Doggos, Digestion, and Fossils, Oh My!

Digestion and the Fossil Record

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Grade Level	6th – 8th Grade	**Time Frame**	2-3 class period(s)
Subject	Science	**Duration**	150 minutes

Essential Question

How can we use fossils to learn about ancient organisms' diets and ecosystems?

Summary

Students will explore the relationship between the fossil record and the digestive system using coprolites (i.e., fossilized poop) as a phenomenon. By investigating the chemical and physical processes of digestion and connecting these to prior knowledge of fossil formation, students will explain what coprolites can tell us about the diet of the organisms they came from. Further exploration of scientific data behind the fossil phenomenon helps students draw conclusions about ecosystem-level interactions. This lesson addresses portions of MS-LS1-7, MS-LS4-1, and MS-LS4-2.

Snapshot

Engage

Students view museum images of fossilized wild dog coprolites and construct initial explanations for how it's possible for us to know how the dogs hunted based only on those fossils.

Explore

Students investigate the process of digestion using a physical model.

Explain

As a class, students discuss how waste products from digestion can provide information about an organism's diet and explain why this evidence is rare in the fossil record.

Extend

Using data from the scientific paper about the wild dog coprolites, students match the scientists' conclusions about the dogs' ecosystem to evidence that supports these claims. In addition, students provide scientific reasoning to justify the way they matched up the scientists' evidence and conclusions.

Evaluate

Students create a model to explain how digestion can produce the type of evidence found in the wild dog coprolites and why that evidence is useful for understanding ancient ecosystems.

Standards

Next Generation Science Standards (Grades 6, 7, 8)

MS-LS1-7: Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.
MS-LS4-1: Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.
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.

Attachments

- CER Explanations—Doggos Digestion and Fossils - Spanish.docx
- CER Explanations—Doggos Digestion and Fossils - Spanish.pdf
- CER Explanations—Doggos Digestion and Fossils.docx
- CER Explanations—Doggos Digestion and Fossils.pdf
- Digestion Model Student Guide—Doggos Digestion and Fossils - Spanish.docx
- Digestion Model Student Guide—Doggos Digestion and Fossils - Spanish.pdf
- Digestion Model Student Guide—Doggos Digestion and Fossils.docx
- Digestion Model Student Guide—Doggos Digestion and Fossils.pdf
- Digestion Model Teacher Guide—Doggos Digestion and Fossils.docx
- Digestion Model Teacher Guide—Doggos Digestion and Fossils.pdf
- Digestion System Model—Doggos Digestion and Fossils - Spanish.docx
- Digestion System Model—Doggos Digestion and Fossils - Spanish.pdf
- Digestion System Model—Doggos Digestion and Fossils.docx
- Digestion System Model—Doggos Digestion and Fossils.pdf
- Evidence and Conclusions—Doggos Digestion and Fossils - Spanish.docx
- Evidence and Conclusions—Doggos Digestion and Fossils - Spanish.pdf
- Evidence and Conclusions—Doggos Digestion and Fossils.docx
- Evidence and Conclusions—Doggos Digestion and Fossils.pdf
- Lesson Slides—Doggos Digestion and Fossils.pptx
- Model Observation Notes—Doggos Digestion and Fossils - Spanish.docx
- Model Observation Notes—Doggos Digestion and Fossils - Spanish.pdf
- Model Observation Notes—Doggos Digestion and Fossils.docx
- Model Observation Notes—Doggos Digestion and Fossils.pdf
- The Digestion System—Doggos Digestion and Fossils - Spanish.docx
- The Digestion System—Doggos Digestion and Fossils - Spanish.pdf
- The Digestion System—Doggos Digestion and Fossils.docx
- The Digestion System—Doggos Digestion and Fossils.pdf

Materials

- Lesson Slides (attached)
- CER Explanations handout (attached; one per student)
- Digestion Model Student Guide (attached; one per student)
- Digestion Model Teacher Guide (attached)
- Model Observation Notes handout (attached; one per student)
- The Digestive System handout (attached; one per student)
- Evidence and Conclusions handout (attached; one per student)
- Digestive System Model handout (attached; one per student)
- Scissors (one pair per small group)

- Gallon plastic bags (one per small group)
- Metal trays (one per small group)
- Plates/trays/dishes (one per small group)
- Small and large plastic cups (one small and one large per small group)
- Paper cups (one per small group)
- Nylon "legs" (pantyhose) (one pair per small group)
- Food samples (seeds, popcorn kernels, raisins, bananas, crackers, etc.) (one per small group)
- Orange juice (one cup per small group)
- Water (one cup per small group)

Engage

Prerequisite Knowledge

Students should have prior knowledge of how fossils form and how we use the fossil record to understand the past. Use **slides 3 and 4** of the attached **Lesson Slides** to review this information.

