How does a footprint become a fossil?

Teaching and Learning Focus

Before conducting this investigation, students should have learned about body fossils. In this investigation, students examine trace fossils, which are physical evidence of the life activities of now vanished organisms. Trace fossils include tracks, trails, burrows, feeding marks, and resting marks. For example, the footprints left by dinosaurs along an ancient river or the hollow tubes created by worms burrowing in soft mud in an ancient ocean. There are more trace fossils than body fossils because one organism can leave many traces (e.g. footprints), but only one set of hard parts (e.g. bones) to become a fossil.

Most trace fossils form in soft mud or sand near a body of water. The imprints left by the organisms were quickly covered by sediment. The sediment dried and hardened before the imprints could be erased by water or wind. The sediment was then buried under more sediment and became compacted and cemented together to form rock. This process is much the same as the formation of body fossils.

In this investigation, students model the formation of a trace fossil. Using 9laster of Paris and small plastic dinosaurs, they make a series of dinosaur foot tracks (forming a mold). After the Plaster of Paris has dried, they paint it to look more realistic. They cover it with non-stick cooking spray and then with a new layer of plaster (forming a cast). After the new layer has dried, groups exchange their plaster pieces. They split the two sections apart and examine the fossil footprints inside. They examine the footprints for information about what the dinosaurs that created them were like.

Materials Needed

Per group:

- plaster of Paris
- plastic measuring spoons
- stirring sticks
- water
- milk carton (with the top portion cut off)
- two measuring cups
- non-stick cooking spray
- brown paint
- paint brush
- plastic dinosaur models
- safety impact goggles for each student
- blunt knives

For the instructor:

- flip chart or whiteboard and markers
- Images of Footprints

Safety

Use disposable craft sticks for mixing the plaster of Paris. Be sure that you, and not your students, mix the plaster of Paris. Do not pour unused portions of Plaster of Pairs, or water mixed with plaster of Paris into the sink or drain. Dispose of them in the trash instead. Students should wear safety impact goggles when cracking the Plaster of Paris. Review the investigation for your specific setting, materials, students, and conventional safety precautions.

Setting the Scene

Many students will not think of ancient tracks, trails, burrows, feeding marks, and resting marks preserved in rock as fossils. Begin the investigation by introducing students to the notion that animals can leave trace marks in sediment and information can be derived from those marks. Show students the Images of Footprints.

Ask them the following:

1. What do you see in the pictures?
2. What may have made the imprints in the sand or mud?

Have students discuss these questions, first in pairs, then groups and then as a whole class. Record their answers on a flipchart that you can refer to throughout the investigation.

Presenting the Investigation Question

Introduce your students to the investigation question: *"How does a footprint become a fossil?"* Have students discuss the question in pairs, then in groups, and then as a whole class. Record their answers on a flipchart.

Have students brainstorm ideas about how this investigation question could be investigated.

1. What materials would you need?
2. What would you have to do?
3. What would you measure?
4. How long would the experiment take?

Tell students that they will be investigating this question and at the end of their study they will be able to provide reliable answers.

Assessing What Your Students Already Know

Here are some questions that your students can discuss, in pairs, then in groups:

1. If a footprint is made by an animal in sediment, such as sand, and the sediment turns to rock, what do you think would happen to the footprint?
2. What can the footprints left behind by an animal tell you about what the animal was like?

Have your students share their ideas with the class and record them as a list on a flipchart. Ask students the following: *"What would you like to learn about how a footprint becomes a fossil?"*

Record their ideas on the flipchart as a list called "Questions we have about how a footprint becomes a fossil." This list will provide further insights into what your students know, and also what they would like to know. By the end of the investigation, some of these questions will probably be answered.

