# Fossil Footprints

National Academy Press: **http://bob.nap.edu/html/evolution98/evol6-e.html** and **http://school.discovery.com/lessonplans/programs/continentaldrift/**

## Focus on Inquiry

The student will use the appropriate tools and techniques to record data, make inferences and predict trends in order to understand the theory of continental drift.

## Lesson Overview

In this two-part activity, students observe and interpret "fossil footprint" evidence. From the evidence, they are asked to construct defensible hypotheses or explanations for fictional events. In Part 2, students use actual fossil evidence to determine whether or not they agree with the current theory that one supercontinent divided into two.

| Duration | Setting | Grouping | PTI Inquiry Subskills |
|---|---|---|---|
| 3- 45 minute periods | Classroom | Individually or in Pairs | 3.7, 4.1, 5.3, 5.1, 6.1, 6.2, 7.3 |

| Lesson Components | Estimated Time | Inquiry Subskills Used | Technology Used | Level of Student Engagement | Brief Description |
|---|---|---|---|---|---|
| ***Engage*** | 20 min. | 5.3, 5.1 | Overhead Projector | 2 | Students are presented with footprint tracks covering parts of the United States and are asked to speculate about the origin of these tracks. |
| ***Explore*** | 25 min. | 5.3, 6.1, 6.2 | Overhead Projector | 2 | Students are given more footprint tracks to analyze and determine their origins. |
| ***Explain*** | 30 min. | 4.1, 6.1, 7.3 | None | 2 | Discussion regarding possible explanations for the cause of the tracks, as well as the process in which the students use should ensue. |
| ***Expand*** | 60 min. | 3.7, 5.3 | Computer with Internet Access (Optional) | 3 | Students will research four different fossils and study maps of the continents throughout the Earth's history. |
| ***Evaluate*** | None | None | None | 3 | Evaluation of student understanding using a three-point rubric. |

**Level of Student Engagement**

| | | |
|---|---|---|
| 1 | Low | Listen to lecture, observe the teacher, individual reading, teacher demonstration, teacher-centered instruction |
| 2 | Moderate | Raise questions, lecture with discussion, record data, make predictions, technology interaction with assistance |
| 3 | High | Hands-on activity or inquiry; critique others, draw conclusions, make connections, problem-solve, student-centered |

**National Science Education Standards – Inquiry**

Use the appropriate tools and techniques to gather, analyze, and interpret data.
Develop descriptions, explanations, predictions, and models using evidence.
Recognize and analyze alternative explanations and predictions.

**National Science Education Standards – Earth Science**

Lithospheric plates on the scales of continents and oceans constantly move at rates of centimeters per year in response to movements in the mantle.
Fossils provide important evidence of how life and environmental conditions have changed.

**Louisiana Grade Level Expectations – Inquiry**

Gr. 8, Inquiry GLE#7 – Record observations using methods that complement investigations (e.g., journals, tables, charts) (SI-M-A3)
Gr. 8, Inquiry GLE#10 – Identify the difference between description and explanation (SI-M-A4)
Gr. 8, Inquiry GLE#16 – Use evidence to make inferences and predict trends (SI-M-A5)
Gr. 8, Inquiry GLE#17 – Recognize that there may be more than one way to interpret a given set of data, which can result in alternative scientific explanations and predictions (SI-M-A6)
Gr. 8, Inquiry GLE#18 – Identify faulty reasoning and statements that misinterpret or are not supported by the evidence (SI-M-A6)
Gr. 8, Inquiry GLE#19 – Communicate ideas in a variety of ways (e.g., symbols, illustrations, graphs, charts,

| |
|---|
| spreadsheets, concept maps, oral and written reports, equations) (SI-M-A7)<br>Gr. 8, Inquiry GLE#21 – Distinguish between *observations* and *inferences* (SI-M-A7) |
| **Louisiana Grade Level Expectations Earth Science**<br>Gr. 8, GLE#9 – Explain the historical development of the theories of plate tectonics (ESS-M-A2)<br>Gr. 8, GLE#11 – Illustrate the movements of lithospheric plates as stated in the plate tectonics theory (ESS-M-A2) |

## Materials List (per individual or pair)

- Computers with Internet access (optional, but very helpful)
- Overhead Projector (1 per class)
- Reference materials, including an atlas
- Colored pencils
- Pencils or pens
- Scissors
- Clear adhesive tape

## Advance Preparation

1. Make an overhead transparency of Blackline Master #1 (http://bob.nap.edu/html/evolution98/evol6-e.html)
2. Make student copies of Blackline Masters #2 and #3.

