Classroom Geology

Lesson by Lacey Moore

Activity Subject: Relative Dating Methods; Law of Superposition, Index Fossils

Grade Level: 6-8 grades

Introduction

This lesson challenges students to create and interpret a representation of Earth's history using relative dating methods that includes the Law of Superposition and index fossils. First students participate in an interactive presentation that introduces the geologic timescale. Then they design and create a model of Earth's rock layers that tells a story in Earth's history. Finally, student switch "sites" with another student group and try to figure out the story being told.

Assessments Informal Discussion, Worksheet

Time 100-120 minutes

Group Size Varies; groups of three, individual, whole class

Materials

- "Classroom Geology" Presentation
- "Classroom Geology Presentation Talking Points"
- Computer and projector
- "Index Fossil" Reference Guide per student
- "Classroom Geology" Worksheet per student
- Sedimentary (or other) Layers for whole class: 1 bag of dark sand, 2 bags of light sands, 2 bags of soil, 1 bag of small gravel (Aquarium size), large spoon per sediment, "index fossils" like cereal or hole punches to mix into a layer of sediment, two or three "other fossil" types like jelly beans, small cereal, small clay pieces, etc., sifter or strainer

NEXT GENERATION SCIENCE STANDARDS

MS-ESS1-4 Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. *[Clarification Statement: Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history. Examples of Earth's major events could range from being very recent (such as the last Ice Age or the earliest fossils of homo sapiens) to very old (such as the formation of Earth or the earliest evidence of life). Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions.] [Assessment Boundary: Assessment does not include recalling the names of specific periods or epochs and events within them.]*

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems
Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

LEARNING OBJECTIVES

After this lesson, students will be able to:

- Explain how the Law of Superposition is used to relatively date Earth's strata, or rock layers, and help sequence major Earth events.
- Describe how index fossils are used to relatively date Earth's strata, or rock layers, and help sequence major Earth events.
- Recognize the geologic timescale as a framework for organizing and sequencing Earth's history.

Classroom Geology-Page 2
Preparation - Teacher's Edition

- Per student group: clear plastic cup or other container, spoon, spray bottle full of water, metric ruler
- "Geologic Time Scale" Worksheet per student
- "Major Earth Event Card Key" from lesson three, Major Earth Events, Part Two (optional)

Preparation

1. *Student Worksheets and Presentation*: Make copies of "Classroom Geology" Worksheet for each student. Make a copy of "Index Fossil" Reference Guide and "Geologic Time Scale" Worksheet for each student. Save paper by printing them back to back. You may also choose to hand out or project "Major Earth Event Card Key" from the previous lesson (included in this lesson) to give students ideas for a storyline. Review "Classroom Geology" Presentation and see "Classroom Geology Presentation Talking Points" for facilitating an interactive presentation.

2. *Gathering Materials:* Reusable and reclaimed materials will be most cost effective and environmentally friendly. For example, a set of 8-16-ounce clear plastic cups can be reused per period and year. Mason jars also will work (remind students they are breakable.) Soil from the school garden or your (or a neighbors) compost is another great option. Other "Earth layers" beside sediments could include wheat germ, rice or anything that is easily layered.

3. *Classroom Set-Up*: Set up a centrally-located materials station where students can add sediment and fossils to their containers. Use dishpan tubs or other large containers to pour sediments into. Choose one of the sediments in which to add biodegradable "index fossils." "Index fossils" could be macaroni, hole punches, or small but distinct cereal like Cheerios, etc. Put "other fossils" like jelly beans, small cereal, small clay pieces, etc., into small containers. Limit these fossils to a maximum of three types.

   As a class, you'll determine what each sediment represents in terms of Earth's rock layers (e.g., volcanic eruption, ocean sand and shells, etc.-see page one of "Classroom Geology Worksheet") as well as the type of index fossil. You may want to do this before class to save time or let students help you determine this.

4. *Clean Up*: Consider what you are going to do with the mixed layers of sediment. Adding it to a compost pile, school garden, etc. are options. Have a few large garbage sacks or container for students to dispose of their sediment layers when done. NOTE: If you use nonbiodegradable index fossils, students will need to do an effective job "cleaning" their site and separating fossils from the soil. A strainer or sifter might help depending on sediment size.

