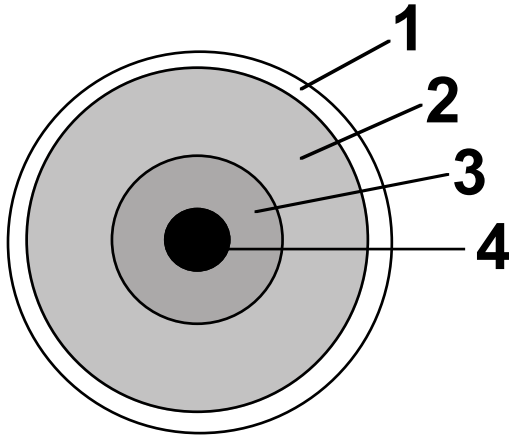


EARTH SCIENCE TEST

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. By examining fossils, scientists think that:
 - a. all existing plants and animals have been unchanged since Earth formed.
 - b. plants have changed over time, but animals have not.
 - c. animals have changed over time, but plants have not.
 - d. many changes have occurred to plants and animals.
 - e. It is not possible to determine the past from fossils.

2. Below is a diagram of Earth's interior.

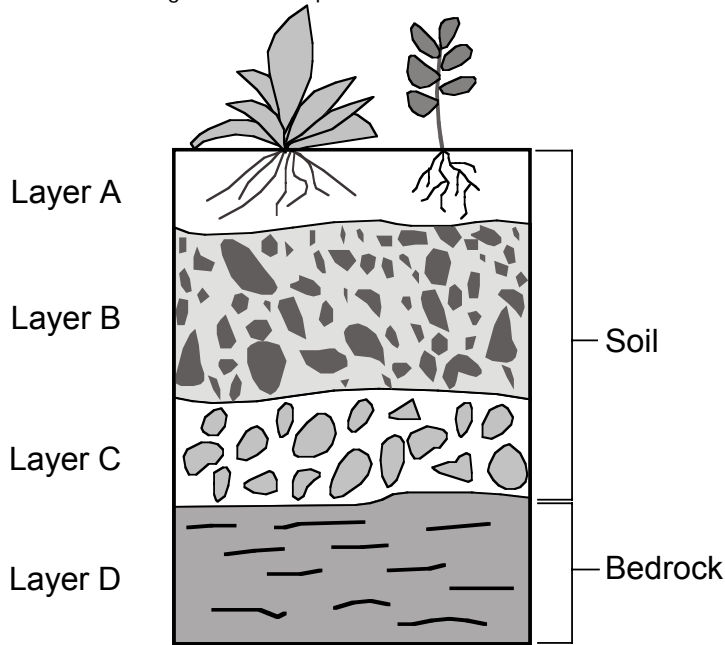


What is layer 2?

- a. Crust
- b. Mantle
- c. Outer core
- d. Inner core
- e. Lithosphere

GO TO QUESTION 3 >>

3. Below is the diagram of a soil profile.



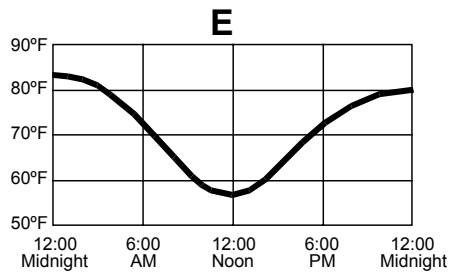
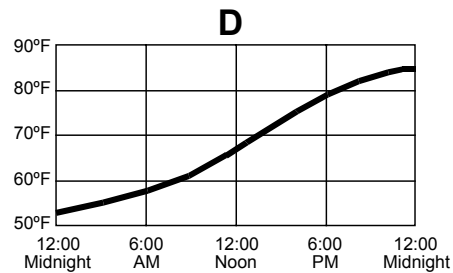
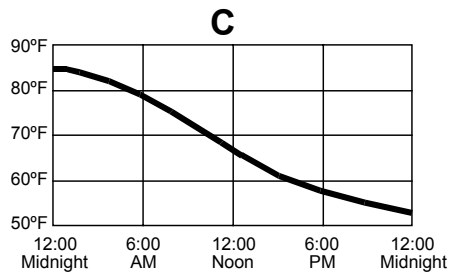
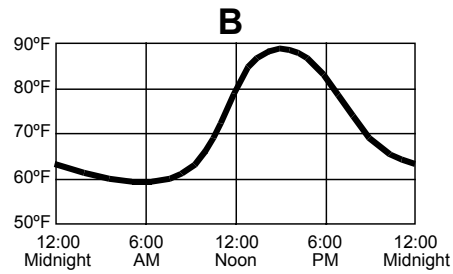
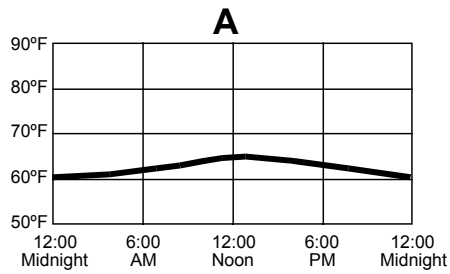
Which layer contains the most organic material?

