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### Unit 4 The Atmosphere and the Oceans

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To the Teacher

This unit-based booklet contains resource materials to help you teach this unit more effectively. You will find the following in the chapters:

Reproducible Pages

Hands-on Activities

MiniLab and GeoLab Worksheets: Each activity in this book is an expanded version of each lab that appears in the Student Edition of *Glencoe Earth Science: Geology, the Environment, and the Universe*. All materials lists, procedures, and questions are repeated so that students can read and complete a lab in most cases without having a textbook on the lab table. All lab questions are reprinted with lines on which students can write their answers. In addition, for student safety, all appropriate safety symbols and caution statements have been reproduced on these expanded pages. Answer pages for each MiniLab and GeoLab are included in the *Teacher Guide and Answers* section at the back of this book.

Transparency Activities

Teaching Transparency Masters and Worksheets: These transparencies relate to major concepts that will benefit from an extra visual learning aid. Most of the transparencies contain art or photos that extend the concepts put forth in the textbook. Others contain art or photos directly from the Student Edition. There are 92 Teaching Transparencies, provided here as black-and-white masters accompanied by worksheets that review the concepts presented in the transparencies. Answers to worksheet questions are provided in the *Teacher Guide and Answers* section at the back of this book.

Intervention and Assessment

Study Guide: These pages help students understand, organize, and compare the main earth science concepts in the textbook. The questions and activities also help build strong study and reading skills. There are six study guide pages for each chapter. Students will find these pages easy to follow because the section titles match those in the textbook. Italicized sentences in the study guide direct students to the related topics in the text.

The Study Guide exercises employ a variety of formats including multiple-choice, matching, true/false, labeling, completion, and short answer questions. The clear, easy-to-follow exercises and the self-pacing format are geared to build your students’ confidence in understanding earth science. Answers or possible responses to all questions are provided in the *Teacher Guide and Answers* section at the back of this book.
Chapter Assessment: Each chapter assessment includes several sections that assess students’ understandings at different levels.

- The Reviewing Vocabulary section tests students’ knowledge of the chapter’s vocabulary. A variety of formats is used, including matching, multiple choice, true/false, completion, and comparison of terms.
- The Understanding Main Ideas section consists of two parts: Part A tests recall and basic understanding of facts presented in the chapter, while Part B is designed to be more challenging and requires deeper comprehension of concepts than does Part A. Students may be asked to explain processes and relationships or to make comparisons and generalizations.
- The Thinking Critically section requires students to use several different higher-order learning skills, such as interpreting data and discovering relationships in graphs and tables, as well as applying their understanding of concepts to solve problems, compare and contrast situations, and to make inferences or predictions.
- The Applying Scientific Methods section puts students into the role of researcher. They may be asked to read about an experiment, simulation, or model and then apply their understanding of chapter concepts and scientific methods to analyze and explain the procedure and results. Many of the questions in this section are open-ended, giving students the opportunity to demonstrate both reasoning and creative problem-solving skills.

Answers or possible responses to all questions are provided in the Teacher Guide and Answers section at the back of this book.

STP Recording Sheet: STP Recording Sheets allow students to use the Standardized Test Practice questions in the Student Edition as a practice for standardized tests. STP Recording Sheets give them the opportunity to use bubble answer grids and numbers grids for recording answers. Answers for the STP Recording Sheets can be found in the Teacher Wraparound Edition on Standardized Test Practice pages.

Teacher Guide and Answers: Answers or possible answers for questions in this booklet can be found in the Teacher Guide and Answers section. Materials, teaching strategies, and content background, along with chapter references, are also provided where appropriate.
Lab Safety Form

Name: ________________________________
Date: ________________________________

Lab type (circle one): Launch Lab, MiniLab, GeoLab

Lab Title: ______________________________

Read carefully the entire lab and then answer the following questions. Your teacher must initial this form before you begin.

1. What is the purpose of the investigation?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

2. Will you be working with a partner or on a team? ____________________________

3. Is this a design-your-own procedure? Circle: Yes No

4. Describe the safety procedures and additional warnings that you must follow as you perform this investigation.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

5. Are there any steps in the procedure or lab safety symbols that you do not understand? Explain.

________________________________________________________________________
________________________________________________________________________
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## Chapter 11 Atmosphere

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<td>Study Guide</td>
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<td>Chapter Assessment</td>
<td>19</td>
</tr>
<tr>
<td>STP Recording Sheet</td>
<td>25</td>
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</table>
Investigate Dew Formation

**How does dew form?** Dew forms when moist air near the ground condenses and the water vapor in the air condenses into water droplets.

**Procedure**

1. Read and complete the lab safety form.
2. Fill a glass about two-thirds full of water. Record the temperature of the room and the water.
3. Add ice cubes until the glass is full. Record the temperature of the water at 10-s intervals.
4. Observe the outside of the glass. Note the time and the temperature at which changes occur on the outside of the glass.
5. Repeat the investigation outside. Record the temperature of the water and the air outside.

**Analysis**

1. **Compare and contrast** What happened to the outside of the glass when the investigation was performed in your classroom and when it was performed outside. If there was a difference, explain.

2. Relate your observations to the formation of dew.
As you go up a mountain, both temperature and air pressure decrease. Temperature decreases as you get farther away from the atmosphere’s heat source—Earth’s surface. Pressure decreases as you ascend the mountain because there are fewer particles in the air above you. Pressure and temperature are also related through the expansion and compression of air, regardless of height.

**PREPARATION**

**Problem**
How does the expansion and compression of air affect temperature?

**Objectives**
In this GeoLab, you will:
- **Model** the temperature and pressure changes that take place as a result of the expansion and compression of air.
- **Relate** the changes to processes in the atmosphere.

**Materials**
clean, clear, plastic 2-L bottle with cap
plastic straws
scissors
thin, liquid-crystal temperature strip
tape
watch or timer

**Safety Precautions**

---

**PROCEDURE**

1. Read and complete the lab safety form.
2. Working with a partner, cut two pieces of straw, each the length of the temperature strip. Then cut two 2-cm pieces of straw.
3. Lay the two long pieces on a table. Place the two shorter pieces within the space created by the longer pieces so that the four pieces form a supportive structure for the temperature strip.
4. Tape the four pieces of straw together. Place the temperature strip lengthwise on the straws. Tape the strip to the straws.
5. Slide the temperature-strip-straw assembly into the clean, dry bottle. Screw the cap on tightly.
6. Place the sealed bottle on the table so that the temperature strip faces you and is easy to read. Do not handle the bottle any more than is necessary so that the temperature will not be affected by your hands.
7. Record the temperature of the air inside the bottle as indicated by the temperature strip.
8. Position the bottle so that half its length extends beyond the edge of the table. Placing one hand on each end of the bottle, push down on both ends so that the bottle bends in the middle. Hold the bottle this way for 2 min while your partner records the temperature every 15 s.
9. Release the pressure on the bottle. Observe and record the temperature every 15 s for the next 2 min.
ANALYZE AND CONCLUDE

1. **Interpret Data**  What was the average temperature of the air inside the bottle as you applied pressure to the bottle? How did this differ from the average temperature of the bottled air when you released the pressure on the bottle?

2. **Graph**  the temperature changes you recorded throughout the experiment.

3. **Explain**  how these temperature changes are related to changes in pressure.
4. **Predict** how the experiment would change if you took the cap off the bottle.

5. **Infer** Given your observations and what you know about the behavior of warm air, would you expect the air over an equatorial desert at midday to be characterized by high or low pressure?

---

**WRITING IN EARTH SCIENCE**

**Research** how pressure changes can affect the daily weather. Share your findings with your classmates. For more information on weather, visit glencoe.com.
Energy Transfer Throughout the Atmosphere

Diagram showing energy transfer through the atmosphere:
- Sun emitting solar radiation
- Radiation reaching Earth's surface
- Conduction through the Earth's surface
- Convection currents moving energy around
- Earth's surface absorbing radiation and emitting conduction and convection energy back into the atmosphere
Energy Transfer Throughout the Atmosphere

1. What is the source of all energy in the atmosphere?

2. List the three methods by which energy is transferred throughout the atmosphere.

3. What role does radiation play in warming the atmosphere?

4. How does conduction transfer energy throughout the atmosphere?

5. How does convection work with conduction to transfer energy throughout the atmosphere?

6. Infer how the transfer of energy in the atmosphere would be different without convection.

7. Describe how air moves and changes in convection currents in the atmosphere.
Temperature Changes in the Atmosphere

Temperature Variations with Altitude

- **Thermosphere**
- **Mesosphere**
- **Stratosphere**
- **Troposphere**

**Stratopause**

**Mesopause**

**Tropopause**

**Highest concentration of ozone**

Temperature (°C) vs. Altitude (km)
Temperature Changes in the Atmosphere

1. How does temperature change with altitude in the troposphere?

2. How does temperature change with altitude in the stratosphere?

3. Contrast how temperature changes with altitude in the stratosphere and mesosphere.

4. Is the temperature profile in the thermosphere more like that of the troposphere or the stratosphere? Explain your answer.

5. Where do major shifts in temperature occur in the atmosphere?

The Water Cycle

- Transpiration
- Solar energy
- Ocean
- Runoff
- Precipitation
- Percolation in soil
- Groundwater (aquifer)
- Lake
The Water Cycle

1. What is the water cycle?

2. How does water move from Earth’s surface to the atmosphere?

3. What happens to water once it moves from Earth’s surface to the atmosphere?

4. How does water move from the atmosphere to Earth’s surface?

5. How does precipitation that falls on land enter bodies of water?

6. What is the source of energy that drives the water cycle?

7. Why is the water cycle important?
SECTION 11.1  *Atmospheric Basics*

*In your textbook, read about the composition of the atmosphere.*

Circle the letter of the choice that best completes the statement.

1. Most of Earth’s atmosphere is composed of
   a. oxygen and hydrogen.
   b. hydrogen and nitrogen.
   c. nitrogen and oxygen.
   d. carbon and ozone.

2. Water vapor in the atmosphere is the source of
   a. clouds and rain.
   b. pollution.
   c. carbon dioxide.
   d. wind.

3. The amount of energy the atmosphere absorbs depends in part on its level of
   a. nitrogen.
   b. argon.
   c. nitrogen dioxide.
   d. carbon dioxide.

4. Solid particles in the atmosphere include salt and
   a. leaves.
   b. ozone.
   c. dust.
   d. lightning.

5. Ozone in Earth’s atmosphere is important because it
   a. causes rain to fall.
   b. absorbs harmful radiation.
   c. absorbs harmful pollution.
   d. helps clouds form.

*In your textbook, read about the structure of the atmosphere.*

Complete the table by writing the layer of the atmosphere that matches each description.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. Contains concentrated ozone</td>
<td></td>
</tr>
<tr>
<td>7. Layer just above the stratosphere</td>
<td></td>
</tr>
<tr>
<td>8. Most weather occurs here.</td>
<td></td>
</tr>
<tr>
<td>9. Outermost layer of the atmosphere</td>
<td></td>
</tr>
<tr>
<td>10. Between mesosphere and exosphere</td>
<td></td>
</tr>
</tbody>
</table>
In your textbook, read about how the atmosphere is heated. Examine the diagram below. Then answer the questions.

11. What is the source of all energy that reaches Earth?

12. What percentage of the Sun's energy does Earth's surface absorb directly or indirectly?

13. What percentage of the Sun's energy is scattered or reflected back into space? What causes this loss of solar energy?

14. Earth's surface is heated by energy from the Sun. For the most part, the rereleased energy from the surface heats the atmosphere. Describe the method by which energy is transferred from Earth's surface to the air above it.

15. Describe convection.
SECTION 11.2 *Properties of the Atmosphere*

In your textbook, read about heat, temperature, and moisture in the atmosphere. Use each of the terms below just once to complete the passage.

**water vapor**  **altitude**  **Fahrenheit**  **heat**  **condensation**  **dew point**  **temperature**  **lifted condensation level**

Heat and temperature are not the same. (1) _________________ is a measure of how rapidly or slowly molecules move. In contrast, (2) _________________ is the transfer of energy that takes place because of temperature differences. Temperature can be measured in degrees Fahrenheit, degrees Celsius, or kelvins. The most commonly used temperature scale in the United States is (3) _________________.

The atmosphere’s temperature plays a role in the formation of rain. Rain drops form when (4) _________________ in the atmosphere cools and turns from a gas to a liquid. This change in state is called (5) _________________.

