Lesson 4
What is Fossilization?
This is a three-part activity.

Summary
Fossils and the study of fossils are central players in our understanding of the geologic world. By studying fossils, paleontologists understand evolution, how plants and animals respond to environmental change, and the great age of the Earth. Fossils can be the whole body, parts of a body, casts and molds, or traces of an organism, such as burrows and footprints. Some fossils are hardly changed at all from the original organism, and may even preserve some soft parts, such as internal organs. Most fossils do not contain soft parts of the body, and only hard parts such as shells, bones and teeth are preserved.

Students often know what a fossil is but may not know how it formed and how different conditions can lead to different types of fossilization. Although organisms can be preserved as fossils in many ways, preservation and subsequent discovery are relatively rare events. Most organisms that have died through geologic time have left no trace behind—it is estimated that less than 1% of organisms have become fossils. In general, in order to become a fossil an organism must be quickly embedded, or covered in a protective material, such as sediments or ash, which prevents it from decomposing, getting torn apart by scavengers, or disintegrating via geologic processes.

In this three-part activity students will make and excavate a "fossil," and evaluate real fossil sites to understand how fossils form. This lesson plan is the fourth core area of geology, along with rocks and minerals, rock types, and the age of the Earth. The ideas addressed here apply directly to the central questions of this box.

Objectives
Students will be able to:
1. Describe how fossils form.
2. List three different environments in which fossils have formed.
3. State how fossils help reveal information about past environments.

Estimated teaching time
Two to three class periods, with some time, preferably a week or so, between parts one and two.

Groups
This should be done as an individual activity within groups.

Materials
For each student:
Teachers will need to provide from their own supplies:
- Disposable cups (Clear plastic ones those work well. If not, Dixie cups work, too.)
- Disposable spoons, one per student

For each group:
Teachers will need to provide from their own supplies:
- An expendable fossil or substitute such as a clam or snail shell.

- Plaster of Paris
- Access to water
- Disposable plastic bowls for holding plaster of Paris, sand, and pebbles
- Sand (if easily accessible-enough for about a tablespoon per student)
- Pebbles (if easily accessible-enough for a few pebbles per student))
- Talcum Powder or Petroleum Jelly (to coat the "fossil" that will be buried")
- Vinegar and nail polish (optional-see Step 6 in Part 2)

Teacher background
See document labeled **Paleontology Background for Montana DIG Box**

Student background
None specifically needed, though it is helpful to have done Lesson Plan Three – Age of the Earth

Part 1: The Process of Fossilization

Set up
Before the lesson: Figure out how many groups of students you will have. About four students per group works well. Each group will need one disposable cup per student. If you have sand and pebbles, put them in some sort of container accessible by the students. Once the students are in their groups, one student from each group cab come up and obtain the sand and pebbles for his or her group. Do the same for the plaster of Paris. You will need a way to allow the students to coat their fossil in talcum powder or petroleum jelly.

Also, you will need to have each student obtain a item to fossilize, such as a small shell. (It needs to fit into a cup.)

Introducing the activity

1. *Begin with a series of basic questions to see what the students know*. These might include:
   - ⇒ What is a fossil? (Paleontologists define a fossil as a sign of past life. Time is not critical though some say that 10,000 years is a rough minimum age. Fossils can be teeth, bones, eggs, tracks, coprolites, etc.)
   - ⇒ Where are they found? (Fossils primarily occur in sedimentary rocks and can be found pretty much anywhere.)
   - ⇒ How many of you have found fossils before?
   - ⇒ What do you know about fossils?
   - ⇒ Why do scientists study fossils? (To better understand the past, to learn about evolution, to better understand modern species…)

Pass around some sample fossils. If possible, have examples of both cast and mold varieties. Ask students:

- ⇒ What do you notice about these fossils?
- ⇒ What seems similar between theses fossils?
- ⇒ What seems different?

⇒ What do you think accounts for the differences? (Variation has to do with how the fossils were formed, what parts fossilized (leaves fossilized differently than bones), how old they are, what happened to them after fossilization.)
⇒ How are fossils formed?

2. Explain to students that one of the central tenets of geology is that the processes we see today operate the same as they did in the past. For example, if they see a cliff of rock eroding, it eroded in the same way in the past; wind and water weakened it and began to erode due in part to the force of gravity. Another way to think of this is that river flows in the same manner in modern times as it did when dinosaurs walked the planet. So think about a modern sea or lake. Ask students:
   ⇒ Who or what might you expect to find in that body of water?
   ⇒ Tell me a bit about how they lived?
   ⇒ What about how they died?
   ⇒ What happened when they died?

3. *Continue by asking students to imagine a lake that existed millions of years ago.* (The goal is to get students to realize that we know about this lake and those who lived there because of fossilization.) Ask students:
   ⇒ What organisms might you expect to find in that body of water? Tell me a bit about how these organisms lived? What about how they died? What happened when they died?
   ⇒ Now think more about when they died. (The goal is to get the students to think about how over time either sediments could cover the body, or the body could have been consumed by something, leaving nothing behind, and thus no chance to fossilize.)
   ⇒ If the body wasn't buried, ask the students to think about how it might become a fossil. (First sediments would have to cover it and protect it. Then some sort of cement would have to mix in.)

At this point you might want to discuss the various ways that plants and animals fossilize. (See Background information on fossilization.)