Exploring the Concept

1. Explain to students that they will be making fossilized dinosaur footprints using Plaster of Paris and model dinosaurs. Each group will receive one or more dinosaurs. Groups should try not to let other groups see what their dinosaur(s) looks like.
2. Have students pour one cup of pre-mixed plaster of Paris in the bottom portion of a milk carton. They should add more water, if necessary, to make a soupy mixture.
3. Students then let the plaster set until it is almost hard. The time will vary from a few minutes to 10 minutes.
4. Instruct students to spray the feet of their plastic model dinosaurs with cooking spray. They will be putting the feet in the plaster, and the cooking spray prevents the plaster from sticking to the plastic.
5. When ready, have students press the feet into the plaster, creating footprints. They should make more footprints to give the impression that the dinosaur was walking. If they have more than one dinosaur, they can make multiple track ways.
6. After students have made their track ways, let the plaster dry. After it has dried, they can paint the plaster brown to make a more realistic-looking fossil.
7. After the paint has dried, have students spray the tops of the samples with non-stick cooking spray. They then cover the samples with a new layer of Plaster of Paris. Ask students the following:
    - How do you think the way in which footprints become fossils is similar to the way in which you created footprints with the plaster?
    - How might it be different?

8. After the plaster has dried, students exchange their plaster pieces with those of another group. Wearing goggles, students should use the blunt knives to split the sections apart (or you can do this yourself) and examine the fossil footprints inside. Have students consider the following questions in their examination:
    - How many types of dinosaurs made tracks?
    - How many legs did each dinosaur have?
    - What kind of feet did each dinosaur have? Are they all the same?
    - How can you tell the direction each dinosaur was walking?
    - If there are more than one set of tracks, in what order were the tracks made?
    - What information do you know for sure from the footprints?
    - What information is only a guess?
9. Discuss students' findings as a class. Help students to understand that fossil footprints happen when an animal steps into a moist surface, such as the mud or sand along a shoreline. The sediment containing the footprints eventually dries. Once it is dry, it is more resistant to the effects of wind or water. Eventually, a new layer of sediment buries the hardened mud or sand, preserving the footprints. As the sediment becomes compacted and cemented together to form rock, the footprints become fossilized. Help students to also understand that, much as they did, scientists analyze fossil footprints to find out more information about an animal, like how it walked or the shape of its feet. Introduce the term "trace fossil" to students. You may want to provide other examples of trace fossils, including trails, burrows, feeding marks, and resting marks.

Applying Students' Understanding

Look again at the Images of Footprints. Discuss the following questions:

1. What can you tell about the size of whatever made the imprints?
2. What does the pattern of the imprints tell you about the behavior of whatever may have made them?
3. Are there any other types of imprints that organisms make that might be fossilized?

Revisiting the Investigation Question

Complete this investigation by asking your students the following:

1. How have your ideas about how a footprint can become a fossil changed as a result of this investigation?

As a result of this investigation, students should be able to state that trace fossils are the remnants of the activities of ancient organisms. Trace fossils include footprints, trails, burrows, feeding marks, and resting marks. Trace fossils provide information about the organism that is not revealed by body fossils. Trace fossils are formed when an organism makes a mark in mud or sand. The sediment dries and hardens. It is covered by a new layer of sediment. As the sediment turns to rock through compaction and cementation, the remnant becomes fossilized.

Digging Deeper

The following passage provides more detailed information related to this investigation that you may choose to explain to your students.

Dinosaurs and Their Tracks

Dinosaurs emerged about 228 million years ago and roamed the Earth for over 160 million years. About 65 million years ago, they vanished from the fossil record. Scientists have come up with many theories as to why the dinosaurs became extinct. A widely accepted theory, based on very strong evidence, suggests that it was due to the impact of an asteroid.

Dinosaurs belong to a group of reptiles known as archosaurs. Modern day archosaurs include crocodiles and birds. An archosaur is defined by an extra hole in the skull, located in front of the eye. Dinosaurs are further defined by a hole in the middle of the pelvis. No other animal on Earth has ever exhibited this feature. The hole in the pelvis allowed dinosaurs to walk with their legs directly beneath them, as opposed to the sprawling stance of other reptiles.

