Student Workbook for Discovering Design with Earth Science

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Daily Assignments

The daily assignments are built into the layout of the textbook. You will basically spend seven days in a given two-week period reading and doing experiments. You will then spend two days answering the questions in the chapter review. Finally, you'll spend one day taking the test.

This book is made up of 16 chapters. Each chapter contains reading and experiments that you need to complete as well as questions you must answer. You are supposed to perform the experiments when they come to you in the reading, because right after the experiment, I will discuss what the experiment means.

The questions that you answer while you are reading are called "Comprehension Check" questions, and they represent important milestones in your work. Each time you reach a "Comprehension Check" box, you are at the end of the day's lesson. You need to answer the questions and then check your answers against the answers that appear right before the Review at the end of the chapter. Once you check your answers and understand anything you answered incorrectly, you are done with science for the day!

Most of the chapters have seven "Comprehension Check" boxes, which means you will use seven school days to work through each chapter. Some of those days will consist of reading, and some of them will consist of less reading and an experiment to do. At the end of those seven days, you need to spend a day or two answering the questions in the Review that appears at the end of each chapter. Your parent/teacher has the answers to those questions, but you should not use them until you have completed the entire Review. Feel free to use the book to help you with the Review.

Once you have finished answering and checking all your answers to the review questions, you are ready to take the test that covers the chapter you have been working on. You cannot use your book for the test, but you can use a calculator if the test has any math-related questions in it.

As you read, you will see some statements and equations that are centered and surrounded by pink boxes. You must memorize any information that you see in the pink boxes. In addition, there are definitions that are centered in the text. They also needed to be committed to memory. Finally, there are some words in boldface type scattered through the text. Those are terms with which you need to be familiar. In the same way, some scientists' names will be in boldface type. They represent the most important scientists that are being discussed.

Most students should try to cover this course in one year of school. If you think about it, all of the Chapters but the first have seven "Comprehension Check" boxes, which means it will take seven days to get through all but the first chapter. After that, suppose you spend two days working on the Review and studying for the test. Then on the next day, you take the test. That means it would take ten school days (two weeks of school) to cover the chapter. That means you would take 32 weeks to finish the entire book. Most school years are 36 weeks long, so you have some built-in "flex time" in case some chapters are harder for you than others.

Worksheets

Chapter 1 Comprehension Check Questions

1.1 If the ocean is curved because it follows the earth's sphere, why does it appear to be flat?

1.2 If you look at a flat map of the world, you will see that Greenland looks almost as big as Africa. On a globe, however, Africa looks a lot bigger than Greenland. In reality, is Africa larger than or roughly the same size as Greenland?

1.3 Automobile exhaust contains CO. We exhale CO_2. A student reasons that since the chemical formulas are similar, the chemicals must be similar as well. Is he correct? Why or why not?

1.4 Rust has the chemical formula Fe_2O_3. How many atoms (total) are in a molecule of rust?

1.5 You might have some Epsom salt in your medicine cabinet. Each molecule has one atom of magnesium (Mg), one atom of sulfur (S), and four atoms of oxygen (O). What is its chemical formula?

1.6 In my research, I often have to heat solid metal. If I heat it long enough, what phase will it become? If I heat it a lot more, what phase will it become?

1.7 Suppose you want to measure how much time you work on this course to finish it. If you want to use a metric unit with one of the three prefixes you need to know, what unit would you use?

1.8 A page from this book has a length of 28 cm and a width of 22 cm. In case you don't recognize it, "cm" stands for "centimeters." What is its area, including the units?

1.9 What is the volume of a tiny box that is 16 mm long, 20 mm wide, and 15 mm tall? Don't forget to include the unit!

1.10 The maximum mass of a regulation bowling ball is 7.3 kg. How many grams is that?

1.11 Light can travel once around the earth in 13.4 centiseconds. How many seconds is that?

1.12 As you determined earlier, the maximum mass of a regulation bowling ball is 7,300 g. What is that mass in slugs? (1 sl = 14,594 g)

1.13 A furlong is another imperial unit for distance. If the distance between Washington, DC and New York, NY is 1,840 furlongs, what is it in meters? (1 furlong = 201 m)

1.14 You are reading a laboratory notebook, and you see several pieces of data: 14.5 mL, 16.2 kg, and 1.2 cm. For each piece of data, indicate (based on the unit) what was being measured.

1.15 You are watching the molecules of a substance and notice that over time, their random motion gets slower and slower. Is the substance increasing in temperature, decreasing in temperature, or remaining at the same temperature?

1.16 Which is warmer: 215 °F or 99 °C?

1.17 At room temperature, silver has a density of $10.5\ \frac{\text{g}}{\text{mL}}$. If you find a 20-mL, 210-g object that looks like it is made of silver. Is it?

1.18 Will a 125-mL, 90-g object float in water, which has a density of $1.0\ \frac{\text{g}}{\text{mL}}$?

1.19 You are blindfolded and asked to taste two drinks. Each one is made by mixing lemon juice and water. Neither is as sour as pure lemon juice, but the first one is a lot more sour than the second. Which was made with the higher percent of lemon juice?

Chapter 1 Review Questions

1. Define the following terms:

a. Mass

b. Derived unit

c. Imperial units

d. Heat

e. Temperature

f. Concentration

2. Why did ancient sailors and people who lived near the ocean understand that the earth is spherical in shape?

3. What made people think that Christopher Columbus couldn't sail around the world?

4. N_2O gas is often called "laughing gas," because it can be used to help people ignore pain that occurs during medical procedures. NO_2 gas is a pollutant found in the air. Does NO_2 have the same effect on people as laughing gas?

5. Sometimes, coal can be contaminated with a chemical whose formula is $CuFeS_2$. How many of each atom is in a molecule of this chemical?

6. The main chemical in limestone is made of one calcium (Ca) atom, one carbon (C) atom, and three oxygen (O) atoms. What is its chemical formula?

7. A chemical is in its liquid phase. Are its molecules closer together or farther apart compared to when it is in its gas phase? Do the atoms move around more or less when it is a liquid as compared to when it is a gas?

8. If you have a gas and want to turn it into a liquid, do you need to heat it up or cool it down?

9. You see the following measurements: 1 kg, 34 ms, 17%, 3 L, 5 g/mL, and 14 cm. Identify each as a measurement of mass, distance, time, volume, concentration, or density.

10. What is the area of a room that measures 3 meters wide and 2 meters long?

11. What is the volume of a cube that is 12 cm long, 10 cm wide, and 5 cm high?

12. On the surface of the earth, an object that weighs 1 pound has a mass of 454 g. How many kilograms is that?

13. An adult human finger is about 20 mm wide. How many meters wide is it?

14. A regulation fencing sword is 90 cm long. If 1 in = 2.54 cm, how many inches long is it?

15. You are watching the molecules in an object move. Suddenly, they start moving faster than before. Was object cooled down or heated up?

16. Water is at a temperature of 95 °C. Someone tells you that's the same as 230 °F. Should you believe that person? Why or why not?

17. You see an object (190 g, 30 mL) that looks like it is made of copper. If copper has a density of 8.96 g/mL, is the object made of copper?

18. The density of air at 25 °C is 0.01 g/mL. You let go of a 500-mL balloon whose total mass is 10 g. Will it float away or fall to the floor?

19. If you could count the molecules in air, you would find that out of 100 molecules, 21 of them are oxygen, 78 are nitrogen, and 1 is another chemical. What percent of air is nitrogen?

20. Another common temperature scale in science is the Kelvin scale. On this scale, water freezes at 273 K and boils at 373 K. Which is warmer: 300 K or 110 °C?

Chapter 2 Comprehension Check Questions

2.1 You are given two positions. The first is 24° N and 17° E. The second is 49° N and 56° W. Which is closer to the north pole?

2.2 Which sphere (geosphere, atmosphere, hydrosphere) do scientists say gaseous water is a part of?

2.3 Of the crust, mantle, inner core, and outer core, which is the hottest? Which is the coolest?

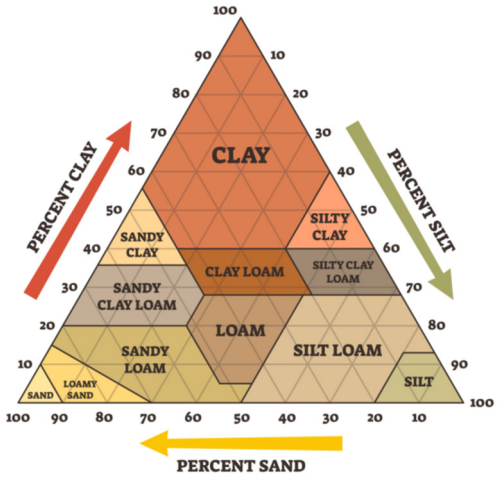
2.4 You learn that the sun is roughly 75% hydrogen and 25% helium. A friend tells you that it is impossible for us to know that, since we have never been to the sun. What should you tell your friend?

2.5 You are shown samples of two different soil horizons. They both contain organic matter and mineral matter, but the first is lighter than the second. Which horizon did each sample come from?

Photo from www.shutterstock.com
© mahey

2.6 Suppose you took handfuls of each material pictured on the left and put them in a tall container of water. Then, you shook the container vigorously. After everything settled out, which of the materials (larger gravel, smaller gravel, or sand) would you expect to be at the bottom of the jar? Which would be closest to the top?

2.7 A loam is 30% clay, 10% silt, and 60% sand. Looking at the illustration on the right, how would that soil be classified?



2.8 Loam "A" is 35% clay, 55% silt, and 10% sand. Compare the size of its pores to the pores in Loam "B," which is 10% clay, 25% silt, and 65% sand.

2.9 You see a large rock with lots of cracks in it and what looks like dirt around its base. Suppose you collect a sample of the "dirt" and find out what chemicals are in it. Then, you analyze the rock and find out what chemicals are in it. If the "dirt" is the result of physical weathering, what can you say about how the chemicals compare. If the "dirt" is the result of chemical weathering, what can you say?

2.10 You see lots of cracks in a rock, but the area doesn't get much rain, there isn't much salt in the area, and there are no roots in the rock. Ignoring the possibility that something hard hit the rock with a lot of force, what type of physical weathering could explain the cracks?

2.11 Later on in the course, you will learn about rocks that form from lava. They often contain the chemical $HAlSi_3O_8$. It can react with water as shown in this chemical equation:

$$2HAlSi_3O_8 + 5H_2O \rightarrow Al_2O_3 + 6H_2SiO_3$$

What are the chemical formulas of the molecules that are reacting? How many of each are needed?

What are the chemical formulas of the molecules that are produced? How many of each is made?

2.12 While we know it would be impossible, think about an earth with no oxygen in its atmosphere. Would the rainbow mountains still be so colorful? Why or why not?

2.13 While I concentrated on water as the main agent of erosion, there is another very important part of the weather that can also cause a lot of erosion. What is it? (HINT: The products of weathering are often very tiny grains.)

2.14 In the definitions of catastrophism and uniformitarianism, I use the word "most." It's important for both, but based on what you learned already, you should see that it is important for the definition of uniformitarianism. Why?

Chapter 2 Review Questions

1. Define the following terms:

a. Atmosphere

b. Geosphere

c. Hydrosphere

d. Mineral

e. Percolation

f. Loam

g. Physical weathering

h. Chemical Weathering

i. Erosion

j. Uniformitarianism

k. Catastrophism

2. The latitude and longitude of city A is 12° S, 77° W. For city B, the latitude and longitude are 35 °S, 58 °W. Which is closer to the equator? Which is closer to the prime meridian?

3. Is the earth's crust part of the atmosphere, geosphere, or hydrosphere?

4. What are the spheres into which the geosphere can be divided? List them in order of their depth.

5. Of the spheres listed above, which is the coolest? Which is the hottest? Which is liquid? Which is solid? Which can be described as being made of "plastic" rock?