Air must be saturated before condensation can occur. Saturation is the point at which the air holds as much water vapor as it possibly can. The (6) _________________ is the temperature to which air must be cooled at constant pressure to reach saturation. Until this temperature is reached, condensation cannot occur and rain cannot fall.

Temperature in the lower atmosphere generally decreases with increased (7) _________________. As air rises, it cools and eventually reaches the temperature at which condensation occurs. The height above the surface at which condensation occurs is the (8) _________________.

---

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SECTION 11.2  Properties of the Atmosphere, continued

In your textbook, read about air pressure and wind.
For each statement below, write true or false.

9. Air is denser near Earth’s surface than high in the atmosphere.  
11. Air pressure is greater at the top of a mountain than at lower elevations.
12. In the troposphere, as air temperature increases, generally air pressure increases, too.
13. Wind is the movement of air from an area of low pressure to an area of high pressure.
14. As you move upward from Earth’s surface, wind speeds increase because the air meets with less friction from Earth’s surface.

In your textbook, read about temperature inversion and relative humidity.
Answer the following questions.

15. What is a temperature inversion? Explain how one can form.

16. What is relative humidity?

17. What is the relative humidity of fully saturated air?
SECTION 11.3  Clouds and Precipitation

In your textbook, read about the formation of clouds. Examine the diagram below. Then answer the questions.

1. What is happening to the air in both A and B that leads to the formation of clouds?

2. What is causing the air to rise in A?

3. What is causing the air to rise in B?

4. What type of cloud formation is shown in B?

5. Explain how condensation nuclei help clouds form.
In your textbook, read about moisture in the atmosphere and clouds.

For each item in Column A, write the letter of the matching item in Column B.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. All forms of water that fall from clouds</td>
<td>a. stratus</td>
</tr>
<tr>
<td>7. Low, layered clouds</td>
<td>b. cirrus</td>
</tr>
<tr>
<td>8. Small cloud droplets join to form larger ones</td>
<td>c. precipitation</td>
</tr>
<tr>
<td>9. Wispy, high clouds made of ice crystals</td>
<td>d. coalescence</td>
</tr>
</tbody>
</table>

In your textbook, read about the movement of water between the atmosphere and Earth’s surface.

Circle the letter of the choice that best completes the statement.

10. The constant movement of water between the atmosphere and Earth’s surface is  
    a. cloud formation.  
    b. the water cycle.  
    c. precipitation.  
    d. temperature inversion.

11. The process of water changing from a liquid to a gas is  
    a. condensation.  
    b. precipitation.  
    c. coalescence.  
    d. evaporation.

12. As water vapor rises in the atmosphere, it cools and changes into liquid cloud droplets in a process called  
    a. evaporation.  
    b. precipitation.  
    c. condensation.  
    d. vaporization.

13. When cloud droplets combine to form larger drops, they fall to Earth as  
    a. ozone.  
    b. condensation.  
    c. precipitation.  
    d. water vapor.

14. The energy that drives the water cycle comes from the  
    a. Sun.  
    b. wind.  
    c. ocean.  
    d. stratosphere.
Atmosphere

Reviewing Vocabulary

Match the definition in Column A with the term in Column B.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The temperature to which air must be cooled at constant pressure to</td>
<td>\textbf{a.} latent heat</td>
</tr>
<tr>
<td>reach saturation</td>
<td></td>
</tr>
<tr>
<td>2. The gas formed by adding a third oxygen atom to an oxygen molecule</td>
<td>\textbf{b.} stability</td>
</tr>
<tr>
<td>3. Heat that is stored in a substance</td>
<td>\textbf{c.} ozone</td>
</tr>
<tr>
<td>4. An air mass's ability to resist rising</td>
<td>\textbf{d.} radiation</td>
</tr>
<tr>
<td>5. All forms of water that fall from clouds</td>
<td>\textbf{e.} dew point</td>
</tr>
<tr>
<td>6. The transfer of energy through space by electromagnetic waves</td>
<td>\textbf{f.} precipitation</td>
</tr>
</tbody>
</table>

Compare and contrast each pair of related terms.

7. heat, temperature

- Heat is a form of energy.
- Temperature is a measure of the average kinetic energy of the particles in a substance.

8. humidity, relative humidity

- Humidity is the amount of water vapor in the air.
- Relative humidity is the ratio of the amount of water vapor in the air to the amount of water vapor that the air could hold at a given temperature.

9. condensation, evaporation

- Condensation is the process by which water vapor becomes liquid water.
- Evaporation is the process by which liquid water becomes water vapor.

10. conduction, convection

- Conduction is the transfer of energy through a medium by direct contact.
- Convection is the transfer of energy through a medium by movement of the medium itself.
Understanding Main Ideas (Part A)

In the space at the left, write true if the statement is true; if the statement is false, change the italicized word or phrase to make it true.

1. The atmosphere is composed mostly of helium and oxygen, with traces of other gases such as carbon dioxide and water vapor.

2. The stratosphere is important because it contains nitrogen, which blocks harmful ultraviolet radiation from the Sun.

3. Both temperature and pressure generally decrease with height in the troposphere.

4. The amount of water vapor in a given volume of air is its relative humidity.

5. The height in the atmosphere at which condensation occurs is the lifted condensation level.

6. A temperature inversion is a decrease in temperature with height in the atmosphere.

Circle the letter of the choice that best completes the statement or answers the question.

7. Condensation nuclei are particles of atmospheric dust around which
   a. ozone collects.  
   b. cloud droplets form.  
   c. evaporation occurs.  
   d. winds form.

8. In orographic lifting, clouds form when moist winds
   a. flow over the sea.  
   b. become drier.  
   c. encounter mountains.  
   d. warm up the ground.

9. Cloud droplets collide to form larger droplets in a process called
   a. coalescence.  
   b. convection.  
   c. condensation.  
   d. composition.

10. What is the constant movement of water between the atmosphere and Earth’s surface?
   a. precipitation cycle  
   b. water cycle  
   c. cloud cycle  
   d. atmosphere cycle
Understanding Main Ideas (Part B)

Answer the following questions.

1. Compare and contrast cumulus and cirrus clouds.

2. What is moving air called? Why does air move in the atmosphere?

3. Explain how a temperature inversion might form on a clear winter night.

4. A temperature inversion hangs over a city area. Is the formation of a towering cumulonimbus cloud likely? Explain your answer.

5. Compare and contrast the troposphere and the stratosphere.
**Thinking Critically**

Use the graph to answer the following questions.

1. Do air pressure and temperature change in the same way with altitude? Explain your answer.

2. Describe the temperature changes that take place in each layer of the atmosphere.

3. Why does temperature increase with height in the stratosphere?
Applying Scientific Methods

A group of students decided to make a simple model of the atmosphere. To create their model, they used a clean glass jar, hot water, and a tray of ice cubes.

The students poured hot water into the jar to a level of about 4 cm. They then filled a small metal container with ice cubes and placed it over the jar’s opening, as shown in the illustration below.

Within a few seconds, the students observed white ribbons of mist forming in the center of the jar. Soon a larger white, misty area had formed inside the jar between the surface of the water and the jar’s opening.

Answer the following questions.

1. What formed inside the jar? Explain how it formed.

2. How does the temperature of the air in the model atmosphere vary with height? Explain your answer.
Applying Scientific Methods, continued

3. How might the results have been different if the tray and ice had not been placed over the opening of the jar?

4. How might the results have been different if students had put cold water in the bottom of the jar instead of hot water?

5. Based on your knowledge of cloud formation, compare the model with the formation of clouds in Earth's atmosphere.

6. Describe how you would change the design of the model to create a continuous water cycle. Explain how water would cycle through the new model.
CHAPTER 11
Assessment

Student Recording Sheet

Standardized Test Practice

Multiple Choice
Select the best answer from the choices given, and fill in the corresponding circle.

1. A B C D
2. A B C D
3. A B C D
4. A B C D
5. A B C D
6. A B C D
7. A B C D
8. A B C D
9. A B C D
10. A B C D

Short Answer
Answer each question with complete sentences.

11. 

12. 

13. 

14. 

15. 

16. 

Reading for Comprehension
Select the best answer from the choices given, and fill in the corresponding circle.

17. A B C D
18. A B C D
19. A B C D
20. A B C D
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## Chapter 12  Meteorology

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MiniLab 12

Compare the Angles of Sunlight to Earth

What is the relationship between the angle of sunlight and the amount of heating? The angle at which sunlight reaches Earth’s surface varies with latitude. This results in uneven heating of Earth.

Procedure

1. Read and complete the lab safety form.
2. Turn on a flashlight, and hold it 20 cm above a piece of paper. Point the flashlight straight down.
3. Use a pencil to trace the outline of the light on the paper. This models the angle of sunlight to Earth at the equator.
4. Keep the flashlight at the same distance above the paper, but rotate it about 30°.
5. Trace the new outline of the light. This is similar to the angle of sunlight to Earth at latitudes nearer the poles.

Analysis

1. Describe how the outline of the light differed between Step 3 and Step 5. Explain why it differed.

   ___________________________________________
   ___________________________________________
   ___________________________________________

2. Compare the amount of energy per unit of area received near the equator to the amount at latitudes nearer the poles.

   ___________________________________________
   ___________________________________________
   ___________________________________________
The surface weather map on the following page shows actual weather data for the United States. In this activity, you will use the station models, isobars, and pressure systems on the map to forecast the weather.

**PREPARATION**

**Question**
How can you use a surface weather map to interpret information about current weather and to forecast future weather?

**Materials**
pencil
ruler
Reference Handbook, Weather Map Symbols, p. 959

**PROCEDURE**

1. Read and complete the lab safety form.
2. The map scale is given in nautical miles. Refer to the scale when calculating distances.
3. The unit for isobars is millibars (mb). In station models, pressure readings are abbreviated. For example, 1021.9 mb is plotted on a station model as 219 but read as 1021.9.
4. Wind shafts point in the direction from which the wind is blowing. Refer to Weather Map Symbols, in the table on the right and the Reference Handbook to learn about the symbols that indicate wind speed.
5. Each number around a city represents a different atmospheric measure. By convention, the same atmospheric measure is always in the same relative location in a station model. Refer to Figure 12.17 and Weather Map Symbols in the Reference Handbook to learn what numbers represent in a station model.

<table>
<thead>
<tr>
<th>Symbols Used in Plotting Report</th>
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</thead>
<tbody>
<tr>
<td>Fronts and Pressure Systems</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>(H) or High</td>
</tr>
<tr>
<td>Center of high- or low-pressure systems</td>
</tr>
<tr>
<td>(L) or Low</td>
</tr>
<tr>
<td>Cold front</td>
</tr>
<tr>
<td>Warm front</td>
</tr>
<tr>
<td>Occluded front</td>
</tr>
<tr>
<td>Stationary front</td>
</tr>
</tbody>
</table>
Interpret a Weather Map

ANALYZE AND CONCLUDE

1. **Identify** the contour interval of the isobars.

2. **Find** the highest and lowest isobars and where they are located.

3. **Describe** the winds across Texas and Louisiana.

4. **Determine** and record with their locations the coldest and warmest temperatures on the map.

5. **Infer** whether the weather in Georgia and Florida is clear or rainy. Explain.

6. **Predict** Low-pressure systems in eastern Canada and off the Oregon coast are moving toward the east at about 24 km/h. Predict short-term weather forecasts for northern New York and Oregon.

**Forecasting** Find your area on the map. Based on the data shown in the map, use the extrapolation method to forecast the next day’s weather for your location.
Interpret a Weather Map

Surface weather map and station weather at 7:00 A.M., E.S.T.
Air Mass Source Regions

- Arctic air masses
- Maritime polar (Atlantic) air masses
- Maritime tropical (Atlantic) air masses
- Maritime tropical (Pacific) air masses
- Maritime tropical (Gulf) air masses
- Continental polar air masses
- Continental tropical air masses

Air masses are characterized by their source regions and temperature and humidity conditions:

- Cool, humid
- Warm, humid
- Dry

Air masses can be classified as:

- Arctic
- Maritime polar
- Maritime tropical
- Continental polar
- Continental tropical
Air Mass Source Regions

1. Compare and contrast the source regions of continental and maritime air masses.

2. How do the source regions of polar and tropical air masses differ?

3. Which air masses influence the northwestern United States? What type of weather do these air masses bring?

4. Which type of air mass brings cold, dry weather to the northeastern United States?

5. Use what you have learned about air masses to explain why cool, dry summer weather in the central United States might change to hot, dry weather.