Facilitating the activity

1. *Divide students into groups. Each student will "make" his or her own "fossil" but it will be easier to dispense the sediments (plaster of Paris, sand, and pebbles), if the students are in a group.*
2. *Give each student a spoon and a cup. Give each group one bowl per sediment. Have students write their names on the bottom of their cup.*
3. *Have one student per group come up a fill their bowl with sand and pebbles (they don't need much perhaps a few pebbles per student and tablespoon of sand per student.) They will need more plaster of Paris and may have to come back for additional material.*
4. Tell the students to add a ¼ inch think layer of plaster of Paris on the bottom of their cup. They can add a bit of sand and a pebble or two if they want. Explain to students that it is a model of the ancient lake floor. It is soft, sandy and powdery with perhaps a larger rock

or to in it. The only difference is that it isn't wet. This will be the final resting place of our shellfish. *Place the shells in this mixture*. *Before putting shell in plaster of Paris make sure to coat it with talcum powder or petroleum jelly, which will make it easier to get out.*

5. *Have students pour a small amount of water onto the layer of plaster of Paris and the shell.* (The water should cover the shell by about a ½ inch. Explain that adding water reminds us that this is a model of the ancient lake. Earlier we talked a bit about what happens after this animal died. Let's think a little more about animals after they die. If there is too much water, that is okay, as the plaster will absorb only as much as it needs: the remaining water can be poured off after the plaster hardens.)
   - ⇒ What are some things that could happen to them? (After they died, the animals could have been exposed to tides, bacterial decomposers, predators, and scavengers, such that just a tiny percentage of the plants and animals that lived made it to the point where they could be fossilized.)
   - ⇒ What part of the animal do you think has the best chance of being fossilized? Think about animals other than ones in shells. (Consider the different parts of the body. Teeth are the hardest part of the vertebrate body and thus are more likely to fossilize than bones. Soft parts rarely fossilize. Bigger bones have a better chance to fossilize than smaller ones.)
6. *Tell the students to use their spoon to sift plaster, sand, and pebbles into the cups, allowing the materials to sink in and cover the shells*. Explain that sand and other sediments would eventually cover those very few animal and plant bodies that remained. Later some sort of cement would mix into the sediments and the remains would begin to fossilize.
7. *Continue to add sediments until a soft mud is formed.* Keep adding the plaster until all of the water is soaked up. The plaster will now dry fairly quickly. Plaster of Paris sets up in about 30 minutes and will only absorb enough water as is needed. Some water may be on top of the plaster after it hardens.
8. Explain that over time, the ancient lake became shallower and shallower. Plants and animals continued to die and built up many layers of fossils. And then the lake began to fill in with sediment and became more of a swamp or marsh than a lake.
9. Explain that fossilization is a long slow process. It takes many thousands or millions of years for a fossil to form. Eventually, the rock and the fossils get exposed at the surface and sometime later may be discovered by someone.
10. *Allow the plaster to dry*.

Assessment

This would be a good time to take stock of what the students have learned. If you have access to some modern bones or shells, you might bring those in and get the students to talk about which ones are fossils and which aren't. Whether or not you have this material available the following series of questions are some you might consider asking.

- ⇒ What is a fossil? Why do so few plants and animals fossilize? (Most remains are eaten, decomposed, or broken up.)
- ⇒ What parts of an animal are most likely to fossilize?
- ⇒ What conditions are best for fossilization? (Area of sediment accumulation, such as a body of water.) Would a volcano be a good area? (No, lava doesn't preserve fossils.)

⇒ What about a river? (Big bones often accumulate on the insides of river bends where the water slows down. Or some animal might leave tracks in the wet mud.)

Part 2: The Fossil Hunt

When the plaster has set up (30-60 minutes) you may begin the excavation process, but you might want to leave it for a few days or weeks. This would allow students to forget which fossil is in which particular location. That will help make the process of the fossil hunt even more realistic.

After the students have successfully completed their cleaning and identification, set up a "museum" to show off their work. As "fossils" are taken home, helping the students to set up their personal "fossil" collections is particularly important. Collecting boxes are easy to come by and not expensive. Student labels can be fixed to the box and the "fossil" cradled on felt or cotton batting for protection from sliding or bumping on the sides of the box. This last "collector's" step is important closure for the process, but is also the best inspiration for a lifetime of collecting.

Materials

For each student:

- Prepared plaster of Paris "rock" containing fossil specimens (from Part 1 of the activity)

For each group:

From the box:

- Magnifying lens: If possible these should be mounted so the hands can stay free and working while looking through the magnifiers at the fossil being removed

Teachers will need to provide from their own supplies:

- "Chisels": a metal butter knife or small screw driver set (ranging in size from a tiny eyeglasses screwdriver to about an eighth of an inch)
- Small bottle of vinegar with an eyedropper (optional)
- Clear nail polish (optional)

Set up

Before the lesson, remove the solid plaster of Paris from the aluminum tray. Have enough tools set up so a group of four students can share a complete set.

Introducing the activity

1. Explain to the students that if they have ever been to a museum, they have probably mostly seen beautiful fossil specimens. Is that how the fossils are found in the field? Do you think it's easy to find fossils? (In some cases this answer might be yes.) You might ask them reasons they think that it would be hard to find a fossil. (It's the wrong rock type; don't have the rocks of the right age (for example, there are no dinosaurs in Washington, mostly because there are no terrestrial rocks from when dinosaurs lived); erosion has removed or damaged specimens; the rock is on private land.) Ask the students if they have found fossils in the field and what they looked like then.

Only very rarely were fossils found in the field as they are displayed in a museum. More often than not, the fossils are encased in stone, which has to be removed very carefully. For example, the first paleontologist to find a *Tyrannosaurus rex* had to use dynamite to remove parts of the fossils. After the *T. rex* died it had settled in a very fine-grained mud, which formed a tight bond to the bones. Bones may also be scattered, broken, eaten by scavengers, or decomposed.

