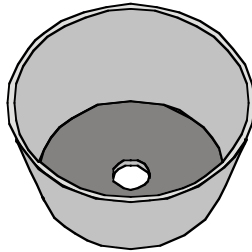


## EARTH SCIENCE TEST

For some questions, there may be more than one correct answer. However, each question has only one best answer. Choose the single best answer from the five choices for each question.

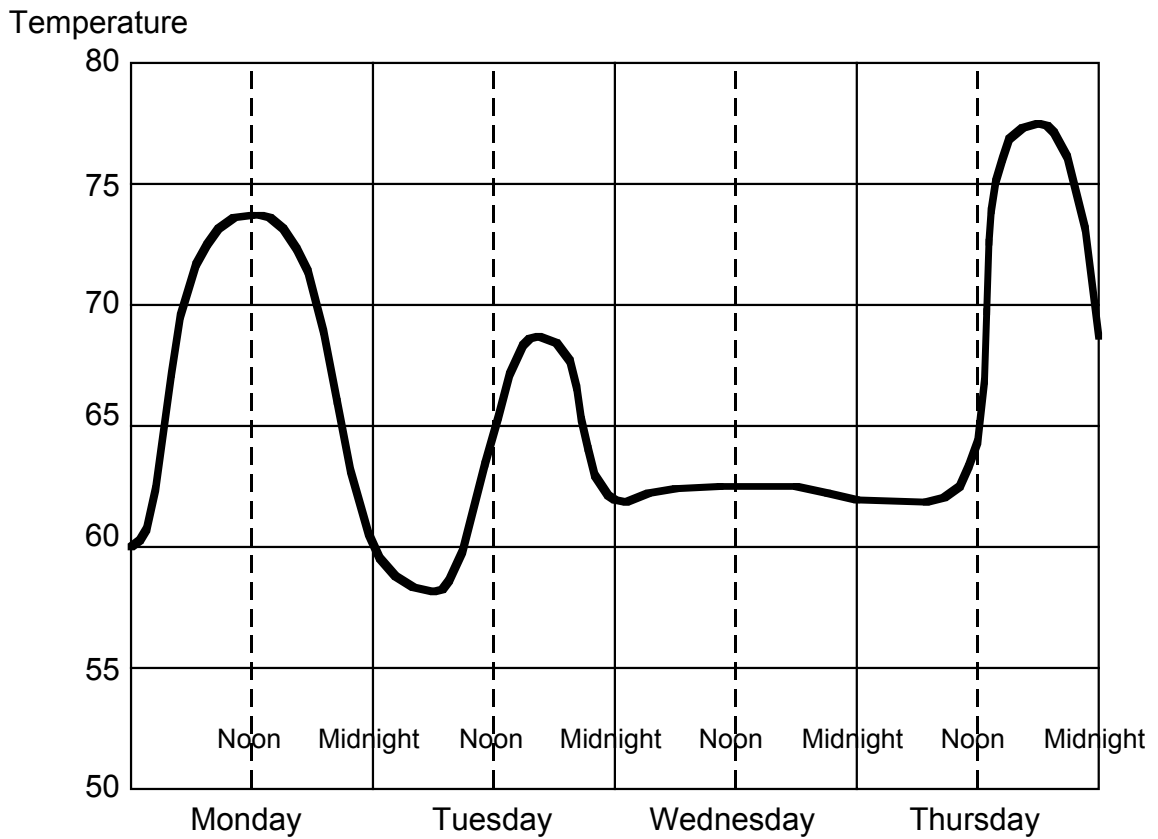
1. We plant tomatoes in soil because tomato plants:
  - a. eat soil.
  - b. get energy from soil.
  - c. use only water from soil.
  - d. get water and nutrients from soil.
  - e. need to have their roots somewhere cold.
2. Tom found a fossil clam in the desert. What would a scientist say was the most likely explanation?
  - a. Someone must have taken the clam from the beach and put it there.
  - b. Someone made a rock look like a clam.
  - c. Some clams live in the desert.
  - d. The desert was once underwater.
  - e. The clam fossil did not come from an animal.
3. One spring day the hottest temperature in the U.S. was 90°F. What was the weather like at the place where it was 90°F?
  - a. It was sunny.
  - b. It was very humid.
  - c. There was no wind.
  - d. More than one of the above was true.
  - e. More information is needed.
4. Which of the following is made from substances found in rocks or soil?
  - a. Aluminum foil
  - b. Gold ring
  - c. Steel nail
  - d. All of the above.
  - e. None of the above.
5. Which is most likely to become a fossil?
  - a. A dead bird that falls on a grassy lawn.
  - b. A mosquito stuck in tree sap.
  - c. A human footprint on a beach.
  - d. A worm crawling through the grass.
  - e. An apple dropped in a pond.
6. Jane and Katherine have identical thermometers next door to each other. Katherine's thermometer usually registers a higher temperature than Jane's. What would mostly likely explain this difference?
  - a. It rains in Katherine's yard more frequently than in Jane's.
  - b. Jane's thermometer is more accurate than Katherine's.
  - c. Jane's thermometer is wrong.
  - d. Jane's yard is uphill from Katherine's.
  - e. The two thermometers get different amounts of sunlight.