Slides 3-4 are hidden by default. To change this setting, navigate to the editing view of the Lesson Slides. Then, in the left-hand column, right-click on slide 3 and deselect "Hide Slide" in the menu."

If you choose not to review before the activity, you may wish to hide slide 3-4 from view. To do so, navigate to the editing view of the Lesson Slides. Then, in the left-hand column, right-click slide 3 and select "Hide Slide" in the menu.

Disciplinary Core Ideas (Dci) & Performance Expectations (Pe)

This lesson is not focused on any one of the standards over another and will not completely address any of the three. The discussion of digestion uses the MS-LS1-7 DC1: "Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy." Students build on this concept through elements of both the MS-LS4 standard DCIs and PEs. The digestive process and outputs are used rather than anatomical similarities, per se, to consider "similarities and differences between modern and fossil organisms" (MS-LS4-2), and discuss "existence, diversity, and extinction...under the assumption that natural laws operate today as in the past" (MS-LS4-1).

Display **slide 5** to introduce the essential question: How can we use fossils to learn about ancient organisms' diets and ecosystems? Display **slide 6** to introduce the lesson objectives to the students.

Display **slide 7**. As a formative assessment, ask students to explain what they know about poop. Use the Collective Brain Dump strategy to structure this conversation. Arrange students into small groups and encourage them to collaborate with their groups to share knowledge. When groups seem to be done sharing with one another, have each group share their knowledge with the whole class. As groups share, list items on the board to create a whole-class product. Using the whole-class list, you can guide the lesson to address misconceptions and gaps in knowledge. Example questions that generate interesting discussion on this topic include:

- What is poop?
- Why do we poop?
- Where does poop come from?

Display **slide 8**. Show students images of the coprolites from the Natural History Museum of LA County. Tell them that scientists were able to figure out how the "bone-crushing" dogs hunted based on these fossils.

Display **slide 9**. Give students the **CER Explanations handout** (attached). Students should now begin to build a Claim, Evidence, Reasoning (CER). Ask them to write an initial explanation for how it was possible for scientists to draw that conclusion.

Images

The photos found on the Natural History Museum of LA County's website are from the original scientific study that inspired this lesson. Additional images of fossilized poop can be found at the Poozeum's website.

Explore

Teacher's Note

The Engage and Explore sections can both be completed in a single 50 minute class period. Use **slides 10 and 11** to provide class-specific instructions for how to aquire the materials and complete the model.

Provide students the materials and **Digestion Model Student Guide** (attached) for conducting the digestion model simulation. A **Digestion Model Teacher Guide** is also included in the attachments. Having students work in pairs is useful for this activity if the class is sufficiently small.

Student groups demonstrate the digestion model. Despite the messy ingredients, the pie pan and plates make clean-up for the investigation easy. With rare exception, clean-up only involved the students' normal post-lab procedure of wiping down their stations with a disinfecting wipe or spray cleaner.

Depending on class size and student responsibility, it may be helpful to have the entire class go through the activity at the same pace. The YouTube video "Lesson Idea: Digestive System Experiment" provides a clear demonstration of the entire model. If necessary, it can be used to help students (or teacher) assemble and use the model. If showing the video to the entire class, consider pausing between steps to ensure students are able to recreate each part of the model. A teacher demonstration of any portion of the model **should not be used as a substitute** for students doing the activity.

Embedded video
https://youtube.com/watch?v=7av19YhNkhE

Alternative Structure

Instead of the entire class creating models, it may be useful to have a small group of students demonstrate the model while their classmates observe. In a class of 27, for example, set up four demonstration stations, each with 3 students working through the model on one side of the table and 3-4 peers observing and offering support (e.g., asking questions, offering trouble-shooting suggestions) from the opposite side.

Guided Inquiry

The methods and materials for this activity are predetermined to ensure that the model is effective for helping students construct an understanding of digestion. While the model is designed as a guided inquiry activity, it is not necessary for the class to go through the model together if students have enough experience with lab investigations to work autonomously/at their own pace.

Teacher's Note

Before beginning the activity, insert any class-specific instructions into slide 13.