Classroom Geology-Page 3
Procedure - Teacher's Edition

Procedure

1. **INTRODUCE LESSON OBJECTIVE. (5 MIN)**
   The focus question of this unit is: *How do scientists figure out and sequence major events in Earth's history?* In this lesson, students design and create a representation of Earth's rock layers and practice using some of the same relative dating techniques used in dating the Cambrian explosion and many other major Earth events. Tell students that in this lesson they'll be looking at how we use rock layers and fossil records to interpret Earth's history. Ask them to share their ideas based on their knowledge so far.

2. **INTRODUCE RELATIVE DATING METHODS AND THE GEOLOGIC TIMESCALE THROUGH AN INTERACTIVE PRESENTATION. (15-20 MIN)**
   Project "Classroom Geology" Presentation. Use the notes on the slides or "Classroom Geology Presentation Talking Points" for talking points and suggestions for students' involvement. It introduces the Law of Superposition and index fossils as methods to relatively date and get insight into Earth's rock layers and history. You will need to pass out the "Index Fossil" Reference Guide per student during the presentation.

3. **IN SMALL GROUPS, STUDENTS DESIGN AND CREATE A REPRESENTATION OF EARTH'S ROCK LAYERS. (45 MIN)**
   Pass out "Classroom Geology" Worksheet to each student. Go over the entire three-part procedure briefly with students so they know what to expect and how to manage time. Divide students into groups of three. You may choose to hand out or project "Major Earth Event Card Key" to give students ideas for storylines for Earth's history. Give them 20-30 minutes to determine as a class what layers of sediment represent (e.g., volcanic eruption, ocean sand and shells, etc.) and then brainstorm a storyline for the representation they will create. Set a timer and encourage students not to overthink the storyline. It should illustrate the Law of Superposition and how index fossils (and fossils in general) are used to figure out and sequence Earth's history.

   Once students begin creating the representation, remind them not to exceed 3 cm in each layer, two of the same layer should not go side by side, and they should use a layer with the pre-mixed "index fossils." This is also stated on their worksheets.

4. **STUDENTS SWITCH REPRESENTATION WITH ANOTHER GROUP AND MAKE OBSERVATIONS TO DECIPHER THE STORY ABOUT EARTH'S HISTORY. (30 MIN)**
   This is part three on students' worksheet. Students will draw a diagram of the representation, identify the oldest and youngest layers as well as interpret what the fossil record, both index fossil and other fossils, tells about that time period in Earth's history. Then they'll meet up with the group they switched with and compare how their inferences about that time period match with the intended story.

5. **DEBRIEF THE LESSON. (5-10 MIN)**
   Take some time to reflect on the lesson as a whole class. This is to ensure students have an accurate understanding about how the Law of Superposition and index fossils help us figure out and sequence Earth's history as well as the learning experience. Questions may include:
   - How easy or hard was it to create a story about Earth's history? What would you do different next time?
   - How easy or hard was it to analyze and decipher a story about Earth's history?
   - How do you think the representations compare to actual geologic sites? Explain.
   - How would you describe index fossils and how they help us figure out Earth's history?
   - Any other comments, questions or suggestions?

6. **HOMEWORK: MAKING SENSE OF GEOLOGIC TIME SCALE (5 MIN)**
   If you haven't already, pass out "Geologic Time Scale" Worksheet per student. Have students compare their timeline of Earth's history to the geologic time scale. Where do the major events they sequenced on their timelines fit in to the geologic time scale?

   Challenge students go back to their personal timelines from previous lessons. Can they divide the timeline into eras or periods based upon life changing events? What might era or period names consist of? What might be a couple examples of index fossils and other fossils from time spans? (E.g., Harry Potter books and favorite snacks might be examples of index fossils and/or a favorite stuffed animal or first bike a fossil from an era long ago)

Extension

1. Find photos or illustrations of index fossils and fossils found around the same time period. Make small thumbnails of the images. Laminate them (or not) and cut them out. Use those images instead of objects representing fossils in the sediment layers to add more authenticity. Cut the images in half or thirds to model fossil fragments and challenge of both uncovering and identifying fossils.