2. Explain that the specimen in front of them is ready for the painstaking process of removing a fossil from it. Paleontologists often protect specimens collected in the field in a jacket made of plaster of Paris and burlap. Sometimes these jackets can weigh several tons. We won't be working with such a large specimen but we will be working with specimens you made several weeks ago. This will give you an idea of how specimens are prepared in the lab. Since the fossil could be fragile and easily damaged, we need to do this with a great deal of care. The slightest misplaced or misapplied force could ruin the fossil we are trying to expose.

3. Explain that when paleontologists are working at a dig site, they might see just a small part of a fossil sticking out of the rock formation or even just an impression above the ground that would lead them to suspect a fossil was contained in the rock at that location. The first step of the fossil hunt is to decide where the fossil might be hiding. Look at your rock to see if there are any bumps or ridges that might indicate a fossil burial. Allow students time to decide where the fossil could be hidden beneath the surface. Help them use a pencil to outline the area. Bumps or irregularities in the surface of the rock are typical clues.

4. Explain that once the students have decided where they want to start their dig and have marked it with a pencil, they can use a metal butter knife or scraper to gently scrape off the top layer of rock just outside the pencil lines. As you work, you may begin to see the edges of the fossil. Carefully scrape around the edges until you think you have a good outline of the fossil. It will take some time for the fossil to reveal itself. It is important for students to remove the matrix a little at a time using a scraping technique. In this exercise, you won't need to use any chipping with hammers. The fossil may stay embedded in the rock matrix. Use the matrix as a sort of ready-made stand. If the students do plan on using the matrix as a sort of display stand, they the student should clean a neat "trough" around the edges of the fossil and then clean the surface. Alternatively, the student can work at removing the fossil entirely. This may take a bit longer, but it will also give the opportunity to try some additional techniques for removal.

5. Tell students that another technique uses a brush to gently remove the "rock" that is covering the "fossil". If some of the rock is thick they can carefully scrape at it with a chisel. Be extra careful, though, because they could chisel off a part of the fossil. Students will continue working to remove the rock around the fossil. The following suggestions imitate the work of paleontologists in labs.

6. Tell students that if the fossil is tightly embedded and scraping away the matrix seems too great of a challenge, they can use a mild acid solution to help dissolve the matrix away. In the lab, paleontologists, protect the exposed parts of the fossil from the acid by painting it

with special glue. Students can imitate this process by using vinegar drops on the matrix around the fossil. Since vinegar is very mild, they can even use it right on the fossil to remove excess matrix. Once most of the fossil is cleaned, you can have the students coat the fossil with clear nail polish to imitate the protective glue coating.

7. Tell students that the last step to completing their fossil hunt is to note the type of fossil, date of acquisition or discovery, and the location. Once their fossil is cleaned and ready for display, make a small information card that shares the name of the fossil, the geologic time period and the location where it was found.

Assessment

- Ask students if they have been to a museum and seen fossils. Did they originally think that fossils came out of the ground looking like the ones in museum? Do they still think this?
- Ask them why they think it's important to show cleaned up specimens in this situation.
- Ask them to research a fossil and see if they can find out its path from field to museum.

Adapted from www.fossils-facts-and-finds.com

Part 3: Fossils in the Field

This activity takes what the students learned in the first two parts and applies it to real fossil situations. They will be given five different paleoenvironments and work together to figure out if and how fossils could have formed.

Materials
For each student:
From the box:

- Handouts of five (5) different Paleoenvironments for students

Introducing the activity
1. Ask the students to review how something gets fossilized.
2. Ask the students to form teams. They will be working together.

Facilitating the activity

1. Tell the student teams that they are going to be given a scenario in which they have to imagine how a plant or animal or group of plants or animals became a fossil and was found by a modern day paleontologist. They also have to speculate on how/why some plant or animal or group of plants or animals might not have become (a) fossil(s) and how it/they might not have been discovered. Remind them that the overwhelming majority of individuals are not fossilized.

2. Hand out one of following five descriptions: (More details are included in the Teacher background.)
   a. A rhinoceros-like animal lives on plains near volcanic activity
   b. A variety of invertebrates live at the bottom of shallow, warm sea
   c. Hordes of fishes live in a large, shallow lake
   d. Horse, camels and pig-like beasts live in a savannah-like environment
   e. Forests of conifers and ferns grow in a floodplain

3. Have students take their scenario and create one situation where the animals or plants are fossilized and one in which they aren't fossilized. Have them either illustrate the successful fossilization process in cartoon format or write a description of the process. The questions on each environment page should help guide them through the fossilization process.

Assessment

- Ask the student groups to describe the environments they studied and to review how the plant or animal could or could not be fossilized. What surprised them about fossil formation in their particular environment?
- Ask the students to think about what they can learn from a cast versus a mold versus a permineralized bone versus a trace fossil. What can they learn from fossils such as those found in amber or tar?
- Ask the students to think about what paleontologists can learn about paleoenvironments from fossils. For example, in the Burgess Shale there is a fossil of

a trilobite with a bite taken out it, which paleontologists hypothesize was from a large predator known as *Anomalocaris*.
- Given what they have learned about how fossils form, ask students where would they go to search for fossils?

Going further
- Students could research additional Montana state fossils and trace their paths from life to fossilization to discovery.
- Students could try to find out where the closest fossils are to the school.
- They could investigate building stones to see if they can find buildings that have fossils in them.