6. Compare and contrast the influence of a maritime polar and a maritime tropical air mass.

7. What change would air mass modification cause in a continental polar air mass that moves south over the central United States?
Global Wind Systems

- Polar easterlies
- Rising air
- Subsiding air
- Prevailing westerlies
- Horse latitudes
- Doldrums
- Northeast trade winds
- Southeast trade winds
- Polar easterlies
1. What wind systems move air from about 30° north or south latitude toward the equator?

2. Describe the movement of air in the huge convection current between 30° north latitude and the equator.

3. According to the diagram, what forms as a result of rising air at the equator? How might this account for the formation of tropical rain forests at the equator?

4. What wind systems move air from about 30° to 60° north or south latitude?

5. Describe the movement of air in the huge convection current between 30° and 60° south latitude.

6. Would you expect high or low air pressure at the poles? Explain your answer.

7. What wind systems move air from about 60° north or south latitude to the poles?
Weather Data

Maximum and minimum thermometer

Aneroid barometer

Hygrometer

Rain gauge

Anemometer

Wind vane and wind sock

Use with Chapter 12
Section 12.3
Weather Data

1. The diagram shows a ground-based weather station. List the instruments located inside the small wooden structure, which is called a weather shack.

2. List the instruments located outside of the weather shack.

3. Infer the purpose of the weather shack.

4. Explain why some of the instruments are placed outside the weather shack.

5. What does a thermometer measure? Many weather stations include maximum-minimum thermometers. Infer what a maximum-minimum thermometer measures.

6. What are the two types of barometers? How does each of them measure air pressure?

7. Which instrument would likely be easiest to replace with human observation: a hygrometer, a rain gauge, or a wind vane? Explain your answer.
Meteorology

SECTION 12.1 The Causes of Weather

In your textbook, read about weather and climate. In the space at the left, write true if the statement is true; if the statement is false, change the italicized word to make it true.

__________ 1. Meteorology is the study of atmospheric phenomena.

__________ 2. Weather is the current state of the lithosphere.

__________ 3. Long-term variations in weather for a particular area make up the climate of the area.

__________ 4. The tropics are hotter than the poles because the sun strikes this area of Earth more indirectly.

In your textbook, read about air masses and source regions. Circle the letter of the choice that best completes the statement.

5. A large parcel of air that takes on the characteristics of the area over which it forms is a(n)
   a. cloud.
   b. air mass.
   c. source region.
   d. wind.

6. An air mass takes on its source region’s
   a. temperature and humidity.
   b. landforms.
   c. clouds and wind.
   d. elevation.

7. Maritime air masses originate over
   a. clouds.
   b. oceans.
   c. glaciers.
   d. mountains.

8. When an air mass travels over land or water that has different characteristics than those of its source region, it undergoes
   a. air source change.
   b. air mass modification.
   c. air pressure modification.
   d. temperature inversion.
SECTION 12.2  Weather Systems

In your textbook, read about global winds and how Earth’s rotation affects their movement. Use each of the terms below just once to complete the passage.

intertropical convergence zone                  rotation                  North America                  jet streams
trade winds                  southwest                  polar jet streams                  Coriolis effect
low pressure                   prevailing westerlies                  polar easterlies                  northeast

The (1) Coriolis effect deflects moving air to the right in the northern hemisphere and to the left in the southern hemisphere. The cause of this is Earth’s (2) rotation.

Each hemisphere has three basic wind systems. The first, at 30° latitude north and south, is known as the (3) intertropical convergence zone. There, air sinks, warms, and moves toward the equator from northeast to southwest in the northern hemisphere and from southeast to northwest in the southern hemisphere. When the air reaches the equator, it rises, then moves back toward 30° to start the cycle again. These winds from both hemispheres converge at the equator. They are forced upward, creating an area of (4) low pressure. This area near the equator is called the (5) equatorial low.

The second wind system, called the (6) prevailing westerlies, flows between 30° and 60° latitude north and south of the equator. Its circulation pattern is opposite that of the wind system discussed above. These winds are responsible for the movement of many weather systems across much of (7) North America.

The third wind system, the (8) polar easterly, lies between the poles and 60° latitude. In the northern hemisphere, these winds flow from the (9) northeast to the (10) southwest. They flow in the opposite direction in the southern hemisphere.

Narrow bands of fast, high-altitude, westerly winds called (11) jet streams flow at the boundaries between wind zones in the middle latitudes. These bands of wind steer weather systems in the middle latitudes. The most important one, the (12) polar jet stream, separates the polar easterlies from the prevailing westerlies.
SECTION 12.2  Weather Systems, continued

In your textbook, read about fronts and low pressure systems. Complete the table by filling in the type of weather system described. Use the following terms: front, cold front, occluded front, stationary front, warm front, low pressure system.

<table>
<thead>
<tr>
<th>Description</th>
<th>Weather System</th>
</tr>
</thead>
<tbody>
<tr>
<td>13. Cold, dense air that displaces warm air, forcing the warm air up</td>
<td></td>
</tr>
<tr>
<td>14. Narrow region separating two air masses of different densities</td>
<td></td>
</tr>
<tr>
<td>15. Advancing warm air that displaces cold air</td>
<td></td>
</tr>
<tr>
<td>16. Pressure system that is associated with cloudy weather and precipitation</td>
<td></td>
</tr>
<tr>
<td>17. Cold air mass that moves rapidly and overtakes a warm front</td>
<td></td>
</tr>
<tr>
<td>18. Two air masses that meet and do not advance</td>
<td></td>
</tr>
</tbody>
</table>

In your textbook, read about pressure systems. Complete the table by checking the correct column for each statement.

<table>
<thead>
<tr>
<th>Statement</th>
<th>High-Pressure System</th>
<th>Low-Pressure System</th>
</tr>
</thead>
<tbody>
<tr>
<td>19. Characterized by sinking air</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. Characterized by rising air</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21. Air flows toward center</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22. Air flows away from center</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23. Air moves clockwise in the northern hemisphere</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24. Air moves counterclockwise in the northern hemisphere</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25. Associated with fair weather</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26. Associated with clouds and precipitation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SECTION 12.3  Gathering Weather Data

In your textbook, read about weather instruments.
For each item in Column A, write the letter of the matching item in Column B.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Radio detecting and ranging</td>
<td>a. thermometer</td>
</tr>
<tr>
<td>2. An instrument that measures wind speed and direction</td>
<td>b. barometer</td>
</tr>
<tr>
<td>3. An instrument that measures temperature</td>
<td>c. anemometer</td>
</tr>
<tr>
<td>4. An instrument that measures air pressure</td>
<td>d. hygrometer</td>
</tr>
<tr>
<td>5. A balloon-borne package of sensors that gathers upper-level weather data</td>
<td>e. radar</td>
</tr>
<tr>
<td>6. An instrument that measures relative humidity</td>
<td>f. radiosonde</td>
</tr>
</tbody>
</table>

In your textbook, read about radar and weather satellites.
Answer the following questions.

7. What is the Doppler effect? How do meteorologists use it to predict weather?

8. How do meteorologists combine data from weather radar and weather satellites to gather information about the atmosphere?

9. What is infrared imagery? How is it used?
SECTION 12.4 Weather Analysis and Prediction

In your textbook, read about station models.
Study the station model. Then answer the questions that follow.

1. What is a station model?

2. What are the advantages of using station models?

3. List three types of information shown on a station model.

4. For the station shown, what is the temperature?

5. For the station shown, how has the barometric pressure changed in the last 3 hours?
SECTION 12.4  Weather Analysis and Prediction, continued

In your textbook, read about isopleths.

For each statement below, write true or false.

6. An isotherm is a line that connects points of equal or temperature.

7. Lines of equal pressure are called isobars.

8. Isobars that are far apart indicate a small difference in pressure and light winds.

9. Contour lines are lines of equal temperature.

10. Isotherms are used to identify temperature gradients and, consequently, frontal systems.

In your textbook, read about weather forecasting.

Use each of the terms below just once to complete the passage.

<table>
<thead>
<tr>
<th>digital forecast</th>
<th>short term</th>
<th>long-term</th>
<th>analog forecast</th>
</tr>
</thead>
</table>

There are two major types of weather forecasts. A(n) (11) relies on numerical data. It is the main method used in modern weather forecasting. Another type of forecast, the (12), involves comparing current weather patterns to patterns that took place in the past.

Regardless of the forecasting method, all forecasts are more reliable in the (13). Forecasts become less reliable as they attempt to predict (14) weather changes.
Meteorology

Reviewing Vocabulary

Compare and contrast each pair of related terms.

1. weather, climate

2. trade winds, prevailing westerlies

3. air mass, front

4. thermometer, barometer

5. anemometer, hygrometer

6. digital forecast, analog forecast
Understanding Main Ideas (Part A)

Circle the letter of the choice that best completes the statement.

1. Narrow bands of fast, high-altitude westerly winds are
   a. polar easterlies.          c. air masses.
   b. jet streams.              d. warm fronts.

2. A weather instrument that measures temperature is a(n)
   a. hygrometer.               c. thermometer.
   b. anemometer.               d. barometer.

3. A balloon-borne package of sensors that gathers upper-level temperature, air
   pressure, and humidity is
   a. a radiosonde.             c. a hygrometer.
   b. a satellite.              d. Doppler radar.

4. The change in wave frequency of energy as it moves toward or away from an
   observer is the
   a. Coriolis effect.          c. convergence effect.
   b. Doppler effect.           d. radar effect.

5. Polar and tropical regions maintain fairly constant average temperatures because
   a. the Sun always strikes these regions at the same angle.
   b. air masses remain stationary near the poles and equator.
   c. Earth radiates extra energy back into space.
   d. the continual motion of air and water reallocates heat energy throughout Earth.

6. Differences in thermal energy can be detected with
   a. ultraviolet imagery.       c. infrared imagery.
   b. visible light.             d. sonar imagery.

7. A record of weather data for a particular site at a particular time is a(n)
   a. station model.            c. isopleth model.
   b. topographic map.          d. climate map.

8. Lines on a map that connect points of equal pressure are
   a. boundaries.               c. fronts.
   b. isobars.                 d. station models.

9. The exchange of heat or moisture with the surface over which an air mass travels
   is known as
   a. intertropical convergence. c. occlusion.
   b. air mass modification.    d. air mass exchange.
Understanding Main Ideas (Part B)

Answer the following questions.

1. Explain how air masses form, and how they help redistribute energy on Earth’s surface.

2. Describe the formation and location of jet streams.

3. Identify the four types of fronts and the weather conditions associated with each one.

4. Compare and contrast a continental polar air mass and a maritime tropical air mass.

5. What problems are associated with long-term weather forecasts?
Thinking Critically

Answer the following questions.

1. You examine two weather maps of your area for two different days. One map shows isobars that are closely spaced; the other shows isobars that are far apart. Predict the difference in weather conditions for those days.

2. How would Earth’s wind systems be different if the whole planet were heated equally?

3. Your town is experiencing a drought in which the weather has been hot and dry for weeks. Infer which type of pressure system is stalled over the area. Explain your answer.

4. There are five weather instruments collecting weather data in a city you are about to visit: an anemometer, a barometer, a hygrometer, a radiosonde, and a thermometer. You need information that will allow you to dress properly when you arrive. You can have the data from just three of the instruments. Which ones would you pick and why?

5. Explain how infrared imagery has the potential to save lives.
Applying Scientific Methods

A meteorology class has set up a small weather station outside of school. It has a few simple instruments: a thermometer, a barometer, a rain gauge to measure rainfall, and a hygrometer. The students took measurements with the instruments once a day for a week. They then filled in the chart below. The barometer broke, so they were not able to finish collecting air-pressure data.

Use the chart and what you know about weather systems and weather forecasting to answer the following questions.

<table>
<thead>
<tr>
<th></th>
<th>Mon</th>
<th>Tue</th>
<th>Wed</th>
<th>Thurs</th>
<th>Fri</th>
<th>Sat</th>
<th>Sun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average temperature (°C)</td>
<td>23.3</td>
<td>22.2</td>
<td>22.2</td>
<td>15.6</td>
<td>16.7</td>
<td>16.7</td>
<td>17.8</td>
</tr>
<tr>
<td>Rainfall (cm)</td>
<td>0</td>
<td>0</td>
<td>3.31</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>40%</td>
<td>60%</td>
<td>100%</td>
<td>80%</td>
<td>60%</td>
<td>50%</td>
<td>40%</td>
</tr>
<tr>
<td>Air pressure (mb)</td>
<td>1000</td>
<td>998</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

1. A cold front passed through the students’ city during the week. Showers occur at fronts. On which day did the front pass through?