Resource

"Who's On First?" A Relative Dating Activity from UC Berkeley:
http://www.ucmp.berkeley.edu/fosrec/BarBar.html#FIG2A

Classroom Geology Presentation Talking Points-Page 1
Teacher's Edition

Slide One: Classroom Geology: How Might We Use Rock Layers and Fossil Records to Interpret Earth's History? (Title Slide)

Slide Two: Rock layers and fossil records, like those observed in the Burgess Shale, tell stories.
The Burgess Shale told stories about the Cambrian Explosion-an evolutionary event from which all modern animal phyla are descended.

Slide Three: What story (or stories) might these rock layers in the Grand Canyon tell?
- Take all student ideas and observations.

- The nearly 40 major sedimentary rock layers exposed in the Grand Canyon tell stories of ages 200 million to nearly 2 billion years ago. Warm, shallow seas and fossilized sand dunes telling of an extinct desert are a few clues to Grand Canyon's history. So is a large river that began excavation of the canyon about 6 million years ago. Volcanic activity deposited lava over the area 1.8 million to 500,000 years ago. The modern CO river still runs through the canyon though it's been the same depth for the last 1.2 million years.

- Part of how we know this is by aging rock layers, observing the appearance and mineral composition of rock layers and studying any fossils found in rock layers.

Slide Four: How do we know the age of rock layers?
To age layers of rock, or sediment, scientists use relative or absolute dating.

There are two methods scientists use to assign an age to materials. Relative age dating and absolute age dating.

- Relative Dating: determining the relative order of past events (i.e., the age of an object in comparison to another)

- Absolute Dating: assigning a specific, or absolute, number to past events. May include an actual date or a range of dates.

Slide Five: What are some examples of absolute and relative dating in your schoolyard?
In lesson one, Schoolyard Geology, students dated features in the schoolyard using both absolute and relative dating methods.

The photo of the fire hydrant is an example of absolute dating (number listed on fire hydrant although it leads to more questions-e.g., is that the year of manufacturing, etc.?). The photo of the rocks in the schoolyard is an example of relative dating. It's hard to tell from the photos but some of the rocks look younger than the paved courtyard of the school and some look like the concrete was poured around them. We don't know how old they are but we can guess that one is older or younger than the other.

Classroom Geology Presentation Talking Points-Page 2
Teacher's Edition

Slide Six: Absolute Dating Methods
Let students know that this lesson doesn't focus on this type of dating and you need special tools for it.

More background: The atoms (a particular kind called isotopes) of some chemical elements break down overtime. By measuring the amount of broken down, or decayed, isotopes, scientists can determine how old the rock is. This method works in igneous and some metamorphic rocks, but not sedimentary rocks (because they are made up of other rocks).

Slide Seven: Relative Dating Methods
- Observing positions of rock layers in relation to one another (e.g., Law of Superposition) and presence of certain kinds of fossils
- In the Schoolyard Geology lesson, you were introduced to relative and absolute dating methods.
- Let's do a quick activity. Grab a piece of paper and find four to five other students. Stack the pieces of paper on top of one another.
- Which was put down, or deposited, first? (The one at the bottom) It's the same principle as with layers of sediment, or rocks.
- Can you think of other analogies like the paper analogy? (e.g., in a hamper-clothes at the bottom were put there first, in a sink-dirty dishes at the bottom were put there first, recycling, etc.)

Slide Eight: Law of Superposition
In geology, this is known as the Law of Superposition.
This basic law of geochronology (science of determining the age of rocks, fossils, and sediments), states that in any undisturbed sequence of rocks deposited in layers, the youngest layer is on top and the oldest on bottom, each layer being younger than the one beneath it and older than the one above it.