## Other Information

### Objectives

The learner will…

- propose explanations and make predictions based on evidence.
- recognize and analyze alternative explanations and predictions.
- evaluate fossil evidence used by scientists to support the theory of continental drift.

### Prior Knowledge Needed by the Students

- Fossils
- Theory of Continental Drift

### Procedure

***Engage***

**Part 1:**

1. Project position 1 of the footprints from the overhead by covering the other two positions with a blank piece of paper. Tell students that fossil tracks like these are common in parts of New England and in the southwestern United States. Point out to the students that they will be attempting to reconstruct happenings from the geological past by analyzing a set of fossilized tracks. Their problem is similar to that of a detective. They are to form defensible explanations of past events from limited evidence. As more evidence becomes available, their hypotheses must be modified or abandoned. The only clues are the footprints themselves.
   Questions you might consider asking include:
   - Can you tell anything about the size or nature of the organisms?
   - Were all the tracks made at the same time?
   - How many animals were involved?
   - Can you reconstruct a series of events represented by this set of fossil tracks?
2. Have the students discuss each of the questions. Accept any reasonable explanations students offer. Try consistently to point out the difference between what they observe and what they infer. Ask them to suggest evidence that would support their proposed explanations.

***Explore***

1. Reveal the second position of the puzzle and allow time for the students to consider the new information. Students will see that the first explanation may need to be modified and new ones added.

2. Next project the complete puzzle and ask students to interpret what happened. A key point for students to recognize is that any reasonable explanation must be based only on those proposed explanations that still apply when the entire puzzle is projected. Any interpretation that is consistent with all the evidence is acceptable.
3. Should it become necessary to challenge the students' thinking and stimulate the discussion, the following questions may help. Students should give evidence or suggest what they would look for as evidence to support their proposed explanations.
    - In what directions did the animals move?
    - Did they change their speed and direction?
    - What might have changed the footprint pattern?
    - Was the land level or irregular?
    - Was the soil moist or dry on the day these tracks were made?
    - In what kind of rock were the prints made?
    - Were the sediments coarse or fine where the tracks were made?
3. The environment of the track area also should be discussed. If dinosaurs made the tracks, the climate probably was warm and humid. If students propose that some sort of obstruction prevented the animals from seeing each other, this might suggest vegetation. Or perhaps the widened pace might suggest a slope. Speculate on the condition of the surface at the time the footprints were made. What conditions were necessary for their preservation?

***Explain***

1. An imaginative student should be able to propose several possible explanations. One of the most common is that two animals met and fought. No real reason exists to assume that one animal attacked and ate the other. Ask students who propose this explanation to indicate the evidence. If they could visit the site, what evidence would they look for that would support their explanation? Certain lines of evidence—the quickened gaits, circular pattern, and disappearance of one set of tracks—could support the fight explanation. They might, however, support an explanation of a mother picking up her baby. The description and temperament of the animals involved are open to question. Indeed, we lack the evidence to say that the tracks were made at the same time. The intermingling shown in the middle section of the puzzle may be evidence that both tracks were made at one time, but it could be only a coincidence. Perhaps one animal passed by and left, and then the other arrived.
2. Discuss the expected learning outcomes related to scientific inquiry and the nature of science. To answer the questions posed by the set of fossil footprints, the students, like scientists, constructed reasonable explanations based solely on their logical interpretation of the available evidence. They recognized and analyzed alternative explanations by weighing the evidence and examining the logic to decide which explanations seemed most reasonable. Although there may have been several plausible explanations, they did not all have equal weight. In a manner similar to the way scientists work, students should be able to use scientific criteria to find, communicate, and defend the preferred explanation.

***Expand***

**Part 2:**

1. Show the class a standard physical map of the world. Tell students to look closely at the continents. Ask if they think the continents always looked as they do on the map, or if they have changed shape or location throughout Earth's history. Write their ideas on the board.
2. Tell students that in early 1915, the German scientist Alfred Wegener developed a theory that the continents once formed a giant supercontinent that he called Pangaea. He speculated that Earth took this form about 245 million years ago, during the Triassic period of the Mesozoic era. (The Mesozoic is the era in which dinosaurs lived.) A few years after Wegener proposed his theory, South African geologist Alexander Du Toit further theorized that Pangaea divided into two supercontinents 205 million years ago. Du Toit called the northern supercontinent Laurasia and the southern one Gondwanaland.