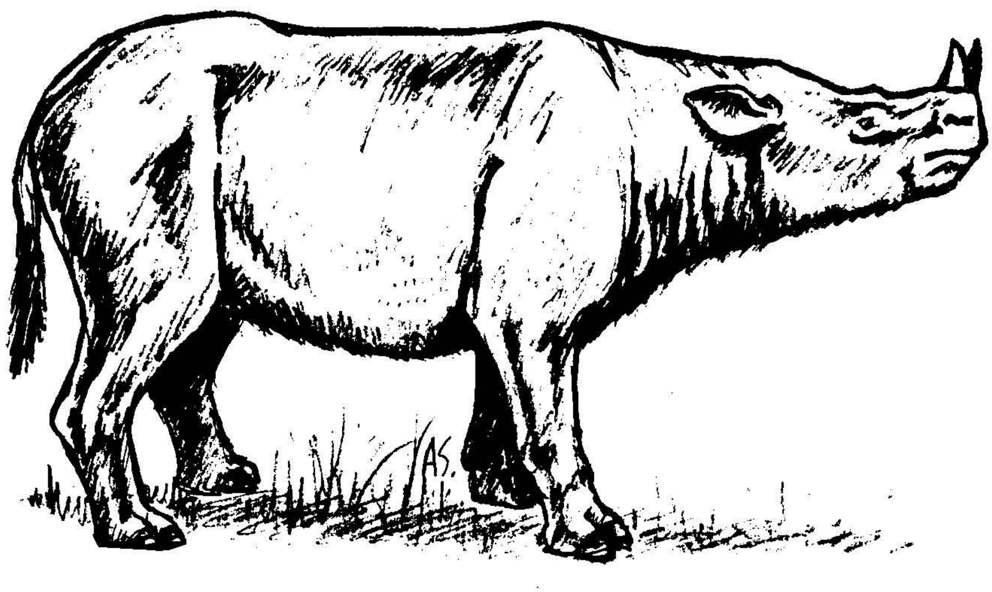
References
Additional information on Montana fossils (at least dinosaurs) can be found here: mtdinotrail.org

Teaching standards
Science Content Standard 4. Students, through the inquiry process, demonstrate knowledge of the composition, structures, processes and interactions of Earth's systems and other objects in space.
Benchmark Grade 4, Number 3 -Use fossils to describe the geological timeline, investigate fossils and make inferences about life, the plants, animals, and the environment at that time

A. Define a fossil as physical evidence of past life
B. Identify body fossils as those that contain plant and animal remains
C. Identify trace fossils as those that record an impression of past life
D. Explain how body and trace fossils are formed
E. Compare a fossil to a plant/animal living today F. Infer what fossils tell us about past life and the environment.

Glossary
- Cast - A replica of the original organism made when a mold is re-filled by sediment.
- Fossil - Remains, imprints or traces of an ancient organism that have been preserved in the rock record. Bones, shells, casts, tracks and excrement can all become fossils.
- Mold - An impression of the organism, which can record either the external or the internal structures of an organism.
- Trace fossils - Evidence of an animal’s activity, such as tracks, burrows, eggs, coprolites, and borings.

Paleoenvironment 1



Rhinoceros near basalt flows — 15 million years ago
Drawing used courtesy of artist Arn Slettebak

For millions of years, lava erupted out of vents in eastern Washington. The lava flowed across the landscape at about 3 mph. Roughly 15 million years ago, a rhinoceros-like animal lived in this landscape of basaltic lava, lakes, and trees. Pollen studies show that elm, alder, cypress, willow and cattails grew in the area. The climate was warm, temperate, and moist.

1. Could this rhinoceros have been fossilized? Why?

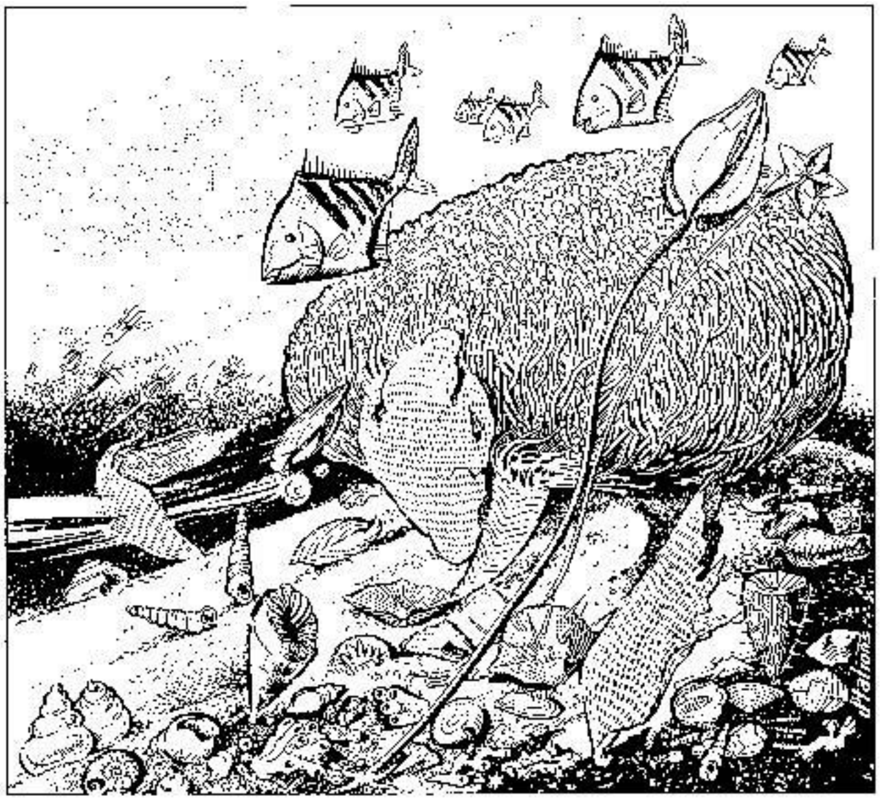
2. What clues do you get from the plants, such as the willows and cattails that lived near the rhino?