2. What evidence does the data provide of the arrival of the front? Give two examples.

3. The students did not record cloud cover data. If they had, what would their observations have been as the front arrived?
Applying Scientific Methods, continued

4. Low-pressure systems are associated with clouds and precipitation. If the students’ barometer had continued to work, would the air pressure reading for Wednesday have been higher or lower than the one for Tuesday, when the weather was clearer?

5. Given the relative humidity on Thursday, would you expect clear or cloudy skies?

6. Would the students be able to make an accurate digital forecast based on the data they have collected? Explain your answer.

7. Use the data in the chart to make an analog forecast of the weather for the Monday following the last day in the chart. Explain your answer.
CHAPTER 12  
Assessment  
Student Recording Sheet

Standardized Test Practice

Multiple Choice

Select the best answer from the choices given, and fill in the corresponding circle.

1. A B C D
2. A B C D
3. A B C D
4. A B C D
5. A B C D
6. A B C D
7. A B C D
8. A B C D

Short Answer

Answer each question with complete sentences.

9. 

10. 

11. 

12. 

13. 

14. 

Reading for Comprehension

Select the best answer from the choices given, and fill in the corresponding circle.

15. A B C D
16. A B C D
# Table of Contents

**Chapter 13  The Nature of Storms**

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- Teaching Transparency Masters and Worksheets .................. 59
- Study Guide ......................... 67
- Chapter Assessment .................. 73
- STP Recording Sheet .................. 79
Model Flood Conditions

How can mild rains cause floods? Flooding can result from repeated, slow-moving storms that drop rain over the same area for a long period of time.

Procedure

1. Read and complete the lab safety form.
2. Place an ice cube tray on the bottom of a large sink or tub.
3. Pour water into a clean, plastic dishwashing-detergent bottle until it is two-thirds full. Replace the cap on the bottle.
4. Hold the bottle upside down with the cap open about 8 cm above one end of the ice cube tray. Gently squeeze the bottle to maintain a constant flow of water into the tray.
5. Slowly move the bottle from one end of the tray to the other over the course of 30 s. Try to put approximately equal amounts of water in each ice cube compartment.
6. Measure the depth of water in each compartment. Calculate the average depth.
7. Repeat Steps 2 to 4, but move the bottle across the ice cube tray in 15 s.

Analysis

1. Compare How did the average depth of the water differ in steps 4 and 5? How might you account for the difference?

2. Infer Based on these results, infer how the speed of a moving storm affects the amount of rain received in any one area.

3. Deduce How could you alter the experiment to simulate different rates of rainfall?
Tropical cyclones form very violent storms. That is why it’s important to have advance warning before they hit land. By tracking the changing position of a storm on a chart and connecting these positions with a line, you can model or predict a cyclone’s path.

**Problem**
What information can you obtain by studying the path of a tropical cyclone?

**Objectives**
In this GeoLab, you will:
- Gather and communicate data about hurricanes.
- Plot data on a tropical cyclone-tracking chart.
- Predict where storm-inflicted damage might occur.

**PREPARATION**

1. Read and complete the lab safety form.
2. Form a hypothesis about how a tropical cyclone’s path can be used to predict the strength of the storm and where the most damage might be inflicted.
3. Visit glencoe.com to find links to tropical cyclone data.
4. Choose the track of a tropical cyclone that has occurred during the past five years.

**PROCEDURE**

5. Plot the position, air pressure, wind speed, and stage of the tropical cyclone at 6-h intervals throughout its existence.
6. Plot the changing position of the tropical cyclone on your hurricane-tracking chart.
7. Incorporate your research into a data table. Add any additional information that you think is important.
Track a Tropical Cyclone

DATA TABLE
Track a Tropical Cyclone

Analyze and Conclude

1. **Identify** What was the maximum wind speed in knots that the tropical cyclone reached?

2. **Calculate** Multiply the value from question 3 by 1.85 to find the wind speed in kilometers per hour. Based on this value, how would the hurricane be classified on the Saffir-Simpson scale shown in Figure 13.15?

3. **List** the landmasses over which the tropical cyclone passed.

4. **Identify** What was the life span of your tropical cyclone? What was the name of your cyclone?

5. **Infer** Where would you expect the storm surge to have been greatest? Explain.

6. **Examine** How was the tropical cyclone’s strength affected when its center passed over land?

Peer Review Visit glencoe.com and post a summery of your data. Compare your data with other data collected for this investigation.
Life Cycle of a Thunderstorm

Stage 1: Developing (Cumulus) Stage

- Height, Kilometers: 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1
- Height, Feet: 40,000, 30,000, 20,000, 10,000, 5,000

Stage 2: Mature Stage

- Height, Kilometers: 3-10 mi (5-16 km)
- Height, Feet: 3-10 mi (5-16 km)

Stage 3: Dissipation Stage

- Height, Kilometers: 5-7 mi (8-11 km)
Life Cycle of a Thunderstorm

1. What factor determines the classification of a thunderstorm stage?

2. What is the first stage in the formation of a thunderstorm?

3. What causes air to rise in stage 1?

4. What event signals the beginning of stage 2?

5. Summarize what happens during the mature stage.

6. What is the last stage in the formation of a thunderstorm?

7. What happens to the updrafts inside the cloud during the last stage? Explain your answer.

8. During which stage does the storm cloud cover the greatest vertical distance through the atmosphere?
Tornado Formation

A

B

C
Tornado Formation

1. Tornadoes are often associated with very severe thunderstorms. What are these violent thunderstorms called?

2. In diagram A, what causes air to rotate horizontally near Earth’s surface? What is this phenomenon called?

3. Describe what is occurring in diagram B.

4. Is the center of the column of twisting air an area of high pressure or low pressure? Explain your answer.

5. What characteristic of a supercell would contribute to tornado formation?

6. Why can we see the air in a tornado?

7. How are the strong winds associated with the tornado in diagram C produced?
Hurricanes

Eye

Eyewall

Rainbands
Hurricanes

1. What is the center of the hurricane called?

2. Describe weather conditions in the center of the hurricane.

3. In the diagram, do the winds circulate around the storm’s center in a clockwise or counterclockwise direction? Infer what hemisphere the storm formed in.

4. Where in this storm do the strongest winds occur?

5. Is this a high-pressure or a low-pressure system? Explain your answer.

6. Use the diagram to explain why the weather is calm in the eye of a hurricane.

7. A hurricane weakens when it moves over land or cool ocean waters. Use the diagram to explain why.
# Wind Chill Index

Use with Chapter 13
Section 13.4

<table>
<thead>
<tr>
<th>Air Temperature (F)</th>
<th>Wind Speed (miles per hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>0-4</td>
</tr>
<tr>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>0</td>
<td>35</td>
</tr>
</tbody>
</table>

| 35                  | 5                            |
| 30                  | 10                           |
| 25                  | 15                           |
| 20                  | 20                           |
| 15                  | 25                           |
| 10                  | 30                           |
| 5                   | 35                           |
| 0                   | 40                           |

| 35                  | 5                            |
| 30                  | 10                           |
| 25                  | 15                           |
| 20                  | 20                           |
| 15                  | 25                           |
| 10                  | 30                           |
| 5                   | 35                           |
| 0                   | 40                           |

| 35                  | 5                            |
| 30                  | 10                           |
| 25                  | 15                           |
| 20                  | 20                           |
| 15                  | 25                           |
| 10                  | 30                           |
| 5                   | 35                           |
| 0                   | 40                           |

| 35                  | 5                            |
| 30                  | 10                           |
| 25                  | 15                           |
| 20                  | 20                           |
| 15                  | 25                           |
| 10                  | 30                           |
| 5                   | 35                           |
| 0                   | 40                           |

| 35                  | 5                            |
| 30                  | 10                           |
| 25                  | 15                           |
| 20                  | 20                           |
| 15                  | 25                           |
| 10                  | 30                           |
| 5                   | 35                           |
| 0                   | 40                           |

| 35                  | 5                            |
| 30                  | 10                           |
| 25                  | 15                           |
| 20                  | 20                           |
| 15                  | 25                           |
| 10                  | 30                           |
| 5                   | 35                           |
| 0                   | 40                           |
Wind Chill Index

1. What is the wind chill factor?

2. What are the limitations of the wind chill index?

3. What do the numbers in the top row of the index indicate?

4. What do the numbers in the lefthand column indicate?

5. What is the wind chill index if the air temperature is 20°F and the wind speed is 10 mph?

6. If actual air temperature remains the same, how does an increase in wind speed affect the wind chill index?

7. If the wind speed remains the same, how does a decrease in actual air temperature affect the wind chill index?

8. If the wind chill index is −51°F and the actual air temperature is −15°F, what is the wind speed?

9. If the wind chill index is −52°F and the wind speed is 35 mph, what is the actual air temperature?
SECTION 13.1  Thunderstorms

In your textbook, read about thunderstorm formation. Use each of the terms below just once to complete the passage.

condensation  warmer  unstable  convection
cumulonimbus  moisture  stable

At any moment, more than 2000 thunderstorms are occurring on Earth. Thunderstorms develop from cumulus clouds that grow into huge (1) _______________ clouds.

Thunderstorms form when three conditions exist that cause cumulus clouds to grow by the energy transfer method of (2) _______________. First, there must be sufficient (3) _______________ in the lower atmosphere to condense and release latent heat. Second, some mechanism must make the air rise, causing the cloud to grow. Third, the portion of the atmosphere that the cloud grows through must be (4) _______________. The rising cloud must stay (5) _______________ than the air around it in order for the growth to continue.

The cloud’s growth stops when the rate of (6) _______________ in the cloud, which diminishes with height, is insufficient to create enough heat to keep the cloud warmer than the air around it. Growth will also stop if the rising air meets a layer of (7) _______________ air that it cannot overcome.

In your textbook, read about different types of thunderstorms. For each item in Column A, write the letter of the matching item in Column B.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>____________ 8.</td>
<td>a.    frontal thunderstorm</td>
</tr>
<tr>
<td>____________ 9.</td>
<td>b.    mountain thunderstorm</td>
</tr>
<tr>
<td>____________ 10.</td>
<td>c.    sea-breeze thunderstorm</td>
</tr>
</tbody>
</table>

Forms when an air mass rises as a result of orographic lifting
Forms because of temperature differences between the air over land and the air over water
Forms as cold air pushes warm air up at a boundary between cold and warm air masses
SECTION 13.1 Thunderstorms, continued

In your textbook, read about air-mass thunderstorms.
Examine the diagram below. Then answer the questions.

11. What phenomenon is pictured in the diagram?

12. Describe how a sea breeze may lead to the formation of a thunderstorm.

13. Why is a sea-breeze thunderstorm considered a type of air-mass thunderstorm?

In your textbook, read about the stages of thunderstorm development.
Number the stages in the development of a thunderstorm in the order in which they occur.

14. Equal amounts of updrafts and downdrafts form convection cells.

15. Warm, moist air rises quickly, and the moisture condenses into a visible cloud. Then updrafts form.

16. Falling precipitation cools the air around it, forming downdrafts.

17. Precipitation begins to fall.

18. The updrafts cease and precipitation stops.

19. The updrafts slow as downdrafts decrease the supply of warm, moist surface air.
SECTION 13.2  Severe Weather

In your textbook, read about thunderstorms and the dangerous conditions they cause. Circle the letter of the choice that best completes the statement.

1. Extremely powerful thunderstorms that develop intense, rotating updrafts are
   a. downbursts.
   b. supercells.
   c. cumulus cells.
   d. convection bursts.

2. Electricity caused by the rapid rush of air in a cumulonimbus cloud is
   a. thunder.
   b. hail.
   c. friction.
   d. lightning.

3. Violent downdrafts that are concentrated in one local area are
   a. downdraft cells.
   b. downstrokes.
   c. downbursts.
   d. updrafts.

4. Powerful downdrafts that affect an area of less than 3 km are
   a. microbursts.
   b. macrobursts.
   c. supercells.
   d. updrafts.

5. Precipitation in the form of balls or lumps of ice is
   a. sleet.
   b. drizzle.
   c. snow.
   d. hail.

6. The intense updrafts and downdrafts that characterize severe thunderstorms are the result of
   a. unstable air caused by temperature differences between the upper and lower parts of a storm.
   b. the contact between rising air and a layer of stable air.
   c. the slowing of the rate of condensation within a cloud.
   d. the cooling of the air inside a cumulonimbus cloud to a temperature lower than the surrounding air.

7. Flooding often occurs if rain falls faster than
   a. snow.
   b. rates of condensation.
   c. the ground can absorb it.
   d. clouds can form.