3. The scientists used many kinds of evidence to advance their theories. They found similar fossil remains of plants and animals on different present-day continents. The scientists hypothesized that the continents were once connected.
4. Tell students that they'll follow steps similar to those of Wegener and Du Toit to see if fossil evidence supports the theory that one supercontinent divided into two. Hand out copies of Blackline Master #2: Classroom Activity Sheet "Prehistoric Landmasses." Tell students they will focus on Gondwanaland, the supercontinent that includes what are now South America, Antarctica, Australia, Africa, Madagascar, and India.
5. Explain that students will map the locations of four different fossils:
    - *Glossopteris*: a fern found on the southern continents
    - *Cynognathus*: a land reptile found in South America and Africa
    - *Lystrosaurus:* a land reptile found in Africa, Antarctica, and India
    - *Mesosaurus*: a freshwater swimming reptile found in Africa and South America

    Students should mark these locations on the sheet, using the map key code. [Note: A graphic of these four fossil locations is available at http://volcano.und.edu/vwdocs/vwlessons/plate_tectonics/part3.html.]
6. Next have students cut out the continent shapes and try to piece them together as Gondwanaland. Ask them to think about how the different shapes fit together. For homework, have students paste their finished version of Gondwanaland on Blackline Master #3: Take-Home Activity Sheet "What Gondwanaland May Have Looked Like."
7. During the next class period, have students share their versions of Gondwanaland. Are most constructions similar? Show students a picture of what scientists believe Gondwanaland looked like. For a picture, visit "An Introduction to Plate Tectonics" available at http://www.hartrao.ac.za/geodesy/tectonics.html.
8. Discuss where the fossil remains have been found. Does this evidence support Wegener and Du Toit's theory? Do students think it is sufficient evidence? What other information would be helpful? Conclude by telling students that over the past century, scientists have continued to find evidence supporting this theory. Discussion questions may include:
    - What characteristics do you think enables a plant or animal to survive the breakup of a continent? Try to think of at least two characteristics.
    - Scientists have found *Mesosaurus* fossils on the east coast of the southern tip of South America and the west coast of South Africa. Even though we know this animal could swim, does the presence of *Mesosaurus* fossil remains in two places support Wegener and Du Toit's theory? Give evidence to support your ideas.
    - Do you think that the breakup of Pangaea into Gondwanaland and Laurasia affected organisms originally living on Pangaea? Do you think that the breakup of Gondwanaland into the southern continents affected the organisms living in Gondwanaland? Give evidence to support your ideas.
    - Do you think the breakup of Pangaea during the Jurassic period led to the extinction of some dinosaurs and the evolution of other dinosaurs?
    - Scientists have evidence that *Glossopteris* was found in what is now India, Antarctica, Australia, and Madagascar. What does this tell you about *Glossopteris*? What does it tell you about the climate and environment of Gondwanaland?
    - Based on the geologic past, we can assume that Earth is always changing. What modern-day evidence supports this idea? Hint: Think about natural disasters. Where do they often occur?

***Evaluate***

Use the following three-point rubric to formally evaluate students' work during the Expand sections of the lesson:

- **Three points:** demonstrated exemplary performance and effort in marking the landmasses, completing the chart, and constructing Gondwanaland; participated actively in the final class discussion.

- **Two points:** demonstrated average performance and effort in marking the landmasses, completing the chart, and constructing Gondwanaland; participated somewhat actively in the final class discussion.
- **One point:** demonstrated unsatisfactory performance and effort in marking the landmasses, completing the chart, and constructing Gondwanaland; did not participate in the final class discussion.

## Blackline Master

1. **Fossil Footprints** (available at http://www.nap.edu/readingroom/books/evolution98/page89.pdf)
2. **Classroom Activity Sheet "Prehistoric Landmasses"** (available at http://school.discovery.com/lessonplans/pdf/continentaldrift/continentaldrift.pdf, pages 7-8)
3. **Take-Home Activity Sheet "What Gondwanaland May Have Looked Like"** (available at http://school.discovery.com/lessonplans/pdf/continentaldrift/continentaldrift.pdf, page 9)

## Supplementary Resources

***Teachers***

1. Read "Learning from the Fossil Record" by Judith Scotchmoor at http://www.ucmp.berkeley.edu/fosrec/ScotchmoorFossil.html. This is an on-line version of a book of the same title, published by the Paleontological Society. It contains a series of articles and lesson plans on paleontology.

***Students***

1. Have students tour **"**Getting into the Fossil Record" at http://www.ucmp.berkeley.edu/education/explorations/tours/fossil/5to8/Intro.html. This interactive web-based lesson gives students a clear and logical explanation of what fossils are, how they are formed, and what they can tell us about past life.
2. Students may enjoy reading "Polar Dinosaurs in Australia?" at http://pubs.usgs.gov/gip/dynamic/polar.html.
3. Students may also enjoy reading "Earth Like A Puzzle" at http://www.sio.ucsd.edu/voyager/earth_puzzle/.