Display **slide 12**. Pass out the **Model Observation Notes handout** (attached). As students explore the model, they should record observations of what they see happening at each step on their Model Observation Notes handout, including what the food materials look like before and after they enter each section. If using the demonstration format, the observing students could record the information and let the demo students copy it down later. Several groups should have "undigestible" materials in their food that all students should have a chance to observe. Ask students to Carousel around the room to observe the final products of each group's model. They should record additional observations about their peers' models and attempt to identify the content of the "waste" products. After the Carousel, have students clean up their lab stations, using **slide 13** for any class-specific instructions.

Explain

Give students the **Digestive System** handout (attached). Display **slide 14**. As a class, ask students to describe what happened in each step of the model. Display **slide 15**. For each step, ask them to describe what part of their body the process is occurring in. (*What organ does this part of the model represent? What process in digestion does this part of the model represent?*) Display **slide 16**. Next, ask students where they think chemical reactions are happening in the system. Have them justify their claims based on prior knowledge and what they observed in the model.

Formative Assessment

This discussion of what the model represents is an opportunity to formatively assess what elements of digestion students already understand and what misconceptions or missing information need to be addressed formally.

After the group discussion, provide students a formal explanation of the digestive system using **slides 17 through 20**. While it's important to cover the entire system, focus more heavily on the structures and processes students misunderstood or left out during the conversation. Additional notes on each structure and process can be found in the Speaker Notes of the Lesson Slides.

Speaker Notes

Food starts in the **mouth** where we chew it up with our teeth. When we swallow the food, it travels down our **esophagus** into the stomach.

Food in the **stomach** is broken down into liquid with digestive juices. Next, food travels through the **small intestine** – a long and windy tube. The small intestine is very important because this is where many of the nutrients are absorbed by your body and travel via your bloodstream to all the body parts (like muscles, bones, eyes, skin, etc.) that need them.

Liver produces bile, removes toxins, stores some vitamins/minerals; Gallbladder stores bile; Pancreas releases enzymes to break food down and neutralize the acidity of stomach contents when they enter small intestine. Lipase, bile: breaks down fats. Protease: breaks down proteins. Amylase: breaks down starches and sugars.

Finally, food travels through the **large intestine** where water and some minerals are extracted and now that your body has taken everything it needs out of your food, the waste temporarily stored in the **rectum** then exits your body through the **anus** – like when you go to the bathroom.

To further reinforce digestive system details, see the following YouTube video called "The Digestive System." A camera travels through the digestive system so students can watch the process in action from inside the human body. After watching the video, consider walking students through the process one more time to ensure they understand where the chemical processes occur. Whenever possible have students answer their classmates' questions during discussion.

If they already know part of the content, a brief overview is all that is necessary for those details. Include in the discussion:

- organs
- enzymes (students don't need to remember the specific names, just the purpose)
- processes
- places where chemical reactions occur

Further Discussion

To further reinforce digestive system details, see the following YouTube video called “The Digestion System”. A camera travels through the digestive system so students can watch the process in action from inside the human body. After watching the video, consider walking students through the process one more time to ensure they understand where the chemical processes occur. Whenever possible have students answer their classmates' questions during discussion.

Display **slide 21**. Once students have a complete understanding of digestive processes, return to their observations from the Explore Carousel. Ask them to describe what they were able to identify in the "waste" products of the models. Help students connect this to their understanding of how fossils form. Some guiding questions to help facilitate this include:

- What types of materials are most/least likely to fossilize?
- Why are coprolites rare?
- When poop does fossilize, what sort of materials might be found inside? Why?

Additionally, interesting conversation synthesizing content can be facilitated through student-generated questions. Student questions may include:

- Why can't we eat our poop?
- Why do some animals eat their poop?

Sample Student Responses

Bones are the most likely to fossilize and soft materials like plants are less likely. Coprolites are soft so they don't fossilize often. You might find bones or seeds inside, because these aren't easy to digest/can't be digested so they would stay in animal poop.

Display **slide 23**. Have students brainstorm the types of conclusions they might be able to draw about an animal based on what they might find in its poop (e.g., whole seeds would tell us that animals can't digest that food).

Extend

Display **slide 24**. Remind students that scientists figured out how the "bone-crushing" dogs hunted based on their coprolites. Ask them to revise their explanation on the CER Explanations handout for how this is possible using what they now understand about digestion.

Display **slide 25**. Have students read about the scientific research on the "bone-crushing" dogs. Some options for readings include this Massive Science article titled "What can ancient dog poop reveal about an ecosystem?" or this NHMLA article titled "The Proof Is in the Pooping." Alternatively, this article from Newsela titled describes how scientists use coprolites more generally. Discuss the article(s) as a class to help students determine why bones and other materials are left behind during digestion (e.g., lack of necessary enzymes, too dense for body to break down physically, etc.).