Slide Nine: Based on the Law of Superposition, where is the oldest layer of rock, or strata?
Based upon the Law of Superposition, it is the layer at the bottom.
What else do you observe? (looks tilted near river but could also be difference in erosion rates)
Which has been around the longest amount of time-river or rock? (Likely the rock and then the river began eroding the sediment and carving the canyon)

Slide Ten: It's not always that simple to use the Law of Superposition. Which layer is the oldest here?
In the description of the Law of Superposition, it states that in an "undisturbed" rock sequence, the oldest layer is on the bottom and the youngest is on the surface. But not all rock sequences are undisturbed.

Classroom Geology Presentation Talking Points-Page 3
Teacher's Edition

- What are some events that would "disturb" a rock layer? Take a look and these images and chat with a partner. (Take students ideas.)
- Movement of plates (plate tectonics), titling, faults (breaks in rock where movements have occurred), folding or folds (bends in rock layers produced by movements of Earth's crust), intrusion (molten rock cutting through preexisting rocks), extrusion (molten rock reaching Earth's surface) are just a few.
- Looking at the image on the right, try to sequence the rock layers from oldest to youngest. (C, B, A D, E). What do you think E represents? (fault line)

Slide Eleven: Index fossils: Another relative dating method

- Think-pair-share: How might we use fossils to figure out and sequence Earth's history?
- Luckily, there are also other relative dating methods that can be use with the Law of Superposition.
- As students think-pair-share, pass out "Index Fossil" Reference Guide. Let them look it over and see if that helps them refine or clarify their answers/thinking.
- If this fossil was the abundant one in the layer of sediment in your site, what geologic time period might be the sediment layer dated to (use the index fossil guide)? Cambrian period in the Paleozoic era

Slide Twelve: Index Fossils

The idea that students are investigating and figuring out in this series of lessons is "How do scientists figure out and sequence major events in Earth's history?" Point out the categories in the far left columns as distinct geologic time spans. Tell them that the far left column includes eons and eras. Those are subdivided into periods in the next column to the right. There are also epochs that fall within periods. (Those are not included on this chart.)

Slide Thirteen: Index Fossils

Have students use their "Index Fossil" Reference Guide to answer the following questions:

- What time periods are fossils A, B and C found in?
- How easy or hard is it to identify the fossils? (A and B might be more difficult as there are other index fossils similar in appearance)
- Sometimes only fossil fragments or traces of an organism (like animal tracks) are found, like you saw in Cambrian Explosion video. What do scientists do then? How might they still use the information?

Slide Fourteen: Index fossils are used to correlate sedimentary layers to time period in the geologic time scale.

The chart to the left is the geologic time scale used by scientists. You can see Earth's history is broken into eons, era, periods, epochs and ages based upon geological events like mountain-building, depositional events, sea level rise, and also biological events like the appearance, abundance and extinction of certain life forms.

Slide Fifteen: Geologic Time Scale (complex)

This is the version used by scientists.

- Scientists use relative and absolute da
- ting methods to establish this.
- Often revised due to more accurate dating methods and current research.

Classroom Geology Presentation Talking Points-Page 4
Teacher's Edition

Slide Sixteen: Let's apply what we just learned.

Slide Seventeen: These fossil records and rock layers tell of the Permian extinction.
The Permian extinction took place from 299-252 million years ago. Although what is known as the dinosaur extinction (66 mya in the Cretaceous period) is likely the most well known, the Permian Extinction, or Great Dying, is the largest of the five known extinctions. Over 95 percent of marine and 70 percent of terrestrial species went extinct and over half of the taxonomic families present at the time disappeared.

- Where is the oldest layer?

- Describe how the fossil record is different below and above the extinction event?

Slide Eighteen: Challenge: Create representation of Earth's rock layers and fossil records to tell a story about Earth's history.
Pass out student sheet. Go over the three parts. In the first part, the class will determine what each sediment layer represents as well as which index fossil is intermixed in one layer. Then each student group will try to tell a story of Earth's history using these layers. Then the groups will switch representations (geologic sites in a cup) and try to tell the story/analyze their representation.