6. List the soil horizons in order of their depth. Which horizon might not exist in an area?

7. For each horizon listed above, describe its contents.

8. Why is broken bedrock sometimes called the "parent material" of soil?

9. List the three kinds of particles found in a loam, from largest to smallest.

10. Why is it important for a loam to have a mixture of those three types of particles?

11. A loam doesn't allow water to percolate through it. If it has the right amount of silt, what kind of particle does it have too much of? What kind of particle would you mix in to make it better for plants?

12. You learned about five things that produce physical weathering. What are they?

13. A geologist describes a chemical weathering process this way: Two molecules of lactic acid ($C_3H_6O_3$) made by bacteria react with one molecule of magnesium carbonate ($MgCO_3$) to make one molecule of water (H_2O), one molecule of carbon dioxide (CO_2), and one molecule of magnesium lactate ($MgC_6H_{10}O_6$). Write the chemical equation that describes this process.

14. Oxygen and water can chemically weather a rock containing pyrite (FeS_2) this way:

$$4FeS_2 + 15O_2 + 8H_2O \rightarrow 2Fe_2O_3 + 8H_2SO_4$$

List the molecules that react and the molecules that are made, including how many of each is involved.

15. Which would usually happen to a rock first: weathering or erosion?

16. Explain how a scientist guided by uniformitarianism would explain how the Grand Canyon was formed. How would a scientist guided by catastrophism explain it?

17. What catastrophe inspired many of the scientists in history to follow catastrophism?

Chapter 3 Comprehension Check Questions

3.1 You are looking at a sample of something from the earth's crust. It is gray with irregular red stripes in it. Is it more likely to be a rock or a mineral?

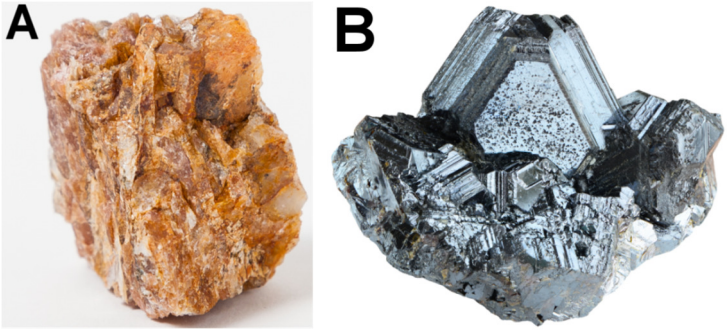
3.2 You will learn about shape and luster in the next section. Just based on the names, which is an optical property?

3.3 You see a sample of quartz shaped like the one in the picture on the right, but it is opaque. What can you say about the room it had to grow and the level of impurities in the area where it grew?

Photo from www.shutterstock.com © Albert Russ

3.4 Using the same specimen, one student claims a mineral's streak is brown, and another student says it is green. Is it possible that both are accurately reporting the results of a streak test? Why or why not?

3.5 The pictures on the right are of two different minerals. Which has cleavage and which has fracture?



Photos from www.shutterstock.com © Moha El-Jaw – left, Albert Russ – right

3.6 An iron nail cannot scratch a mineral, but that mineral will not scratch a glass plate. If you are told it is one of the minerals used to define the Mohs Hardness Scale, which is it?

3.7 A mineral doesn't attract any metal to it. However, after being put next to a strong magnet, the mineral attracts bits of iron to itself. Is this mineral ferromagnetic, diamagnetic, or paramagnetic?

3.8 Horneblend's chemical formula can be given as $Ca_2(Fe, Mg)_5Si_8O_{22}(OH)_2$.

a. Is this a silicate or non-silicate mineral?

b. How many different chemical formulas can horneblend have?

c. Give the possible chemical formulas of horneblend.

d. List the number and type of atom in each chemical formula.

3.9 There is a mineral group called augite. One member is $MgSiO_3$. Which of the following would also be a member of the augite group: $KAlSi_3O_8$, $FeSiO_3$, or $MgSiO_2$?

3.10 Which of the following are non-silicate minerals: SiO_2, Cu, $FeSiO_2$, $CaSO_4$, KCl, Al_2O_3?

3.11 You are given two samples of a silicate mineral that both come directly from the earth's crust. The first contains large crystals, while the second contains small crystals. If you are told one of them formed from the cooling of lava and the other from the cooling of magma, which is which?

3.12 A sample of magma is cooling. The first mineral you see forming is biotite mica. Later on, muscovite mica is formed. Which mineral is easier to dissolve in magma?

3.13 "A diamond is a chunk of coal that did well under pressure" is an inspirational quote you might read from time to time. Given that coal is a form of carbon found in the earth's crust, is this quote accurate? Why or why not?

3.14 Of the nonmetallic resources I discussed (halite, graphite, quartz, and mica), which are silicate minerals?

3.15 If a mineral has a lot of facets, what was probably done to it after it was pulled from the ground?

3.16 A ring has a 3.5-carat ruby in it. What is the mass of the ruby in grams? (1 carat = 0.2 grams)

3.17 A scientist starts out with a sample of quartz that is nearly clear. She puts it in a box and lets it sit there for a long time. When it comes out, it has a purple color to it, but its shape and hardness have not changed. What happened to the quartz while it was in the box?

Chapter 3 Review Questions

1. Define the following terms:

a. Streak

b. Luster

c. Cleavage

d. Effervescence

e. Ferromagnetic mineral

f. Paramagnetic mineral

g. Diamagnetic mineral

h. Precipitation

i. Magma

j. Lava

k. Ore

2. You are looking at two solid objects that came from the earth's crust. The first has lots of different chemicals all mixed together. The second is mostly made up of one chemical. Which is a mineral?

3. Which of the following are optical properties: hardness, luster, cleavage, color, effervescence?

4. If you cannot find parallel, flat surfaces on a mineral, does it have cleavage or fracture?

5. Refer to Tables 3.1 and 3.2 on page 72 to answer the following questions:

a. You have a sample of fluorite. Can it scratch a glass plate? Can a penny scratch it? What about an iron nail?

b. A mineral can scratch a glass plate but not a streak plate. What is its range in hardness?

c. A mineral cannot scratch a glass plate, can be scratched by a nail and a penny, but can't be scratched by a fingernail. What is its range in hardness?

6. A mineral is attracted to a magnet but cannot become a magnet. What word describes this?

7. You have two samples of quartz. Sample A is white, and if you try to look through it, you cannot see anything on the other side. Sample B is somewhat clear, and you can partially see things through it. How would you describe each sample's optical property, using a single word for each?

8. The chemical formula for the mineral anthophyllite can be given as $(Mg,Fe)_7Si_8O_{22}(OH)_2$.

a. List the possible chemical formulas of the molecules in this mineral.

b. How many of each type of atom exist in each of the molecules?

c. Which of the following molecules would be in a mineral from the same group: $Mg_3Si_4O_{10}(OH)_2$, $Fe_2Al_4Si_5O_{18}$, or $Ca_2Mg_5Si_8O_{22}(OH)_2$?

9. Which of the following are non-silicate minerals: $NaAlSi_2O_6$, PbS, $CaSiO_3$, $Ca_5(PO_4)_3(OH)$?

10. Magma is rising through a volcano. Mineral A precipitates out while it is magma, but mineral B doesn't precipitate out until it is lava. Which mineral precipitates at a higher temperature?

11. Calcite and aragonite are polymorphs. If calcite's chemical formula is $CaCO_3$, what is aragonite's chemical formula?

12. A metallic resource is mined from the ground, but it must be treated so that the metal can be extracted and used. What is the name we use to refer to what was mined?

13. The sapphire in a ring is 2.2 carats. What is its mass in grams?

14. You measure the mass of a diamond to be 1.1 grams. How many carats is it?

Chapter 4 Comprehension Check Questions

4.1 While it's not considered metamorphosis, there is a way that igneous rock can be turned into sedimentary rock. How?

4.2 You have four igneous rocks that are described as follows: (I) intermediate extrusive, (II) ultramafic intrusive, (III) felsic extrusive, (IV) mafic intrusive.

a. Which of the rocks should have smaller mineral crystals in them?

b. Order them in terms of the percentage of silicate minerals, starting with the lowest percentage and ending with the highest percentage.

c. Two of them were pulled from an underground mine. Which two?

4.3 If you had shale to use in your experiment, how would it have felt compared to the sandstone and siltstone?

4.4 Some sedimentary rocks form as a result of water evaporating. Are they clastic, chemical, or organic?

Slate Quartzite Mylonite

Photos from www.shutterstock.com © (left to right) Yes058, www.sandatlas.org, Lu Mikhaylova

4.5 Which of the three rocks on the left is foliated?

4.6 Suppose you took sedimentary rock and used a blowtorch to get it so hot that it transforms. Which kind of metamorphic rock would you have made?

4.7 Igneous rock becomes metamorphic rock and then eventually becomes sedimentary rock. Which of the following things had to have happened, and in which order did they happen: freezing, lithification, melting, weathering, exposure to heat and/or pressure?

4.8 Rock A has a lot of sharp corners and is really rough. Rock B is smooth and rounded. Which has probably experienced more weathering?

4.9 Can you definitively say which of the rocks in the previous question is older? Why or why not?

4.10 You are examining a rock formation that is composed of four distinct strata of sedimentary rock. How many bedding planes are present?

4.11 In the rock formation from the previous problem, the bottom layer is made of igneous rock. The other layers are all sedimentary rock. How many nonconformities are there?

4.12 In the rock formation from the previous problems, the strata all exhibit planar bedding. How many angular unconformities are present?

4.13 You are examining a dike. How can you tell if it was formed by magma being pushed up into a crack in the surrounding rock or sediments being pushed down into the crack?

4.14 While it is rare, some igneous rocks do have fossils in them. Are they extrusive or intrusive?

4.15 As mentioned in the book, we only know trilobites from their fossils. Does that mean we know for certain that there are no trilobites alive today?

4.16 Fossils of placoderm fish are found in sedimentary strata that are lower than the strata in which fossils of trees are found. Using the Principle of Superposition, which existed on earth first? Can you be certain of that conclusion?

4.17 If burning coal makes NO and NO_2, what element must also be in that coal?

Chapter 4 Review Questions

1. Define the following terms:

a. Igneous rock

b. Sedimentary rock

c. Metamorphic rock

d. Rock cycle

e. Lithification

f. Bedding plane

g. Unconformity

h. Disconformity

i. Angular unconformity

j. Nonconformity

k. Paraconformity

l. Principle of Superposition

2. You have the following set of rocks: (I) mafic extrusive igneous rock that has holes and pits in it (II) felsic intrusive igneous rock that has no holes or pits in it, (III) intermediate extrusive igneous rock that has no holes or pits in it, and (IV) ultramafic intrusive igneous rock that has no holes or pits in it.

a. Which one has the most silicate minerals in it?

b. Which has the least silicate minerals in it?

c. Which ones do you expect to have the larger mineral crystals?

d. Which one had lots of gas in it when it was still molten rock?

e. Which ones formed above ground?

3. You have a conglomerate, a siltstone, and a sandstone. Which is probably the smoothest? Which is probably the roughest?

4. Rock A is composed mostly of chemicals that have precipitated out of water. Rock B is composed mostly of sediments that came from weathering and erosion. Rock C is composed mostly of carbon particles from the decayed remains of organisms. Identify each as clastic, chemical, or organic.

5. A layer of limestone is just under the soil, but there is a pocket of magma below it. The limestone right above the magma goes through metamorphosis. Is a regional, contact, or dynamic metamorphic rock formed? If that layer had been under many other layers of rock, how would that change the answer?

6. In the rock cycle, what must happen for a sedimentary rock to become an igneous rock?

7. If a metamorphic rock is weathered, what kind of rock can form from the remains?

8. Sediments that were originally part of an igneous rock are now in a sedimentary rock. There are two possible ways that could happen. What are they?

9. Contrast how those who are guided by uniformitarianism and those who are guided by catastrophism view the rock cycle.

10. Can we say for certain how long the lithification process for a specific sedimentary rock took? Why or why not?

11. There are two basic kinds of bedding planes. What are they and what is the difference between them?

12. If you are looking at strata with planar bedding and see an obvious unconformity, what kind of unconformity is it?

13. You are examining what looks to be a conformal bedding plane. What could it be instead of a conformal bedding plane?

14. You see folded strata with very few cracks or breaks in them. Most likely, did lithification occur before or after the folding?