3. If so, would it be likely to preserve the bones and teeth, or do you think only a mold would have been preserved?

4. If so, do you think that a rhinoceros preserved in basalt (hardened lava) is unusual in the fossil record?

5. If not, why wouldn't the rhinoceros have survived?

Paleoenvironment 2



Shallow Tropical Sea — 330 million years ago

From www.indiana.edu/~librcsd/etext/hoosier/DS-04.html

Between 300 and 330 million years ago, a quiet, tropical sea spread across an area that would become the Midwest. Like the Bahamas, where modern limestone is forming, the sea was warm, clear and shallow. The warm waters supported a diverse range of swimming, crawling and bottom-dwelling invertebrates.

1. Do you think these sea creatures were fossilized?

2. If so, do you think the fossils are molds or did something else happen, such as minerals replacing the bone and producing an more or less exact copy of the bone?

3. Any guess what color the fossils might be?

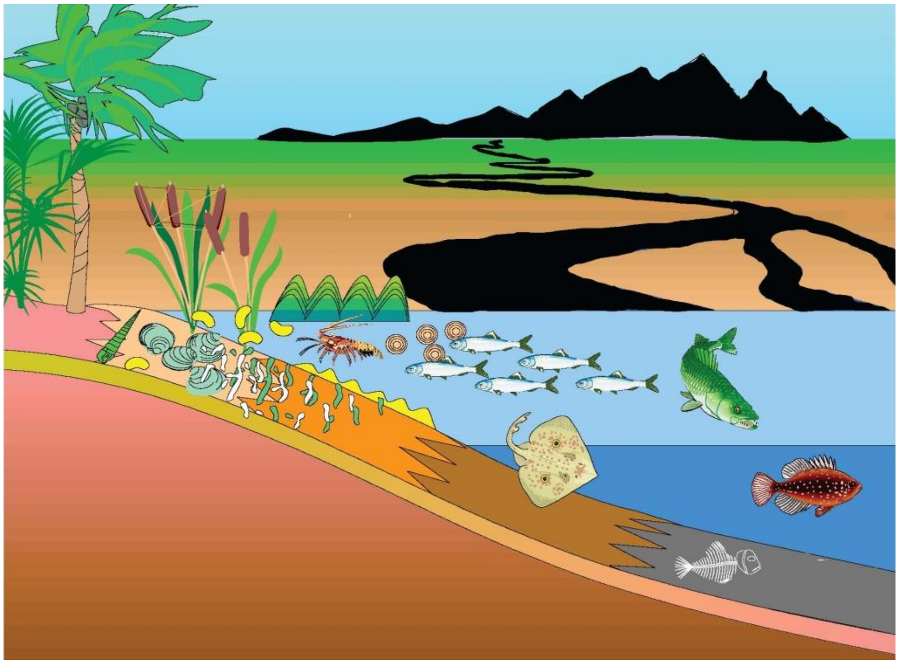
4. Are they whole or broken?

5. Which were more likely to fossilize — shells or fishes?

6. Any guess what the species are in this drawing?

7. If they did not fossilize, what happened?

Paleoenvironment 3



Shallow Lake — 50 million years ago
Drawing used courtesy Paul Buchheim

Fifty million years ago, Fossil Lake was 50 miles long and 20 miles wide at its maximum. It covered part of Wyoming, but unlike modern Wyoming the climate was subtropical with forests of palms, figs and cypress. Willows, beeches, oaks, and ferns grew on the lower slopes of mountains that rose near the water. The warm lake supported 25 kinds of fish, insects, crocodiles, turtles, birds and dog-sized horses.

1. Did any of these species fossilize?

2. Did the volcanoes in the background play any role?

3. What about the stream flowing into the lake?

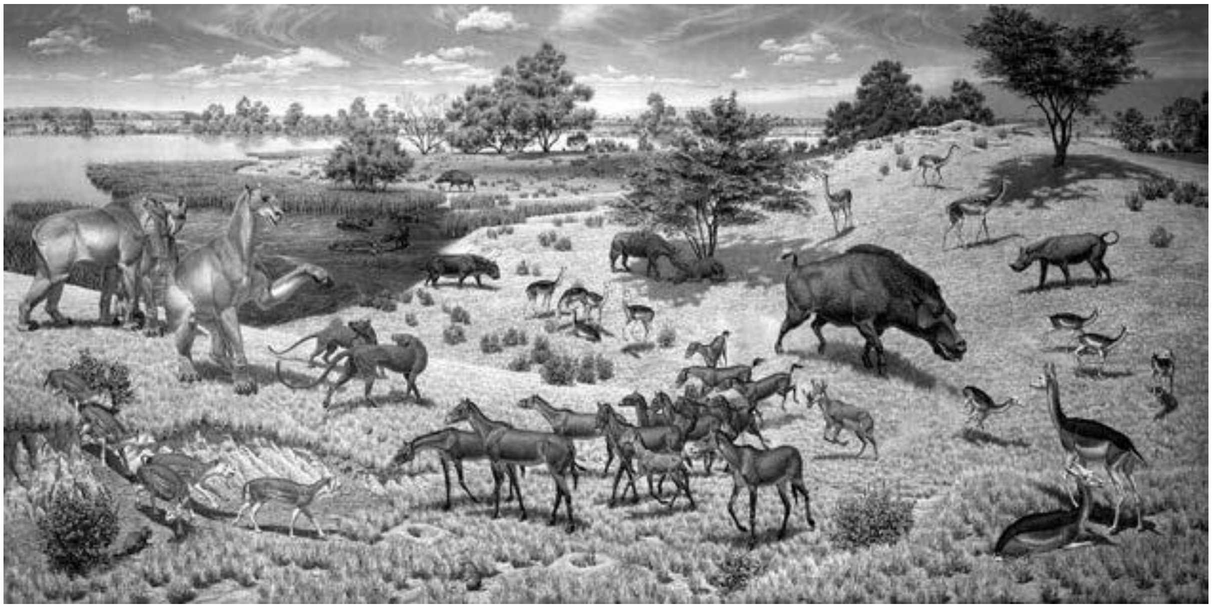
4. Do you think it made a difference that the climate was warm?

