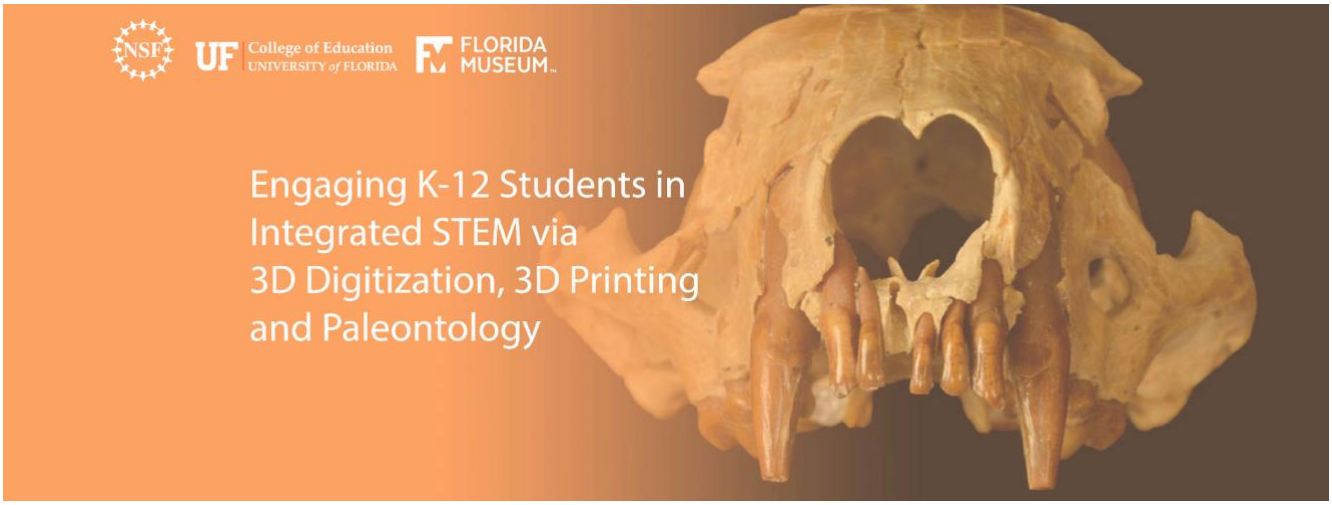

AUTHOR

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LESSON TITLE

Fossil Forensics: Using Taphonomy to Solve Mysteries of the Past

GRADE LEVEL

Grades 3-4

TIME FRAME

Five 45-minute class periods (implemented four times with four different classes)

DRIVING QUESTION

How do fossils and 3-D models help paleontologists solve prehistoric mysteries?

LEARNING GOALS

Students will **explore** a new topic and engage in an authentic challenge.
Students will apply former knowledge and understandings and engage in critical thinking and creative problem solving.
Students will **create models** of animal fossils found in the Pleistocene epoch using a 3-D printer.
Students will use 3-D models to help **analyze and interpret data**.
Students will **plan and carry out an investigation** to classify fossils and taphonomic alterations by types.

Students will practice using calipers to measure canine width using 3D model animal skulls.
Students will **analyze** different tooth models and taphonomic alterations on bones.
Students will **test and evaluate** possible solutions based on scientific observation and analysis.
Students will **construct explanations** for scientific findings.
Students will **communicate information** to a real audience.

ANCHORING EVENT

Students will be presented with a prehistoric mystery involving multiple large herbivores unearthed in one location with peculiar markings on many of the bones. Students will be invited to put their knowledge of paleontology and geology to use as they postulate possible causes for the strange markings on the fossil bones and attempt to reconstruct what might have occurred long ago at this specific location.

I will inform students that my colleague, Michael Ziegler, at the University of Florida, has requested assistance with a fossil forensics project that he began several years ago. A large number of long-horned Pleistocene Giant Bison, the largest bovid species in the fossil record, were discovered and excavated in a quarry in Brunswick, Georgia. Strange markings were found on many of the bison bones. No fossil evidence of predators was found, so a taphonomic analysis of the giant bison fossils is being performed to provide evidence of postmortem alteration by predators. Mr. Ziegler would like our help with the taphonomic analysis, comparing the damage on the bison bones to the skulls and teeth of several known Pleistocene predators. Students will match the incisors and canines of several different predators with the marks left on the *Bison latifrons* bones.