Dinosaur footprint trace fossils have been discovered on all continents except Antarctica. They have been found in layers of sedimentary rock ranging in age from 230 million years ago to 65 million years ago. Paleontologists have learned much about dinosaurs from their footprints, mainly by comparing them with living animals. Mammals are the best modern organisms for comparison because they walk erectly, like the dinosaurs. For example, elephant tracks and Apatosaurus dinosaur tracks are very similar.

Images of Footprints

Credit Line: t Courtesy Nevada Division of State Lands
URL: http://www.lands.nv.gov/policies/policies.htm

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What can fossil footprints tell us?

Teaching and Learning Focus

Trace fossils are useful for paleontologists because they tell about the activity of ancient organisms. For example, the study of dinosaur footprints has contributed significantly to our understanding of dinosaur behavior. In fact, paleontologists have learned much more about dinosaur behavior from footprint trace fossils than from dinosaur body fossils. From many sets of dinosaur footprints or tracks, scientists have learned that some types of dinosaurs traveled in large groups or herds. Sets of tracks have also shown that some herds protected their young by keeping them in the centers of migrating groups. Other tracks show that dinosaurs did not drag their tails when they walked. Paleontologists can also estimate dinosaur gait and speed from some footprint track ways. If the footprints are close together, this might show they were running. If the footprints are spaced farther apart, the dinosaurs may have been walking. These are just a few of the insights that can be gained from studying trace fossils.

In this investigation, students examine an image of multiple fossil footprint tracks. They try to construct an explanation for the events that created the pattern of tracks. Even though students come up with different explanations for the tracks, they see that tracks provide valuable information for dinosaur behavior.

Materials Needed

For the class:

- overhead transparency of the Footprint Puzzle
- blank piece of paper to cover parts of the puzzle when it is put on the projector
- Images of Sauropod Trackways
- overhead projector
- flip chart or whiteboard
- markers

Safety

Review the investigation for your specific setting, materials, students, and conventional safety precautions.

Setting the Scene

In the last investigation, students developed ideas about what dinosaurs were like based on their fossilized footprints. They considered their size, what kind of feet they had, how many legs they had, and how they walked. In this investigation, students

broaden their examination of fossil footprints and consider dinosaur behavior. Begin the investigation by having students reflect on the previous investigation.

1. What did you learn about what dinosaurs were like from their fossil footprints?
2. What kind of information can you get from studying footprints?

Have students discuss these questions, first in pairs, then groups and then as a whole class. Record their answers on a flipchart to refer to throughout the investigation.

Presenting the Investigation question

Introduce students to the investigation question: *"What can fossil footprints tell us?"* Have students discuss the question in pairs, then in groups, and then as a whole class. Record their answers on a flipchart.

Assessing What Your Students Already Know

In the last investigation, students developed ideas about what dinosaurs were like based on their fossilized footprints, but they did not consider dinosaur behavior in their analysis.

Here are some initial questions that your students can discuss, in pairs, then in groups:

1. What can a set of dinosaur footprints tell us about the dinosaurs?
2. What would the footprints of a running dinosaur look like? A walking dinosaur?
3. What dinosaur behaviors could you see in a set of fossilized footprints?

Have students share their ideas with the class and record them as a list on a flipchart. Then ask: *"What would you like to learn about what fossil footprints can tell us?"*

Record their ideas on the flipchart as a list called "Questions we have about what fossil footprints can tell us." This list will provide further insights into what your students know, and also what they would like to know. By the end of the investigation, some of these questions will probably be answered.

Exploring the Concept

1. Explain to students that you will be showing them a drawing of fossilized dinosaur footprints. Their job is to interpret the footprints and try to explain what the dinosaurs may have been doing when the footprints were produced.