5. If fossils formed, would paleontologists find anything beside bones, such as skin or internal organs?

6. Do you think the fossils show good details or not?

7. Why wouldn't a plant or animal fossilize?

Paleoenvironment 4



Savannah Teeming with Animals — 20 million years ago
Drawing courtesy of the Smithsonian Institution

About 21 million years ago the plains of western Nebraska looked much like the modern-day Serengeti, with extensive grasslands dotted with trees through which great herds of grass- and leaf-eating animals wandered. Carnivores stalked the herds and small mammals burrowed in the rich soils.

1. Did all of these animals fossilize?

2. Could every single individual of a particular species be preserved?

3. Did climate make a difference in fossilization?

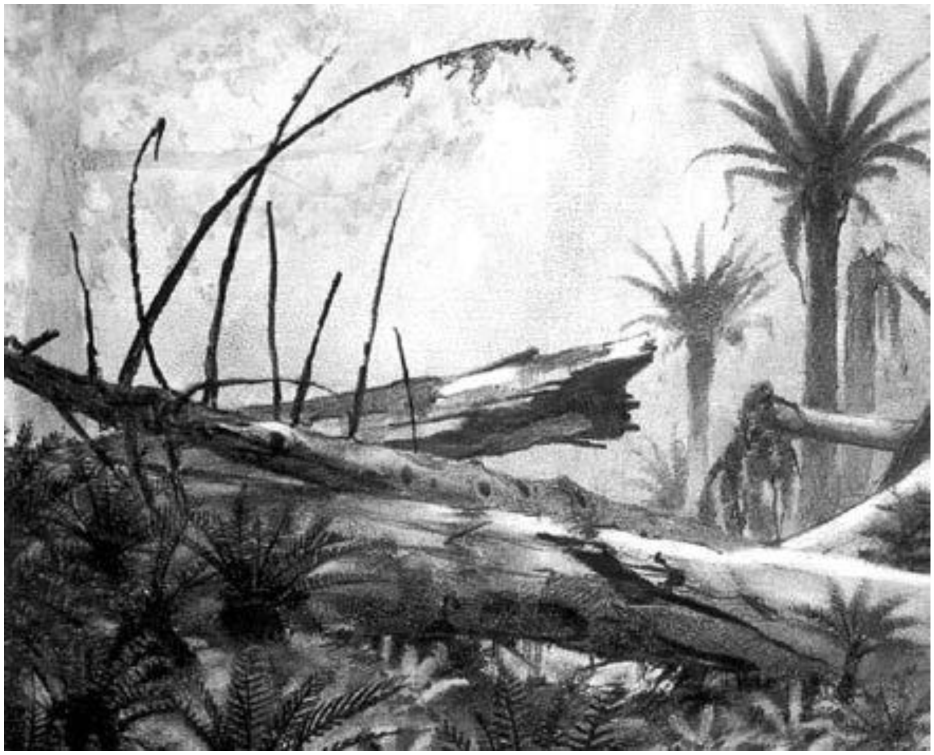
4. Did the size of the animal make a difference in fossilization?

5. How did they fossilize?

6. If they fossilized, were the fossils casts, molds or the bones themselves?

7. Do you think there were great accumulations of fossils or just a few bones here and there?

Paleoenvironment 5



Forest of trees — 225 million years ago
Drawing used courtesy of Petrified Forest Museum Association and artist Doug Henderson

About 225 million years ago, northeastern Arizona was located near the equator. A lush landscape with coniferous trees grew in a large basin with numerous rivers and streams flowing through the lowland. Volcanoes to the west spewed ash, which washed into the basin. When the trees died, rivers and streams carried the trees downstream. Many tree trunks came to rest on the river banks and others were buried in the stream channel.

1. What was fossilized in this environment?

2. Do you think that there are great accumulations of the fossils or just a few plants here and there?

3. How did the fossils form?

4. Do you think the ash, which is made of silica (quartz) and could be dissolved by the water, was important to the fossilization process?

5. Do you think it is unusual for plants to be fossilized?

6. How else are plants fossilized?

Background and Answer Key to Paleoenviroments

Paleoenvironment 1: Blue Lake Rhino

In 1935, a group of hikers discovered one of Washington's most famous fossils near Blue Lake, a few miles south of Dry Falls in eastern Washington. The Blue Lake rhino fossil includes a few bone fragments and partial jaw found near a natural mold of the creature formed when the dead rhino was engulfed by a lava flow. The mold is preserved in pillow basalt overlying a thin sand bed. The rhino probably lay dead in a small pond when lava flowed into the water and hardened, forming a mold around the bloated body.

In the late 1940s a crew from the University of California at Berkeley made a cast of the interior of the mold using jellied soap to coat the interior of the mold, then making sector casts of plaster, which were removed through the tail orifice and reconstructed. The animal was on its back, feet outstretched to the sky, when it died. A copy of this mold of the Blue Lake Rhino is at the Burke Museum.