- A
 - B
 - C
 - D
 - They all have the same amount of organic material.
4. If mountains erode over long periods of time, what can happen?
- The mountains decrease in height.
 - Parts of mountains become steeper.
 - Valleys decrease in depth.
 - Only two of the above can happen.
 - a, b and c can all happen.
5. Carlos has a metamorphic rock in his rock collection. Where did the rock most likely form?
- In a volcano.
 - In a swamp.
 - On a coral reef.
 - At the bottom of a river.
 - Deep underground.
6. What is true about evaporation of water?
- It happens only in the daytime when the sky is clear.
 - It happens only when water boils.
 - It happens when water changes from liquid to gas.
 - Only two of the above are true.
 - a, b and c are true.

7. Which is always true about a day when there are strong winds?
- There are lots of clouds.
 - The air temperature is low.
 - It is raining.
 - The air is moving.
 - All of the above.
8. Minerals are in our water supply because:
- minerals are part of the chemical makeup of water.
 - water evaporates from the ocean.
 - people put minerals in the water.
 - water dissolves minerals in rock and soil.
 - No one knows why there are minerals in water.
9. What is true about all soils?
- They are the same color and texture.
 - They contain weathered rock.
 - They contain no air.
 - They are very young.
 - All of the above.
10. The oxygen that fish take in has been:
- dissolved in water.
 - condensed in water.
 - precipitated in water.
 - mixed in water.
 - None of the above.

GO TO QUESTION 11 >>

11. The graphs below show the air temperature readings for five different days. On which day was the sky most likely covered by clouds daytime and nighttime?

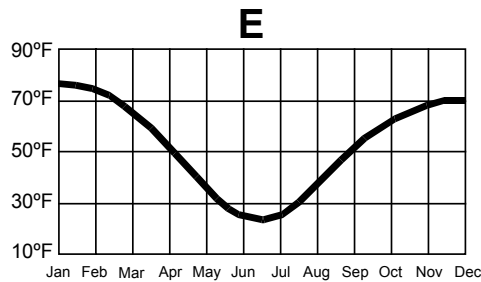
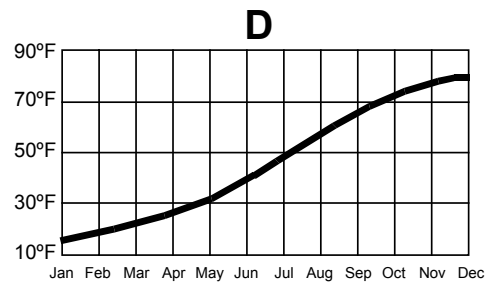
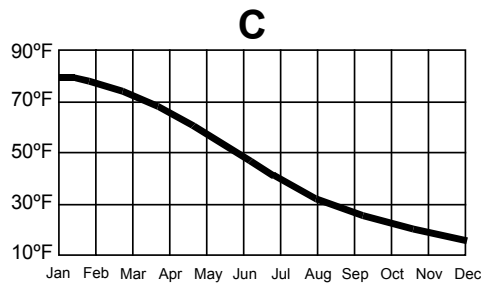
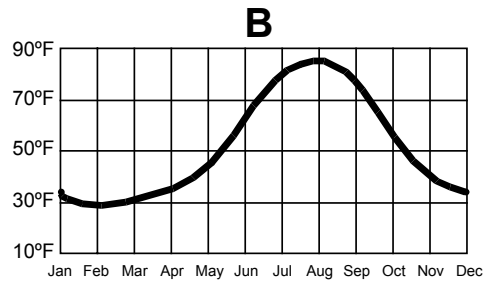
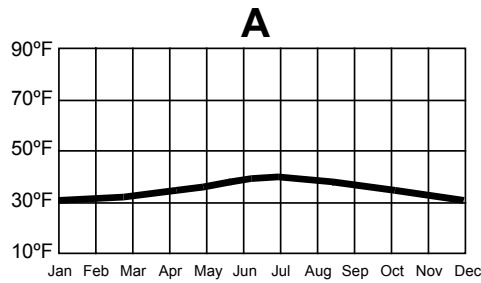


12. Scientists study fossils to:
- find out what past climates were like.
 - figure out how plants and animals have changed.
 - learn how the Solar System formed.
 - Only a and b.
 - a, b and c.
13. In comparison to the base, at the top of a tall mountain it will be:
- warmer and there will be more oxygen.
 - warmer and there will be less oxygen.
 - the same temperature and have as much oxygen as at the base.
 - cooler and there will be less oxygen.
 - cooler and there will be more oxygen.
14. Scientists think which of the following has affected Earth for billions of years?
- Flowing water, such as rivers.
 - Weathering processes.
 - Earthquakes and volcanic eruptions.
 - a, b and c have all affected Earth.
 - None of the above has affected Earth for that long.