COLLABORATIONS

Students will work in small groups to examine various types of taphonomic alteration of bones from fire, weathering and predators from other fossil sites. Student groups will classify animal teeth by type (molars, canines and incisors) and attempt to group teeth according to type of predator. Students will also measure different teeth of various shapes and sizes as well as the bite radius of different predators and conduct tests to determine if particular teeth in different model animal skulls could have created specific alterations on fossil bones. As information is collected and analyzed, students will share findings with their peers, engage in argument based on evidence and test emerging hypotheses. Students will communicate findings and solutions with one or more audiences.

STEM INTEGRATION

Students will engage in multiple scientific, mathematical and engineering processes: observation, measurement and computational thinking, recording data, forming hypotheses, comparing and contrasting, developing and using models, analysis, interpretation and synthesis of data, summarizing, evaluating and communicating findings.
Science: Observe, measure and record length and width of predator teeth and dimensions of various alterations on bones; compare, contrast and synthesize data; form hypotheses about which predators made the different alterations on the fossil bison bones

Technology: Develop 3-D models of fossil predator skulls and Bison latifrons bones; document findings with photos and videos; develop mixed-media presentation to share findings
Engineering: Manipulate 3-D model predator skulls on different bison bones to determine possible fit
Math: Measure dimensions of canines on 3D printed fossil predators to calculate bite radius

ASSESSMENT

Formative assessment with each lesson will occur as students demonstrate their daily questions, discoveries, challenges, understandings and analysis of the relevant information in this investigation. Students will document their progress and understandings with photos of their work such as 3-D printed models, sketches, diagrams, measurements and hand-written notes. These photos and notes will be added to each individual student's science journal or digital portfolio (I use the *SeeSaw for Education* app with my students to keep an ongoing record of their work each week, but there are other similar digital portfolios available online). Students will also prepare a mixed-media presentation to explain their conclusions related to the evidence they have examined and analyzed. This will be shared with students in other classes and will serve as the summative assessment.

PROCEDURE

Day 1 - *Fossil Forensics: Chew on This!*

Engage – In a whole group setting, present the anchoring event about the mysterious markings on the bones found in the Georgia quarry. Show students photos of what we think *Bison latifrons* looked like and fossil bones from this species, as well as photos from the quarry's excavation site. Show students close-up photos of some of the marks on the bison bones.

Explore – Ask students to generate ideas about what might have caused the strange marks on the bison fossils. Next, brainstorm a list of questions that students have about this prehistoric scene. What might we need to learn in order to solve this mystery?

Explain – Explain the role of geology, taphonomy and forensics in the field of paleontology. Also explain the way that scientists have divided up our geologic history into periods and epochs. Show students a geologic timeline and explain that the Pleistocene Period occurred between two million and 10,000 years ago. What were some of the major geologic events that occurred during this time period, and what types of creatures were alive during this time?

Explain that sometimes bones are altered post mortem (after time of death) by natural weathering events like wind, ice, rock slides and fire. Show students pictures of bones that were altered by such events and point out evidence of cracking and discoloration. Sometimes, bones are also altered by animals. Show students photos of four different types of alterations of bones that were made by teeth (scalloped-out markings, furrows, depressions and puncture marks).

Elaborate – To solve this mystery, we will be examining different marks left on the fossil bison bones, and comparing those marks to 3-D printed models of teeth from various predators that were alive during the Pleistocene Period and whose fossil remains have been discovered in what is now North America.

Show students the video made my Michael Ziegler
YouTube Link: https://youtu.be/IkHNOrOMFZs

Caveat from Michael Ziegler: Skyping with a class is possible upon request. Contact the idigfossils staff on our website http://www.idigfossils.org, find me on http://www.idigfossils.org, or contact via email: michael.ziegler@ufl.edu

Evaluate – Have students summarize what they have just learned about our Fossil Forensics mystery with a short video recording in their digital SeeSaw journals**.** What will they need to learn to solve this mystery? What do they think will be most challenging part of this project? What do they find most interesting or exciting about this project?