2. Put students into groups.
3. Show students Position 1 of the Footprint Puzzle (above) on an overhead projector by covering the other two positions with a blank piece of paper. Explain to students that this is a drawing of fossil footprints that were found in a partially exposed, flat-lying section of ancient rock. Ask groups to consider the following:
    - Can you tell anything about the size of the dinosaurs?
    - Were all the tracks made at the same time?
    - How many animals were there?
    - In what directions did the animals move?
    - Did they change their speed and direction?
    - What may have changed the footprint pattern?
    - What happened to create this set of fossil tracks?
4. Have groups share their ideas with the class and record them as a list on a flipchart. Show students Position 2 of the Footprint Puzzle. Tell them that as more rock was excavated or uncovered by scientists, more footprints were found in the rock. Ask students to consider the following:
    - How does this new information change your ideas about the dinosaurs?
5. Have groups share their ideas with the class and record them as a list on a flipchart.
6. Show students Position 3 of the Footprint Puzzle. Tell them that this last section was discovered with the removal of more layers of rock, soil, and vegetation. Ask students to consider the following:
    - How does this new information change your ideas?
7. Have groups share their ideas with the class and record them as a list on a flipchart.
8. Discuss students' findings as a class. Help students to understand that there are several possible explanations. Perhaps the tracks were made by dinosaurs of different size. The dinosaurs began running, met, and fought. Possibly the bigger dinosaur attacked and ate the smaller one. Another explanation is that the bigger dinosaur was a mother and carried away its smaller offspring. It might also be that the tracks were made at different times: one dinosaur passed by and left, and then the other arrived. The intermingling of the tracks in the middle might just be a coincidence.

Applying Students' Understanding

Show students the Images of Sauropod Trackways. These track ways were made by Sauropod dinosaurs. Ask them to answer the following questions:

1. Describe what you see in the images.
2. What explanation can you give for the many track ways close together? (Sauropod track ways in close proximity indicate that they probably traveled in herds.)

Revisiting the Investigation Question

Complete this investigation by asking your students: *"How have your ideas about what fossil footprints can tell us changed as a result of this investigation?"*

As a result of this investigation, students should be able to recognize that much information can be learned from the fossilized footprints of an ancient organism. This includes not only what the organism was like physically, but also some of its behavior patterns.

Digging Deeper

The following passage provides more detailed information related to this investigation that you may choose to explain to your students.