15. Scientists think Earth's moon formed when:
- Earth formed.
 - a piece of Earth spun off into space.
 - Earth captured a large object as it tried to pass by.
 - Earth and a large object collided.
 - It is impossible to know.
16. Which of the following is not part of the water cycle?
- Snow falling from clouds.
 - Water evaporating from the ocean.
 - Water absorbed by plants.
 - Water in the ground.
 - All of the above are part of the water cycle.
17. Air contains which of these gases?
- Nitrogen
 - Oxygen
 - Water vapor
 - Only a and b.
 - a, b and c.
18. The portion of Earth with the highest average density is the:
- material in the inner core.
 - rock in the lower crust.
 - water in deep ocean trenches.
 - sediments on the seafloor.
 - gases in the lower atmosphere.
19. Which human activity directly adds the most carbon dioxide to the atmosphere?
- Using nitrogenous fertilizer to grow crops.
 - Burning fossil fuels.
 - Using air conditioning.
 - Generating electricity from nuclear reactions.
 - Increasing the amount of paved surfaces.
20. Scientists think that the primary cause of mountain building is:
- the cooling and shrinking of Earth.
 - the heating and expanding of Earth.
 - the Moon's gravitational pull.
 - local climate factors.
 - plate tectonics.

GO TO QUESTION 21 >>

21. The graphs below show the highest air temperature reading every day for one year at five different locations. Which graph most likely is for a town in the middle of a large continent?



22. If there were no weathering and erosion, which type of rock would be least common?
- Sedimentary rock.
 - Molten rock.
 - Intrusive igneous rock.
 - Extrusive igneous rock.
 - Metamorphic rock.
23. Scientists think that compared to today, in the past Earth's climate has:
- always been the same.
 - cooled only during the Ice Age.
 - warmed and cooled many times.
 - warmed only since humans started burning fossil fuels.
 - been much less stormy.

24. Which of these is a piece of scientific evidence for plate tectonics?

- a. The location patterns of earthquakes.
- b. The path of the Gulf Stream.
- c. The Earth's magnetic field.
- d. The tilt of Earth on its axis.
- e. There is no scientific evidence.

25. If you were flying inside a puffy looking cloud, you would see:

- a. smoke.
- b. fog.
- c. dust.
- d. cotton.
- e. All of the above are possible.

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. Which of these is a piece of scientific evidence for plate tectonics?
 - a. The location patterns of earthquakes.
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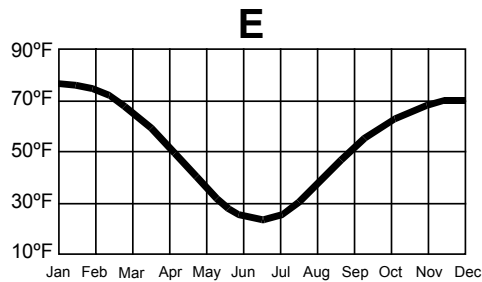
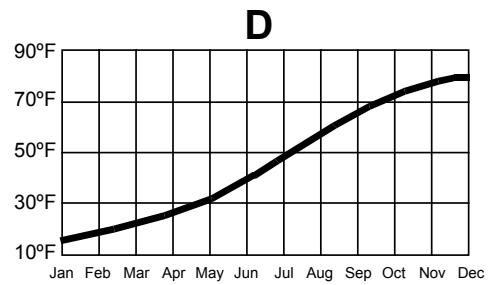
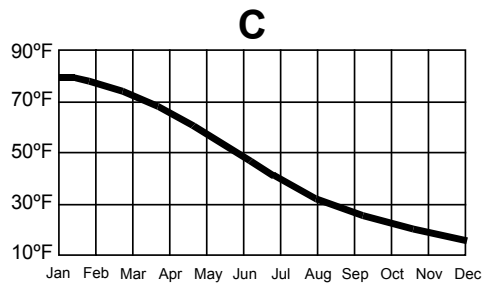
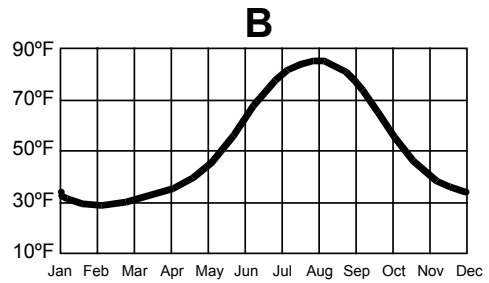
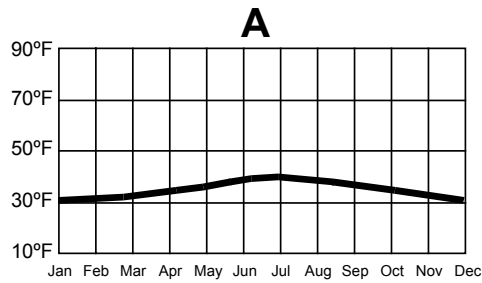
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 - a. find out what past climates were like.
 - b. figure out how plants and animals have changed.
 - c. learn how the Solar System formed.
 - d. Only a and b.
 - e. a, b and c.