Day 2 - *Fossil Forensics: Sink Your Teeth into This!*

Engage and Explore – Show students a staple-remover and a set of two rough, flat rocks. Highlight the two sharp "fangs" on the staple remover, and the rough surfaces of the two rocks. Tell students that these objects represent two different types of teeth. Ask students to predict which type of teeth would work best for ripping apart meat (balls of cotton), and which teeth would be best suited for grinding up some grass and leaves. Allow students to experiment with both types of teeth to break down the cotton and plant matter. Share findings and discuss.

Explain - Tell students that the teeth in any animal's mouth (even our teeth) are shaped in particular ways to serve different purposes. The **incisors** are in the front of the mouth on top and bottom, and these teeth are used to bite into food. **Canines** are the next teeth, and they are the sharpest teeth. They are used for tearing apart food. **Molars** are the back teeth. They are flat and used for grinding and crushing food for digestion. **Carnivores**, the meat eaters of the world, have very defined canine teeth for tearing at meat. **Herbivores,** or plant eaters, have flat teeth for grinding and crushing plant matter. **Omnivores,** which eat both meat and plants, have a combination of sharp front teeth and flat molars for grinding.

Elaborate - Divide students into small groups and challenge each group of students to sort pictures of animal teeth by shape and size and to try to determine if each animal is a carnivore, herbivore or omnivore, based on the size and shape of its teeth. Have students share their ideas.

Show students photos of the four skulls of the American Alligator, Short-Faced Bear, Dire Wolf, and Saber-Toothed Cat. Ask students for ideas about what each animal ate, based on the shape of its teeth. Tell students that these four carnivores are our "prime suspects" for leaving the markings on the bison bones because their fossils were discovered not far from the bison fossils in Georgia.

Provide students with photos of each of the "prime suspects" and brief information about their size and behavior.

Evaluate – Have students label the different types of teeth (incisors, canines and molars) in pictures of the skulls of the American Alligator, Short-Faced Bear, Dire Wolf, and Saber-Toothed Cat. Have them also examine photos of the alterations on the bison bones and predict which carnivore might have made the mysterious markings.

Day 3 – *Fossil Forensics: If the Tooth Fits…*

Teacher preparation: Before this activity, a 3-D printed model of each of several bison bones (rib, femur, scapula and vertebra) will need to be prepared for each group of students. Markings can easily be made with the use of an inexpensive wood-burning kit (available from Michael's or most any hobby store). Decide ahead of time the predator or predators that have created the marks on the fossils. Make sure that the model teeth from the chosen predator(s) match up with the markings you create on the bones.

Engage –Remind students of the work that was done yesterday, and allow them time to share their hypotheses about the different predators that might have made the various marks on the bison bones.

Explore – Ask students why it might be difficult to solve this mystery with just photos of the teeth and photos of the different markings. Might there be a better way to determine which predators made the mysterious marks? (lead students to suggesting 3-D models)

Explain – Today we will be examining 3-D printed replicas of several of the bison fossils with mysterious markings and comparing those post mortem alterations with the model teeth and animal skulls that we have printed. Your goal is to determine which of our "prime suspect" predator(s) probably left the marks found on the bison bones.

Elaborate – Students will work in small groups to compare the alterations on the 3-D printed bison bones with the 3-D printed teeth and animal skulls. Show students how to measure the bite radius of each "prime suspect" predator with calipers.

Evaluate – Each student should document the group's process on a Fossil Forensics recording sheet and with one or more photos posted to the digital SeeSaw portfolio.

Day 4 – *Fossil Forensics: Dig Deep!*

Engage - Yesterday, students worked to identify a "prime suspect" predator (one or more), based on the model teeth and the specific markings on the fossil bones. Tell students that their challenge today is to make a strong case to support their conclusions in this case, based on the information they collected and analyzed. You think you know which predator made the marks…prove it! If you have ruled out one or more of our prime suspects in this case, explain why.

Explore and Explain: Students will review and discuss their notes and findings from the past three days with their small group. Each group will determine the most likely predator(s) that could have created the markings found on the *Bison latifrons* fossils, based on tooth shape and size and bite radius. During this group work, students will refer to their observations and measurements of carnivore teeth and fossil alterations on bison bones to support their conclusions. Students may want to take pictures of their measurements and sketches to use in their presentation.

