

**BACKGROUND**

Through the year, students have been engaged in a number of analysis, evaluation, and synthesis activities with science content as the canvas for their thinking. They have developed an understanding of the rationale behind question development, model construction, planning investigations, collecting and analyzing data, constructing explanations, and communicating, defending and critiquing those explanations.

In this unit, students will be encouraged to use their repertoire of skills to begin to extend their problem solving techniques. They will be working like geologists and paleontologists. By doing so, they will be developing metacognitive awareness by repeatedly answering the question “How do you know?”

It is important to note, our awareness of dinosaurs and other long extinct organisms is based solely on evidentiary conclusions rather than direct observations. There is a necessity to develop models because of the impediment of time. Students will be relying on evidence to construct models and explanations based on their creative conjectures.

In science, previous to this unit, students were able to observe the characteristics of plants and animals. They constructed explanations for the functionality of the structures of those characteristics and the benefit those characteristics provided each organism within their environments. They also created taxonomy solutions through classification systems for the organisms based on those characteristics. They will be using their experience of characteristic observation and inferring to help them develop similar classification models and connections.

In social studies, previous to this unit, students have been exploring the sociologic, environmental, geographic, geologic, historic, and economic nature of Colorado. Colorado is full of paleontological activities and the content can be made relevant in the context of those studies. The students have discovered Colorado is a catalogue of geologic diversity which contains paleontological records including trace fossils, mold fossils, cast fossils, true form fossils, and vast fossil fuel reserves.

**STANDARDS****NGSS**

3-LS4 Biological Evolution: Unity and Diversity

- 3-LS4-1 Analyze and interpret data from fossils to provide evidence of the organisms in which they lived long ago.

**Disciplinary Core Ideas**

Evidence of Common Ancestry and Diversity

- Some kinds of plants and animals which once lived on Earth are no longer found anywhere.
- Fossils provide evidence about the types of organisms which lived long ago and also about the nature of their environments.

**Science and Engineering Practices**

Constructing Explanations and Designing Solutions

- Use evidence to construct an explanation.

Engaging in Arguments from Evidence

- Construct an argument from evidence.

**Crosscutting Concepts**

Systems and System Models

- A system can be described in terms of its components and interactions.

**Connection to Nature of Science**

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Science assumes consistent patterns in natural systems.

**Jefferson County School Report Card Descriptors**

Demonstrates understanding of science concepts and content

**ENGAGING CONTEXT**

In past summers, you have been able to go hiking through several of Colorado's public lands. Certainly, you have found peculiar items which didn't seem like they belonged in the landscapes. Our working objective is to allow you to be able to understand and explain those items as you encounter them in the same types of landscapes.

Last summer, I visited several of places with these peculiar items in Colorado. When I visited the National Monument in Florissant, I saw large rock formations which looked like they had grown out of the ground. And, when I was hiking over the hogback near Morrison, just a few miles away from here, I saw footprints which looked like they were made by some 3-toed, cartoon animal...in solid rock. Then, I was able to travel to the National Monument in Northwest Colorado. There seemed to be several animal skeletons trapped although the skeletons didn't look like they came from any animals I've seen in the zoo...not exactly, anyhow.

Where did the tracks and bones come from? What could have been from and what left them in those places? And, why did they all look like or were in solid rock?

On top of that, a ranger told me Colorado was once covered by oceans and large riparian habitats. How did she know?

### **JUSTIFICATION OF SCIENCE PRACTICES**

The initiation of the task allows the initiation of science practices. At the start, upon the presentation of the fossils, students begin to plan an investigation with intent of carrying it out. The process will begin with the students developing guiding questions and then a thinking process with which to organize the constructs of an investigation process.

By the time the students have organized their thinking, and conducted the investigation of their design they will be prepared to construct explanations and design a solution to the essential questions which they previously developed.

Ultimately, the students will be presenting their analysis of the fossil items, only after they have conducted a session of research to find evidence which supports their thinking. In a dynamic classroom environment, a number of processes and explanations will be developed. Each of the creators of those explanations will be able to present their conclusions and investigate conclusions like and unlike their own. Through their own evaluation process, students will be able to compare and contrast solutions in order to broaden their understanding of the concept. They can then engage in discourse with their peers, where they will be able to evaluate, support, and revise their own thinking about the concept.