7. According to scientists, the tall mountains in the western U.S. are younger than the low mountains in the eastern U.S. How can the younger mountains be taller?
- The volcanoes in the eastern mountains erupted long ago.
  - There are more earthquakes in the western U.S.
  - There are more landslides in the eastern U.S.
  - The eastern mountains have been eroding longer.
  - The ages are only estimates; scientists cannot tell actual ages.
8. Which of the following is made from substances found in rocks or soil?
- Asphalt
  - Concrete
  - Brick
  - All of the above.
  - None of the above.
9. Soil is placed in a pot with a hole in the bottom. How would you measure how much water the soil can retain?



- Plant seeds and measure plant growth.
  - Measure the amount of water that drains from the pot.
  - Observe how wet the soil looks after water has been added.
  - Feel the soil before and after adding water.
  - Measure how long it took for the soil to dry.
10. Which of these substances is **not** found naturally on Earth, but is **made** by humans?
- Coal in a furnace.
  - Copper in pipes.
  - Glass in a window.
  - Granite in a building's wall.
  - Marble on a countertop.
11. What would a scientist most likely think if she found fish bones preserved in rock far from any water?
- A tidal wave had hit the area.
  - A bird dropped the fish while flying.
  - A lake or sea once covered the land.
  - A glacier had carried the rock there.
  - A tornado had passed through the area.

12. Below is a graph of the temperature for four days.



Which day was most likely cloudy?

- Monday
  - Tuesday
  - Wednesday
  - Thursday
  - It is impossible to tell.
13. Each of the following can exist as a fossil except:
- fish.
  - dinosaurs.
  - trees.
  - cave drawings.
  - leaves.
14. What happens as summer changes to fall?
- The days get longer.
  - The days get warmer.
  - The nights get longer.
  - The nights get warmer.
  - It is less windy.

**GO TO QUESTION 15 >>**

15. What is true about soil?
- a. Good soil is always brown.
  - b. Soil always feels the same.
  - c. Soil completely absorbs water from rain.
  - d. Soils support plants' growth.
  - e. The particles of different soils are the same size.