15. A dike is formed when the material that makes up the rock falls down through a crack in the underlying rock. Is this dike made of sedimentary or igneous rock?

16. Which of the three types of rock is most likely to contain fossils?

17. You are looking at a series of sedimentary rock strata. The lowest strata contain fossils of trees, the middle strata have fossils from the same kind of trees as well as bird fossils, and the upper strata have only mammal fossils. According to the Principle of Superposition, which fossils are the oldest? Which are the youngest?

18. Can you be sure of the conclusion you gave for 17?

19. Which of the four types of coal produces the least amount of energy per gram when it is burned?

20. Which of the four types of coal produces the least amount of pollution when it is burned?

21. CO_2 is the only product when carbon is burned completely. Why does burning coal produce chemicals like SO_2, SO_3, NO, and NO_2?

22. Is coal always an organic sedimentary rock?

Chapter 5 Comprehension Check Questions

5.1 The density of rocks varies, but on average, you can compare the densities of igneous, metamorphic and sedimentary rock. Keeping in mind that I am asking about the *average* rock, which of the three types would you think has the lowest density? Which has the highest density?

5.2 Suppose you had a compass and brought the magnet from your kit close to the compass. What would happen to the compass needle? What would happen when you pulled the magnet far from the compass? If you have a compass, feel free to test whether or not your answer is correct.

5.3 The electromagnet you made was pretty weak. It didn't move the needle nearly as strongly as the magnet from your kit. What could you do to increase the strength of your electromagnet? Don't try it, because depending on what you do, it could be dangerous!

5.4 Seafloor spreading also explains why there is not much sediment on the seafloor near an ocean ridge, but there is a lot of it on the seafloor next to a continent. How?

5.5 In 2012, film director James Cameron spent three hours exploring the ocean at the deepest point humans have ever explored. Was he near an ocean ridge, in the abyssal plain, or near a continent?

5.6 Suppose you could accurately measure the date at which the igneous rock in the ocean crust formed. If you measured those dates near a continent and then near a ridge, which crust would be the youngest?

5.7 In the experiment, I told you that you had to measure the mass of the graduated cylinder again after you dumped the water out of it. You had already measured the mass of the empty graduated cylinder. Why did I make you measure it again?

5.8 You didn't measure the density of the corn syrup in your experiment, because it would have been really messy. Had you measured it, however, how would it have compared to the densities of water and vegetable oil?

5.9 Rift valleys at divergent plate boundaries can have rivers in them, making them look a bit like canyons. If you are looking at something with high walls of rock and a river flowing through the bottom, how could you tell if it is a canyon or a rift valley?

5.10 You are studying a boundary between two oceanic plates. How could you decide whether it was a convergent plate boundary or a divergent plate boundary by just observing the seafloor at the boundary?

5.11 A mountain range has some volcanoes in it. Were the mountains formed at a plate boundary between two continental plates or a plate boundary between an oceanic plate and a continental plate?

5.12 You are studying a line of volcanic islands. What would you look for to determine which island was formed most recently?

5.13 In the illustration on the right, the lithosphere is pointed out. If a plate were sitting where the arrow is pointing, in what direction would it be moving?

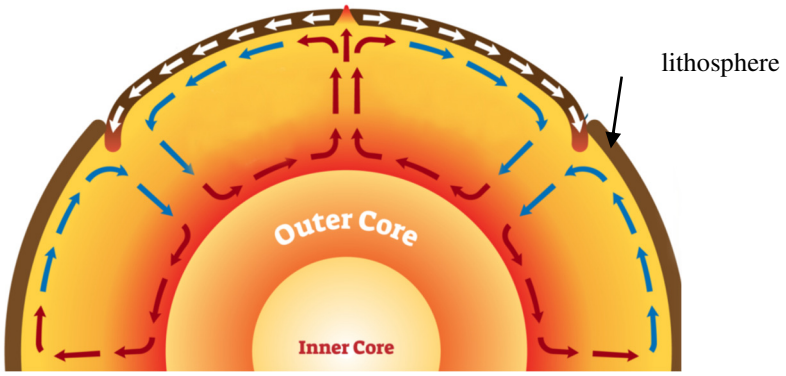


Illustration from www.shutterstock.com © VectorMine

5.14 As time goes on, what will happen to the temperature difference between the asthenosphere and the lower parts of the mantle?

Chapter 5 Review Questions

1. Define the following terms:

a. Lithosphere

b. Paleomagnetism

c. Magnetic reversal

d. Tectonic plate

e. Divergent boundary

f. Convergent boundary

g. Subduction

h. Transform boundary

i. Fault

j. Mantle hotspot

k. Convection

2. List the following from least to most dense: oceanic crust, asthenosphere, continental crust.

3. List the following in order of how deep they are found in the earth, starting with the deepest: transition zone, outer core, inner core, lower mantle, lithosphere, asthenosphere.

4. What was Pangaea?

5. What causes the earth's magnetic field, and in what two ways does it help us?

6. What geographic location is the south pole of earth's magnetic field near?

7. Explain how seafloor spreading works, making sure to use the terms "rift," "ridge," "abyssal plain," "subduction," and "trench."

8. How did magnetic reversals and paleomagnetism help confirm the idea of seafloor spreading?

9. What are the major features found at a divergent boundary between oceanic plates? What about divergent boundaries between continental plates?

10. What kinds of plates will produce subduction at a convergent boundary? Which plate will go underneath?

11. Which kinds of plates at what kind of boundary produce continental arc volcanoes? Which kinds of plates at what kind of boundary produce volcanic island arcs? Which kinds of plates at what kind of boundary produce no volcanoes?

12. Distinguish between faults and plate boundaries.

13. If volcanic islands form in a line, what structure in the mantle produced the volcano? If there are several islands, how can you identify the one over that structure?

14. Where are the convection currents that drive the motion of the plates? Is that the only place under the lithosphere where convection currents exist?

15. If molten rock in the mantle is sinking, how does its temperature compare to the surrounding mantle rock? Is it more likely near a place where subduction is occurring or where magma is breaking through the crust and becoming lava?

Chapter 6 Comprehension Check Questions

6.1 There are two types of friction: static friction and kinetic friction. Static friction must be overcome to get an object moving. Kinetic friction needs to be overcome to keep the object moving once it has started. Based on the experiment (and your general experience), which is stronger?

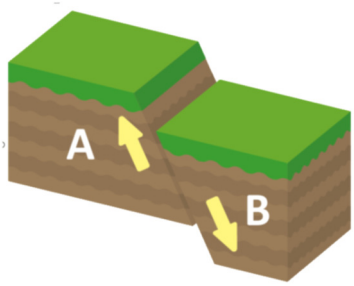


Illustration from www.shutterstock.com © Barks

6.2 In the drawing on the left, which block (A or B) is the hanging wall? What kind of fault is this?

6.3 Suppose you could measure the force that is required to overcome friction in a fault and produce an earthquake. If so, how would the strength of an earthquake along a fault where the required force is low compare to the strength of an earthquake along a fault where the required force is high?

6.4 An earthquake is magnitude 5 on the Richter scale, while another one is magnitude 8. Which is the stronger one? How much energy does it release compared to the other?

6.5 Suppose the focus of an earthquake is in the crust below a large lake. A helicopter is hovering above the lake the moment it happens, and the pilot sees waves produced by the earthquake on the surface of the lake. How could the pilot tell where the epicenter of the earthquake is?

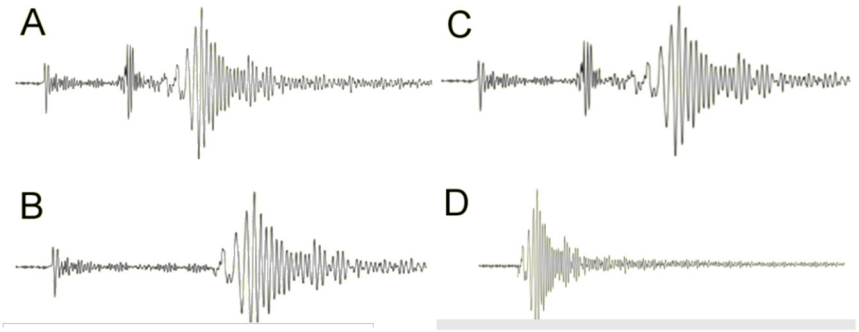
6.6 Light is a transverse wave, and the frequency of the wave determines the energy of the light. The higher the frequency, the more energy the light has. You are studying two light waves. The first has a long distance between its crests (a long wavelength). The second has a short distance between its crests (a short wavelength). Which light wave has more energy?

6.7 Imagine that you are inside the earth, watching a seismic wave. The rocks vibrate up and down, but the wave moves from your left to your right. Were you watching a P-wave, an S-wave, or a surface wave?

6.8 For the seismograms shown below:

a. Which is not from an earthquake?

b. Of the ones that are from an earthquake, which one can you tell is the closest to it?



c. Of the ones that are from an earthquake, which is in the S-wave shadow zone?

6.9 Suppose you are standing in a shallow pool and looking down into the water. Off to one side, you see a rock sitting underwater, and you decide to lean down and pick it up. Will the rock be where it appears to be? Why or why not?

6.10 If they have time, boaters are told to quickly move their boats out from the shore and into deep water when a tsunami is approaching. Why?

6.11 Careful measurements show that a fault-block mountain is actually getting shorter, even though it is a part of the block that is rising along the fault. What is happening to cause it to get shorter?

6.12 Geologists are drilling down a dome mountain. They are currently drilling through sedimentary rock. Will they continue to drill through sedimentary rock all the way to the bottom of the mountain? If not, what type of rock (be as specific as you can be) will they eventually hit?

6.13 Identify the phase (solid, liquid, or gas) of each of the following volcanic emissions:

Pyroclastic material

Water

Lava

6.14 Are the volcanoes in the Ring of Fire more likely to be grouped in straight lines or arcs?

6.15 A volcano is very, very tall. Most likely, what kind of volcano is it?

6.16 A xenolith in some extrusive, igneous rock has properties that indicate it was formed at a temperature of 1,000 °C. Did it form above or below the depth where diamonds form?

Chapter 6 Review Questions

1. Define the following terms:

a. Linear scale

b. Logarithmic scale

c. Focus of an earthquake

d. Epicenter

e. Transverse wave

f. Longitudinal wave

g. Refraction

h. Fault-block mountain

i. Folded mountain

j. Dome mountain

k. Volcanic mountain

l. Pyroclastic material

2. Draw and label the four types of faults, indicating the hanging wall and foot wall in each type.

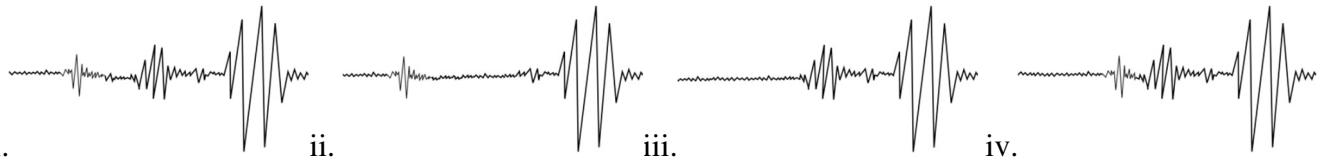
3. Explain elastic rebound theory in your own words.

4. A seismograph measures an earthquake of magnitude 3 on the Richter scale, followed by one of magnitude 7, followed by one of magnitude 4. Identify the foreshock, aftershock, and main earthquake. Compare the strength the main earthquake to the foreshock and the aftershock.

5. You are comparing two waves. The first has a longer wavelength than the second. How do their frequencies compare?

6. Of the two types of seismic body waves, which is longitudinal and which is transverse? Which moves faster? Which cannot travel through liquids underneath the earth's crust?