### **OBJECTIVES**

Students will be able to know:

- fossils have similarities to current organisms.
- fossils reveal features of prehistoric environments and provide information about organisms and environments which exist today.
- conditions which most likely lead to something becoming a fossil.
- vocabulary terms: fossil, evidence, compare and contrast, evidence, prediction, geologic time

Students will be able to understand:

- prehistoric environments have similarities to modern environments.
- scientists use fossils to understand modern organisms.
- scientists use evidence from fossils to construct explanations about prehistory.
- fossils form in a variety of ways under particular conditions.

- A variety of evidence-based conclusions can be developed using similar evidence.

Students will be able to:

- formulate questions to guide their scientific investigation.
- compose procedures to identify fossil types, placement, source, and structure-function relationship
- investigate fossils and compose conclusions to explain prehistoric environments based on fossil evidence.
- analyze similarities and differences of fossil organisms to modern organisms.
- obtain information from a variety of sources in order to support claims.
- evaluate applicable evidence and apply it to support claims.
- provide and receive feedback from peers about proposals through relevant evidence.
- compare and contrast interpretations.

### **PHYSICAL MATERIALS**

- Thinking Maps reference posters and accompanying Frame of Reference Question poster

For Part A

- Plaster of Paris, water, mixing materials
- Dixie (2.oz) cups (one/student)
- Small plastic toys (bulk sets commonly found at Dollar General) (one/student)
- Excavation tools: toothbrushes, toothpicks, scissors, paper clips

For Part B

- 24 piece puzzle (commonly found at Dollar General), preferably of an animal

For Part C

- Dinosaur skeleton 3-D puzzles (one/student group)

For Part E

- Fossils Kit provided by University of Colorado at Boulder
- Magnifying glasses (one/students)
- Rulers (one/students)

## **LESSON PLAN**

### **ENGAGE**

Here are some of the items I was able to collect. Several of them are like the ones I came across in the public lands all around Colorado. I made some pencil mark impressions of some of the “footprints” I found. Today, in order to find out how they got in the places I found them, we are going to work like paleontologists!

Define (Greek) paleo-ancient, -onto-being, -ology-study; the study of ancient organisms.

Have students create a Circle Map titled “Paleontologist” for them to periodically add to their definition of a paleontologist. As they progress through working like a paleontologist, they will add terms and phrases to reflect their acquisition of knowledge; this can serve as a formative assessment.

Show the video for the song “I am a Paleontologist” by They Might Be Giants, which outlines the work of paleontologists.

### **EXPLORE**

#### **Part A**

**Objective: Investigate procedures by which paleontologists recover fossils. Investigate advantages and obstacles encountered in excavation.**

Students will excavate the toys from the Plaster of Paris molds. During the excavations, several molds will be revealed, which can be observed. Some toys may break, which will reveal possible obstacles paleontologists face.

Student will add ideas about the difficulties paleontologists encounter to their Circle Map title “Paleontologist.”

**Formative Assessment:** Students will know they are successful when they have excavated the “fossil” and they have begun to list some possible difficulties a paleontologist encounters.

### Part B

Present a 24-piece puzzle, in pieces, to whole class. The puzzle works best with an image which students are generally familiar with. An image of an animal works great, as it reveals a familiar image to which generalizations can be applied (the head is at the top, the feet are at the bottom, etc.).

**Objective: Develop a set of problem solving criteria based on what we can observe about the puzzle.**

Possible guiding questions:

- How do we know we are successful?
- What characteristic of each piece can give us clues to where each piece belongs in the puzzle?
- What do we know about the putting puzzles together which can help us?
- What is one way to begin? What steps do we take next?

Develop success criteria statements: “We will know we are successful when we have fit the pieces together to create a recognizable image. The pieces will fit so there are not gaps between them and form in a regular rectangular shape with well-shaped edges.”