## EARTH SCIENCE TEST

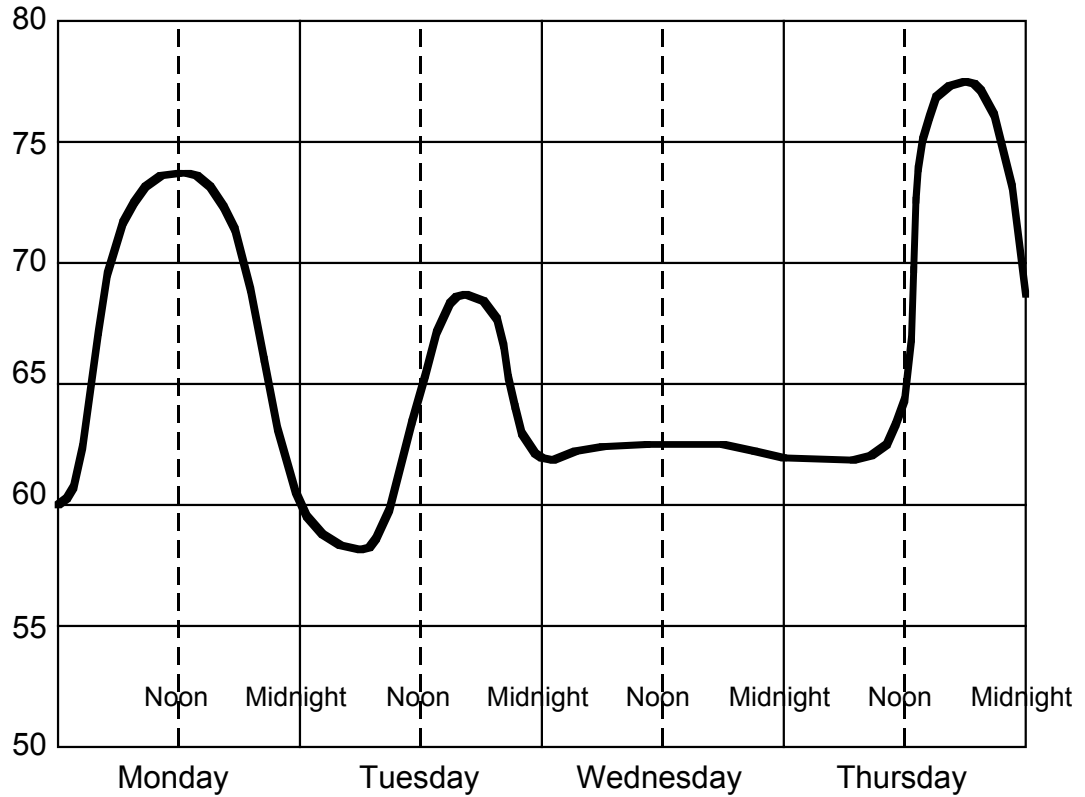
For some questions, there may be more than one correct answer. However, each question has only one best answer. Choose the single best answer from the five choices for each question.

1. What would a scientist most likely think if she found fish bones preserved in rock far from any water?
  - a. A tidal wave had hit the area.
  - b. A bird dropped the fish while flying.
  - c. A lake or sea once covered the land.
  - d. A glacier had carried the rock there.
  - e. A tornado had passed through the area.
  
2. What is true about soil?
  - a. Good soil is always brown.
  - b. Soil always feels the same.
  - c. Soil completely absorbs water from rain.
  - d. Soils support plants' growth.
  - e. The particles of different soils are the same size.
  
3. Jane and Katherine have identical thermometers next door to each other. Katherine's thermometer usually registers a higher temperature than Jane's. What would mostly likely explain this difference?
  - a. It rains in Katherine's yard more frequently than in Jane's.
  - b. Jane's thermometer is more accurate than Katherine's.
  - c. Jane's thermometer is wrong
  - d. Jane's yard is uphill from Katherine's.
  - e. The two thermometers get different amounts of sunlight.

**GO TO QUESTION 4 >>**

4. Below is a graph of the temperature for four days.

Temperature

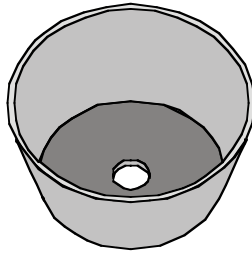


- Which day was most likely cloudy?
- Monday
  - Tuesday
  - Wednesday
  - Thursday
  - It is impossible to tell.
5. Which of these substances is **not** found naturally on Earth, but is **made** by humans?
- Coal in a furnace.
  - Copper in pipes.
  - Glass in a window.
  - Granite in a building's wall.
  - Marble on a countertop.
6. Each of the following can exist as a fossil except:
- fish.
  - dinosaurs.
  - trees.
  - cave drawings.
  - leaves.

7. What happens as summer changes to fall?
  - a. The days get longer.
  - b. The days get warmer.
  - c. The nights get longer.
  - d. The nights get warmer.
  - e. It is less windy.
  
8. One spring day the hottest temperature in the U.S. was 90°F. What was the weather like at the place where it was 90°F?
  - a. It was sunny.
  - b. It was very humid.
  - c. There was no wind.
  - d. More than one of the above was true.
  - e. More information is needed.
  
9. Which of the following is made from substances found in rocks or soil?
  - a. Aluminum foil
  - b. Gold ring
  - c. Steel nail
  - d. All of the above.
  - e. None of the above.
  
10. Which is most likely to become a fossil?
  - a. A dead bird that falls on a grassy lawn.
  - b. A mosquito stuck in tree sap.
  - c. A human footprint on a beach.
  - d. A worm crawling through the grass.
  - e. An apple dropped in a pond.
  