7. Consider the four seismograms shown below, each of which comes from the same earthquake:



i. ii. iii. iv.

a. Which is from a seismograph in the P-wave shadow zone?

b. Which is from a seismograph in the S-wave shadow zone?

c. Which is closer to the epicenter: The seismograph that made (i) or the one that made (iv)?

d. Which are the surface waves in the sesimograms?

8. What one word can be used to explain why there is a P-wave shadow zone?

9. Where must the epicenter of an earthquake be in order to produce a tsunami? In what depth of water does the tsunami move quickly? In what depth of water are the waves large?

10. Which types of mountains can be formed by magma? What type can be formed by the convergence of plates that both have continental crust?

11. What single plate is responsible for the volcanoes in the Ring of Fire?

12. The tallest volcanoes are what type of volcano? What type is made mostly from pyroclastic material? What type is made mostly from lava and tends to be wide instead of really tall? What type is made from a lot of both lava and pyroclastic material?

13. How do xenoliths help us understand the geosphere below the crust of the earth?

Chapter 7 Comprehension Check Questions

7.1 When you looked at specimen 16, you probably noticed right away that it was a fossil of a clam. What made you think it was a fossil and not just a rock that simply looked like a clam?

7.2 Suppose you are looking at a gallery of fossils that were entombed in amber. Next door, there is a gallery of fossils that were entombed in ice. Overall, which gallery would house the larger fossils? Why?

7.3 Classify each of the fossils below as being a fossil mold, fossil cast, or compression fossil.

a.  b.  c. 

Photos from www.shutterstock.com © (left to right) Breck P. Kent,Carolina Jaramillo, AlicanA

7.4 A paleontologist says that she has found chemicals from an extinct animal in a fossil. Of the fossils you have learned about so far, she was probably analyzing one of two kinds. Which kinds?

7.5 Gastroliths (gas' truh liths) are rocks that some reptiles swallow to aid in digestion. If a reptile vomits a gastrolith that ends up preserved as a fossil, which of the definitions you learned best fits it?

7.6 Hot springs are produced when water running underground is naturally heated and then rises to the surface. Would water from such a spring make petrifaction more likely or less likely?

7.7 You have a fossil that is shaped like a log. One person tells you it's petrified wood. Another tells you it's part of a crinoid stem. How can you tell which person is correct?

7.8 Of all the fossils pictured on pages 200-202 of the textbook, which one or ones would be considered trace fossils?

7.9 You find what you think is coprolite from an extinct animal that was a vegetarian. What would you expect to find inside the coprolite?

7.10 In 2015, paleontologists published a paper saying that they had discovered a new kind of prehistoric human based on finding a single fossilized pinky finger. How confident should they be of their conclusion?

7.11 Suppose you are studying two dinosaurs: diplodocus (26 meters long) and microraptor (77 centimeters long). For which can you be more confident that it is actually extinct?

7.12 The Principle of Superposition is also used to correlate strata. Does it help in physical correlation or temporal correlation?

7.13 Clam fossils have been found in rocks that contain trilobite fossils and rocks that contain mammoth fossils. Are they good index fossils? If so, which layer of rock would they be used for?

Chapter 7 Review Questions

1. Define the following terms:

a. Fossil

b. Fossil mold

c. Fossil cast

d. Compression Fossil

e. Trace fossil

f. Petrifaction

g. Coprolite

h. Extant

i. Physical correlation

j. Temporal correlation

k. Principle of Faunal Succession

l. Index fossil

2. What must be slowed down in order for fossilization to occur?

3. By what two things can the remains of an organism be entombed in order to preserve them? Which can entomb the remains of larger organisms? Which comes from trees? Explain how each helps to preserve the organism's remains.

4. If you see a fossil mold and cast of the same organism, which formed first?

5. For the two statuses "extinct" and "extant," which can you be certain of

6. Explain the part and counterpart of a fossil. How can they help to determine if it is fake?

7. You see fossils of a bone, a tooth, feces, a shell, and footprints. Which are trace fossils?

8. Of the fossils you learned about, which ones can contain soft tissue from the organism?

9. What kind of fossil could have remains of chemicals from the organism but not soft tissue?

10. How does soft tissue in dinosaur fossils demonstrate that science can develop blind spots?

11. Which is more likely to fossilize: a clam or a jellyfish. Why?

12. Are all fossils prehistoric?

13. What do Nebraska Man and *Pakicetus* tell us about interpreting fossils?

14. Why do people sometimes make fake fossils?

15. James Leonard Brierly Smith had seen coelacanth fossils and a sketch of a recently-dead coelacanth. Nevertheless, he made a big mistake in his interpretation. What was it?

16. A paleontologist is showing you fossils she recently discovered. She shows you a dinosaur fossil, an elephant fossil, and a trilobite fossil. Referring to the geological column on page 209, which was found in the lowest layer of rock? Which was found in the highest layer?

17. What kind of correlation is used to construct the geological column? On which principle is it based?

18. Is there somewhere on earth that you can go and see all the layers of the geological column and the fossils upon which it is based?

Chapter 8 Comprehension Check Questions

8.1 If you heat washing soda (Na_2CO_3) to about 850 °C, it will melt and form liquid washing soda. Is it possible to melt baking soda ($NaHCO_3$)?

8.2 Lithium-8 has three protons and 5 neutrons in its nucleus. If it undergoes beta decay, how many protons and neutrons will it have?

8.3 Potassium-40 is an isotope found in nature. It has 19 protons and 21 neutrons in its nucleus. If it decays by electron capture, how many protons and neutrons will it have?

8.4 Americium-241 has 95 protons and 146 neutrons in its nucleus. If it undergoes alpha decay, how many protons and neutrons will it have?

8.5 A radioactive atom has a half-life of 15 minutes. If you have 1,000 atoms and wait 15 minutes, how many will have decayed? If you wait 15 more minutes, how many more will have decayed?

8.6 Uranium-234 can alpha decay into thorium-230 with a half-life of 80,000 years. If the rock is analyzed for those two specific atoms and it is determined that uranium-234 has been reduced to ¼ of its original content since the rock formed, how old would radiometric dating say it is?

8.7 An intrusion of igneous rock is found in a layer of sedimentary rock that has an index fossil indicating it is Permian rock. Which of the following is possible for an age of that igneous intrusion: 450 million years, 350 million years, or 250 million years? (Feel free to use the geological column illustration on page 227.)

8.8 A student is studying a rock layer that he says must be Silurian. You find a dinosaur fossil in it. What does that tell you about the student's conclusion? (Feel free to use the geological column illustration on page 227.)

8.9 If you read much about evolution, you will eventually hear about the "Cambrian Explosion." To what does that refer?

8.10 According to YECs, when were dinosaur fossils formed? What about mammoth fossils? (Feel free to refer to the illustration on page 233.)

8.11 Suppose someone found a rabbit fossil in Cambrian rock. What would that tell you about the YEC interpretation of the geological column?

8.12 Evergreen tree fossils are usually found in rock layers below the rocks where you find fossils of deciduous trees (trees that lose their leaves in the winter). In the YEC interpretation, which trees would have been found at lower elevations at the time of the Flood?

8.13 If a Cretaceous index fossil were found below the Great Unconformity, what would that mean about the YEC interpretation of the Great Unconformity?

8.14 Why can't runaway subduction occur at a boundary between two continental plates?

8.15 Compare the depth of the oceans during the Flood to after the Flood.

Chapter 8 Review Questions

1. Define the following terms:

a. Isotopes

b. Radioactive isotope

c. Beta decay

d. Electron capture

e. Alpha decay

f. Half-life

g. Radiometric dating

h. Hydrothermal vent

i. Geyser

2. Why must we be careful about putting too much faith in our geological interpretations?

3. Does "The present is the key to the past" describe uniformitarianism or catastrophism?

4. What's the main difference between the uniformitarian's approach to plate tectonics and the catastrophist approach?

5. You have 100 grams of a stable isotope and 100 grams of a radioactive isotope, each in a sealed jar. If you wait a long time, will anything change in either jar? If so, what will change in which?

6. A radioactive isotope has a half-life of 1 year. If you start with 1,000 atoms and wait 3 years, how many atoms of the radioactive isotope will be left?

7. You have 100 atoms each of two different radioactive isotopes. After 24 hours, you have 75 atoms of the first isotope and only 12 atoms of the second. Which has the shorter half-life?

8. Of the three kinds of rocks, which is best suited for radiometric dating?

9. What does the potassium-argon dating method assume about the amount of argon in an igneous rock when it is first formed?

10. Explain what bracketing is and how it is used by uniformitarians to determine how old sedimentary rock is.

11. In the uniformitarian interpretation, what do the layers in the geological column represent? How is the Principle of Faunal Succession explained in that interpretation?

12. What are the differences between atheists, theistic evolutionists, those who believe in intelligent design, old-earth creationists, and YECs when it comes to the earth's history?

13. What historical evidence (outside of the Bible) points to a worldwide Flood?

14. In the YEC interpretation, what do the layers in the geological column represent? How is the Principle of Faunal Succession explained in that interpretation?

15. In the YEC interpretation, what does the Great Unconformity represent?

16. In the YEC interpretation, what is runaway subduction? Is there evidence that it happened?

17. What three processes work together in the YEC interpretation to explain how the entire surface of the earth was covered in water? What happened to cause the water to recede?

Chapter 9 Comprehension Check Questions

9.1 The reaction in the hot vinegar was faster than the reaction in the cold vinegar, but that's not the only reason more bubbles were produced in the hot vinegar. What's the other reason? (HINT: Think about an experiment you did in the previous chapter.)

9.2 In the illustration on page 248, the 0.4 MY points to Hawaii, and the 5.1 MY points to Kauai. According to uniformitarians, did Oahu (which is in between) formed 11 MY, 6 MY, or 3 MY ago?

9.3 If an igneous intrusion in Quaternary rock (the top layer of the geological column) was determined to have a potassium-argon age of 32 MY, would a uniformitarian think it was accurate?

9.4 A bird fossil found in Quaternary rock has a carbon-14 age of 26,000 years. Would a uniformitarian believe it was an accurate age? What evidence could a YEC use to show that the uniformitarian must at least be a bit skeptical about the date?

9.5 If Chicxulub had been dated to be 100 million years old, how would that have changed the way uniformitarians explained the mass extinction at the end of the Cretaceous era?

9.6 There are certain insects that depend on nectar from flowers in order to survive. Would a uniformitarian expect to find them in Silurian rock, which contains only fossils of gymnosperms?

9.7 If you are examining a series of very thin strata, what would you look for to see if they are varves?

9.8 A geologist says a bed of limestone was deposited quickly by erosion caused by a catastrophe. How would the size of the mineral crystals compare to those in the White Cliffs of Dover?

9.9 Do the marine fossils at the top of Mount Everest tell YECs that the Flood waters were as deep as Mount Everest is tall?

9.10 Why wouldn't a YEC think that the sandstone found throughout North America could be explained by local catastrophes that covered specific regions of the continent?

9.11 Suppose you are looking at a series of sedimentary strata. You find lots of saltwater fish fossils in one layer, lots of freshwater fish in the next layer above, and lots of land animal fossils in the layer above that. You then look at a second series of sedimentary strata. In that series, you find lots of saltwater fish fossils, freshwater fish fossils, and land animal fossils all mixed together in one layer. Which gives evidence for the YEC view?

9.12 Cane toads were brought to Australia in an attempt to get rid of a pest in the sugar cane fields. The toads are very large, and they are poisonous to snakes. Snakes in the parts of Australia where cane toads exist have, on average, smaller heads than snakes in parts of Australia where cane toads are not found. Explain this in terms of natural selection.

9.13 Suppose a fossil that is part of the whale macroevolution sequence was found in rocks that are supposed to be 40 million years old. How would an evolutionist expect its rear legs to compare to those of *Rodhocetus*? (Look at the illustration on page 264.)

9.14 The eyes of land reptiles are nearly identical to those of marine animals like the octopus, despite the fact that the octopus is not a part of the macroevolutionary sequence that is supposed to have led to land-based reptiles. How does an evolutionist explain this?