GO TO QUESTION 7 >>

7. The graphs below show the highest air temperature reading every day for one year at five different locations. Which graph most likely is for a town in the middle of a large continent?



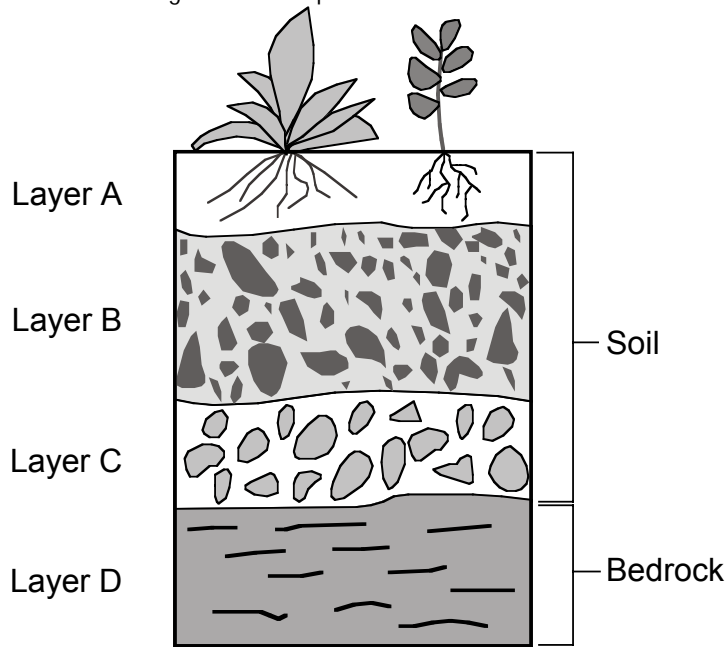
8. The portion of Earth with the highest average density is the:
- material in the inner core.
 - rock in the lower crust.
 - water in deep ocean trenches.
 - sediments on the seafloor.
 - gases in the lower atmosphere.
9. Which human activity directly adds the most carbon dioxide to the atmosphere?
- Using nitrogenous fertilizer to grow crops.
 - Burning fossil fuels.
 - Using air conditioning.
 - Generating electricity from nuclear reactions.
 - Increasing the amount of paved surfaces.

10. Carlos has a metamorphic rock in his rock collection. Where did the rock most likely form?
- In a volcano.
 - In a swamp.
 - On a coral reef.
 - At the bottom of a river.
 - Deep underground.
11. What is true about evaporation of water?
- It happens only in the daytime when the sky is clear.
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 - The air temperature is low.
 - It is raining.
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15. By examining fossils, scientists think that:
- all existing plants and animals have been unchanged since Earth formed.
 - plants have changed over time, but animals have not.
 - animals have changed over time, but plants have not.
 - many changes have occurred to plants and animals.
 - It is not possible to determine the past from fossils.
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- a. smoke.
 - b. fog.
 - c. dust.
 - d. cotton.
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18. What is true about all soils?
- a. They are the same color and texture.
 - b. They contain weathered rock.
 - c. They contain no air.
 - d. They are very young.
 - e. All of the above.
19. Air contains which of these gases?
- a. Nitrogen
 - b. Oxygen
 - c. Water vapor
 - d. Only a and b.
 - e. a, b and c.
20. The oxygen that fish take in has been:
- a. dissolved in water.
 - b. condensed in water.
 - c. precipitated in water.
 - d. mixed in water.
 - e. None of the above.