Make observations of the pieces. Illicit and record responses:

- the pieces are colorful
- each piece has a unique image
- they have regular loops and sockets, which the fits are exact because they were cut from each other
- some of the pieces have edges without loops or sockets
- some of those pieces have two edges which form a vertex (corner)

Identify what is known about fitting puzzles together. Illicit and record responses:

- there is a picture on the box to guide us
- find corner pieces and edge pieces
- the images reveal characteristics of the image ( i.e. eyes, mouth and head features should go at the top of the complete puzzle's image)
- when fitting pieces, check for gaps or imperfect fits of loops and sockets

Fit puzzle together, with student input and attention to success criteria and developed procedure. Review steps and celebrate success.

Have students add learned information to circle map "Paleontologist":

- Detectives
- Make observations
- Use clues
- Use what they know
- Categorize
- Solve puzzles and problems

**Formative Assessment:** Students will know they are successful when they have developed and enacted a set of procedural steps to solve the puzzle.

### Part C

Present the dinosaur skeleton puzzles. Allow students to explore the pieces and make informal observations.

**Objective: Formulate and apply problem solving procedures to assemble puzzles.**

Review problem solving procedures from puzzle building activity. Direct student groups to develop problem solving strategies to apply to 3-D puzzles (observe characteristics of pieces; apply previous knowledge of animal structures; categorize pieces; identify parts to construct first, etc.).

Give students time to assemble puzzles.

Before all student groups finish, direct a class discussion to reveal encountered obstacles and discuss possible solutions.

Have students add to Circle Map “Paleontologist”:

**Formative Assessment:** Students will know they are successful when they have developed and enacted a set of procedural steps to solve the puzzle.

## Part D

Begin session with the [Sid Shuffle – Ice Age: Continental Drift \(3:25\)](#) dance video

**Objective: Investigate changes in Earth’s geographic and geologic structures which could reveal clues to knowing more about fossil function. Develop theories according to visual evidence.**

Access [Google Slides \*Continental Drift\*](#) to guide discussion on Earth’s change through time. Key points:

- Slide 1: Fossil’s of the same animal are found in areas of South American and Africa. Allow students to develop a theory about the fossil’s geographic relationship. The theories should begin to reflect the rubric criteria (thesis statement supported by observational evidence). Students can use sentence stems to express their theory:
  - o I believe... because.
  - o The evidence tells me... because...
- Slide 2: Fossil’s of the same animals have been found all over the world, with seemingly no connections. (Allow students to redevelop or refine their theory about the fossils’ geographic relationships).
- Slide 3: Scientists believe Earth’s continents looked much differently, because of a process which they call continental drift. They have used evidence, including the geographic placement of fossils to develop this theory.
- Slide 4: Scientists have evidence the continents sit on “shelves” and rift on Earth’s mantle.
- Slide 5: Two videos: [Continental Drift: 3.3 Billion Years \(4:20\)](#) illustrates scientist’s theories about previous continental drift (all video is interesting, most recognizable at 3:40-4:20); [300 Million Years into the Future World \(Pangea Proxima\) \(1:17\)](#) illustrates what scientists predict will happen to the drifting continents.
  - o Note the proximity of North America (Colorado) to the equator as the movement occurs. Could this affect the structure or function of animals and plants which lived in the region?

Give information about absolute and relative time. Use a Tree Map to define the characteristics:

- Absolute time
- Relative time

Allow students to explore the concepts of fossil dating in the Edpuzzle video, "Fossils: how are fossils dated."

**Formative Assessments:** Students will know they are successful when they develop and refine theories to explain the geographic location of fossils throughout the world. Students will know they are successful when they have generated a list of characteristics and can explain the key elements of absolute and relative time.

### Part E

Present the contents of the fossil kit to students. The fossil kit contains a variety of fossils or fossil replicas, including casts, molds, petrified woods, true form fossils, and trace fossils.

**Objective: Categorize fossils based on observable characteristics and implications.**

Examine the article "[Colorado Earth Science](#)" which outlines evidence based conclusions about the fossilized sequoia from Florissant Fossil Beds National Monument. Allow student to identify the elements of conclusion statements in order to develop a rubric to guide the development of their evidence statements (See EVALUATION for possible student observed success criteria). The statements will be used as the students' summative assessment for this investigation.