9.15 Evolutionists are trying to find Precambrian fossils of animals that are more complex than the ones that are currently found. If they do, how would that help the problem of the Cambrian Explosion?

9.16 Suppose you are looking at pictures of a wolf, a domestic dog, a horse, a fox, and a rat. If a YEC told you that three of those animals all came from a single pair of animals that were on the ark, what three would he or she be referring to?

9.17 Suppose someone discovers a radioactive isotope in nature that has a half-life of 1 million years. What would uniformitarians most likely do? What about YECs?

9.18 We don't know whether or not Pluto (which rotates very slowly) has a magnetic field. The YEC theory says that its magnetic field should have decayed long ago. Once Pluto's magnetic field is measured, can the result be used to indicate the superiority of one theory over the other?

Chapter 9 Review Questions

1. Define the following terms:

a. Calibration

b. Mass extinction

c. Gymnosperms

d. Angiosperms

e. Varve

f. Natural selection

g. Microevolution

h. Macroevolution

i. Convergent evolution

j. Cambrian Explosion

k. Biogeography

2. How do uniformitarians use the potassium/argon dates of rocks in the Hawaiian Islands to support their view? What do YECs say to challenge that?

3. What is odd about the potassium/argon dates of igneous rocks formed from the Mount Saint Helens eruption? What do YECS conclude from this? What do uniformitarians say about it?

4. Lots of people say that carbon-14 dating demonstrates that the earth is billions of years old. What is wrong with that statement?

5. When is carbon-14 dating very accurate and why? How do uniformitarians and YECs address the carbon-14 dating of dinosaur fossils?

6. What is Chicxulub and how does it support the uniformitarian view?

7. How does pollen in the fossil record support the uniformitarian view? How does grass in the fossil record contradict the uniformitarian view?

8. How do the varves in the Green River formation support the uniformitarian view? What do YECs say about them?

9. What kinds of fossils can be found at the tops of many mountains, and how does that support the YEC view?

10. How do layers of rock like the sandstone layer found across most of North America support the YEC view? What about sandstone made from sediment that was transported long distances?

11. How do fossil graveyards support the YEC view? How do uniformitarians address them?

12. How do paraconformities support the YEC view? What about folded sedimentary rocks?

13. Why do evolutionists think the fossil record demonstrates that macroevolution produced whales? What do YECs say about that?

14. Both evolutionists and YECs have an "explosion" that challenges their view. What are these explosions and how do they challenge each view?

15. What problem do animals like kangaroos present to the YEC view?

16. Explain the piece of evidence discussed at the end of this chapter that supports a billions-of-years-old earth. Explain the piece of evidence that supports a thousands-of-years-old earth.

Chapter 10 Comprehension Check Questions

10.1 Most minerals are ionic compounds, which means they are made of positively- and negatively-charged particles called ions. Would you expect minerals to be more attracted to water molecules or oil molecules?

10.2 A standard stick of butter has a volume of 8 tablespoons, which is 120 mL. Suppose you melted an entire stick of butter and measured its volume. Which of the following volumes could it be: 115 mL, 120 mL, or 125 mL.

10.3 Suppose the illustration on page 288 of the textbook showed you the average high temperatures of those same places in July. How would the two numbers compare for each latitude?

10.4 Suppose you added 1 teaspoon of salt to a gallon of water, and you added 5 cups of salt to another gallon of water. If you tried to freeze both gallons, which would freeze at the higher temperature?

10.5 Suppose you made a very concentrated solution of saltwater, and you carefully added freshwater to the top of the solution. Would diffusion or osmosis act to even out the salt concentration?

10.6 Suppose you made a very concentrated solution of saltwater and covered it with a thin, semipermeable film. If you then carefully added freshwater on top of the film, would diffusion or osmosis act to even out the salt concentration? Which way would the water travel in the process?

10.7 If a sample of water was randomly taken from somewhere on the earth, would it most likely be freshwater or saltwater?

10.8 If a sample of freshwater were randomly taken from the earth, would it most likely be solid, liquid, or gas?

10.9 Suppose you find a lake that has a river flowing into it, but there is no river flowing out of it. You sample the water and find that it is freshwater. What can you conclude from this? (**HINT**: Look at the middle pie chart on page 296 of the textbook).

10.10 A molecule of water starts out in the ocean and ends up in groundwater flow. What hydrological cycle steps occurred to make that possible?

10.11 Based on the residence times shown in the table below, which flows faster: shallow groundwater or deep groundwater?

Reservoir	Residence Time		Reservoir	Residence Time
Antarctica	20,000 years		**Shallow groundwater**	100-200 years
Oceans	3,200 years		**Deep Groundwater**	10,000 years
Glaciers	20-100 years		**Lakes**	50-100 years
Seasonal Snow	2-6 months		**Rivers**	2-6 months
Soil Moisture	1-2 months		**Atmosphere**	9 days

Chapter 10 Review Questions

1. Define the following terms:

a. Polar molecule

b. Equilibrium

c. Heat capacity

d. Diffusion

e. Semipermeable

f. Osmosis

g. Distillation

h. Hydrologic cycle

i. Precipitation

j. Residence time

2. What makes the earth appear to be blue when seen from space?

3. A metal paperclip floats on the surface of liquid A easily, while the same paperclip sinks in liquid B. If the density of the paper clip is significantly greater than the densities of both liquids, which liquid has the higher surface tension? If one is polar and the other is nonpolar, identify the nonpolar one.

4. Your DNA is made of two helices that are held together with hydrogen bonds. Is DNA polar or nonpolar?

5. Bismuth freezes the way water does, but lead freezes like most substances. You are given two densities for bismuth: 10.0 g/mL and 9.8 g/mL. Which is for solid bismuth? You are given two densities for lead: 11.3 g/mL and 10.7 g/mL. Which is for solid lead?

6. Two objects have equal mass and temperature. You give them each the same amount of heat. The first becomes hotter than the second. Which has the higher heat capacity?

7. You compare the temperatures of several locations at the same latitude. Do you expect the summer temperatures to get higher or lower as you approach the ocean? What about in the winter?

8. Suppose you had a layer of saltwater and a layer of freshwater in the same container. Before they mixed together, which would be on top?

9. You have three samples of a clear liquid water that are all in the midst of freezing. You are told that one is freshwater, one is saltwater, and the other is not water at all. Sample A is freezing at 2°C, sample B is freezing at 0 °C, and sample C is freezing at -1 °C. Identify the samples.

10. You measure the concentration of a solute at two different places in a large container that holds a solution. There are no barriers of any kind in the solution. The concentrations you measure are different. If you measured them again a long time later, would you expect the difference to be the same, more, or less than the difference between the first measurements? Which process (diffusion or osmosis) do you expect to have happened?

11. You have two solutions of different concentration separated by a semipermeable membrane. The concentration of solutes in the solution on the right is much higher than the concentration of solutes in the solution on the left. What will happen to the volumes of the solutions over time? What process would cause that to happen?

12. List the following forms of water in order of increasing abundance in the hydrosphere: freshwater ice, freshwater liquid, and saltwater.

13. What phase is most of the earth's surface freshwater found in?

14. If a lake is salty, how can water leave it?

15. A molecule of water is a gas in the atmosphere. What are the hydrologic cycle steps that could happen to put it in the ocean as quickly as possible? Name another set of steps that would take longer but still get the water molecule into the ocean.

16. A water molecule starts off in a cloud, precipitates on land, and ends up in the ocean, but it was never part of a lake, river, stream, or groundwater. How did it get there?

17. List these reservoirs in terms of increasing residence time: a fast-flowing river, a lake, an ocean, and a slow-flowing river.

Chapter 11 Comprehension Check Questions

11.1 Two coastlines are drawn on the right. Assuming that the weather conditions are similar in both regions, which you would expect to experience larger, more powerful waves?

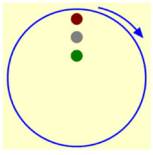
11.2 Suppose a day lasted 32 hours rather than 24. Roughly how many hours would exist between low tide and high tide?

11.3 If the moon were significantly less massive, it would exert significantly less gravity. How would that affect low tide and high tide at any given place?

11.4 If the moon were closer to the earth, how would that affect low tide and high tide at any given place?

11.5 Look at the rock formations in the picture of Hopewell Cape on page 312. If you were to look at a drawing of those rock formations from 100 years ago, would they look the same? Why or why not?

11.6 Suppose you have a circle with dots inside, as shown on the right. If the circle starts rotating around its center, which dot moves the slowest? Which moves the fastest?



11.7 Suppose you are in the Southern Hemisphere and have a long-range cannon. You want to hit a target that is 200 miles directly south of your location. In order to hit that target, in which direction would you aim your cannon (south, southeast, or southwest).

11.8 An ocean surface current flows north but curves east. Which hemisphere is it in?

11.9 On the east coast of a continent in the Southern Hemisphere, upwelling is occurring. Is the wind blowing to the north or south?

11.10 Suppose the poles got warmer and less sea ice froze there. Would that affect the thermohaline current? If so, how?

11.11 You have two samples of ice. You are told that one is from an iceberg, and one is from frozen seawater. How could you determine which is which?

11.12 You have a sample of soil, and you are told that it was taken from in between a bunch of tree roots. Was the soil probably taken from above the water table or below? Would the soil have been saturated or unsaturated?

11.13 The water table in a particular region is measured to be at a depth of 3.1 meters. In a few months, it is measured to be at a depth of 2.5 meters. Most likely, what was the rainfall like in that region between the times the two measurements were taken?

11.14 You have two containers holding water vapor. You blow a gentle stream of cold air through one of them. In the other, you insert a flat piece of glass at the same cold temperature as the air you blew into the other container. Which of those two situations will produce more condensation?

Chapter 11 Review Questions

1. Define the following terms:

a. Tides

b. Spring tide

c. Neap tide

d. Coriolis effect

e. Gyre

f. Salinity

g. Thermohaline current

h. Ice sheet

i. Ice shelf

j. Glacier

k. Water table

l. Humidity

2. If you were able to watch a single water molecule in the ocean, how would you see it moving when it is part of a surface wave?

3. Why are surface waves near the shore very different from surface waves that are far from the shore?

4. What is the main cause of the ocean's surface waves?

5. What two bodies influence the earth's tides? Which is more important?

6. You watch the ocean at a beach for 24 hours. How many high tides should you see? How many low tides?

7. What is the main difference between a tidal wave and a tsunami?

8. Where did Matthew Maury find inspiration for his discovery of the ocean's surface currents?

9. What effect causes surface currents in the ocean to form ovals?

10. Suppose you measure the speed at which the land is moving as it rotates with the earth. The first place you measure the speed is near the North Pole. The second place is near the equator. How do those speeds compare?

11. What is the Great Pacific Garbage Patch, and what causes it?

12. Where does upwelling and downwelling occur? Why is it important?

13. You have two samples of water. The salinity of the first is higher than the salinity of the second. If they are in layers, which is on top?

14. For thermohaline currents, in what part of the earth does ocean water sink? What makes it sink?

15. Which part of the thermohaline current is warmer: the part that runs in shallow water or that part that runs in deep water?

16. What is the difference between an ice sheet and an ice shelf?

17. Where is the most important ice sheet in the hydrosphere?

18. Think about the terms “glacier” and “ice sheet.” Which is the more general term?

19. What is calving? What does it produce?

20. Suppose all the earth’s icebergs suddenly melted, but none of the glaciers did. Would the ocean level rise, fall, or remain the same?

21. What happens to the depth of the water table when an area experiences a long period without rain?

22. Where is groundwater in relation to the water table?

23. When soil moisture stays frozen for a long time, what is it called?

24. What are the possible phases for water that makes up a cloud?

25. Besides water, what else must a cloud have?

Chapter 12 Comprehension Check Questions

12.1 Suppose the earth's gravity were a lot stronger. Would you expect the amount of air in the atmosphere to be the same as it is now? If not, would there be more or less air in the atmosphere?