Tech Opportunity

Newsela offers an opportunity for your students to read the articles online, make annotations in the text as they're reading, take online comprehension quizzes, and respond to written prompts. Alternatively, you can always upload the PDFs of the articles to your students and have them read and annotate the text on their tablets using programs such as Noteability.

Science Literacy

This part of the lesson can be facilitated as a read-aloud, the text could be chunked, or the teacher might develop a paraphrased version to meet the literacy needs and reading level of students. There is also a two-part kids' science podcast about dinosaur coprolites that addresses many of these same ideas: Dinosaur Poop Part 1: Who Dung It? and Dinosaur Poop Part 2: The Coprolite Queen.

Display **slide 26**. Provide students with the **Evidence and Conclusions** handout. It contains the evidence scientists found within the coprolites and the specific things they concluded about the "bone-crushing" dogs' ecosystem. Ask students to match the evidence and conclusions by deciding what evidence supports each conclusion and explain why using what they understand about digestion and fossils. *Note that pieces of evidence can be used to support more than one conclusion and conclusions may be supported by more than one piece of evidence.* Display **slide 27**. After students complete the task, have them compare their answers and reasoning with a partner. They should discuss why their ideas do or do not match one another using the evidence and their learning so far.

Students may generate questions which provide an opportunity for a discussion connecting previous knowledge and the content learned during the lesson. The following questions may be particularly useful for reinforcing conceptual understanding of both the process of fossilization and chemical reactions during digestion, respectively:

- Why is poop less likely to fossilize?
- Why do poop and gas smell?

Sample Student Responses

Poop is less likely to fossilize because it is mostly soft material which doesn't fossilize as easily. Poop and gas smells due to gas that gets released during chemical reactions in digestion.

Evaluate

Display **slide 28**. Have students explain how the process of digestion left bone fragments in the coprolites of "bone-crushing" dogs. Provide the students with the **Digestive System Model** handout for them to use as part of their explanation.

In addition, students should revise their Engage/Extend explanation one more time to describe why scientists can use materials found in coprolites to understand ancient ecosystems. They should structure their final explanation as a CER, using evidence from the lesson to support their claim.

Display **slide 29**. Use the Muddiest Point strategy to close the lesson. Ask the students "What is your muddiest point about how we can use fossils to learn about ancient organisms' diets and ecosystems?" Use student responses to address any remaining misconceptions or wonderings.

Resources

- Coprolites & Dinosaur Poop. (n.d.). Explore the Fascinating World of Coprolites & Dinosaur Poop. Poozeum. https://poozeum.com/coprolites
- Dinosaur Poop Part 1: Who Dung It? (2018, March 15). Tumble. http://www.sciencepodcastforkids.com/single-post/2018/03/09/Dinosaur-Poop-Part-1-Who-Dung-It
- Extinct Doggos' Bone-Crushing Diet Preserved in Fossil Poop. (n.d.). Live Science. https:///62666-extinct-doggos-munched-bones.html
- Fritts-Penniman, A. What can ancient dog poop reveal about an ecosystem? (2018, July 5). Massive Science. https://massivesci.com/articles/ancient-dog-fossils-bones/
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- K20 Center. (n.d.). Collective brain dump. Strategies. https://learn.k20center.ou.edu/strategy/baee4e90c5fa1a7060ca04dd8b00450e
- K20 Center. (n.d.). Muddiest point. Strategies. https://learn.k20center.ou.edu/strategy/baee4e90c5fa1a7060ca04dd8b003a81
- K20 Center. (n.d.). Gallery walk/carousel. Strategies. https://learn.k20center.ou.edu/strategy/d9908066f654727934df7bf4f505a54d
- K20 Center. (n.d.). Newsela. Tech Tools. https://learn.k20center.ou.edu/tech-tool/649
- Lesson Idea: Digestive System Experiment: Reach Out Cpd. (2014). YouTube. https://www.youtube.com/watch?v=7av19YhNkhE
- Plant-eating Dinosaurs ate Shellfish. (n.d.). Newsela. https://newsela.com/read/dinosaurs-crustaceans/id/35605/
- The Digestive System. (2012). YouTube. http://youtu.be/_QYwscALNng
- The Proof Is in the Pooping. (n.d.). National History Museum. https://nhm.org/stories/proof-pooping
- Wang, X., White, S. C., Balisi, M., Biewer, J., Sankey, J., Garber, D., & Tseng, J. First bone-cracking dog coprolites provide new insight into bone consumption in Borophagus and their unique ecological niche. (2018, May 22). eLife. https://elifesciences.org/articles/34773