Have student develop questions "thick" which will guide the research. Developing "thick" questions are skills which students have used. It is the skill of developing a question which elicits a thick answer (conversely, "thin" questions elicit "thin" answers: yes, no, etc.). Possible investigative questions to elevate:

- How can we sort the items?
- What do the items reveal? (What are the items from? Where did they come from?, etc.)
- Which characteristics make each item unique?
- What do the characteristics tell us about the source of the fossils?
- Why would paleontologists use replicas of their materials?
- Why would paleontologists use models to make observations?
- What are the processes which form trace, full form, mold, and cast fossils?
- How did the fossils get in the stone?

Other procedural questions may arise:

- What do we need to know in order to investigate these items best?

- What tools can we use to investigate these items best?

Ground the planning of the investigation the task in the thinking processes which are available via Thinking Maps (define, describe, compare and contrast, sequence, identify cause and effect, part-to-whole (and visa-versa) relationships, classify, develop analogies).

*Elevated questions: How can we sort the items? What tools can we use to investigate these items best?*

Elevate the thinking process of categorizing to initially explore the items. This is a time to remind students about the processes of sensory observation (touch, taste, smell, hear, see). The primary observation qualities used will be see and touch, as the items lack distinctive smells, tastes, or sounds. After initial observations, several suggestions may be made to classify the items: by size, color, shape, texture, and type (trace, mold, cast, true form). Type categorization will become the class' exploration focus.

\*Magnifying glasses and ruler can be introduced to the investigation.

*Elevated questions: Which characteristics make each item unique? What do we need to know in order to investigate these items best?*

As students begin to recognize the differences of characteristics in the type forms of the fossils, some vocabulary may be introduced. Begin by allowing students to use their observations of the differences to lead them to the vocabulary which paleontologists use to categorize the types of fossils.

*Elevated questions: How did the fossils get in the stone?*

Allow students to explore the concepts of fossilization in the Edpuzzle video, "What is a Fossil?" (edited by Bradley Peel). They will create a lab write up to record their information they acquire from the video. The video has been edited to guide students through their inquiry:

- Question-How did the fossils get in the stone?
- Acquire definitions of types of fossils:
  - o Trace fossils reveal the behavior of the organism, like footprints.
  - o True form fossils are remains of an actual organism, like bones.
  - o A mold is a cavity or hole which once contained the organism's remains. The remains were dissolved by flowing groundwater.
  - o A cast is the result of a process which minerals enter the mold's cavity to the form of the original organism's shape.
- Formulate a hypothesis
- Learn more about unique fossils through the discovery a feathered dinosaur tail fossilized in amber in "[Dinosaur's Feathered Tail Found Remarkably Preserved in Amber](#)" (1:28).
- Gather information and organize it in a sequence (using a flow map):

- o 1. Organism dies (in the video's example, a stegosaurus)
- o 2. The flesh rots until only bones remain
- o 3. Sediments become rock
- o 4. The bones are washed away by groundwater leaving a mold
- o 5. Ground water brings minerals to fill the mold, forming a cast
- o 6. Fossils rise to the Earth's surface

**Formative Assessment:** Students can access the [Scratch program "PeelDinosaurQuiz,"](#) a quiz designed to reinforce the students' acquisition of the fossil vocabulary presented.

### Part F

**Objective: Investigate fossils and formulate conclusions about their structure, function, and preservation with supporting evidence.**

Students will be grouped and given an opportunity to choose three fossils to investigate more closely. The intent of the investigation is to begin to formulate explanations about the origination of the fossils and to construct hypotheses about the organisms from which the fossils came from and their environments.

### EXPLAIN

Previous to developing their explanations for the origin of each of their three fossils, students will collaborate, with the facilitation of the teacher, to construct a 2-point rubric. The rubric is to outline the outcomes which will guide the students to achieve grade-level indication (3) and access above grade-level indication (4). It is to be inferred and discussed, not meeting an aspect of grade level

achievement results in below grade-level indication (2). The students will access the knowledge of their previous experiences with construction of explanations to include (not limited to): presenting thesis (topic and main idea), (two pieces of) evidence to support their thesis (see example rubric in Resources section).

To support their argument presentation, students can access a Mad Libs style app through MIT app inventor, called Fossil Mad Libs. The statements the students will compose:

- Based on our evidence, we (past tense verb) the fossils of a (organism type). Because of the (adjective)-ness of the fossil's (noun), we believe it (past tense verb) in (environment type), because (evidence statement).