12.2 Suppose you are at the top of a very high mountain. You drink a bottle of water, but like a good hiker, you don't just leave the empty bottle there. You put the lid back on it and take it down to the bottom of the mountain, where you can dispose of it properly. Assuming the lid is airtight, will the bottle look different when you get to the bottom of the mountain? If so, what will it look like?

12.3 Suppose you were to determine the percentage of nitrogen in air that has a lot of humidity. Would be it higher, lower, or equal to 78%?

12.4 If a gas makes up 0.00012% of the air, what is its concentration in ppm?

12.5 You are looking at temperatures being measured by a craft that is rising in altitude. If the temperature is steadily increasing but then levels off and starts decreasing, what region of the atmosphere did the craft enter when the temperature leveled off?

12.6 You are looking at a range of mountains. Some of the peaks are closer to you than others, so it is hard to judge which peaks are the tallest. However, some of the peaks have snow on them, while others don't. What does that tell you about the peaks' relative heights?

12.7 A good friend of mine grew up in Los Angeles, California in the 1970s. He says that when he would ride his bicycle for a long time, his lungs would feel like they were burning. He recently went back to his hometown and rode a bicycle for several miles, but his lungs never felt uncomfortable. Why?

12.8 Fireworks have gunpowder in them to produce their explosions, but they have other things in them that produce pretty colors when they burn. Fireworks that produce blue colors, for example, have copper in them. What do you think would be the name of the chemical produced when that copper burns during the explosion?

12.9 You are working in a plant, and an analysis of the air inside the plant is done. There is a pollutant found with a concentration of 1 ppm, and the plant is immediately closed down until the pollutant concentration can be lowered. If the pollutant is one of those discussed in this chapter, which one is it?

12.10 The atmosphere of Venus is 96% carbon dioxide. Compare the greenhouse effect on Venus to the greenhouse effect on the earth.

12.11 Suppose you open a fresh bottle of soda and measure its pH. Then, you set it out on the counter without the cap on and forget about it. A couple of days later, you see it again and measure its pH. Would you expect the pH to have changed? If so, how?

12.12 Greenland is currently covered in ice, and the temperature rarely goes above 10 °C (50 °F). However, there are remains of forests in the southern parts of Greenland, under the ice. When might those forests have grown?

12.13 Suppose scientists determine that the equilibrium climate sensitivity is 2 °C. Does that mean the temperature of the earth will be 2 °C warmer when the amount of carbon dioxide in the atmosphere doubles?

12.14 Fill in the blank: Some scientists who study the ocean say that ocean acidification is a bad term to use, because the ocean is not really becoming more acidic. They say that a better way to express what is happening right now is that the ocean is becoming less _____.

Chapter 12 Review Questions

1. Define the following terms:

a. Pressure

b. Parts per million

c. Troposphere

d. Stratosphere

e. Ozone layer

f. Mesosphere

g. Thermosphere

h. Combustion

i. Ocean acidification

j. Climate proxy

k. Climate sensitivity

2. What holds the atmosphere in place around the earth?

3. You have a water bottle that has no more water in it. You put the top on, which is airtight. Is it possible to crush the bottle so that there is absolutely no space left inside the bottle? Why or why not?

4. What two units for pressure did you learn in this chapter?

5. How does the air pressure change with altitude?

6. List the two main components of dry air. Which is more concentrated?

7. NO_2 can start having toxic effects on the body when it reaches a concentration of 150 ppm. What percent of the air would it make up at that concentration?

8. If a gas makes up 0.5% of the air, what is its concentration in ppm?

9. List the main sections of the atmosphere and the regions that separate them, starting with the lowest altitude and then continuing with higher and higher altitudes.

10. In which regions of the atmosphere does temperature decrease with increasing altitude? In which regions does it increase with increasing altitude?

11. Why is the ozone layer important to life, and why is its position in the atmosphere also important?

12. In which region of the atmosphere do you find the ozone layer?

13. When air expands without the addition of energy, what happens to its temperature?

14. Have the concentrations of pollutants in the air increased or decreased over the past 40 years?

15. What are the four main pollutants we discussed in this chapter? Is it possible to completely eliminate them from the atmosphere?

16. What is the greenhouse effect, and why is it a good thing?

17. What are the potential consequences of the increase in carbon dioxide concentration in the atmosphere?

18. What is the pH scale? What value on the scale represents something that is neither acidic nor alkaline? What numbers represent something acidic? What numbers represent something alkaline?

19. You have two substances. One has a pH of 13, while the other has a pH of 8. Based solely on that information, which would be safer to put on your skin?

20. Generally, has the average temperature of the earth been increasing, decreasing, or staying the same over the past 40 years?

21. What do climate proxies indicate was the warmest period in the past 2,000 years? You don't need to know the dates, just the word that refers to that time period.

22. Generally, has the pH of the ocean increased, decreased, or stayed the same over the past 30 years?

Chapter 13 Comprehension Check Questions

13.1 Which color of visible light has the most energy? Which has the least?

13.2 Certain snakes, called pit vipers, have pits in their head that can sense infrared light. Suppose a pit viper is hunting at night. Will it be more likely to find a mouse (which is a warm-blooded) or a lizard (which is cold-blooded)?

13.3 The planet Mercury has the highest difference between daytime and nighttime temperatures (427 °C during the day and -173 °C at night). It has no atmosphere. How does the speed of its rotation compare to that of the moon?

13.4 The eccentricity of Mercury's orbit around the sun is greater than the eccentricity of the earth's orbit around the sun. Which orbit is less circular?

13.5 Mars is 20% farther from the sun at aphelion than at perihelion. Is its orbit more or less oval than the earth's orbit?

13.6 The height of the sun in the sky over the course of a year is measured in two cities. The maximum height is lower in the first city. Which city is closer to the equator?

13.7 If you are in the Southern Hemisphere, when would you see the sun reach its maximum height in the sky: at noon on the June solstice, noon on the September equinox, noon on the December solstice, or noon on the March equinox?

13.8. You are in the Northern Hemisphere. The days have been getting shorter, but then on a specific day, the day is just as long as the night. Have you reached the June solstice, the September equinox, the December solstice, or the March equinox?

13.9 Imagine a city that has been exposed to the sun all day. You are standing in a grassy field outside the city and feel a breeze. If the breeze is caused by the urban heat island effect (as shown on page 381), would you feel the breeze blowing towards the city or away from it? If someone were measuring the wind high above your position, would it be blowing towards the city or away from it?

13.10 You are watching data from a weather balloon that starts at the surface of the earth in the Northern Hemisphere and rises to the tropopause. Initially, the balloon says that the winds near the earth are blowing mostly towards the north, but the winds near the tropopause are blowing mostly to the south. Is the balloon in the Hadley cell, Ferrel cell, or polar cell?

13.11 A wind-driven ship is caught in the doldrums and has no oars or other mechanical means of propulsion. Is there any chance it can get out of the doldrums?

13.12 The westerlies in your area are blowing south and east. Which hemisphere are you in?

13.13 You are comparing four air masses: cT, cA, mE, and mP. Which two are the most humid? Order all four of them according to temperature, starting with the coldest and ending with the warmest.

13.14 Light from an LED flashlight or a smartphone has a lot more blue in it than light that comes from an old-style flashlight. How would Experiment 13.3 change if you used an old-style flashlight?

13.15 You are looking at some clouds, and a meteorologist says you are seeing both cumulus clouds and altostratus clouds. Are all the clouds at the same altitude? If not, which is higher?

13.16 A cumulus cloud is composed entirely of ice crystals. What should it be called?

13.17 Compare how cirrostratus clouds affect the earth's temperature as compared to stratus clouds.

Chapter 13 Review Questions

1. Define the following terms:

a. Climate

b. Radiation

c. Insolation

d. Perihelion

e. Aphelion

f. Solstice

g. Equinox

h. Albedo

i. Air mass

2. What is the difference between climate and weather?

3. What do we call gamma rays, X-rays, ultraviolet rays, visible light, infrared waves, microwaves, and radio waves? If we order them in terms of wavelength, what is that called?

4. What is the relationship between wavelength and energy for electromagnetic waves?

5. Which has more energy: blue light or red light?

6. Why is it warmest at the equator, at least on average?

7. What causes the seasons that you experience if you don't live on the equator?

8. When the earth is farthest from the sun, which hemisphere is experiencing summer?

9. Which has more effect on the insolation received in the earth's different hemispheres: the change in distance between the earth and the sun or the axial tilt of the earth?

10. You experience a 24-hour period where you can always see the sun in the sky. What season is it? Roughly where are you on the earth?

11. For any region on the earth that is not on the equator, compare the maximum height the sun reaches in summer to the maximum height it reaches in winter.

12. You have been experiencing summer in the Northern Hemisphere, but the days begin getting shorter, while the nights begin getting longer. Which month is the next equinox? Which month is the next solstice?

13. You are in the Southern Hemisphere and it is the March equinox. Will the days start becoming longer or shorter?

14. You have two objects the same size and the same shape. One is black, while the other is white. Which has the higher albedo? Which would be warmer if they both sat in the bright sun for a while?

15. It has been a warm, sunny day at the beach, but now it is night. As you sit on the beach, do you feel the breeze blowing towards the shore or towards the ocean?

16. Using the terms "away from the equator" and "towards the equator," indicate the way the winds near the surface of the earth blow in the Hadley cell, the Ferrel cell, and the polar cell.

17. Which of the three cells in the previous question is responsible for most of the earth's deserts? At what latitudes are those deserts found?

18. What causes the winds near the surface of the earth to curve?

19. If you are on a wind-driven ship and are experiencing the doldrums, what part of the earth are you on?

20. You are comparing a maritime equatorial air mass to a continental tropical air mass. Which is less humid? Which is warmer?

21. Which light is more likely to scatter off of things in the air: red light or blue light?

22. Without an atmosphere, what color would the sky be?

23. Use the terms “cirrus,” “cumulus,” “stratus,” “nimbostratus” and “cumulonimbus” to answer the following questions:

a. In which type of cloud is all the water in its solid phase?

b. Which clouds form layers low in the sky but do not indicate rain will come soon?

c. Which clouds are the tallest?

d. Which clouds form layers in the sky and are very dark?

e. Which clouds form low in the sky, are fluffy, and resemble big cotton balls?

Chapter 14 Comprehension Check Questions

14.1 As the day progresses, you see cirrus clouds forming, followed by altocirrus clouds, followed by stratus clouds. What's happening to the temperature? Is it increasing, decreasing, or staying the same?

14.2 The atmospheric pressure in your area is low, but over the course of the day, it rises significantly. What's happening to the temperature? Is it increasing, decreasing, or staying the same?

14.3 In the weather map on page 404 of the textbook, there is an occluded front over northern Mexico and southern Texas. However, another occluded front could potentially form. Based on the other fronts shown, where could that happen: central United States, northern United States, or southern Canada?

14.4 Based on the weather radar map given on page 405 of the textbook, where is it raining the heaviest: Indiana, Mississippi, Alabama, or Texas?

14.5 In a tall cumulonimbus cloud, which of the two processes discussed on pp. 406-408 of the textbook makes the water drops heavier near the bottom of the cloud? Which makes them lighter near the top?

14.6 One day the temperature is 30 °C (86 °F), and the relative humidity is 75%. You leave a bowl of water outside for your dog. The next day, the temperature is the same, but the relative humidity is 30%. You refill your dog's bowl. Assuming the dog drinks the same amount of water each day, on which day is it more likely for the bowl to become empty?

14.7 Precipitation falls out of a cloud as rain. What kinds of precipitation could it be by the time it hits the ground?

14.8 There are parts of Antarctica that receive very little snow each year. On average, do you think those parts of Antarctica are warmer, colder, or the same temperature as the parts that receive a lot of snow every year?

14.9 You see the ground covered in white, but you don't know whether it is snow or sleet. If you have a microscope, how could you tell which it is?