Elaborate – Each group will create a short presentation that explains their process and their findings to share with students from other classes next week.

Day 5 – *Fossil Forensics: Reveal Your Discovery!*

Engage – Each group of students will engage their peers and teachers in other classes with a short presentation of their observations, analysis and conclusions in the Fossil Forensics mystery. The presentation should be short and concise and have one or more interesting visuals to help explain the group's process and conclusions related to the mysterious markings on the fossil bones of the *Bison latifrons* in Georgia.

Explore, Explain and Elaborate - Each group of students will provide details of the different ways that they explored taphonomy and forensics and used 3-D models to draw conclusions about the predator(s) responsible for leaving the different markings on the bison fossils.

Evaluate – Each student will produce a written or oral reflection on the processes involved in this project for his or her digital SeeSaw portfolio or science journal.

STANDARDS

NEXT GENERATION SCIENCE STANDARDS (NGSS)

- **4-PS1-1. Plan and conduct an investigation to describe and classify kinds of materials by their observable properties.**
- **5-PS1-3. Make observations and measurements to identify materials based on their properties.**
- **2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.**
- **4-LS1-1. Write opinion pieces or texts, supporting a point of view with reasons and information.**

Science Practices	Connection to the Lesson
• **Asking questions and Defining Problems** • **Planning and Carrying Out Investigations** • **Developing and Using Models** • **Using Mathematics and Computational Thinking** • **Analyzing and Interpreting Data** • **Constructing Explanations and Designing Solutions** • **Engaging in Argument from Evidence**	Students will generate questions and define challenges in a Fossil Forensics mystery involving post mortem alterations of *Bison latifrons* fossils. Students will brainstorm possible ways to investigate and solve this mystery, and work in small groups to examine various types of taphonomic alteration of bones from fire, weathering and predators from other fossil sites. Students will classify animal teeth by type (molars, canines and incisors) and attempt to group teeth according to type of animal (carnivore, herbivore or omnivore). Students will also measure different teeth of various shapes and sizes as well as the bite radius of different predators and conduct tests to determine if particular teeth in different model animal skulls could have created specific alterations on fossil bones. As information is collected and analyzed, students will share findings and engage in argument from evidence with

• **Obtaining, Evaluating, and Communicating Information**	their peers and test emerging hypotheses. Students will communicate findings with an audience.
Disciplinary Core Ideas	**Connection to the Lesson**
• **PS1: Matter and Its Interactions** • **LS1: From Molecules to Organisms: Structures and Processes** • **ETS1.B: Developing Possible Solutions**	Students see that matter can be classified by its observable properties, as they classify animal teeth and post mortem alterations on bison fossils. Students will understand that designs can be conveyed through sketches, drawings and physical models and that these representations are useful in communicating ideas for a problem's solutions to other people.
Crosscutting Concepts	**Connection to the Lesson**
• **2-LS2-2. Structure and Function** • **2-LS1-1. Cause and Effect**	Students will understand that the shape and stability of structures of natural and designed objects are related to their functions. Students will understand that events have causes that generate observable patterns.

Framework for 21st Century Learning

Creativity and Innovation
- Use a wide range of idea creation techniques (such as brainstorming)
- Create new and worthwhile ideas

Work Creatively with Others
- Develop, implement and communicate new ideas to others effectively
- Be open and responsive to new and diverse perspectives; incorporate group input and feedback into the work
- Demonstrate originality and inventiveness in work

Critical Thinking and Problem Solving
- Use systems thinking
- Analyze how parts of a whole interact with each other to produce overall outcomes in complex systems

Solve Problems
- Solve different kinds of non-familiar problems in both conventional and innovative ways

Communication
- Articulate thoughts and ideas effectively using oral, written and nonverbal communication skills in a variety of forms and contexts
- Listen effectively to decipher meaning (including knowledge, attitudes, values and intentions)
- Use communication for a range of purposes (to inform, instruct, motivate and persuade)

Collaboration

- Demonstrate ability to work effectively and respectfully with diverse teams
- Exercise flexibility and willingness to be helpful in making necessary compromises to accomplish a goal
- Assume shared responsibility for collaborative work, and value the individual contributions made by each team member