8. Hail forms in part because of the presence of
   a. supercooled water droplets.
   b. above-freezing temperatures.
   c. high-pressure systems.
   d. melting snow.
In your textbook, read about tornado formation.

**SECTION 13.2  Severe Weather, continued**

Answer the following questions.

9. What is a tornado?

10. Describe how a tornado forms.

11. During which time of year do most violent tornadoes form? Explain why.


In your textbook, read about tornado classification.

Examine the table below. Then answer the questions.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Category</th>
<th>Path of Destruction</th>
<th>Wind Speed (mph)</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>F0 and F1</td>
<td>Weak</td>
<td>up to 3 miles</td>
<td>60–115</td>
<td>1–10 minutes</td>
</tr>
<tr>
<td>F2 and F3</td>
<td>Strong</td>
<td>15+ miles</td>
<td>110–205</td>
<td>20 minutes or longer</td>
</tr>
<tr>
<td>F4 and F5</td>
<td>Violent</td>
<td>50+ miles</td>
<td>more than 200</td>
<td>1 hour or longer</td>
</tr>
</tbody>
</table>

13. The Fujita scale classifies tornadoes according to what criteria?

14. What is the wind speed of the most violent tornadoes on the scale?

15. How long would an average F3 tornado last?
SECTION 13.3  Tropical Storms

In your textbook, read about the life cycle of a hurricane. Number the stages in the development of a hurricane in the order in which they occur.

1. tropical disturbance
2. hurricane
3. tropical storm
4. tropical depression

In your textbook, read about tropical cyclones and the damage they cause. Determine if the statement is true. If it is not, rewrite the italicized part to make it true.

5. To people living near the Atlantic Ocean, tropical cyclones are known as hurricanes.

6. Tropical cyclones are large, rotating, high-pressure storms.

7. Tropical cyclones originate over the warm waters of most tropical oceans.

8. Hurricanes are classified according to the Fujita scale.

9. The minimum wind speed for a Category 1 hurricane is 74 mph (120 kph).

10. The eye of a hurricane is surrounded by a band of strong winds called the eye current.

11. Hurricane winds can drive a mound of water toward the coast, where it washes over land. This is called a storm surge.
SECTION 13.4 Recurrent Weather

In your textbook, read about weather patterns and problems they cause.

Complete the table by writing the result of each weather pattern. Choose from the following: cold wave, drought, flood, heat wave.

<table>
<thead>
<tr>
<th>Weather Pattern</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Thunderstorm remains over an area for many hours</td>
<td></td>
</tr>
<tr>
<td>2. Extended period of well-below-normal rainfall</td>
<td></td>
</tr>
<tr>
<td>3. Extended period of above-normal temperatures</td>
<td></td>
</tr>
<tr>
<td>4. Extended period of below-normal temperatures</td>
<td></td>
</tr>
</tbody>
</table>

Complete the table by writing the name of each weather pattern associated with each atmospheric event. Choose from the following: cold wave, flood, heat wave, drought.

<table>
<thead>
<tr>
<th>Atmospheric Event</th>
<th>Weather Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Large pools of extremely cold air develop strong high-pressure systems over</td>
<td></td>
</tr>
<tr>
<td>polar continental areas. Jet streams move systems.</td>
<td></td>
</tr>
<tr>
<td>6. Large, warm, high-pressure system develops, remains over an area, and blocks</td>
<td></td>
</tr>
<tr>
<td>cooler air masses from entering the area.</td>
<td></td>
</tr>
<tr>
<td>7. Sinking air from a strong high-pressure system stops air from rising and</td>
<td></td>
</tr>
<tr>
<td>condensation from occurring over a long period of time.</td>
<td></td>
</tr>
<tr>
<td>8. A thunderstorm unleashes heavy precipitation.</td>
<td></td>
</tr>
</tbody>
</table>
Reviewing Vocabulary

Compare and contrast each pair of related terms.

1. air-mass thunderstorm, frontal thunderstorm

2. supercell, downburst

3. Fujita tornado intensity scale, Saffir-Simpson hurricane scale

4. tornado, tropical cyclone

5. eye, eyewall
Understanding Main Ideas (Part A)

Circle the letter of the choice that best completes the statement or answers the question.

1. A mound of water driven toward coastal areas by hurricane winds is called a
   a. cyclone.  
   b. supercell.  
   c. storm surge.  
   d. cold front.

2. An extended period of well-below-normal rainfall is a
   a. flood.  
   b. drought.  
   c. heat wave.  
   d. tropical cyclone.

3. The phenomenon in which the effects of cold air are worsened by wind is the
   a. supercell.  
   b. sea breeze.  
   c. wind chill factor.  
   d. cold wave.

4. Which of the following conditions does NOT contribute to the formation of hail?
   a. the ability of water droplets to exist in a liquid state in parts of a cloud where the temperature is below freezing
   b. the encounter between supercooled water droplets and ice pellets
   c. the dissipation of warm, moist air at Earth's surface by downdrafts
   d. the existence of strong updrafts and downdrafts side by side within a cloud

Put a check next to the correct responses to each question.

5. The conditions needed for the towering clouds of thunderstorms to develop include:
   ______ very low humidity  
   ______ unstable air  
   ______ strong winds  
   ______ large area of high air pressure  
   ______ abundant moisture

6. The dangers associated with severe thunderstorms include:
   ______ lightning  
   ______ hail  
   ______ tornadoes  
   ______ high winds  
   ______ thunder  
   ______ flooding  
   ______ drought

7. Places where a tropical cyclone is most likely to develop include:
   ______ Arctic Ocean  
   ______ tropical Atlantic Ocean  
   ______ tropical Pacific Ocean  
   ______ central United States
Understanding Main Ideas (Part B)

Answer the following questions.

1. Describe the life cycle of a thunderstorm.

2. What makes some thunderstorms more severe than others?

3. Explain how a hurricane forms.

4. Describe the weather pattern that causes droughts, and explain how it is similar to the weather pattern that causes a heat wave.
Thinking Critically

Answer the following questions.

1. A community in Texas broadcasts public service announcements on tornado safety. Would the broadcasts be more effective right before winter, spring, summer, or fall? Explain your answer.

2. Could a hurricane form over the northern Atlantic, off the eastern coast of Canada? Explain your answer.

3. Why are people who live along the coast or other low-lying areas often in more danger from hurricanes than people who live inland?

4. A Category 4 hurricane has just become a Category 5. Explain what has happened to air pressure in the storm and the strength of its winds.

5. Could the atmospheric conditions that cause a drought also cause the formation of a supercell? Explain your answer.

6. Why do weather forecasters often report the wind chill factor in winter?
Applying Scientific Methods

Table 1 shows the effect on water level of a strong thunderstorm moving through the Green River area. The normal level of Green River at Wilson Bend is about 3 m. Three houses are located near the bank of the river along Wilson Bend. Their elevations are shown in Table 2.

**Table 1: Water Level at Wilson Bend, Green River**

<table>
<thead>
<tr>
<th>Time</th>
<th>10:00 A.M.</th>
<th>11:00 A.M.</th>
<th>NOON</th>
<th>1:00 P.M.</th>
<th>2:00 P.M.</th>
<th>3:00 P.M.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Level (m)</td>
<td>3</td>
<td>3.1</td>
<td>3.4</td>
<td>4.0</td>
<td>5.0</td>
<td>5.2</td>
</tr>
</tbody>
</table>

**Table 2**

<table>
<thead>
<tr>
<th>House</th>
<th>Elevation (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>8.0</td>
</tr>
<tr>
<td>Y</td>
<td>3.5</td>
</tr>
<tr>
<td>Z</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Answer the following questions.

1. What general effect did the thunderstorm have on the river level?

2. By what time did the river rise 0.4 meters above its normal level?

3. How high above its normal level did the river rise by 3:00 P.M.?

4. Which houses most likely flooded as a result of the storm? Explain your answer.
Applying Scientific Methods, continued

5. The thunderstorm was moving over the area at about 3 km/h. How would the weather and its effects on the area have been different if the storm had moved over the area at 7 km/h?

6. Why is the accurate forecasting of storms such as this one important?
CHAPTER 13
Assessment
Student Recording Sheet

Standardized Test Practice

Multiple Choice

Select the best answer from the choices given, and fill in the corresponding circle.

1. A B C D
2. A B C D
3. A B C D
4. A B C D
5. A B C D
6. A B C D
7. A B C D
8. A B C D
9. A B C D

Short Answer

Answer each question with complete sentences.

10. 
11. 
12. 
13. 
14. 
15. 
16. 

Reading for Comprehension

Select the best answer from the choices given, and fill in the corresponding circle.

17. A B C D
18. A B C D
# Chapter 14 Climate

<table>
<thead>
<tr>
<th>Resource</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>MiniLab</td>
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<tr>
<td>GeoLab</td>
<td>83</td>
</tr>
<tr>
<td>Teaching Transparency Masters and Worksheets</td>
<td>87</td>
</tr>
<tr>
<td>Study Guide</td>
<td>95</td>
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<tr>
<td>Chapter Assessment</td>
<td>101</td>
</tr>
<tr>
<td>STP Recording Sheet</td>
<td>109</td>
</tr>
</tbody>
</table>
How does the atmosphere top radiation? The greenhouse effect is a natural phenomenon that occurs because the atmosphere traps outgoing radiation.

**Procedure**

1. Read and complete the lab safety form.
2. On a clear day, place a **cardboard box** outside in a shaded area.
3. Prop two **thermometers** vertically against the box. Make sure the thermometers are not in direct sunlight.
4. Cover one thermometer with a **clean glass jar**.
5. Observe and record the temperature changes of each thermometer every 2 minutes over a 30-minute period.

**Analysis**

1. **Identify** the independent variable and the dependent variable in this investigation.

2. **Construct** a graph showing how the temperatures of the two thermometers changed over time, using the space below.

3. **Evaluate** Based on your graph, which thermometer experienced the greatest increase in temperature? Why?

4. **Relate** your observations to the greenhouse effect in the atmosphere.
Microclimates can be caused by tall buildings, large bodies of water, and mountains, among other things. In this activity, you’ll observe different microclimates and then attempt to determine which factors strengthen microclimates and how these factors change with distance from Earth’s surface.

**Problem**
Which type of surface creates the most pronounced microclimate?

**Materials**
- thermometer
- psychrometer
- paper strip or wind sock
- meterstick
- relative humidity chart

**Objectives**
*In this GeoLab, you will:*
- **Design** and **carry out** an experiment to study microclimates both at Earth’s surface and above its surface.
- **Observe** and **record** temperature, relative humidity, and wind speed.
- **Infer** how different surfaces and changes in height above these surfaces affect microclimates.

**Safety Precautions**
WARNING: Be careful when you handle glass thermometers, especially those that contain mercury. If the thermometer breaks, do not touch it. Have your teacher properly dispose of the glass and the mercury.

**PROCEDURE**

1. Read and complete the lab safety form.
2. Working in groups of three to four, determine a hypothesis based on the question listed above.
3. Create a plan to test your hypothesis. Include how you will use your equipment to measure temperature, relative humidity, and wind speed on different surfaces and at various heights above these surfaces. Make sure you include provisions for controlling your variables.
4. Select your sites.
5. Make a map of your test sites on the following page. Design and construct data tables for recording your observations.
6. Identify your constants and variables in your plan.
7. Have your teacher approve your plan before you proceed.
8. Carry out your experiment.
9. Map your data on the following page. Color-code the areas on your map to show which surfaces have the highest and lowest temperatures, the highest and lowest relative humidity, and the greatest and least wind speed. On your map, include data for surface area only.
10. Graph your data for each site on the following page, showing differences in temperature with height. Plot temperature on the x-axis and height on the y-axis. Repeat this step for relative humidity and wind speed.
Identify a Microclimate

MAPS, GRAPHS, AND DATA TABLE
Identify a Microclimate

**ANALYZE AND CONCLUDE**

1. **Analyze** your maps, graphs, and data to find patterns. Which surfaces had the most pronounced microclimates?

2. **Conclude** Did height above the surface affect your data? Why or why not.

3. **Thinking Critically** Analyze your hypothesis and the results of your experiment. Was your hypothesis supported? Explain.

4. Why did some areas have more pronounced microclimates than others? Which factors seemed to contribute most to the development of microclimates?

5. Which variable changed most with height: temperature, relative humidity, or wind speed? Which variable changed least? Infer why some variables changed more than others with height.

6. **Determine** which variable changed most with height: temperature, relative humidity, or wind speed.