11. We plant tomatoes in soil because tomato plants:
  - a. eat soil.
  - b. get energy from soil.
  - c. use only water from soil.
  - d. get water and nutrients from soil.
  - e. need to have their roots somewhere cold.
  
12. Which of the following is made from substances found in rocks or soil?
  - a. Asphalt
  - b. Concrete
  - c. Brick
  - d. All of the above.
  - e. None of the above.

**GO TO QUESTION 13 >>**

13. Soil is placed in a pot with a hole in the bottom. How would you measure how much water the soil can retain?



- a. Plant seeds and measure plant growth.
  - b. Measure the amount of water that drains from the pot.
  - c. Observe how wet the soil looks after water has been added.
  - d. Feel the soil before and after adding water.
  - e. Measure how long it took for the soil to dry.
14. According to scientists, the tall mountains in the western U.S. are younger than the low mountains in the eastern U.S. How can the younger mountains be taller?
- a. The volcanoes in the eastern mountains erupted long ago.
  - b. There are more earthquakes in the western U.S.
  - c. There are more landslides in the eastern U.S.
  - d. The eastern mountains have been eroding longer.
  - e. The ages are only estimates; scientists cannot tell actual ages.
15. Tom found a fossil clam in the desert. What would a scientist say was the most likely explanation?
- a. Someone must have taken the clam from the beach and put it there.
  - b. Someone made a rock look like a clam.
  - c. Some clams live in the desert.
  - d. The desert was once underwater.
  - e. The clam fossil did not come from an animal.



## K-4 Earth Science Tests

The tests in this section contain items related to five of the K-4 standards in earth science from the NRC's *National Science Education Standards (NSES)*; below are the standards as stated in the *NSES*.

**NOTE:** These tests do not contain any items probing the astronomy component of the K-4 earth science standards; see tests 611 / 612 under Astronomy / Space Science.

K-4 Earth Science Standard 1:

"Earth materials are solid rocks and soils, water, and the gases of the atmosphere. The varied materials have different physical and chemical properties, which make them useful in different ways, for example, as building materials, as sources of fuel, or for growing the plants we use as food. Earth materials provide many of the resources that humans use."

K-4 Earth Science Standard 2:

"Soils have properties of color and texture, capacity to retain water, and ability to support the growth of many kinds of plants, including those in our food supply."

K-4 Earth Science Standard 3:

"Fossils provide evidence about the plants and animals that lived long ago and the nature of the environment at that time."

K-4 Earth Science Standard 4:

"The surface of the earth changes. Some changes are due to slow processes, such as erosion and weathering, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes."

K-4 Earth Science Standard 5:

"Weather changes from day to day and over the seasons. Weather can be described by measurable quantities, such as temperature, wind direction and speed, and precipitation."

The items are identical on both test forms, but arranged in different sequences so that the forms can be used as a pretest / post-test pair (either form may be used as the pretest). Either form can be used by itself as a diagnostic test.

The K-4 tests are intended for use primarily with 5th grade students. Project MOSART did not develop tests for use with students in grades K-4 due to the difficulty of writing reliable multiple choice items for students whose reading levels may vary widely. The tests can also be administered to any persons who possess at least a 5th grade reading level fluency in English.

**NOTE:** Administering the tests to anyone with less than the indicated minimum reading level may result in invalid test results due to the test performing more as a reading comprehension test rather than as a science test.

Item # Form 811	Item # Form 812	Text of item	Std. <sup>1</sup>	Correct response & percent <sup>2</sup> responding correctly	Commentary <sup>3</sup>
1	11	We plant tomatoes in soil because tomato plants: a. eat soil. b. get energy from soil. c. use only water from soil. d. get water and nutrients from soil. e. need to have their roots somewhere cold.	2	D: 72% (n=932)	Only one incorrect response, B, attracted more than 5% of students, which is consistent with the misconception that soil is food for plants.
2	15	Tom found a fossil clam in the desert. What would a scientist say was the most likely explanation? a. Someone must have taken the clam from the beach and put it there. b. Someone made a rock look like a clam. c. Some clams live in the desert. d. The desert was once underwater. e. The clam fossil did not come from an animal.	3	D: 78% (n=1147)	Student responses were distributed rather evenly (3% to 7%) among the four incorrect choices, a pattern that suggests guessing. It should be noted that students who did not chose the correct response tended to score lower overall on the nationwide field tests than their peers who answered correctly.
3	8	One spring day the hottest temperature in the U.S. was 90°F. What was the weather like at the place where it was 90°F? a. It was sunny. b. It was very humid. c. There was no wind. d. More than one of the above was true. e. More information is needed.	5	E: 11% (n=1186)	The most frequent responses were D (39%), A (31%) and B (14%). Students might have been drawing more on personal experience than on knowledge of the weather when answering this item.