GO TO QUESTION 21 >>

21. Below is the diagram of a soil profile.

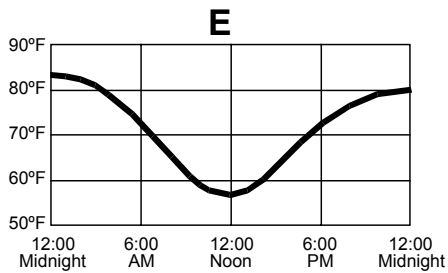
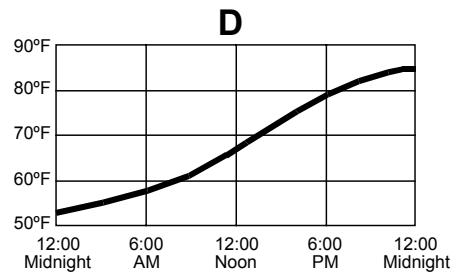
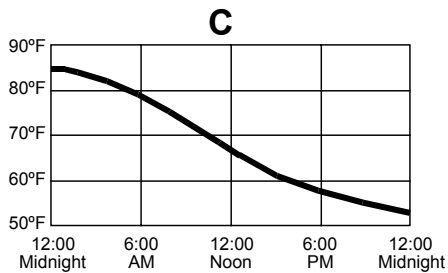
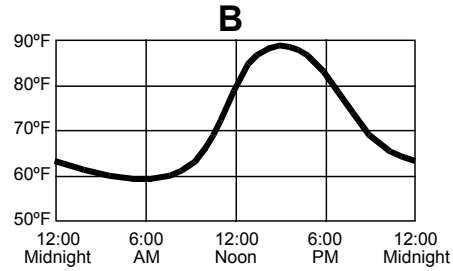
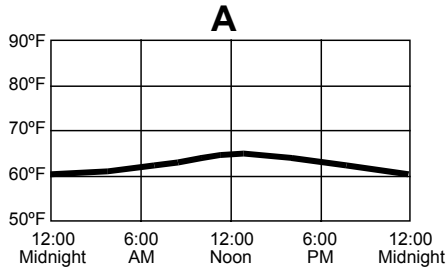


Which layer contains the most organic material?

- a. A
- b. B
- c. C
- d. D
- e. They all have the same amount of organic material.

GO TO QUESTION 22 >>

22. The graphs below show the air temperature readings for five different days. On which day was the sky most likely covered by clouds daytime and nighttime?



23. Which of the following is not part of the water cycle?

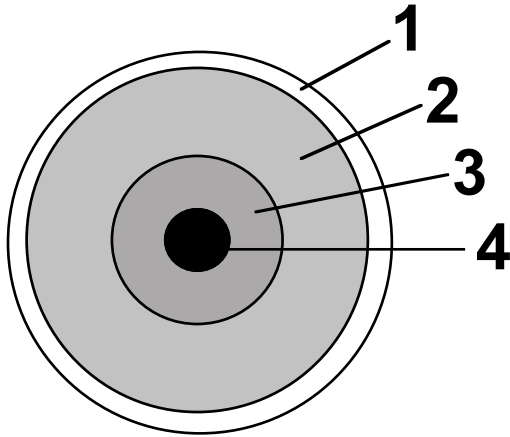
- Snow falling from clouds.
- Water evaporating from the ocean.
- Water absorbed by plants.
- Water in the ground.
- All of the above are part of the water cycle.

24. Minerals are in our water supply because:

- minerals are part of the chemical makeup of water.
- water evaporates from the ocean.
- people put minerals in the water.
- water dissolves minerals in rock and soil.
- No one knows why there are minerals in water.

GO TO QUESTION 25 >>

25. Below is a diagram of Earth's interior.



What is layer 2?

- a. Crust
- b. Mantle
- c. Outer core
- d. Inner core
- e. Lithosphere

Grades 5–8 Earth Science Tests

The tests in this section contain items related to 12 of the grades 5–8 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 grades 5–8 earth science standards; see tests 621 / 622 under Astronomy / Space Science.

5–8 Earth Science Standard 1:

"The solid earth is layered with a lithosphere; hot, convecting mantle; and dense, metallic core."

5–8 Earth Science Standard 2:

"Lithospheric plates on the scales of continents and oceans constantly move at rates of centimeters per year in response to movements in the mantle. Major geological events, such as earthquakes, volcanic eruptions, and mountain building, result from these plate motions."

5–8 Earth Science Standard 3:

"Land forms are the result of a combination of constructive and destructive forces. Constructive forces include crustal deformation, volcanic eruption, and deposition of sediment, while destructive forces include weathering and erosion."

5–8 Earth Science Standard 4:

"Some changes in the solid earth can be described as the "rock cycle." Old rocks at the earth's surface weather, forming sediments that are buried, then compacted, heated, and often recrystallized into new rock. Eventually, those new rocks may be brought to the surface by the forces that drive plate motions, and the rock cycle continues."