14.10 As you might already know, light travels much faster than sound. If you are close to a lightning strike, you will hear the thunder and see the lightning at the same time. However, if you are far from the lightning strike, you will experience one before the other. Which will you experience first?

14.11 Suppose you could measure the air pressure at the center of a tornado. How would it compare to the air pressure right outside the tornado?

14.12 A supercell is rotating rapidly but doesn't produce a funnel cloud. Will it form a tornado?

14.13 A friend tells you about being caught in a "weak tornado." What could you ask him or her to determine whether it was a weak tornado or a dust devil?

14.14 Which has faster winds: a tropical depression, a tropical storm, or a tropical disturbance?

14.15 A hurricane is currently a category 4. If it hits land, will its category stay the same or change? If it changes, will the category number go up or down?

14.16 Hurricane Carl is about to hit Florida. How many hurricanes formed that same year before Carl?

14.17 You see a satellite image of a tropical cyclone but there are no landmarks to figure out where it is. How can you determine the hemisphere it is in?

Chapter 14 Review Questions

1. Define the following terms:

a. Weather front

b. Cohesion

c. Saturated

d. Relative humidity

e. Absolute humidity

f. Storm cell

g. Wind shear

h. Mesocyclone

i. Tropical cyclone

2. You see cumulonimbus clouds forming. What kind of weather front is probably moving in?

3. You see cirrus clouds form, followed by stratus clouds. What kind of weather front is probably moving in?

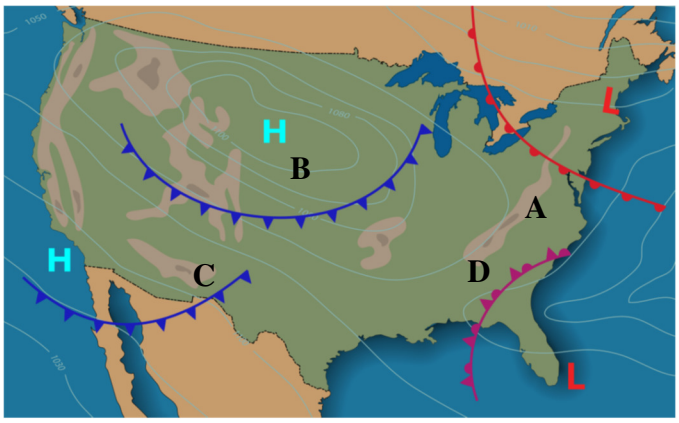
4. What do we call a weather front in which neither air mass really moves?

5. You see cirrus clouds form, followed by stratus clouds. Then, cumulonimbus clouds start to form. What kind of weather front is probably moving in?

6. In the weather map on the right, at which point (A-D) is the atmospheric pressure highest?

7. In the weather map on the right, which point (A-D) is about to experience an occluded front?

8. In the weather map on the right, which point (A-D) just experienced a decrease in temperature?



9. In the weather map above, which point (A-D) is about to experience an increase in temperature?

10. In a cumulonimbus cloud, water drops are growing by the collision-coalescence process. Is this happening high in the cloud or low in the cloud?

11. An ice crystal in a cloud is growing. What is happening to the size of the water drops in the same part of the cloud?

12. One day, the temperature is 29 °C, and the relative humidity is 90%. The next day, the temperature is still 29 °C, but the relative humidity is 20%. Which day feels more uncomfortably hot?

13. Snow crystals are falling out of a cloud. Does that mean snow is falling on the ground? Why or why not?

14. Snow is falling on the ground. Have the snow crystals always been solid since the time they were first formed in the cloud? Why or why not?

15. Rain is falling, but the roads are icy. What do we call this kind of precipitation?

16. Sleet is falling. Has the sleet been ice since it left the cloud?

17. What are the three stages of a thunderstorm? At which stage are there both updrafts and downdrafts in the cloud?

18. In a cumulonimbus cloud, what kind of electrical charge is found near the top?

19. What are the two stages of a lightning strike, and which one is more powerful?

20. In a cumulonimbus cloud, balls of ice are seen traveling upwards. What will this cloud produce in addition to rain?

21. A supercell has formed. What must it make before it can make a tornado?

22. What do we call a tornado that forms on water?

23. If you see a rotating column of air rising from the ground into the sky on a sunny day, what are you witnessing?

24. Consider the terms “tropical cyclone,” “tropical storm,” “typhoon,” and “tropical depression.” Which of these terms can refer to the other three? For those other three, list them according to increasing wind speeds.

25. What two other terms not listed in the question above can be used to refer to a typhoon? What determines which term is used?

26. A hurricane is getting stronger. Has it hit land, or is it still on the ocean?

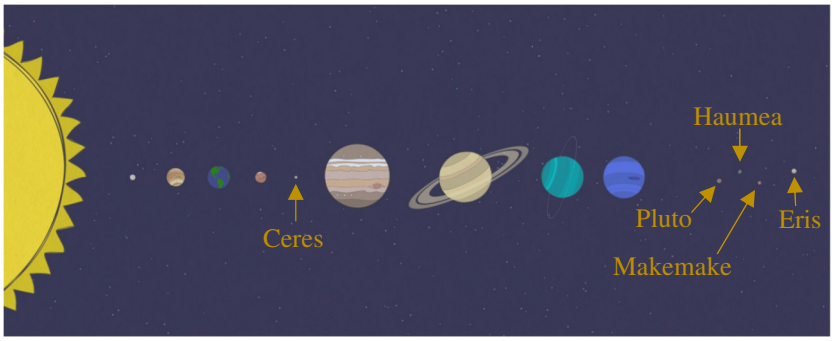
Chapter 15 Comprehension Check Questions

15.1 It takes one year for the earth to travel around the sun. Mercury is the closest planet to the sun. Does it take Mercury a longer time to travel around the sun, a shorter time, or the same time as the earth?

15.2 Which planet travels faster as it orbits the sun: Mars or Saturn?

15.3 You are studying an asteroid and a comet. Which has the more eccentric orbit?

15.4 Suppose you observe a comet as it approaches perihelion, and you watch it for many nights in a row, until it is far from perihelion. How would the brightness of the comet change over that time period?



15.5 Looking at the drawing on the left, which of the dwarf planets (the ones labeled in the drawing) almost certainly did not come from the Kuiper belt? Where did it most likely come from?

15.6 When a theory needs to be adjusted to make it consistent with observations, scientists often say that epicycles are being added to the theory. Why?

15.7 Suppose you could stand at the surface of the sun and view all the planets. Would any of them have retrograde motion? What about the moon?

15.8 What two planets cannot be in opposition to the sun? You might want to go back to the drawing on page 436 to answer this question.

15.9 Suppose you looked at a candle's flame using the spectrometer you made in your experiment. Would its rainbow look more like the one from an incandescent light, a fluorescent light, or an LED light?

15.10 In a nuclear reaction, more nuclei are produced than what was used to get the reaction going. Is this nuclear fission or nuclear fusion?

15.11 Over time, what do you expect to happen to the amounts of hydrogen and helium in the sun?

15.12 Since 1990, the average number of sunspots on the photosphere has been decreasing. What do you think happened to the average number of solar flares over the same time period?

15.13 Suppose something happened that caused lots of gases to be added to the sun. What would happen to the amount of light coming from the sun?

15.14 Suppose we find another solar system with two planets. One is far from that solar system's star, while the other is near to it. Which planet is more likely to have at least one moon?

15.15 You observed a full moon one night, but heavy clouds obscured it for the next four nights. The clouds go away on the fifth night. When you see the moon on that night, will it be a quarter moon? If not, will you see more or less than half of it illuminated?

15.16 If you took a sample of rock from a part of the moon called the "Sea of Tranquility," would you expect it to be an extrusive igneous rock or an intrusive igneous rock? You might want to look back at page 98 to remind yourself what those terms mean.

Chapter 15 Review Questions

1. Define the following terms:

a. Asteroid

b. Comet

c. Geocentric

d. Heliocentric

e. Spectroscopy

f. Nuclear fission

g. Nuclear fusion

h. Solar flare

i. Hydrostatic equilibrium

j. Satellite

2. What keeps gravity from pulling the earth into the sun?

3. List the planets in the solar system in order based on their distance from the sun. Start with the one that is closest. How does the speed at which they orbit the sun vary with their distance?

4. What is the largest body in the solar system? What is the largest planet? What is the smallest planet?

5. What do we call the structure that holds most of the solar system's asteroids? Where is it?

6. What makes up the two tails of a comet? Which way do they point relative to the sun?

7. What are the two broad classes into which all comets can be placed?

8. What do we call bodies like Pluto that orbit the sun and are bigger than asteroids but smaller than planets?

9. What is an epicycle, and in which view of the solar system (geocentric or heliocentric) was it used?

10. What does the phrase "retrograde motion" refer to? Which view of the solar system (geocentric or heliocentric) explains it better?

11. When is Mars brightest in the night sky – when it is on the same side of the earth as the sun or when it is on the opposite side?

12. Does the Bible indicate that the sun moves in the solar system?

13. What are the two main gases that make up the sun? Which one is present in larger quantities?

14. What process does the sun use to produce energy? What is used up, and what is made?

15. What happens to the amount of energy the sun puts out as time goes on?

16. What is the hottest: the sun's core, radiative zone, convection zone, or photosphere? Why is it so hot there?

17. What do we call the surface of the sun?

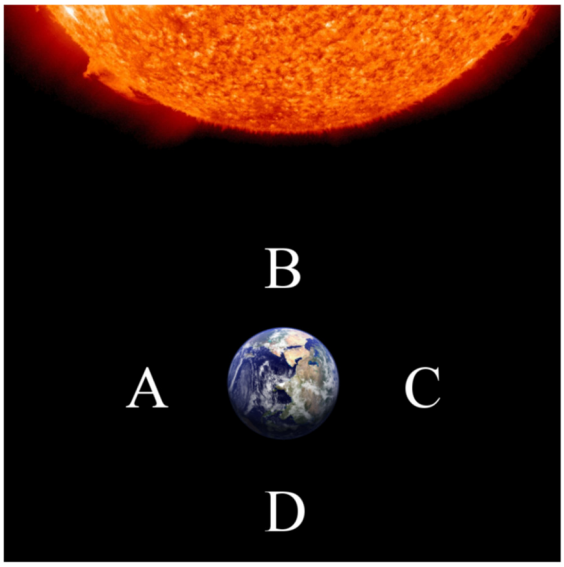
18. What are sunspots, and what do they tell us about how active the sun is?

19. What would happen to the size of the sun if the amount of fusion happening in the core increased? What would that change in size do to the amount of fusion happening in the core?

20. Which planets don't have at least one moon? Why?

21. What does the moon do for the earth's axial tilt? How does that help make the earth a place where life can flourish?

22. In the diagram on the right, indicate the letters that are positioned where the new moon, the full moon, and the two quarter moons would be.



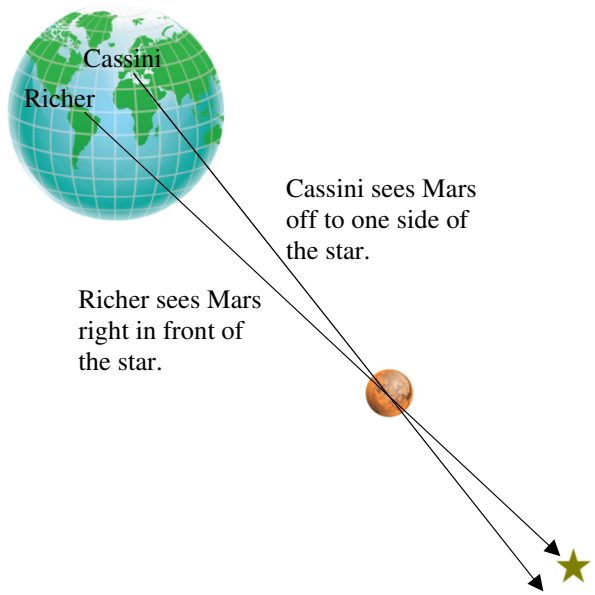
23. You take a picture of the full moon when you are at a latitude of 45 degrees north. You then take a picture of the full moon six months later when you are at a latitude of 45 degrees south. How will the pictures compare to one another?