This example was chosen because it is a particularly spectacular example of a fossil mold. It is also unique. There is no other mold like this and thus it does not illustrate the typical mold process, which is described above. This is a key point to make for the students.

For those interested in more information about the Blue Lake Rhino, please consult: Kaler, Keith L., 1988. "The Blue Lake rhinoceros." *Washington Geologic Newsletter* 16(4): 3-8

Answers to questions asked of students on Paleoenvironment 1 handout

1. Could this rhinoceros have been fossilized? **Yes**
2. What clues do you get from the plants, such as the willows and cattails that lived near the rhino? **These plants indicate the presence of permanent water, which is what led to the preservation of the rhino.**
3. If so, would it be likely to preserve the bones and teeth, or do you think only a mold would have been preserved? **A few bones and teeth did fossilize.**
4. If so, do you think that a rhinoceros preserved in basalt (hardened lava) is unusual in the fossil record? **Yes.**
5. If not, why wouldn't the rhinoceros have survived? **Basalt would have burned the rhino carcass beyond the point of preservation, which is why it is so extremely rare to see a fossil preserved in an igneous rock,**

Paleoenvironment 2: Salem Limestone, Indiana

Deposition of the Salem Limestone occurred 300 to 330 million years ago in a quiet, tropical sea that spread across an area that would become the Midwest. Like the Bahamas, where modern limestone is forming, the sea was warm, clear and shallow. The warm waters supported a diverse range of swimming, crawling and bottom-dwelling invertebrates. When they died, their bodies collected in a watery cemetery on the sea floor, eventually being covered by limy muds that precipitated from the sea water. The entire mass solidified into a 40-to-100-foot-thick limestone menagerie.

Crinoid stems, 3-10mm wide discs, are the next most common recognizable fossil. Crinoid were small invertebrates related to starfish, sand dollars and sea urchins. They resembled plants with a base attached to the substrate, a stem of varying length, and a flower-like top. The stems look like a stack of poker chips. Another important fossil is from a colonial animal known as a bryozoan. These sedentary animals formed communities that resembled a mass amalgamation of Rice Chex cereal. Only bits and pieces of their fragile homes remain. Careful investigation of the Salem Limestone reveals a hodge-podge of other miniature fossils, including half-inch-long snails, oysters, clams and scallops.

Quarrying began in the early 1800s. The Salem Limestone is one of the most commonly used building stones in the United States. Fossil-rich structures include the Empire State Building, Grand Central Station, Holocaust Memorial Museum, and San Francisco City Hall. In Seattle, the Seattle Times building, Rainier Club, and new Seattle Art Museum incorporate Salem building blocks.

Detailed information about this site is available at the following Web sites.
igs.indiana.edu/geology/structure/compendium/html/comp3mzo.cfm
www.indiana.edu/~librcsd/etext/hoosier/DS-04.html

Answers to questions asked of students on Paleoenvironment 2 handout
1. Do you think these sea creatures were fossilized? **Yes**.
2. If so, do you think the fossils are molds or did something else happen, such as such as minerals replacing the bone and producing a more or less exact copy of the bone? **Mineral replaced the bones.**
3. Any guess what color the fossils might be? **White, usual color of calcium carbonate.**
4. Are they whole or broken? **Both, but mostly broken. Think of shells on a beach where waves break them.**
5. Which were more likely to fossilize — shells or fish? **Mostly shells. Fish too fragile.**
6. Any guess what the species are in this drawing? **Corals, brachiopods, crinoids, snails, etc.**
7. If they did not fossilize, what happened? **Possible scenarios for non-fossilization or not being found: Wave action could have broken up the shells beyond recognition. A scavenger could have eaten the plant or animal. The chemistry in sea environment in which the plants and animals died could have been altered by an outside environmental event, which prevented fossilization. After fossilization, the rock unit that contained the fossils could have been eroded away or could still be buried so that a paleontologist couldn't find the fossil.**

Paleoenvironment 3: Fossil Buttes National Monument

Fifty million years ago, three large lakes covered Wyoming, Colorado, and Utah. The smallest, now called "Fossil Lake", was 50 miles long and 20 miles wide at its maximum. Unlike modern Wyoming, the climate was subtropical with verdant forests of palms, figs and cypress. Willows, beeches, oaks, maples and ferns grew on the lower slopes of mountains that rose near the water. The warm lake waters supported 25 kinds of fish, insects, crocodiles and turtles, birds and dog-sized horses.

When the animals died, many settled to the bottom of the lake. Over time, a constant rain of calcium carbonate, which precipitated out of the water, dropped to the bottom of the lake and covered the fossils in layer after layer of fine grains. Although the lake once covered 1,000 square miles, the richest fossil beds only cover about 15 square miles. More rich fossil beds may be buried, but that is all that are exposed on the surface today.

The great 19th-century paleontologist Edward Drinker Cope was one of the first to excavate at Fossil Buttes. He worked there in the 1870s.