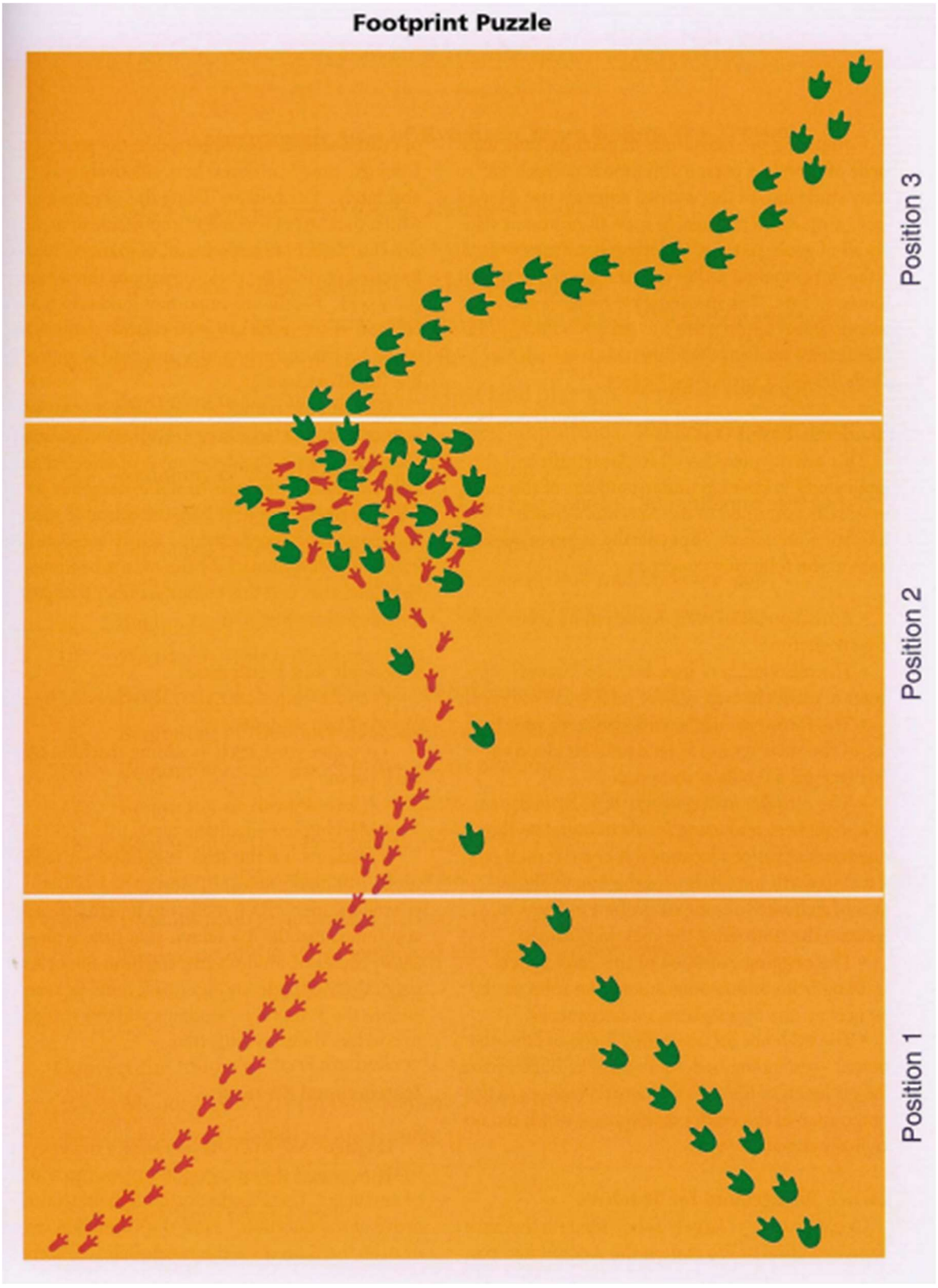
Glen Rose Dinosaur Tracks

In the 1930s, a scientist named Roland T. Bird made a magnificent discovery of dinosaur footprints along the Paluxy River in Glen Rose, Texas. The rock at this location contains two track ways that are parallel to each other and were made by two very different dinosaurs. The first track way shows broad footprints from a Sauropod's back feet, as well as narrower footprints made by its front feet. Scientists estimate that the dinosaur may have been 40 to 50 feet long and weighed 30 tons. A second track way shows three-toed prints made by a smaller Theropod dinosaur. The Theropod, walking on hind legs, was perhaps 30 feet in length. There are no tail-drag marks in the rock, leading scientists to believe that the Sauropod and Theropod held their tails off the ground when walking.

Some scientists believe the footprints document shows an attack sequence between the Theropod and the Sauropod. They think the predator was probably the smaller Theropod and the prey was the larger Sauropod. At first, the Theropod footprints run parallel to the Sauropod footprints, indicating the Theropod was stalking the Sauropod. The Theropod prints then get closer and closer to the Sauropod prints, until the Theropod attacked the Sauropod. Two consecutive right footprints suggest that the Theropod clung to its victim for a short distance, hopping on one leg. After the attack, the tracks indicate the Sauropod dragged its back right foot as if injured.

The tracks were such an incredible find that they were hammered out of the rock and transported by truck and train to a new destination that was less prone to weathering. Today, the tracks are on display in a small building and are maintained by the Texas Natural Science Center. They are considered among the finest examples of dinosaur track ways ever discovered!

Footprint Puzzle



Images of Sauropod Trackways

Credit Line: t © USDA Forstservice, Picketwire Canyonlands Dinosaur Tracksite
URL: http://www.fs.fed.us/r2/psicc/coma/palo/life.shtml

John & Henry from digsfossils.com
http://digsfossils.com/fossils/pics/Colorado_Picketwire_Canyonlands-tracks_in_sunset.jpg

USDA Forstservice, Picketwire Canyonlands Dinosaur Tracksite
URL: http://www.fs.fed.us/r2/psicc/coma/palo/images.shtml