24. What are the dark gray patches on the moon's surface called? What are they made of?

25. Scientists have used seismic waves to determine the moon's internal structure. How did they detect those seismic waves?

26. How do we get the most accurate information about the distance between the earth and the moon?

Chapter 16 Comprehension Check Questions



16.1 Looking at the drawing on the left, how could Richer and Cassini have improved their observation to make it even more sensitive?

16.2 As I said, the heliosphere extends to about 180 AU from the sun. How many kilometers is that?

16.3 If you observe a planet in the night sky over many months, will its size be constant?

16.4 You have a bright red balloon in your hands. If you take it into a windowless room and darken the room until you can just barely see the balloon, what color will it appear to be?

16.5 Suppose you are using a telescope on a cold night where you need a fire to stay warm. For the best views, should the fire be between the telescope and what you are viewing or behind the telescope?

16.6 Suppose you are looking at the stars in the night sky from your backyard, which is in the center of town. Now suppose you decide to leave the city and take a drive into the country that same night. Once you get far from all the buildings, street lights, etc., will stars in the night sky look any different? If so, how?

16.7 A star has an apparent magnitude of 3.4 and an absolute magnitude of 5.0. Is it more or less than 10 parsecs from the earth?

16.8 Which of the two pictures of the Cepheid variable on page 478 (the left one or the right one) shows the star at a higher apparent magnitude?

16.9 Looking at the HR diagram on the right, if a star has an absolute magnitude of -7 and a temperature of 6,000, is it a white dwarf, main sequence, giant, or supergiant?

16.10 Looking at the image on page 481, which is the hottest supergiant: Betelgeuse, Antares, or Rigel?

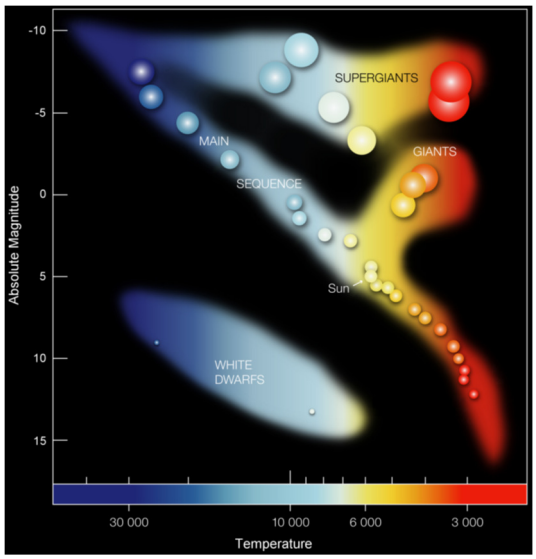
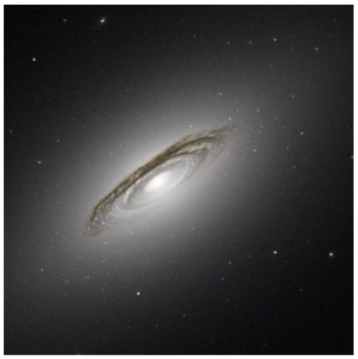


Illustration from www.shutterstock.com © Designua

16.11 What kind of galaxy is pictured on the right (spiral, elliptical, lenticular, or irregular)?



16.12 You are studying a star with a telescope. Based on all that you have seen, you think it is a single star. However, an astronomer says you must be skeptical of any star that appears to have no companions. Why?

16.13 A friend tells you about seeing an amazing nebula, and he indicates where you should look in the sky to see it for yourself. The next night, you look as hard as you can with the same equipment your friend has, but you don't see anything. What is the most likely explanation for the discrepancy?

16.14 A star is 511 light-years from earth. If the distance to that star had been measured 2,000 years ago, which would be a possible result: 500 light-years, 511 light-years, or 520 light-years?

16.15 Suppose twins are born on earth. At an early age, one of them moves to a space station orbiting the earth and stays there most of her life. When she comes back to the earth, how would her age compare to the age of her twin?

Chapter 16 Review Questions

1. Define the following terms:

a. Parallax

b. Universe

c. Astronomical unit

d. Heliosphere

e. Magnitude

f. Apparent magnitude

g. Light-year

h. Absolute magnitude

i. Standard candle

j. Galaxy

2. There are two main factors that affect the ability to measure distance by parallax: the distance between the two observations being made and the distance to the star itself. How does an increase in each of them affect the sensitivity of parallax?

3. When we measure the distance to a star by parallax, what is the timespan between the first and second observation? Why?

4. Name the inner planets and then the outer planets. What separates these two groups?

5. At perihelion, Saturn is 9.0 AU from the sun. How many kilometers is that? (1 AU = 150,000,000 kilometers)

6. When it is farthest away, Mars is 401,000,000 kilometers from the earth. How many AU is that? (1 AU = 150,000,000 kilometers)

7. What human-made technology exists outside the heliosphere?

8. At a given time and day of the year, do the stars occupy the same position in the sky? What about the planets?

9. Why do telescopes make it easier to see stars?

10. Why do we build telescopes on tall mountains or put them in orbit around the earth?

11. Why don't you see the stars during the day?

12. Why don't you see stars in the black sky of pictures taken on the moon?

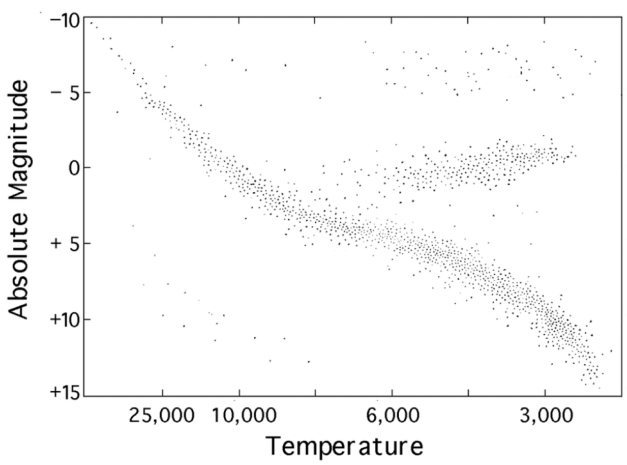
13. If one star has an apparent magnitude of 1.1 and another has an apparent magnitude of 5.6, which is brighter?

14. A star has an apparent magnitude of -0.7 and an absolute magnitude of 4.1. Is it more or less than 10 parsecs from the earth?

15. What is a Cepheid variable and how can it be used as a standard candle?

16. What determines the color of a star?

17. If a star is in the main sequence, how does it produce its energy?



18. Using the HR diagram on the left, suppose a star has an absolute magnitude of -8 and a temperature of 5,000. What kind of star is it?

19. Using the HR diagram on the left, suppose a star has an absolute magnitude of 0 and a temperature of 10,000. What kind of star is it?

20. Using the HR diagram on the left, suppose a star is a white dwarf and its absolute magnitude is 10. Which is a possible temperature: 5,000 or 15,000?

21. What type of galaxy (spiral, lenticular, elliptical, or irregular) is the Milky Way?

22. What is the name of the cluster to which the Milky Way belongs?

23. What are companion stars and how common are they?

24. What is a nebula? What did you learn about in this chapter that can produce one?

25. What is redshift, and how does it give evidence for the idea that the universe is expanding?

26. How is the passage of time affected by gravity?

Documenting Experiments

The problem with learning things is that you can forget them pretty easily. As a result, it is important to document what you learn. That way, you can always go back later and review the material. When it comes to documenting what you learned by taking this course, you answer questions and take tests. How do you document what you learned in an experiment? By recording important aspects of the experiment in your laboratory notebook.

Start your record by writing the number and title of the experiment. Then write "Data:" underneath the title. That's how you should start to document every lab you do. You should write the experiment number and its title. Underneath, you should write "Data:" to indicate that what follows will be all the data you collect from the experiment.

What are the data you collect in an experiment? Those are your *observations*. Every experiment has data, because every experiment requires you to make observations as the experiment progresses. So under "Data:" you should list every observation you make. Each new observation should be written underneath the previously-made observation. Some experiments require more than just observations. Some require measurements. If the experiment instructions tell you to measure how long something is, that measurement is also considered data and should be written down along with your observations.

Each piece of data needs to have a short explanation regarding when you collected it in the experiment. That allows you to remember what you did right before you made the observation. It doesn't need to be a long explanation. It just needs to be a short note that will help remind you of what was done right before the observation was made.

The data section of each lab report, then, contains the quick notes you make while you are doing the experiment. They help remind you what you saw at each important step in the experiment. You write these things down while you are doing the lab so that they are fresh in your mind.

But that's not all you need to do to document your lab. So far, I have discussed things you write down *while you are doing the lab*. Once the lab is over, you need to finish documenting it. How do you do that? You add another section to your lab report that is labeled "Summary:". In that section of the lab, you write your own summary of what you did. It should not be a step-by-step listing of the instructions, and it *cannot* be a copy of the lab instructions that are in the book. Instead, it needs to be your "story" about what you did in the experiment.

Once you have finished your summary, there is one more section you need to add. Label this section "Conclusions:", and it should contain a discussion of what you were supposed to learn by doing the experiment. This is actually easy, because I always explain that after the experiment. So all you have to do is give that same explanation, but in your own words. Once you've done that, you are finished documenting your lab.

While this might seem like a lot of work, it's important for three reasons. First, it gives you something you can review later so that you can remember what you learned. Second, when you write something out in your own words, you think through it. As a result, you learn it better. Finally, there are times where you have to actually show evidence that you did experiments. Most universities, for example, require that students do experiments as a part of their high-school science courses. If you apply to a university, the people who decide whether or not you can come to the university might ask you to demonstrate that you did experiments. A lab notebook is exactly what they are looking for.

Now remember, the main goal for doing this is so that you can go back and review it later to recall what you did, what you saw, and what you learned. However, it is also possible that you will need to use this report to give evidence that you did laboratory work in your science course. Since that's one of the goals, you need to write your report so that someone who has never seen the book can understand what you did and what you learned. Obviously, just reading the data section will be confusing to someone who doesn't have access to the instructions, but that's why you add a summary after the data. It helps someone who has not read the book to understand what you did, what you saw, and what you learned.

Now please understand that there is no standard among science courses regarding how you should document your labs. Some high school science courses require you to write at least a few of your experiments the way you would write about them in a scientific journal. This is usually called a "formal laboratory report."

I don't think students in middle school and high school should do those kinds of reports. First, most students who take science will never actually write such a report in real life. As a result, it seems like a waste of time for most students. More importantly, the way you write a formal lab report changes depending on the kind of science you are doing. As a nuclear chemist, for example, the papers that I have published in the scientific literature follow a completely different format than the papers my wife (a biophysicist) has published in the scientific literature. In my opinion, you should determine what kind of science you will be doing before you start worrying about writing a formal laboratory report.

Other science courses want you to follow the scientific method when you document your lab work. They want you to start your report with a hypothesis and end your report with a conclusion about whether or not your hypothesis was confirmed. I don't see that as reasonable for most situations involving students. After all, that's not what you are doing. You aren't making or testing a hypothesis. You are simply following my instructions. Also, when you make a hypothesis, you should design your experiment to address the hypothesis. Making a hypothesis for an already-designed experiment is backwards when it comes to the scientific method.

If you follow my method for documenting your labs, you will practice the most important aspect of laboratory work: making a record of what you did, what you saw, and what you learned. No matter what kind of science you end up doing, you will have to do that. Thus, by getting experience documenting labs in this way, you will be honing a skill that you will use if you pursue any kind of science.

This is important, since a scientist's laboratory notebook can become a legal document. If you discover something new and need to demonstrate that you were the one who discovered it, you can do that with your laboratory notebook. In addition, if someone disputes what you have concluded based on your experiments, your laboratory notebook can be used to resolve that dispute. In the end, then, getting used to properly documenting your experiments is an important part of science education.

Laboratory Notebook