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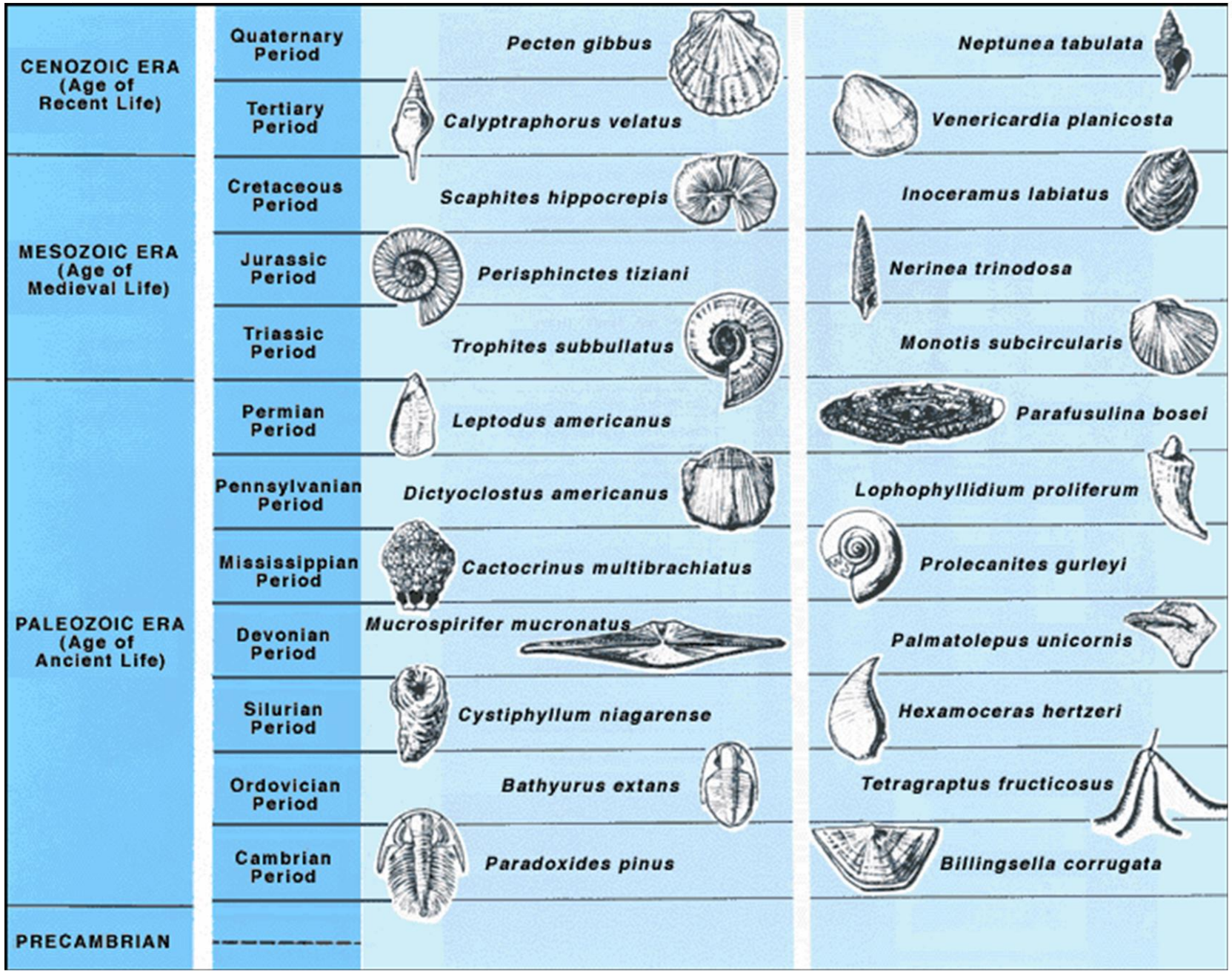
Index Fossil Reference Guide-Page 1
Student's Edition



Source: United States Geological Survey, https://pubs.usgs.gov/gip/geotime/fossils.html

Name_____ Period/Class_____ Date_____

Classroom Geology-Page 1

Student's Edition

How can we use fossil records and rock layers to tell and interpret Earth's history?