<sup>1</sup> These test items are valid psychometrically and represent standards commonly included in elementary school earth science curricula.

<sup>2</sup> Students were selected randomly in classes to be a nationally representative sample of all grade 5 students in U.S. public and private schools. The sample number (n) is included for each item because the number of students per item varied considerably.

<sup>3</sup> The commentary reflects item response patterns. Common misconceptions in earth science are discussed in a separate section.

Item # Form 811	Item # Form 812	Text of item	Std. <sup>1</sup>	Correct response & percent <sup>2</sup> responding correctly	Commentary <sup>3</sup>
4	9	Which of the following is made from substances found in rocks or soil? a. Aluminum foil b. Gold ring c. Steel nail d. All of the above. e. None of the above.	<b>1</b>	D: 29% (n=4385)	E was chosen slightly more frequently (30%) than the correct answer. Another 25% of students chose A. Younger students do have difficulty in identifying the sources of materials.
5	10	Which is most likely to become a fossil? a. A dead bird that falls on a grassy lawn. b. A mosquito stuck in tree sap. c. A human footprint on a beach. d. A worm crawling through the grass. e. An apple dropped in a pond.	<b>3</b>	B: 57% (n=511)	Although more than half of students chose the correct answer, 24% chose A, consistent with the misconception that a fossil must contain bones. Another 11% selected choice C.
6	3	Jane and Katherine have identical thermometers next door to each other. Katherine's thermometer usually registers a higher temperature than Jane's. What would mostly likely explain this difference? a. It rains in Katherine's yard more frequently than in Jane's. b. Jane's thermometer is more accurate than Katherine's. c. Jane's thermometer is wrong d. Jane's yard is uphill from Katherine's. e. The two thermometers get different amounts of sunlight.	<b>5</b>	E: 53% (n=349)	With over half of students choosing the correct answer, the number of students choosing any one of the incorrect responses was fairly small: A, 8%; B, 13%; C, 11%; and D, 16%. Students with any of these incorrect responses had lower average total scores on the national field tests than students who chose the correct answer.

Item # Form 811	Item # Form 812	Text of item	Std. <sup>1</sup>	Correct response & percent <sup>2</sup> responding correctly	Commentary <sup>3</sup>
7	14	<p>According to scientists, the tall mountains in the western U.S. are younger than the low mountains in the eastern U.S. How can the younger mountains be taller?</p> <p>a. The volcanoes in the eastern mountains erupted long ago.</p> <p>b. There are more earthquakes in the western U.S.</p> <p>c. There are more landslides in the eastern U.S.</p> <p>d. The eastern mountains have been eroding longer.</p> <p>e. The ages are only estimates; scientists cannot tell actual ages.</p>	4	D: 40% (n=1043)	The majority of students chose an incorrect answer and were fairly evenly divided in their choices: 10% chose A; 14%, B; 17%, C; and 18% chose E. The origin and nature of mountains is overall poorly understood by younger students.
8	12	<p>Which of the following is made from substances found in rocks or soil?</p> <p>a. Asphalt</p> <p>b. Concrete</p> <p>c. Brick</p> <p>d. All of the above.</p> <p>e. None of the above.</p>	1	D: 46% (n=980)	None of the incorrect responses attracted more than 20% of students, the most popular being A (17%) and C being the least frequently chosen (10%).
9	13	<p>Soil is placed in a pot with a hole in the bottom. How would you measure how much water the soil can retain? (See picture in item on test.)</p> <p>a. Plant seeds and measure plant growth.</p> <p>b. Measure the amount of water that drains from the pot.</p> <p>c. Observe how wet the soil looks after water has been added.</p> <p>d. Feel the soil before and after adding water.</p> <p>e. Measure how long it took for the soil to dry.</p>	2	B: 58% (n=975)	Nearly 60% of students were able to correctly figure out this problem, but 12% of students chose C, while 11% chose either D or E. Choice A was chosen by 8% of students.