5–8 Earth Science Standard 5:

"Soil consists of weathered rocks and decomposed organic material from dead plants, animals, and bacteria. Soils are often found in layers, with each having a different chemical composition and texture."

5–8 Earth Science Standard 6:

"Water, which covers the majority of the earth's surface, circulates through the crust, oceans, and atmosphere in what is known as the "water cycle." Water evaporates from the earth's surface, rises and cools as it moves to higher elevations, condenses as rain or snow, and falls to the surface where it collects in lakes, oceans, soil, and in rocks underground."

5–8 Earth Science Standard 7:

"Water is a solvent. As it passes through the water cycle it dissolves minerals and gases and carries them to the oceans."

5–8 Earth Science Standard 8:

"The atmosphere is a mixture of nitrogen, oxygen, and trace gases that include water vapor. The atmosphere has different properties at different elevations."

5–8 Earth Science Standard 9:

"Clouds, formed by the condensation of water vapor, affect weather and climate."

5–8 Earth Science Standard 10:

"Global patterns of atmospheric movement influence local weather. Oceans have a major effect on climate, because water in the oceans holds a large amount of heat."

5–8 Earth Science Standard 11:

"The earth processes we see today, including erosion, movement of lithospheric plates, and changes in atmospheric composition, are similar to those that occurred in the past. earth history is also influenced by occasional catastrophes, such as the impact of an asteroid or comet."

5–8 Earth Science Standard 12:

"Fossils provide important evidence of how life and environmental conditions have changed."

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 5–8 tests are intended for use primarily with 7th and 8th grade students. The tests can also be administered to any persons who possess at least a 7th 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 821	Item # Form 822	Text of item	Std. ¹	Correct response & percent ² responding correctly	Commentary ³
1	15	By examining fossils, scientists think that: a. all existing plants and animals have been unchanged since Earth formed. b. plants have changed over time, but animals have not. c. animals have changed over time, but plants have not. d. many changes have occurred to plants and animals. e. It is not possible to determine the past from fossils.	12	D: 73% (n=121)	About three fourths of students chose the correct answer. Students who answered this question incorrectly were, generally, those who performed poorly on the overall test in our national field trials.
2	25	Below is a diagram of Earth's interior. (See diagram in item on test.) What is layer 2? a. Crust b. Mantle c. Outer core d. Inner core e. Lithosphere	1	B: 72% (n=427)	About three fourths of students chose the correct answer. Here, as in item 1, students who answered this question incorrectly were, generally, those who performed poorly on the overall test.

¹ These test items are valid psychometrically and represent standards commonly included in middle school earth science curricula.

² Students were selected randomly in classes to be a nationally representative sample of all grades 7 and 8 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.

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

3	21	<p>Below is the diagram of a soil profile. (See diagram in item on test.) Which layer contains the most organic material?</p> <p>a. A b. B c. C d. D e. They all have the same amount of organic material.</p>	5	A: 25% (n=461)	Interestingly, 46% of students chose B, the second layer in the profile.
4	12	<p>If mountains erode over long periods of time, what can happen?</p> <p>a. The mountains decrease in height. b. Parts of mountains become steeper. c. Valleys decrease in depth. d. Only two of the above can happen. e. a, b and c can all happen.</p>	3	E: 41% (n=121)	Although the correct answer was the most frequently chosen, the second most common response was A, chosen by 22%. Perhaps these students might have associated erosion in mountains only with catastrophic events such as landslides.
5	10	<p>Carlos has a metamorphic rock in his rock collection. Where did the rock most likely form?</p> <p>a. In a volcano. b. In a swamp. c. On a coral reef. d. At the bottom of a river. e. Deep underground.</p>	4	E: 30% (n=268)	53% of students chose A. Possibly these students were focused on the heat associated with metamorphism and therefore might have been attracted to volcanoes.
6	11	<p>What is true about evaporation of water?</p> <p>a. It happens only in the daytime when the sky is clear. b. It happens only when water boils. c. It happens when water changes from liquid to gas. d. Only two of the above are true. e. a, b and c are true.</p>	6	C: 55% (n=517)	While a majority of students responded correctly, 27% indicated that two of the ideas were true (D). Given that many students associate evaporation with boiling, those who chose D might have had B in mind as one of the two scenarios.