Information Literacy

- Use and manage information accurately and creatively for the issue or problem at hand

RESOURCES & MATERIALS

Youtube video, **"**Help a Paleontologist with a Fossil Bison Mystery!" at https://www.youtube.com/watch?v=IkHNOrOMFZs
Youtube video, "Super *Bison latifrons*: Largest Bovid in Fossil Record" at https://www.youtube.com/watch?v=FWsIbeunCEc

Ziegler, M. and Mead, A.J., 2013. Taphonomic Analysis of *Bison Latifrons* Fossils from Pleistocene Deposits in Brunswick, Georgia. Presentation by faculty in the Department of Biological and Environmental Sciences at Georgia College and State University.

Geologic time-line showing the Pleistocene epoch in relation to other time periods

No Fur, No Feathers, Just Skulls paperback book by Mike Artel. ISBN-10: 0991089420

Online 3-D Print Data Files:
Smilodon Skull - https://www.morphosource.org/Detail/MediaDetail/Show/media_id/7786 or https://sketchfab.com/3d-models/skull-of-smilodon-saber-toothed-tiger-840cea79937e45438d139a9d4061ab4d
Short-Faced Bear Skull – https://morphosource.org/Detail/MediaDetail/Show/media_id/6773
Dire Wolf Skull – https://sketchfab.com/models/a6cc7c39da40487282d3ccbe8527dedc
Alligator Skull – https://www.morphosource.org/Detail/SpecimenDetail/Show/specimen_id/10759
***Bison latifrons* Rib:** https://sketchfab.com/models/7d5600fda85a43abacddbb9a8c984db6
***Bison latifrons* Scapula:** https://sketchfab.com/models/54a42d8857a541a4a15a306612d62b90
***Bison latifrons* Metapodial Leg Bone (Metacarpal or Metatarsal):** https://sketchfab.com/models/a735fd7b096b4f849e411db8953e79ea
***Bison latifrons* Cervical Vert:** https://sketchfab.com/models/1929e8e39e8a46acacc67182ebb81df2

Photos of teeth from each of the following species:
American Alligator: https://www.floridamuseum.ufl.edu/florida-vertebrate-fossils/species/alligator-mississippiensis/

Dire Wolf: https://www.floridamuseum.ufl.edu/florida-vertebrate-fossils/species/canis-dirus/ & https://tarpits.org/la-brea-tar-pits/timeline
Saber-Toothed Cat: https://www.floridamuseum.ufl.edu/florida-vertebrate-fossils/species/smilodon-fatalis/ & https://tarpits.org/la-brea-tar-pits/timeline
Short-Faced Bear: https://www.floridamuseum.ufl.edu/florida-vertebrate-fossils/species/arctodus-pristinus/

Photos:
Bison latifrons skeleton and also what we think it looked like with skin and fur
Fossil bones with different markings from predators, fires and weathering events (furrowed grooves, scalloped out sections, puncture marks, spiral fracturing, discoloration, cracking and flaking)

Furrowing:  

Scalloped:  

Puncture:  

Spiral: 

Wood-burning Set

Assorted 3-D printed rib bones, femurs, scapulae and vertebrae to scale, with various markings (furrowed grooves, scalloped out sections, puncture marks and spiral fracturing) created with wood-burner that match different model teeth

One or more sets of calipers for measuring the bite radius of the four “prime suspect” predators

SeeSaw app and set of iPads for student use in documenting progress in their digital journals (optional)

Drawing of teeth in animal skulls for students to label

Recording sheets for student measurements and observations: See an example below

Alteration Replication Station

Directions:

1. Make a clay bone of any shape

2. Try to replicate each of the 4 types of markings (depressions, scalloped out, furrow marks and puncture marks) on your clay bone and then take a picture, and post it to your See Saw portfolio.