Item # Form 811	Item # Form 812	Text of item	Std. <sup>1</sup>	Correct response & percent <sup>2</sup> responding correctly	Commentary <sup>3</sup>
10	5	Which of these substances is <b>not</b> found naturally on Earth, but is <b>made</b> by humans? a. Coal in a furnace. b. Copper in pipes. c. Glass in a window. d. Granite in a building's wall. e. Marble on a countertop.	<b>1</b>	C: 45% (n=346)	More than half of students apparently did not know that window glass is not a natural substance. The incorrect responses were chosen by fairly equal numbers of students: 13% chose A; 12%, B; and 15% each for D and E. As seen in item 4, younger students do have difficulty identifying the sources of materials.
11	1	What would a scientist most likely think if she found fish bones preserved in rock far from any water? a. A tidal wave had hit the area. b. A bird dropped the fish while flying. c. A lake or sea once covered the land. d. A glacier had carried the rock there. e. A tornado had passed through the area.	<b>3</b>	C: 79% (n=3202)	More than three quarters of students appear to understand how scientists explain the origin of aquatic fossils found on land. Just 8% of students chose A; 7%, B; 5%, D; and only 1% chose E.
12	4	Below is a graph of the temperature for four days. Which day was most likely cloudy? (See graph in item on test.) a. Monday b. Tuesday c. Wednesday d. Thursday e. It is impossible to tell.	<b>5</b>	C: 29% (n=1291)	The responses of students suggest guessing, with E receiving the same response as the correct answer. 20% of students chose B, with 11% and 12% choosing A and D, respectively. This pattern may be due as much to graph reading skills as to the presence of misconceptions.
13	6	Each of the following can exist as a fossil except: a. fish. b. dinosaurs. c. trees. d. cave drawings. e. leaves.	<b>3</b>	D: 47% (n=419)	Although the most frequent response was the correct item, 36% of students chose C. Fewer than 10% chose A, B, or E. Some students do tend to think of fossils as containing bones, which might explain the low response to A and B.

Item # Form 811	Item # Form 812	Text of item	Std. <sup>1</sup>	Correct response & percent <sup>2</sup> responding correctly	Commentary <sup>3</sup>
14	7	What happens as summer changes to fall? a. The days get longer. b. The days get warmer. c. The nights get longer. d. The nights get warmer. e. It is less windy.	<b>5</b>	C: 56% (n=500)	More than half of students correctly answered this item. Only A was chosen by a substantial number of students (29%), denoting a common misconception that the days get longer during the summer.
15	2	What is true about soil? a. Good soil is always brown. b. Soil always feels the same. c. Soil completely absorbs water from rain. d. Soils support plants' growth. e. The particles of different soils are the same size.	<b>2</b>	D: 64% (n=1910)	Nearly two thirds of students chose the correct answer, while 13% chose E and 12% chose A. Neither B (2%) nor C (9%) received a significant response. Students' knowledge of soil may be linked to personal experience.

### Major Misconceptions in K-4 Earth Science

Listed below are some student earth science misconceptions. The list is not intended to be exhaustive, but rather a summary of some of the more common prior ideas we identified from our analysis of the student response patterns to the items on the tests.

- Plants get their food from the soil.
- Objects made by humans using natural substances are natural, e.g., a brick is a rock.
- Materials used by humans to manufacture items are all made by humans, e.g., the gold in a piece of gold jewelry has no natural origin. (Note that introducing "pure" to describe a substance can further confuse the issue because many students equate "pure" only with "clean.")
- All mountains are either active, dormant or extinct volcanoes.
- All clouds are cold and therefore their presence makes the air cold.
- All fossils contain bones and therefore only organisms with bones can become fossils.

The following resources are useful for additional background information about students' science misconceptions:

Driver, R. (Ed.), *Children's Ideas in Science*, Philadelphia: Open University Press (1985).

Driver, R., *Pupil as Scientist?*, Philadelphia: Open University Press (1983).

Hapkiewicz, A. "Naive Ideas in Earth Science" in the *Michigan Science Teachers Association (MSTA) Journal*, 44(2), pp. 26–30 (1999).

Philips, W.C. "Earth Science Misconceptions" in *The Science Teacher*, 58(2), pp. 21–23 (1991).