7. **Infer** why some variable changed more than others with height.
Mountains and Climate

Moist air

Windward side

Leeward side

Dry air
Mountains and Climate

1. On which side of the mountain is rainfall more abundant?

2. Why is precipitation more abundant on one side of the mountain?

3. What happens to the air after it crosses the peak of the mountain and descends?

4. On which side of the mountain is the air drier? Explain why.

5. On which side of the mountain would you be most likely to find a forest? Explain your answer.

6. On which side of the mountain would you be most likely to find a desert? Explain your answer.

7. How might you expect the climate at the top of the mountain to differ from the climate at the base of the mountain? Explain your answer.
World Climate Map

Tropical climates
- Tropical wet
- Tropical wet and dry

Mild climates
- Marine west coast
- Mediterranean
- Humid subtropical

Dry climates
- Semiarid
- Arid

Continental climates
- Warm summer
- Cool summer
- Subarctic

Polar climates
- Tundra
- Ice cap

High elevation
- Highlands
- Uplands
World Climate Map

1. List the six major climate zones shown on the map.

2. Compare and contrast the two types of tropical climates in terms of location and characteristics.

3. Which climate is most extensive in the northern part of North America?

4. Which climate is most extensive in the southeastern United States?

5. What climate occurs in Antarctica?

6. Which climate is most extensive in northern Africa?

7. Between which latitudes, north and south of the equator, do dry climates occur?

8. In which part of the United States do high elevation climates occur?

9. Which of the six major climate zones shown on the map do not occur in Australia?
El Niño

Normal Pattern

Polar jet
Subtropical jet
Warm water
Strong trade winds
Strong equatorial currents
Cold pool

Australia
North America
South America

El Niño Pattern

Polar jet
Subtropical jet
Strong countercurrent

Asia
South America

Australia
1. Describe the normal flow of ocean currents along and off the west coast of South America.

2. How does the flow of the El Niño current differ from that of the normal ocean currents?

3. Compare and contrast the air-pressure systems off the west coast of South America and north of Australia during a normal period and during El Niño.

4. Describe the change in the polar jet stream during El Niño.

5. What climate changes does El Niño bring to North America?

6. What climate change does El Niño bring to Australia?

7. Would cold-water fish species be easier to catch along the northwest coast of South America during El Niño or normal periods? Explain your answer.
Sunlight

Energy is trapped by atmospheric greenhouse gases.

Solar radiation is absorbed by Earth’s surface and released as infrared radiation.

Infrared radiation cannot pass through greenhouse glass.

Solar radiation is absorbed by soil and other materials and released as infrared radiation.

The Greenhouse Effect
1. What is the source of the energy in the greenhouse?

________________________________________________________________________

2. What happens to solar energy inside the greenhouse?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

3. What is the source of energy entering Earth’s atmosphere?

________________________________________________________________________

4. How is the atmosphere heated?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

5. Compare and contrast the heating of the greenhouse with the heating of the atmosphere.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

6. How would Earth be different if there were no greenhouse effect?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

7. What are the two sources of energy that heat Earth’s surface?

________________________________________________________________________
SECTION 14.1  Defining Climate

In your textbook, read about climate and different types of climate data. Put a check (√) next to the types of data that describe climate.

1. annual wind speed  4. average air temperature
2. average ocean depth  5. average thickness of atmosphere
3. average precipitation  6. one day’s temperature

In your textbook, read about what causes climate variation. Answer the following questions.

7. How does latitude affect climate?

8. Explain how the presence of a large body of water can affect climate.

9. How do mountains affect climate?

10. Describe the effect that air masses can have on climate and give an example.
SECTION 14.2  Climate Classification

In your textbook, read about the Koeppen classification system.

Write the name of the types of climate in the Koeppen classification system described by each group of terms below. Choose from the following: dry climate, polar climate, mild climate, continental climate, tropical climate.

1. Continental tropical air dominates, precipitation is low, vegetation is scarce, solar radiation is intense, and clouds are few
2. Located between the polar zones and the tropics, violent weather changes occur, and summer and winter temperatures are extreme
3. Prevails in the southeastern United States, summers are warm and muggy, and winters are dry and cool
4. Mean temperature of warmest month is less than 10°C and precipitation is generally low
5. Characterized by constant high temperatures, up to 600 cm of rain falls each year, and lush rain forests predominate

In your textbook, read about microclimates.

Use each of the terms below just once to complete the passage.

heat island  microclimate  precipitation  temperatures

A localized climate that differs from the main regional climate is called a (6) _________________.
A (7) ________________ is a place in a city where the climate is warmer than in the surrounding countryside. This added heat can cause strong convection currents, increased cloudiness, and more total (8) _________________. Buildings can also change the surrounding climate by casting shadows that lower (9) _________________.

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A (7) ________________ is a place in a city where the climate is warmer than in the surrounding countryside. This added heat can cause strong convection currents, increased cloudiness, and more total (8) _________________. Buildings can also change the surrounding climate by casting shadows that lower (9) _________________.
SECTION 14.3  Climatic Changes

In your textbook, read about different types of climatic changes. For each statement below, write true or false.

1. During ice ages, Earth’s climate was colder and much of its surface was covered by vast sheets of ice.
2. Earth is currently experiencing a warm period between ice ages, called an interglacial period.
3. Seasons are short-term periods of climatic change caused by regular variations in daylight, temperature, and the curvature of Earth.
4. During El Niño, cold ocean currents along the western coast of South America are replaced by warm waters from the western Pacific.
5. El Niño can bring stormy weather to areas that are normally dry and drought conditions to areas that are normally wet.
6. Some scientists think that changes in the angle of Earth’s tilt caused ice ages.
7. Europe’s “Little Ice Age” of 1645 to 1716 is believed to have been the result of an elongation of Earth’s orbit.

Answer the following questions.
8. How does the tilt of the Earth affect climate?

9. How will seasons on Earth change when Earth’s axis points away from Polaris and toward Vega in 13,000 years?
SECTION 14.3  Climatic Changes, continued

In your textbook, read about why climatic changes occur.
Circle the letter of the choice that best completes the statement.

10. English astronomer E. W. Maunder discovered that changes in Earth’s climate have coincided with cycles of low activity for
   a. tidal changes.          c. occurrence of tornadoes.

11. Each cycle of low activity referred to in question 10 is called the Maunder minimum and closely corresponds to an unusually
   a. cold period.           b. dry period.          c. warm period.          d. wet period.

12. Climatic changes may be triggered by changes in Earth’s axis and
   a. orbit.                b. continents.          c. circumference.        d. density.

13. The shape of Earth’s orbit changes over a 100,000-year cycle, becoming more circular, and then more
   a. parabolic.            b. elliptical.          c. straight-lined.        d. spiral-shaped.

14. When its orbit elongates, Earth passes closer to the Sun and climates become
   a. colder.               b. warmer.            c. wetter.               d. drier.

15. When its orbit is more circular, Earth is farther from the Sun and its climates become
   a. drier.                b. warmer.            c. colder.               d. wetter.

16. Some scientists hypothesize that changes in the angle of Earth’s tilted axis cause
   a. volcanic eruptions.   b. ice ages.           c. high winds.          d. droughts.

17. Warmer summers and colder winters in the northern hemisphere could occur in several thousand years because
   a. Earth’s orbit reverses direction.          c. Earth’s axis points to the Moon.
   b. sunspot activity increases.               d. Earth wobbles on its axis.

18. A lowering of global temperatures caused by dust blocking solar radiation can be triggered by
### SECTION 14.4  *Impact of Human Activities*

*In your textbook, read about the greenhouse effect and global warming.*

For each item in Column A, write the letter of the matching item in Column B.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. One possible effect of global warming</td>
<td>a. greenhouse effect</td>
</tr>
<tr>
<td>2. The main source of Earth’s energy</td>
<td>b. carbon dioxide</td>
</tr>
<tr>
<td>3. Natural heating of Earth’s surface caused by certain atmospheric gases</td>
<td>c. global warming</td>
</tr>
<tr>
<td>4. A rise in global temperatures</td>
<td>d. flooded coastal cities</td>
</tr>
<tr>
<td>5. A major greenhouse gas</td>
<td>e. the Sun</td>
</tr>
</tbody>
</table>

Circle the letter of the choice that best completes the statement.

6. Most scientists agree that global warming is occurring, but they mainly disagree about
   a. how much has occurred.           c. what global warming really is.
   b. whether there are greenhouse gases.  d. what is causing it.

7. Scientists hypothesize that an increase in atmospheric carbon dioxide leads to an
   increase in Earth’s absorption of
   a. solar radiation.                c. gamma rays.
   b. water vapor.                   d. volcanic ash.

8. If the global-warming trend continues, the effects on the planet could include
   a. a rise in sea level.            c. the loss of Earth’s atmosphere.
   b. a colder climate like that of Mars.  d. increase in the size of polar ice caps.
SECTION 14.4 Impact of Human Activities, continued

In your textbook, read about human impacts on climate.

In the space at the left, write true if the statement is true; if the statement is false, change the italicized word or phrase to make it true.

9. The burning of fossils releases the greenhouse gas carbon dioxide into the atmosphere.

10. Automobile exhaust and industrial emissions are major sources of carbon dioxide.

11. The mass removal of trees, or desertification, plays a role in increasing levels of atmospheric carbon dioxide.

12. Trees decrease atmospheric levels of carbon dioxide by using the gas during photosynthesis.

13. Because global warming is linked to human activities, maintaining those activities could work to reduce their impact.

14. During the past 200 years, there has been a gradual increase in world air pressure levels.

Describe three ways that individuals can combat global warming.

15. ________________________________________________________

16. ________________________________________________________

17. ________________________________________________________
Climate

Reviewing Vocabulary

Compare and contrast each pair or group of related terms.

1. climate, normal

2. tropics, temperate zones, polar zones

3. microclimate, heat island

4. greenhouse effect, global warming

Match the definition in Column A with the term in Column B.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. The study of Earth’s climate and the factors that affect past, present, and future climate changes</td>
<td>a. season</td>
</tr>
<tr>
<td>6. A short-term period of climatic change caused by regular variations in daylight, temperature, and weather patterns</td>
<td>b. ice age</td>
</tr>
<tr>
<td>7. Period when much of Earth’s surface was covered by vast sheets of ice</td>
<td>c. climatology</td>
</tr>
<tr>
<td>8. A warm ocean current that develops off the west coast of South America</td>
<td>d. El Niño</td>
</tr>
</tbody>
</table>
Understanding Main Ideas (Part A)

In the space at the left, write *true* if the statement is true; if the statement is false, change the italicized word to make it true.

1. The Koeppen classification system classifies *climate* based on mean monthly values of temperature and precipitation.
2. One of the effects of El Niño is that the ocean along western South America is *colder* than normal.
3. The Maunder minimum is a period of very low *precipitation* activity that closely corresponded to an unusually cold climatic episode.

Circle the letter of the choice that best completes the statement.

4. Types of climate data include annual variations in temperature, precipitation, and
   a. air pollution.
   b. water cycle.
   c. wind.
   d. topography.

5. Two climates that are at the same latitude may be different because of
   a. bodies of water.
   b. distance from the poles.
   c. Earth’s magnetic field.
   d. soil type.

6. When moist winds approach a mountain, they often drop rain as they rise over the mountain, and come down the other side of the mountain much
   a. cooler and drier.
   b. cooler and wetter.
   c. warmer and drier.
   d. warmer and wetter.

7. The climatic zone that receives the least solar radiation and has the coldest climate is the
   a. polar zone.
   b. tropical zone.
   c. equatorial zone.
   d. temperate zone.
Understanding Main Ideas (Part B)

Answer the following questions.

1. How can the periodic change in the shape of Earth’s orbit cause a change in climate?

2. Compare and contrast a continental and a polar climate.

3. List several natural cycles that could cause climatic change on Earth.

4. Explain how a huge volcanic eruption can cause a change in Earth’s climate. Describe the change.

5. Explain how the greenhouse effect influences Earth’s climate.

6. List two major reasons for climate variation.
Thinking Critically

Answer the following questions.

1. Why would knowing the climate of an area be important for architects? Explain your answer.

2. Explain how an area in the tropics might typically experience abundant snowfall.

3. Why can’t you use normals to predict the daily weather?

4. How would seasonal climatic changes be different if Earth were not tilted on its axis?

5. How might taking a bus instead of driving a car help ease global warming?

6. Why might temperature data recorded inside a large city be inaccurate for a rural region located just a few kilometers outside the city?
Applying Scientific Methods

The graphs below compare the annual average temperature and precipitation of two cities, City X and City Y. Use them to answer the questions that follow.