3. Ball your clay back up and replace it in your bag before you leave to go to your next station.

Pleistocene Predators

Directions:
Use a set of calipers to measure the following and record measurements in centimeters below:

Dire Wolf

1. The width of the last 3 back molars of the dire wolf skull (top jaw _____cm) and (bottom jaw _____ cm)
2. The distance between the bottom two canine teeth on the dire wolf skull (_____ cm)

Smilodon

3. The distance between the top two canine teeth on the Smilodon (_____ cm)
4. The distance between the lower canine tooth and 1st back molar (_____ cm)

Alligator Mississippiensis

5. The distance between the first set of teeth on the lower jaw (_____ cm)
6. The distance between the 2nd set of teeth on the lower jaw (____ cm)
7. The distance between the 3rd set of teeth on the lower jaw (____cm)

Short-Faced Bear

8. The width of the back 3 top molars (____cm)
9. The distance between the top canine tooth and the start of the back molars (____ cm)

Fossil Forensics

Directions:

1. Separate bones into two piles, those with taphonomic alterations and those without.

2. On the **metapodial** (leg bone), measure the distance between the two furrow marks (____ cm)

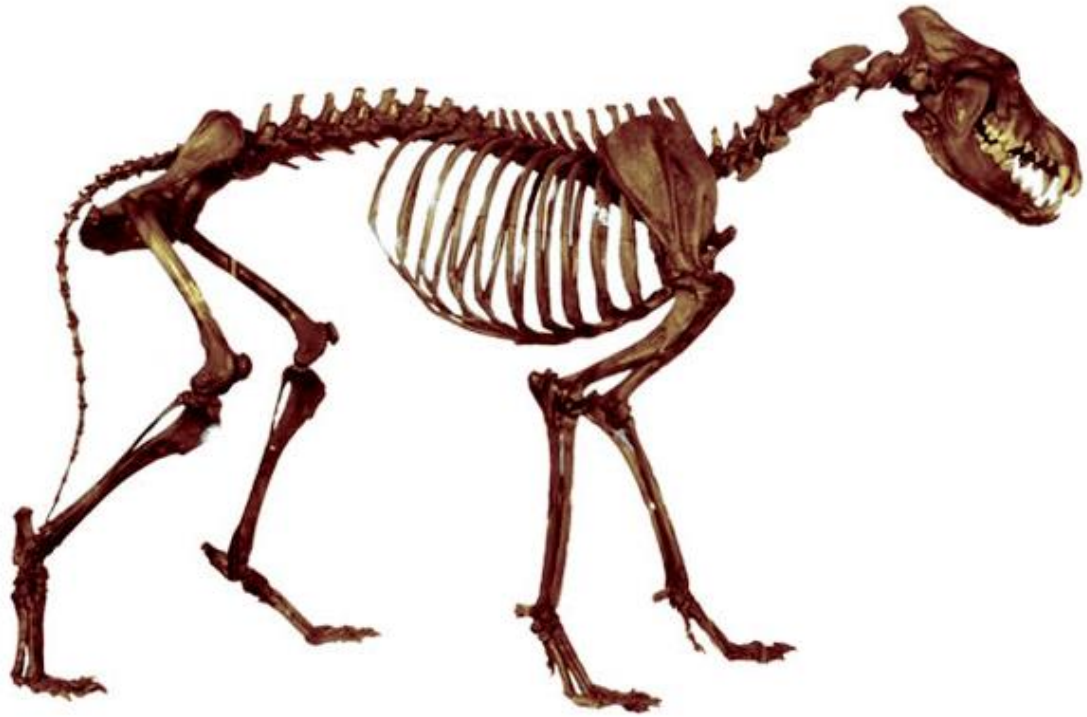
3. On the **rib** bone, measure the distance between each set of puncture marks. Place calipers in the deepest part of the puncture marks. (Smaller set = ____ cm) and
   (Larger set =_____ cm)

4. On the **vertebra**, measure the width of each of the 3 depression marks:
   (top rib depression =_____ cm)
   (bottom rib depression =_____cm)
   (back of vertebra depression = _____ cm)

5. On the **scapula**, some of the bone has been removed. Measure the distance between the beginning and end of where you think bone has been removed or scalloped out (_____ cm). Also measure the distance between the end of the scalloped-out mark and the puncture mark (____ cm)

Prime Suspect information sheets: See Below

Pleistocene Predators



*Common Name: Dire Wolf
*Scientific Name: *Canis dirus* which translates to their nickname meaning 'fearsome dog.'

* Dire Wolf were common predators that lived from 500,000 (500 ka) to 11,000 (11 ka) years ago.