7	14	<p>Which is always true about a day when there are strong winds?</p> <p>a. There are lots of clouds. b. The air temperature is low. c. It is raining. d. The air is moving. e. All of the above.</p>	10	D: 55% (n=1066)	<p>The majority of students recognized that the only constant characteristic of strong winds was that the air was moving.</p> <p>The most common incorrect response was E, chosen by 25%, suggesting that these students might think of strong winds as being associated only with stormy weather.</p>
8	24	<p>Minerals are in our water supply because:</p> <p>a. minerals are part of the chemical makeup of water. b. water evaporates from the ocean. c. people put minerals in the water. d. water dissolves minerals in rock and soil. e. No one knows why there are minerals in water.</p>	7	D: 52% (n=427)	<p>Most students selected the correct response to this item, while 27% of students chose A, which for some might be a misinterpretation of the answer.</p> <p>Here, too, students who answered this question incorrectly were, generally, those who performed poorly on the overall test.</p>
9	18	<p>What is true about all soils?</p> <p>a. They are the same color and texture. b. They contain weathered rock. c. They contain no air. d. They are very young. e. All of the above.</p>	5	B: 66% (n=426)	<p>Two thirds of students responded correctly to this item, and none of the incorrect responses attracted more than 13% of students, with C and E receiving equal rates of selection.</p>
10	20	<p>The oxygen that fish take in has been:</p> <p>a. dissolved in water. b. condensed in water. c. precipitated in water. d. mixed in water. e. None of the above.</p>	7	A: 11% (n=515)	<p>This was a difficult item as evidenced by the low correct response rate. Choice E was selected by 37%, the most popular answer, while D received 24%; B, 20%; and C, 8%. Given that E does not specify how oxygen used by fish exists in water, no firm conclusion can be made about students' ideas. However, students do sometimes talk about air bubbles and many do not think any gas can dissolve in water.</p>

11	22	The graphs below show the air temperature readings for five different days. On which day was the sky most likely covered by clouds daytime and nighttime? (See graphs in item on test.)	9	A: 58% (n=518)	A majority of students selected the correct response. The responses of the other students are distributed almost at random, with 12% choosing B and E each, 10% choosing D, and 7% choosing C. Note that B represents the temperature curve for a typical clear day.
12	6	Scientists study fossils to: a. find out what past climates were like. b. figure out how plants and animals have changed. c. learn how the Solar System formed. d. Only a and b. e. a, b and c.	12	D: 51% (n=121)	The only incorrect option that attracted a substantial number of students was B (31%). This might reflect a focus on fossils as evidence for evolution. Fewer than 10% of the students chose A, C or E.
13	3	In comparison to the base, at the top of a tall mountain it will be: a. warmer and there will be more oxygen. b. warmer and there will be less oxygen. c. the same temperature and have as much oxygen as at the base. d. cooler and there will be less oxygen. e. cooler and there will be more oxygen.	8	D: 83% (n=518)	Students clearly understood that the atmosphere changes as one ascends a mountain. None of the incorrect choices received a significant response, suggesting guessing by those who did not chose the correct answer.
14	5	Scientists think which of the following has affected Earth for billions of years? a. Flowing water, such as rivers. b. Weathering processes. c. Earthquakes and volcanic eruptions. d. a, b and c have all affected Earth. e. None of the above has affected Earth for that long.	11	D: 67% (n=518)	Although two thirds of students answered correctly, 18% chose C, possibly suggesting a narrow view of factors affecting Earth over its lifetime. Fewer than 10% chose any other option.

15	4	<p>Scientists think Earth's moon formed when:</p> <ol style="list-style-type: none"> Earth formed. a piece of Earth spun off into space. Earth captured a large object as it tried to pass by. Earth and a large object collided. It is impossible to know. 	11	D: 16% (n=518)	<p>Three choices attracted more students than did the correct response. The majority of incorrect responses were relatively evenly distributed across three options: 27% chose B, 24% chose C, and 23% chose E. The current theory (D), well supported by evidence, has been accepted by planetary astronomers since the early 1990s. The other three scenarios were each at one time considered as plausible and may still exist in some textbooks, especially older editions.</p>
16	23	<p>Which of the following is <u>not</u> part of the water cycle?</p> <ol style="list-style-type: none"> Snow falling from clouds. Water evaporating from the ocean. Water absorbed by plants. Water in the ground. All of the above are part of the water cycle. 	6	E: 43% (n=1522)	<p>The most interesting finding was that 29% of students did not see plants as key components of the water cycle, i.e., of the 57% of students who chose an incorrect answer, about half chose C.</p>
17	19	<p>Air contains which of these gases?</p> <ol style="list-style-type: none"> Nitrogen Oxygen Water vapor Only a and b. a, b and c. 	8	E: 34% (n=463)	<p>Interestingly, about 25% of the students chose B and another 24% chose D. Only 10% chose A. Many students think of water vapor as tiny droplets of liquid water, not as a gas.</p>
18	8	<p>The portion of Earth with the highest average density is the:</p> <ol style="list-style-type: none"> material in the inner core. rock in the lower crust. water in deep ocean trenches. sediments on the seafloor. gases in the lower atmosphere. 	1	A: 50% (n=269)	<p>Although one half of students chose the correct answer, 19% chose B, 16% chose C, 11% chose D, and only 4% chose E. It might be that some students think of the inner core as being molten, i.e., a liquid, and hence have a low density.</p>