Part One: Tell a Story About Earth's History

1. Determine what layers of sediments represent (e.g., volcanic eruption, ocean sand and shells, coal rich layer, etc.).

Sediment A	Sediment B	Sediment C	Sediment D	Sediment E

- Which layer has index fossils?

- Which index fossil is it? Era: Time Period:

2. In your group, brainstorm about the storyline you want the layers to support. You may want to use the "Major Earth Event Card Key" from the previous lesson for ideas.
   - Will you add other fossils? If so, where? What do they represent.
   - How thick will you make the layers and what might that represent?
   - Jot your ideas down on a separate piece of paper with group names. (You will use this later in this lesson.)

Part Two: Create a Representation of Earth's History

Materials: plastic cup or other container, 1-3 cm layers of different sediments, one layer of sediment with intermixed "index fossils" (macaroni, hole punches, etc.) spoon, spray bottle, metric ruler, "other fossils" (jelly beans, small cereal, small clay pieces, etc.)

Suggested procedure:

1. Gather your cup (or container), spoon and metric ruler.

2. Use spoons and the metric ruler to add alternate layers of sediment. Don't exceed 3 cm in depth.

3. After each layer you add, use spray bottles to lightly dampen sediment and tamp down with hand or spoon.

4. Include at least one layer of the sediment with intermixed "index fossils."

5. Add additional fossils (objects representing fossils) to one or more layers.

Rules:

- DO NOT exceed 3 cm.
- Don't add like layers next to each other.
- Don't add more than five layers.

6. Exchange with another student pair.

Part Three: Interpreting a Representation of Earth's History

1. On a separate sheet of paper, draw a scale diagram of your geologic site. *Note: By looking at this illustration, another geologist needs to be able to know the type of layer, thickness of layer and types of fossils uncovered.* Label:
   - Oldest layer
   - Youngest layer
   - Name of index fossil and time period in which its found

2. Use the spoon to look for other fossils. (You might want to separate into separate piles.) Be sure to take accurate data on which layer each type of fossil was found in. (Add to your diagram.) Based upon its location compared to the index fossil, where might it fit into the geologic timescale?

3. Based on the sequence of the layers, what might you infer this representation is telling you about Earth's history?

4. Meet with the group you exchanged with. Compare your group's interpretation with the intended story about Earth's history. How did the Law of Superposition and presence of index fossils help you understand the representation? What did you misinterpret? Why?

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Major Earth Event Card Key-Page 1
Student's Edition

Note: These are approximations as of 2018. Per the nature of science, dates may change as new discoveries are made (and more quickly than this lesson is updated).

YEARS AGO	EVENT
Carbon dioxide level is 385.5 parts per million	X years ago (measurement from 2009)
IPCC report links human to climate change	X years ago (published in 2007)
Ocean pH is 8.09	X years ago (measurement from 2000)
First Earth Day	X years ago (1970)
Carbon dioxide level is 279 parts per million	Over 250 years ago (1750)
First modern humans	200,000 years ago
"Lucy"	3,200,000 years ago
Beginning of most recent ice age	2.6 million years ago
Non-avian dinosaur extinction	66 million years ago
Early flowering plants	120 million years ago
Archaeopteryx (first bird)	140 million years ago
Modern continents form	175 million years ago
Early mammals	210 million years ago
Early dinosaurs	247 million years ago
"The Great Dying"-Permian extinction event	251 million years ago
Siberian Traps volcanic eruptions	252 million years ago
Carboniferous Period	354 million years ago
Oxygen level near present	400 million years ago
Great mountain ranges form	425 million years ago
Time of the Burgess Shale	508 million years ago
Middle of the Cambrian explosion	550 million years ago
Protective ozone layer in place	600 million years ago
First snowball Earth	635-800 million years ago
First supercontinent-Rodinia	1.1 billion years ago
First breathable air	2.4 billion years ago
First modern cell	2 billion years ago
Evidence of photosynthesis	3.7 billion years ago
First evidence of life	3.8-4.2 billion years ago
Oceans form	4.2 billion years ago
Formation of Earth	4.6 billion years ago

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Classroom Geology Geologic Timescale-Page 1

Student's Edition

(Far right column is millions of years ago)