Additional information about this site is available at the following Web site.
nps.gov/fobu/expanded/fos.htm

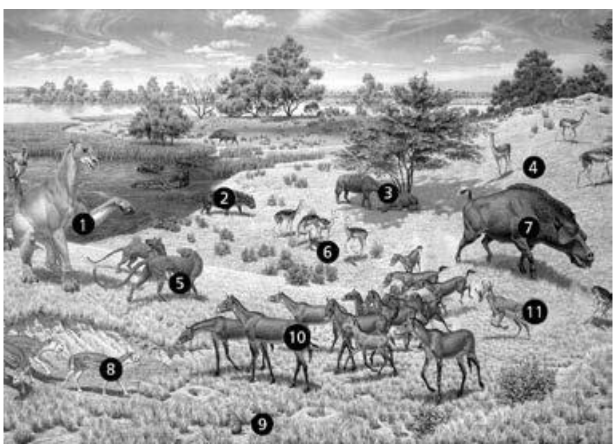
Answers to questions asked of students on Paleoenvironment 3 handout
1. Did any of these species fossilize? **Yes**.
2. Did the volcanoes in the background play any role? **Yes, ash could have altered chemistry of water flowing into lake, which facilitated the formation of cement to bind sediments into a stone.**

3. What about the stream flowing into the lake? **Yes, altered chemistry of lake, which induced the calcium carbonate to precipitate out.**
4. Do you think it made a difference that the climate was warm? **Warm environment led to more evaporation of water and precipitation of calcium carbonate.**
5. If they did fossilize, do paleontologists find anything beside bones, such as skin or internal organs? **Mostly just bones; internal organs are extremely rare because they decompose too quickly.**
6. Do you think the fossils show good details or not? **Yes, quiet water at bottom of lake led to less decay and less breakup of bodies. Quiet water also meant that very fine-grained sediments rained down the dead plants and animals, which also helps preserve details.**
7. Why wouldn't a plant or animal fossilize? **A scavenger could have eaten the plant or animal. The chemistry in the lake environment in which the plants and animals died could have been altered by an outside environmental event, which prevented fossilization. After fossilization, the rock unit that contained the fossils could have been eroded away or could still be buried so that a paleontologist couldn't find the fossil.**

Paleoenvironment 4: Agate Fossil Beds National Monument

About 21 million years ago, the plains of western Nebraska looked much like the modern-day Serengeti, with extensive grasslands dotted with trees through which great herds of grass- and leaf-eating animals wandered. Carnivores stalked the herds and small mammals burrowed in the rich soils. A wide river flowed through the area, creating watering holes and sand bars. A prolonged drought hit, killing hundreds to thousands of animals. When the rains returned, they filled the river beds and carried hundreds of bones to a backwater or lake. Over time the skeletons were buried under silt, fine sand and volcanic ash, carried by the wind and reworked by streams. A large fossilized waterhole with hundreds of skeletons is preserved today in the Niobrara River valley at Agate Fossil Beds National Monument.

The first excavations at the Agate Fossil Beds took place in the summer of 1904. Paleontologists from the Carnegie Museum at Pittsburgh discovered a rich quarry, containing a type of rhinoceros that was new to science. During a bigger dig in 1909, the Carnegie Museum removed at least 40 skeletons. The American Museum of Natural History began collecting the following year and continued for about 20 years.



Key to drawing (species names)
1. *Moropus*
2. *Merycochoerus*
3. *Menoceras*
4. *Oxydactylus*
5. *Daphaenodon*
6. *Stenomylus*
7. *Dinohyus*
8. *Merychyus*
9. *Palaeocastor*
10. *Parahippus*
11. *Syndyoceras*

Detailed information about this site is available at the following Web sites.
www.npwrc.usgs.gov/resource/1998/agate/agate.htm
nps.gov/agfo/

Answers to questions asked of students on Paleoenvironment 4 handout
1. Did all of these animals fossilize? **No. Some were eaten. Some decomposed. Some were washed away.**

2. Could every single individual of a particular species be preserved? **No, same reasons as above.**
3. Did climate make a difference in fossilization? **Yes, cycle of dry and wet key to preserving lots of animals. If climate had been consistent, probably would have gotten fossil formation but not such diversity or volume.**
4. Did size of animal make a difference in fossilization? **Yes, bigger skeletons would not travel as far and would be less susceptible to break up.**
5. How did they fossilize? **Permineralization.**
6. If they fossilized, were the fossils casts, molds or the bones themselves? **Bones.**
7. Do you think there were great accumulations of fossils or just a few bones here and there? **Great accumulations, most likely due to lots of animals and streams carrying the fossils away and depositing them in a single location.**

Paleoenvironment 5: Petrified Forest National Park

About 225 million years ago, northeastern Arizona was located near the equator. A lush landscape with coniferous trees grew in a large basin with numerous rivers and streams flowing through the lowland. Volcanoes to the west spewed ash, which washed into the basin. When the trees died, rivers and streams carried the trees downstream. Many tree trunks came to rest on the river banks and others were buried in the stream channel. Some were buried by sediments before they could decompose. Ground water dissolved silica from the volcanic ash and carried it through the logs. This solution filled the cells and sometimes replaced the cell walls, a process called permineralization.

U.S. Army mappers found the petrified wood in the mid-1800s. Unfortunately, visitors soon started to remove vast quantities of the beautiful and interesting wood specimens. Naturalist John Muir, who spent time in the area, called for creation of a national park to protect the petrified wood and, in 1906, President Theodore Roosevelt made it into the 2nd National Monument.

Detailed information about this site is available at the following Web sites.
petrified.forest.national-park.com/info.htm#his
www.shannontech.com/ParkVision/PetForest/PetForest.html#parkhistory

Answers to questions asked of students on Paleoenvironment 5 handout
1. What was fossilized in this environment? **Plants and animals.**
2. Do you think there are great accumulations of the fossils or just a few plants here and there? **Great accumulations of plants, due to great quantities to begin with and due to rivers carrying remains to one spot, such as a river bend or onto a flood plain.**
3. How did the fossils form? **Permineralization**.
4. Do you think the ash, which is made of silica (quartz) and could be dissolved by the water, was important to the fossilization process? **Very important. It provided the material in the ground water that replaced the tree cells.**
5. Do you think it is unusual for plants to be fossilized? **No**.
6. How else are plants fossilized? **Examples include settling in a lake bed, falling into amber, being covered by ash or to make molds and casts.**