*These wolves were larger than modern day wolves and could weigh up to 150 pounds!

*In your own backyard: Dire Wolf mainly lived in North America and fossils have been found all the way from Southern Canada to Mexico.

*Although these wolves were around 150 pounds, they are thought to be able to hunt animals up to four times their weight, around 600 pounds!

*Similar to modern wolves, dire wolves may have hunted in small packs for horse, camel, and small bison and mastodon.

*With sharp front teeth and larger back teeth, Dire Wolf could crush large bone!

*Common Name: Saber-toothed Cat

*Scientific Name: (*Smilodon Fatalis*)

**Smilodon fatalis* was a ferocious predator living from around 700,000 (700 ka) to 11,000 (11 ka) years ago.

*These saber-toothed cats could weigh anywhere from 350 to 600 pounds!

*In your own backyard: *Smilodon fatalis* is famous due to the abundant fossils found at the La Brea tar pits in California, but Smilodon have been found across most of the United States with major discoveries in Texas, Louisiana, and Florida!

*Big Mouth! These predators could open their mouths up to 120 degrees. Humans can only open their mouths about 45 degrees.

*Using chemistry, scientists have found out that Saber-toothed cats may have hunted camel and bison.

*Famous for their sharp front teeth, the canines could get up to 9 inches long!

*Common Name: Alligator
*Scientific Name: *Alligator mississippiensis*

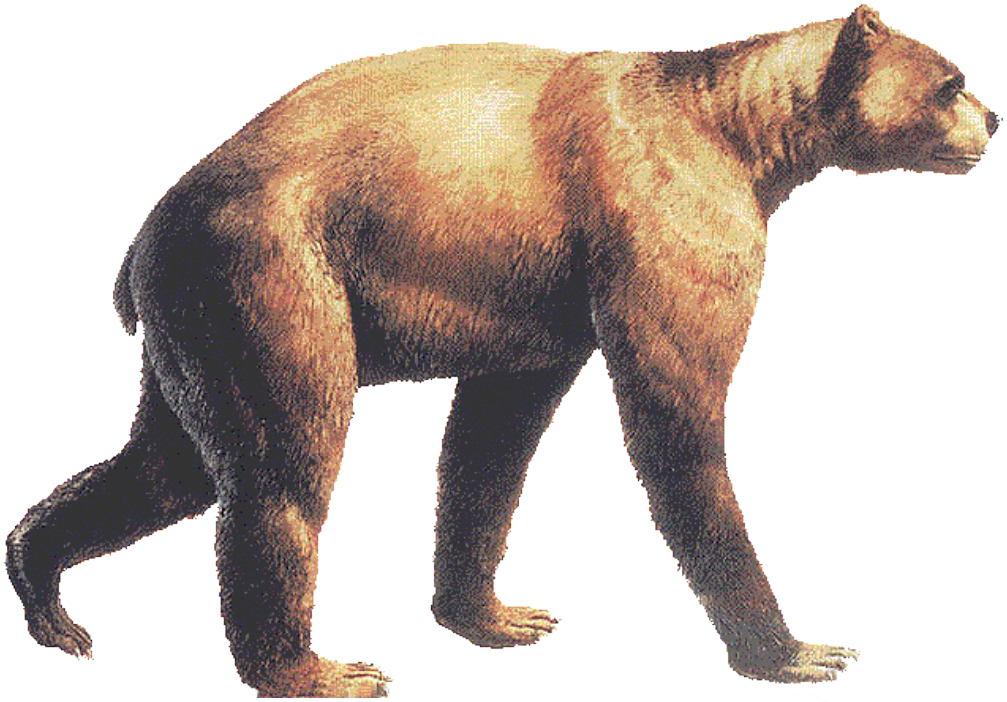
*An incredibly efficient predator, *Alligator mississippiensis* lived from 5 million (Ma) to 11,000 (11 ka) years ago without changing much. It survived
many periods of time where the climate and sea levels changed.

*Alligators are well protected with large circular shaped bones along their backs called 'osteoderms' or 'scutes'.

*In your own backyard: *Alligator mississippiensis* is mainly found in the southern part of the United States with major discovery sites in Florida and Texas!