1. Describe the temperature and precipitation for City X.

2. Based on the yearly data, classify the climate of City X. Explain your answer.

3. Based on your answer to question 2, on what part of Earth’s surface is City X probably located?
Applying Scientific Methods, continued

4. Describe the temperature and precipitation at City Y.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

5. Based on the yearly data, classify the climate of City Y. Explain your answer.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

6. If graphs were to show temperature and precipitation for a city in a dry climate, how would the data differ?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

7. In which climate would City Y be located if its average yearly temperature was below 0°C and its annual precipitation was less than 2 cm? Explain your answer.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

8. Contrast the vegetation you might find in or around City X and City Y.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Standardized Test Practice

Multiple Choice
Select the best answer from the choices given, and fill in the corresponding circle.

1. A B C D
2. A B C D
3. A B C D
4. A B C D
5. A B C D
6. A B C D
7. A B C D
8. A B C D
9. A B C D
10. A B C D

Short Answer
Answer each question with complete sentences.

11. 

12. 

13. 

14. 

15. 

16. 

Reading for Comprehension
Select the best answer from the choices given, and fill in the corresponding circle.

17. A B C D
18. A B C D
Chapter 15  Earth’s Oceans

MiniLab ......................................................... 110
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MiniLab 15  Model Seawater

What is the chemical composition of seawater? Determine the chemical composition of seawater using the following ingredients. The salinity of seawater is commonly measured in parts per thousand (ppt).

<table>
<thead>
<tr>
<th>Material</th>
<th>Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium chloride (NaCl)</td>
<td>23.48 g</td>
</tr>
<tr>
<td>Magnesium chloride (MgCl₂)</td>
<td>4.98 g</td>
</tr>
<tr>
<td>Sodium sulfate (Na₂SO₄)</td>
<td>3.92 g</td>
</tr>
<tr>
<td>Calcium chloride (CaCl₂)</td>
<td>1.10 g</td>
</tr>
<tr>
<td>Potassium chloride (KCl)</td>
<td>0.66 g</td>
</tr>
<tr>
<td>Sodium bicarbonate (NaHCO₃)</td>
<td>0.19 g</td>
</tr>
<tr>
<td>Potassium bromide (KBr)</td>
<td>0.10 g</td>
</tr>
</tbody>
</table>

Procedure
1. Read and complete the lab safety form.
2. Carefully measure the ingredients listed in the table above and put them all in a large beaker.
3. Add 965.57 g of distilled water and mix.

Analysis
1. Calculate How many grams of solution do you have? What percentage of this solution is made up of salts?

2. Apply Given that 1 percent is equal to 10 ppt, what is the salinity of your solution in parts per thousand?

3. Identify the ions in your solution.

4. Infer how your solution differs from actual seawater.
The water in the oceans is layered because water masses with higher densities sink below those with lower densities. The density of seawater depends on its temperature and salinity.

**PREPARATION**

**Question**
How do changes in salinity and temperature affect water density?

**Materials**
- scale
- 500-mL graduated cylinder
- 100-mL glass beakers (4)
- water
- red, yellow, and blue food coloring
- salt
- thermometer
- eyedropper
- graph paper
- ruler
- calculator

**Objectives**
In this GeoLab you will:
- **Compare** and **contrast** the movement of different water samples.
- **Determine** the relative densities of the water samples.
- **Predict** the arrangement of layers in a body of water.
- **Construct** and **interpret** a temperature profile.

**Safety Precautions**

**PROCEDURE**

1. Read and complete the lab safety form.
2. Mix 200 mL of water and 7.5 g of salt in the graduated cylinder. Pour equal amounts of the salt solution into two beakers. Fill each of the other two beakers with 100 mL of freshwater.
3. Put a few drops of red food coloring in one of the salt solutions. Put a few drops of yellow food coloring in the other salt solution. Put a few drops of blue food coloring in one of the beakers of freshwater. Do not add food coloring to the other beaker of freshwater.
4. Place the beakers with the red salt solution and the blue freshwater in the refrigerator. Refrigerate them for 30 minutes.
5. Measure and record the temperature of the water in all four beakers.
6. Put several drops of the cold, red saltwater into the beaker with the warm, yellow saltwater and observe what happens. Record your observations.
7. Put several drops of the cold, blue freshwater into the beaker with the warm, clear freshwater and observe what happens. Record your observations.
8. Put several drops of the cold, blue freshwater into the beaker with the warm, yellow saltwater and observe what happens. Record your observations.
GeoLab Model Water Masses

ANALYZE AND CONCLUDE

1. **Describe** the movement of the cold, red saltwater in step 6. Compare this to the movement of the cold, blue freshwater in step 8. What accounts for the differences you observed?

2. **Identify** Based on your observations, list the water samples by color in order of increasing density.

3. **Explain** If you poured the four water samples into the graduated cylinder, how would they arrange themselves into layers by color, from top to bottom?

APPLY

4. **Construct** Assume that four water masses in a large body of water have the same characteristics as the water in the four beakers. The warm water layers are 100 m thick, and the cold layers are 1000 m thick. Graph the temperature profile of the large body of water.
Infer The temperature profile above, was constructed from measurements taken from the Atlantic Ocean off the coast of Spain. Study the profile, then infer why a high-temperature layer exists beneath the thermocline. Is this layer denser than the colder layer above it? Explain.
Sonar
Sonar

1. What does sonar stand for?

2. What two factors does sonar use to determine ocean depth?

3. Describe how sonar is used to determine ocean depth.

4. What is the depth of the ocean if a sonar signal takes 4 seconds to travel from a ship to the ocean floor and back?

5. If the depth of the ocean at a particular place is 1817.5 m, how long would it take a sonar signal to travel from a ship to the ocean bottom and back again?

6. How does side-scan sonar differ from ordinary sonar?
Processes that Add and Remove Sea Salts

- Volcanic eruptions
- River discharge
- Sea spray
- Biological processes
- Chemical reactions
- Formation of evaporites
- Bottom sediments
- Sulfur discharge
Processes that Add and Remove Sea Salts

1. What salts do volcanoes add to seawater? How are these salts added?

2. How do such minerals as sodium, calcium, iron, and magnesium become part of seawater?

3. Why does the salinity of seawater remain constant?

4. How does wind help remove salts from seawater?

5. By what process do salts become part of the ocean sediments?

6. How does the formation of evaporites affect ocean salinity?

7. What might happen to the salinity of the ocean if animals were no longer living in it?
Solar and Lunar Tides

[Diagram showing the Earth, Sun, Moon phases, and tide types: Spring tide, Neap tide, Full Moon, New Moon, First-quarter Moon, Third-quarter Moon, Solar tide, Lunar tide]
Solar and Lunar Tides

1. What is a spring tide and when does it occur?

2. Describe the relative positions of the Sun, the Moon, and Earth during a spring tide.

3. What is a neap tide and when does it occur?

4. Describe the relative positions of the Sun, the Moon, and Earth during a neap tide.

5. Which are higher—lunar high tides or solar high tides? Explain your answer.

6. During which phases of the Moon does the Sun enhance a lunar tide? Explain your answer.

7. Why are tidal changes less extreme during a neap tide?

8. During which phases of the Moon do solar and lunar tides occur at different places on Earth?
### Section 15.1 An Overview of Oceans

In your textbook, read about modern oceanography. For each item in Column A, write the letter of the matching item in Column B.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Submersible used to study the deep oceans</td>
<td>a. oceanography</td>
</tr>
<tr>
<td>2. Satellite used to monitor ocean surface temperatures</td>
<td>b. TOPEX/Poseidon</td>
</tr>
<tr>
<td>3. Device that uses echoes to map features of the ocean floor</td>
<td>c. sonar</td>
</tr>
<tr>
<td>4. First ship to use sophisticated measuring devices to study the ocean</td>
<td>d. Challenger</td>
</tr>
<tr>
<td>5. Scientific study of Earth’s oceans</td>
<td>e. Alvin</td>
</tr>
</tbody>
</table>

In your textbook, read about the origin of the oceans. Circle the letter of the choice that best completes the statement.

6. Oceans on Earth have existed for
   a. 4.6 million years.     
   b. almost 4.6 billion years.  
   c. 46 billion years.     
   d. half as long as Earth has existed.

7. One possible source of Earth’s water is
   a. hurricanes.       
   b. earthquakes.     
   c. comet impacts.  
   d. violent storms.

8. Gases emitted by volcanoes contain mostly
   a. water vapor and ultraviolet radiation.  
   b. carbon dioxide and oxygen.        
   c. water vapor and carbon dioxide.    
   d. water vapor and nitrogen.

9. In Earth’s early history, water vapor in the atmosphere condensed into the
   a. crust.       
   b. oceans.     
   c. continents. 
   d. mountains.

10. Water is still being added to Earth’s hydrosphere by
    a. volcanism.  
    b. ultraviolet radiation.  
    c. comet impacts.  
    d. earthquakes.

11. The total amount of water on Earth stays the same because water molecules in the atmosphere are destroyed by
    a. ozone.       
    b. meteors.   
    c. evaporation.  
    d. ultraviolet radiation.
SECTION 15.1  An Overview of Oceans, continued

In your textbook, read about the distribution of Earth’s water.

Use the terms in the list to complete the statements.

sea level  rising  tectonic  oceans  frozen ice caps

12. The ________________ contain 97 percent of the water found on Earth.

13. Approximately 3 percent of Earth’s water is located in the ________________ of Greenland and Antarctica, and in rivers, lakes, and underground sources.

14. Global ________________ has risen and fallen by hundreds of meters in response to warm periods and ice ages.

15. ________________ forces that lift or lower portions of the seafloor also affect sea level.

16. Today average global sea level is slowly ________________ at a rate of about 3 mm per year.

Answer the following questions.

17. Why is Earth known as the blue planet?

18. What is the average depth of the oceans?

19. How much of the northern hemisphere is covered by oceans?

20. How much of the southern hemisphere is covered by oceans?

In the space at the left, write true if the statement is true; if the statement is false, change the italicized word or phrase to make it true.

21. The three major oceans are the Atlantic, the Pacific, and the Arctic.

22. The Pacific is Earth’s largest ocean.

23. The Atlantic Ocean extends for more than 20,000 km from north to south.

24. North of the antarctic circle, the Atlantic is known as the Arctic Ocean.

25. The Indian Ocean is located mainly in the northern hemisphere.
SECTION 15.2  Seawater

In your textbook, read about the chemical properties of seawater.
Circle the letter of the choice that best answers the question.

1. About what percentage of seawater is dissolved salts?
   a. 96.5 percent  b. 9.65 percent  c. 3.5 percent  d. 35 percent

2. Which of the following salts is most abundant in seawater?
   a. sodium chloride  c. potassium chloride
   b. magnesium sulfate  d. calcium chloride

3. What is salinity?
   a. the amount of dissolved salts in seawater  c. the amount of dissolved gases in seawater
   b. the amount of water in the oceans  d. another name for salt

4. What unit is commonly used to measure the salt content of water?
   a. parts per liter  c. kilograms per cubic liter
   b. grams per liter  d. parts per thousand

5. In addition to salts, which of these substances is dissolved in seawater?
   a. sugars  b. nutrients  c. shells  d. seaweed

6. Which of the following would cause surface ocean water to have a higher salt content?
   a. a river flowing into the ocean  c. volcanic gases
   b. the melting of sea ice  d. flow of rivers into the ocean

7. What evidence indicates that the salt content of ancient oceans was about the same as it is today?
   a. seafloor sediments  b. comparisons of modern seashells and fossil shells
   c. ancient lava flows that formed in seawater  d. salt content in surface water versus the salt content in bottom water

8. Which process does NOT add salts to seawater?
   a. weathering of crustal rock  c. volcanic gases
   b. decay of hard-shelled sea creatures  d. flow of rivers into the ocean

9. Which process removes salt from seawater?
   a. ultraviolet radiation  b. weathering of feldspars
   c. evaporation of elements near arid coastal regions  d. consumption of sediments by bottom-feeding organisms
SECTION 15.2  Seawater, continued

In your textbook, read about ocean layering.
Use the terms below to label the diagram of ocean temperatures.

surface layer  bottom layer  thermocline

13.  
14.  
15.  

In your textbook, read about water masses.
Use the letters A through D to sequence the stages of water-mass movement.

16.  Cold, salty water sinks.
17.  Sea ice forms during the winter.
18.  Salty water migrates along the ocean floor toward the equator.
19.  Salt ions accumulate beneath the ice.
SECTION 15.3  Ocean Movements

In your textbook, read about wave characteristics.
Use the diagram to answer the following questions.