Allow students to compose their own sentences first, then direct them to apply their observational evidence to create evidence statements about the characteristics of the fossil and the ideas they inferred from their fossil's characteristics.

Evidence statements should be developed according to rubric criteria.

### **ELABORATE**

Allow students to begin to investigate their conclusions and evidence through web searches. The web searches can reveal or support more information, comparisons, or evidence.

Students may also redevelop or refine their classification and characteristic evaluations.

### **EVALUATE**

After evaluating the exemplar, students will generate evaluation criteria before beginning Part E. The evaluation will guide the students' summative assessment for the entirety of the investigation. The grading criteria is related to the report card indicators (1-No submission or evidence of standard; 2-Moving toward meeting grade level standard; 3-Meeting grade level standard; 4-Exceeding grade level standard) and the grade will be entered to reflect proficiencies in "Demonstrates understanding of science concepts and content."

4	<ul style="list-style-type: none"> <li>• Everything in a 3</li> <li>• Reveals more than one possible conclusion</li> <li>-or-</li> <li>• Use of more than one statistical or observational evidence statement to support conclusion</li> </ul>
3	<ul style="list-style-type: none"> <li>• Thesis statement reflects conclusion</li> <li>• Use of one statistical or observational evidence statement to support conclusion</li> <li>• Uses academic vocabulary specific to paleontology</li> <li>• Uses "Show Me the Evidence" statements to support presentation of evidence (because, according to</li> <li>• Suggest the environment which the fossil thrived, based on structure and implied function</li> <li>• Inferred process through which fossil was formed</li> </ul>

**Resources**

[Particle Men]. (2009, Sep 8). *I Am a Paleontologist-They Might Be Giants w/Danny Weinkauf (official TMBG video)*. [Video file]. Retrieved from <https://www.youtube.com/watch?v=B7zo2zY1Zqg>.

(15 Jun 2012). *Sid Shuffle – Ice Age: Continental Drift*. [Video File]. <https://www.youtube.com/watch?v=uMuJxd2Gpxo>.

(3 Mar 2019). *Continental Drift*. [Google Slides, Bradley Peel]. [https://docs.google.com/presentation/d/1e9\\_-F8J9nmahhfS86xiQEzA\\_WYkEUE1rGuAvfnUF7E/edit?usp=sharing](https://docs.google.com/presentation/d/1e9_-F8J9nmahhfS86xiQEzA_WYkEUE1rGuAvfnUF7E/edit?usp=sharing).

(20 Apr 2015). *Continental Drift: 3.3 Billion Years*. [Video file]. <https://www.youtube.com/watch?v=UwWWutntnio>.

(7 Jun 2015). *330 Million Years in the Future World (Pangea Proxima)*. [Video file]. <https://www.youtube.com/watch?v=bQywDr-btz4>.

[EdPuzzle]. (2017, Jan 17). *Fossils: how fossils are dated*. [Video file]. <https://edpuzzle.com/assignments/587e55485596633e24ba90fd/watch>.

Veatch, S. (2010, Dec 5). *Colorado Earth Science*. [Blog post]. Retrieved from <http://coloradoearthscience.blogspot.com/2010/12/florissants-sequoias-redwood-giants-of.html>.

[Edpuzzle]. (2019, Feb 9). *What's a Fossil? (Edited by Mr. Peel)* [Video file]. <https://edpuzzle.com/media/5c5f3d26f2c1ed408602ec10>.

[National Geographic]. (2016, Dec 8). *Dinosaur's Feathered Tail Found Remarkably Preserved in Amber* [Video file]. Retrieved from <https://www.youtube.com/watch?v=CsRskR1LbMQ>.

CU-Boulder Museum of Natural History. (2016). "Fossils in the Classroom, 4<sup>th</sup> Edition." [Lesson guide and fossil kit].

[Scratch]. (2019, Feb 10). *PeelDinosaurQuiz* [Scratch program]. <https://scratch.mit.edu/projects/285773319/>

[MIT App Inventor]. (2019, Feb 10) FossilMadLibs [MIT App Inventor program]. <http://ai2.appinventor.mit.edu/#5132924872687616>.