*These fossils alligators are found in many fresh-water fossil sites. Since they often would travel from one fresh-water site to another during their life, fossil alligators have been found in sinkholes and caves as well.

*That's a lot of teeth! Alligators can produce hundreds or even thousands of teeth over their lifetime.



*Common Name: Short-faced Bear
*Scientific Name: Arctodus simus

*Greek translation: *Arctos* = bear; *odus* = tooth, and *Simus* = snub or blunt-nosed.

*Short-faced bears were large predators that were carnivores and lived from 1.8 million (Ma) to 11,400 years ago.

*These bears were about 6 feet tall on all fours and closer to 10 feet when standing straight up. It is estimated that the Short-faced bear could weigh 2,500 pounds!

*In your own backyard: Short-faced bears are only found in North America from Alaska to Mexico with many fossils found in California.

*Similar to modern bears, the Short-faced bears probably lived in caves or dens and traveled alone, with the exception of mother bears and their young.

*With flexible limbs and special wrist bones, these bears have been hypothesized to be able to skillfully climb trees!

KEY ACADEMIC AND/OR SCIENTIFIC LANGUAGE

Fossils – the remains of prehistoric animals, plants and micro-organisms, as well as traces, tracks, impressions, etc. they may have left. Only a small portion of all the organisms that ever lived became fossils and have been preserved and discovered.
Paleontology – the study of ancient life, on the basis of fossil remains
Taphonomy – the branch of paleontology that deals with the processes of fossilization
Geology – the science that deals with the earth's physical structure and substance, its history and the processes that act on it
Pleistocene Period – the first epoch of the Quaternary period, between the Pliocene and Holocene epochs, beginning about two million years ago and ending 10,000 years ago, characterized by widespread glacial ice and the advent of modern humans
Bovid – a member of the cattle family with hollow horns
Forensics – scientific tests or techniques used in connection with the detection of a crime
Post Mortem – an examination or analysis of an event after it occurred
Alteration – the action or process of being altered or changed in some way
Predator – an animal that naturally preys on others
Herbivore – an animal that feeds on plants
Carnivore – an animal that feeds on flesh
Incisors – a narrow-edged tooth at the front of the mouth, adapted for cutting
Molars – a grinding tooth at the back of a mammal's mouth
Canines – a pointed tooth between the incisors and premolars of a mammal, often greatly enlarged in carnivores
Calipers – an instrument for measuring external or internal dimensions, having two hinged legs
Extinct – a species, family or other larger group that no longer has living members
American Alligator – a large semiaquatic reptile that is similar to a crocodile but with a broader and shorter head, native to the Americas and China
Dire Wolf – a large extinct wolf of the Pleistocene epoch that preyed on large mammals
Saber-Toothed Cat – a large extinct carnivorous mammal of the cat family with large, curved upper canine teeth
Short-Faced Bear- an extinct bear that inhabited North America during the Pleistocene epoch
Giant Bison- an extinct species of bison that lived in North America during the Pleistocene epoch
Furrow Marks – grooved marks that run in a patterned direction (think of a dog chewing on rawhide)
Puncture Marks - impact mark on bone that leaves a rounded depression often by incisors.
Scalloped Out – rough edges that often have a semi-circle impression.
Spiral Fracture – fracture or break of bone that is curved in a cylindrical pattern around the bone (like a corkscrew or spiraling staircase).

PRIOR KNOWLEDGE

Students should have some knowledge and understanding of the following:

- The ways that geologists and paleontologists work together to determine the relative age of fossils in layers of the earth's crust;
- The different classifications of animals and their defining physical characteristics;
- Forensic taphonomy can be used to provide details on the circumstances that happened during death;
- Post mortem changes can include loss of bones, cracks, pits, grooves and other marks on bones or modification of bone shape;
- Scavengers often leave tooth and claw marks on the bones of their prey, including furrowed grooves, scalloped out sections, puncture marks and spiral fracturing;
- Evidence of fire activity on post mortem change may include shrinking, cracking and discoloration;
- Examples of weathering activity on postmortem change may include cracking, flaking and discoloration;
- Due to changes in environmental conditions, some species of animals are now extinct
- 3-D printers can be used to produce a physical object from a three-dimensional digital model, typically by laying down many thin layers of melted material in succession.