19	9	<p>Which human activity directly adds the most carbon dioxide to the atmosphere?</p> <ol style="list-style-type: none"> Using nitrogenous fertilizer to grow crops. Burning fossil fuels. Using air conditioning. Generating electricity from nuclear reactions. Increasing the amount of paved surfaces. 	8	B: 72% (n=426)	Nearly three fourths of students responded correctly and the distribution of incorrect responses was relatively random, ranging from a low of 3% to a high of 11% (for E and C, respectively).
20	2	<p>Scientists think that the primary cause of mountain building is:</p> <ol style="list-style-type: none"> the cooling and shrinking of Earth. the heating and expanding of Earth. the Moon's gravitational pull. local climate factors. plate tectonics. 	2	E: 52% (n=265)	<p>Most students responded correctly to this item and incorrect responses were distributed almost at random: 17% chose B; 12%, D; 11%, C; and 9%, A.</p> <p>Here, too, students who answered this question incorrectly were, generally, those who performed poorly on the overall test.</p>
21	7	<p>The graphs below show the highest air temperature reading every day for one year at five different locations. Which graph most likely is for a town in the middle of a large continent? (See graphs in item on test.)</p>	10	B: 50% (n=425)	One half of students chose the correct answer, while 26% of students chose A. No other option attracted more than 10% of students. Choice A does show a basic annual temperature curve consistent with seasonal variation, but with very little range (from about 30° F to 40° F over a year).

22	16	<p>If there were no weathering and erosion, which type of rock would be <u>least</u> common?</p> <ol style="list-style-type: none"> Sedimentary rock. Molten rock. Intrusive igneous rock. Extrusive igneous rock. Metamorphic rock. 	4	A: 38% (n=453)	This item displays a random response pattern with 14-17% of students choosing each of the incorrect options. This pattern suggests guessing and therefore perhaps an incomplete understanding of the rock cycle.
23	13	<p>Scientists think that compared to today, in the past Earth's climate has:</p> <ol style="list-style-type: none"> always been the same. cooled only during the Ice Age. warmed and cooled many times. warmed only since humans started burning fossil fuels. been much less stormy. 	11	C: 18% (n=1066)	Very few students responded correctly to this item, while 33% chose D and an equivalent proportion (32%) chose B. It may be that the recent emphasis in the news and elsewhere on global warming might be generating a misconception about the dynamic nature of global climate throughout Earth's existence.
24	1	<p>Which of these is a piece of scientific evidence for plate tectonics?</p> <ol style="list-style-type: none"> The location patterns of earthquakes. The path of the Gulf Stream. The Earth's magnetic field. The tilt of Earth on its axis. There is no scientific evidence. 	2	A: 64% (n=115)	There was only one incorrect option that was chosen by more than 10% of students, C, chosen by 18%. This choice might be related to the topic of magnetic zones detected in ocean crustal rock that scientists use as one piece of evidence for plate tectonics. But the magnetic field itself is not evidence for plate tectonics.

25	17	<p>If you were flying inside a puffy looking cloud, you would see:</p> <p>a. smoke.</p> <p>b. fog.</p> <p>c. dust.</p> <p>d. cotton.</p> <p>e. All of the above are possible.</p>	9	B: 72% (n=518)	Nearly three fourths of students chose the correct answer; there was only one incorrect response that attracted more than 10% of students: 15% chose E (which is interesting in that it includes choice D, cotton).
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Major Misconceptions in Grades 5–8 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.

- All clouds are cold and therefore their presence makes the air cold.
- Cold causes hydrogen and oxygen to combine to form water.
- Heat causes water to break up into hydrogen and oxygen, i.e., water is destroyed when it evaporates.
- Air pressure increases with an increase in altitude.
- The atmosphere is mostly oxygen.
- Gases cannot dissolve in water.
- Soil is old, it has existed since Earth formed.
- Soil is a precursor of rock formation.
- Soils are always deposited by rivers.
- Sedimentary rocks are volcanic in origin because of the heat from the compression that formed them.
- Fossils provide evidence of past conditions to which individuals made adaptations and then passed on to their offspring.

- The hole in the ozone layer is the main cause of global warming. (Note that the ozone "hole" is often thought of by students as an actual hole or gap in the atmosphere, not as a region of relatively low ozone concentration.)

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

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

Driver, R., et al., *Making Sense of Secondary Science*, Philadelphia: Open University Press (1994).

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).