1. Describe the rhythmic movement of a wave. What is the direction of its energy?

2. What is the highest point of a wave called?

3. What is the lowest point of a wave called?

4. What is the vertical distance between the highest and lowest points of a wave?

5. What is the horizontal distance between the top of one wave and the top of the next?

6. What is the relationship between the wave speed in deep water and wavelength?

7. How does an ocean wave become a breaker at the shoreline?
SECTION 15.3  Ocean Movements, continued

In your textbook, read about tides and the causes of tides.

For each item in Column A, write the letter of the matching item in Column B.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.</td>
<td>a.</td>
</tr>
<tr>
<td>9.</td>
<td>b.</td>
</tr>
<tr>
<td>10.</td>
<td>c.</td>
</tr>
<tr>
<td>11.</td>
<td>d.</td>
</tr>
<tr>
<td>12.</td>
<td>e.</td>
</tr>
</tbody>
</table>

In your textbook, read about ocean currents.

In the space at the left, write true if the statement is true; if the statement is false, change the italicized word or phrase to make it true.

13. A current caused by differences in the temperature and salinity of ocean water is called a gyre.

14. Surface currents are caused by wind.

15. The gyres of the northern hemisphere circulate in a ___________ direction.

16. An example of a warm, poleward-flowing current is the ___________.

In your textbook, read about upwelling.

Use each of the terms just once to complete the passage.

cold nutrients offshore trade-wind upwelling vertically

In addition to moving horizontally, ocean water moves (17) ________________. The upward motion of ocean water is called (18) ________________. Upwelling waters originate from the bottom of the ocean and are (19) _________________. Areas of upwelling exist mainly off the western coasts of continents in the (20) ________________ belts. The trade winds blow surface water (21) ________________, and the surface water is replaced by upwelling deep water. Upwelling waters are rich in (22) ________________, which support abundant marine life populations.
Earth’s Oceans

**Reviewing Vocabulary**

For each item in Column A, write the letter of the matching item in Column B.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Measure of the amount of dissolved salts in seawater</td>
<td>a. oceanography</td>
</tr>
<tr>
<td>2. Periodic rise and fall of sea level</td>
<td>b. side-scan sonar</td>
</tr>
<tr>
<td>3. Technique that directs sound waves toward the ocean floor at an angle</td>
<td>c. sea level</td>
</tr>
<tr>
<td>4. Current caused by wind</td>
<td>d. salinity</td>
</tr>
<tr>
<td>5. Collapsing wave</td>
<td>e. temperature profile</td>
</tr>
<tr>
<td>6. Set of data that plots changing water temperature with depth</td>
<td>f. thermocline</td>
</tr>
<tr>
<td>7. Lowest point of a wave</td>
<td>g. wave</td>
</tr>
<tr>
<td>8. Current caused by differences in the temperature and salinity of</td>
<td>h. crest</td>
</tr>
<tr>
<td>ocean water</td>
<td>i. trough</td>
</tr>
<tr>
<td>9. Highest point of a wave</td>
<td>j. breaker</td>
</tr>
<tr>
<td>10. Scientific study of Earth’s oceans</td>
<td>k. tide</td>
</tr>
<tr>
<td>11. Level of the ocean’s surface</td>
<td>l. density current</td>
</tr>
<tr>
<td>12. Upward motion of ocean water</td>
<td>m. surface current</td>
</tr>
<tr>
<td>13. Rhythmic movement that carries energy through matter</td>
<td>n. upwelling</td>
</tr>
<tr>
<td>14. Transitional layer of the ocean characterized by rapidly decreasing</td>
<td></td>
</tr>
<tr>
<td>temperatures with depth</td>
<td></td>
</tr>
</tbody>
</table>
Understanding Main Ideas (Part A)

In the space at the left, write the word or phrase in parentheses that makes the statement correct.

1. The mechanism by which water deep within Earth’s interior is brought to the surface is (radiation, volcanism).

2. The oceans contain 97 percent of Earth’s water, and (saltwater, freshwater) sources contain 3 percent.

3. Today, the (melting, thickening) of glaciers is causing a slow rise in the average global sea level.

4. The oceans are theorized to be about (4.56, 46) million years old.

5. As marine organisms die, their solid parts drift to the bottom of the ocean, causing salts to be (added to, removed from) seawater.

6. The freezing point of salt water is somewhat (higher, lower) than that of freshwater.

7. Oceans are dark below the depth of about (1000 m, 100 m).

8. The surface layer and the (bottom layer, thermocline) are absent in polar seas.

9. The coldest and densest water mass in all the oceans is (Antarctic Bottom Water, North Atlantic Deep Water).

10. Earth’s tidal bulges are always aligned with the (Sun, Moon).

11. Closed, circular surface current systems are called (density currents, gyres).

12. Upwelling waters bring (warm water, nutrients) to the ocean’s surface.
Understanding Main Ideas (Part B)

Describe the concept or process that is shown in each diagram.

1. Absorption of Light

![Diagram of absorption of light in the ocean](image)

2. Cause of Tides

![Diagram of tidal causes](image)

3. Sources of Sea Salt

![Diagram of sea salt sources](image)
Thinking Critically

Use the diagram of Earth's gyres to answer the following questions.

1. What might be the course of the South Atlantic Gyre if Africa did not exist?

2. How might the absence of South America affect the size and course of the South Atlantic and South Pacific gyres?

3. What would be the likely effect on the currents near Japan and Korea if the prevailing midlatitude winds blew from east to west instead of west to east?
Applying Scientific Methods

Your Earth science class is conducting an experiment to determine the salt concentrations in an estuary, a place where a freshwater river flows into the salty seawater of an ocean. You have been told that in the inland portion of an estuary, the less-dense river water overrides the denser seawater.

You have collected seven samples of water from different locations in the estuary. You have also collected a sample of pure river water and a sample of pure seawater. You make concentrated samples by boiling each estuary sample until it is reduced to 250 mL. Then you fill seven test tubes halfway with each concentrated sample. Next, you make reference samples in seven more test tubes. The table shows the contents of each reference test tube.

Study the illustration and table and answer the questions that follow.

<table>
<thead>
<tr>
<th>Test Tube</th>
<th>Percentage of River Water</th>
<th>Percentage of Seawater</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>4</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>5</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>6</td>
<td>20</td>
<td>80</td>
</tr>
</tbody>
</table>

1. Knowing that river water is usually brownish in color and seawater is clear, how could you use the river water/seawater samples to determine the composition of the estuary water samples?

2. Would the method described in question 1 provide a precise measurement of the ratio of river water to seawater in the estuary samples? Why or why not?
Applying Scientific Methods, continued

3. What property of seawater might you use to determine the actual ratio of river water to seawater in the estuary samples? Explain your answer.

4. Would you expect the concentration of salt to be the same or different in each estuary sample? Explain your answer.

5. How might estuary samples taken from deep water affect your results?
Standardized Test Practice

Multiple Choice

Select the best answer from the choices given, and fill in the corresponding circle.

1. A B C D
2. A B C D
3. A B C D
4. A B C D
5. A B C D
6. A B C D
7. A B C D
8. A B C D
9. A B C D
10. A B C D

Short Answer

Answer each question with complete sentences.

11. 

12. 

13. 

14. 

15. 

16. 

Reading for Comprehension

Select the best answer from the choices given, and fill in the corresponding circle.

17. A B C D
18. A B C D
19. A B C D
# Table of Contents

**Chapter 16 The Marine Environment**

- MiniLab .................................................. 136
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How fast do sediment grains sink?

**Procedure**

1. Read and complete the lab safety form.
2. Obtain sediment grains with approximate diameters of 0.5 mm, 1 mm, 2 mm, 5 mm, and 10 mm.
3. Measure the diameters of each specimen using a set of sieves. Record these measurements in the data table below.

<table>
<thead>
<tr>
<th>Type of Particle</th>
<th>Diameter (mm)</th>
<th>Distance (cm)</th>
<th>Time (s)</th>
<th>Settling Speed (cm/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Fill a 250-mL graduated cylinder with cooking oil. Measure the height of the cooking oil.
5. Drop the largest specimen into the oil. Use a stopwatch to measure the time it takes for the specimen to sink to the bottom of the cylinder. Record this time in your data table.
6. Repeat step 5 for the remaining specimens.

**Analysis**

1. Calculate the settling speed for each specimen, and fill in the data table.

2. Plot the settling speed (cm/s) against particle diameter (mm) on a graph.

3. Explain How do settling speeds change as particle sizes decrease?
Mapping GeoLab

**Identify Coastal Landforms**

Topographic maps of coastal areas show a two-dimensional representation of coastal landforms. You can identify an emergent coast by the landforms along the coastline as well as landforms found inland.

**PREPARATION**

**Question**
How can you identify and describe the coastal landforms of an emergent coast on a topographic map?

**Safety Precautions**

**Materials**
- metric ruler
- graph paper
- drafting compass
- calculator
- pencil

**PROCEDURE**

1. Read and complete the lab safety form.
2. Determine the map scale and the contour interval.
3. On the inset map, plot a west-east cross section of the coast just north of Islay Creek from the 60–ft depth contour to a point 5000 feet inland. Use a scale of 1:24 000 and a vertical exaggeration of 4.
4. Use both maps to answer the following questions.

**ANALYZE AND CONCLUDE**

1. **Describe**  What kind of coastal landform is the Morro Rock Peninsula?

2. **Explain**  What kind of feature is Pillar Rock, and how was it formed?

3. **Interpret**  On what coastal feature is Morro Bay State Park located? How was the feature formed?

4. **Identify**  What are the irregular sand hills in Morro Bay State Park?
5. **Infer** What is the direction of the longshore transport along Morro Bay? Explain.

6. **Apply** Your west-east cross section shows an elevated flat area next to the shoreline. What kind of coastal landform is this? How was it formed?

7. **Draw Conclusions** If sea level dropped 10 m, how would the shoreline change? How far would it move seaward? Would it become more regular or irregular? What would happen to Morro Bay?

8. **Suggest** the major changes that could occur to the coastal region if sea level rose 6 m.

**Compare and contrast** this coastal section with a section of the Texas coast between Corpus Christi and Galveston. Which coastal features are similar? Which are different?
Identify Coastal Landforms

[Image of a map showing coastal features]
Depositional Shoreline Features

- Bay
- Lagoon
- Spit
- Mainland beach
- Baymouth bar
- Tombolo
- Lagoon
- Spit
- Barrier islands
Depositional Shoreline Features

1. What is a spit?

2. Which feature shown formed as a result of the growth of a spit?

3. Describe how the tombolo formed.

4. Which bodies of water shown are completely protected from the ocean waves? Which shoreline features are responsible for this protection?

5. Which body of water shown is somewhat protected from ocean waves? What shoreline feature is responsible for this protection?

6. Where did the sediment needed to build the depositional features shown come from?

7. Are the barrier islands permanent or temporary features? Explain your answer.
Features of the Continental Margin

- Continental margin
- Continental shelf
- Continental slope
- Continental rise
- Abyssal plain
- Mid-ocean ridge
- Seamount
- Submarine canyon
- Oceanic crust
- Continental crust
- Continental shelf
- Continental slope
- Continental rise
- Trench
- Land
- Continental margin
Features of the Continental Margin

1. What are the continental margins?

2. What is the shallowest part of the continental margin called?

3. Where on the diagram would you expect to find shoreline features such as beaches and spits?

4. How do submarine canyons form?

5. Submarine canyons are part of what feature of the continental margin?

6. Where on the diagram does the boundary between the continental crust and the oceanic crust occur?

7. Which feature shown probably represents the flattest surface on Earth?

8. What is the continental rise and where is it found?
SECTION 16.1  Shoreline Features

In your textbook, read about erosional landforms, beaches, estuaries, longshore currents, and rip currents.
For each statement below, write true or false.

_________ 1. Waves move more slowly in deep water than in shallow water.

_________ 2. Wave crests bend as they move into shallow water in a process called wave refraction.

_________ 3. The force of breakers, along with rock fragments suspended in water, can erode solid rock.

_________ 4. Rocky headlands, which are points of land reaching into the ocean, are eroded by waves.

_________ 5. Most of a breaker's energy is concentrated along beaches.

_________ 6. A wave-cut platform ends against a steep wave-cut cliff.

_________ 7. Sea caves are formed by erosion from breakers.

_________ 8. Wide, sandy beaches are the result of loose sediments carried away from the shore by waves.

_________ 9. Beaches made of pebbles are usually found on rocky coasts.

_________ 10. The particles on a beach are always sand.

_________ 11. Sea stocks are isolated rock towers left on wave-cut platforms.

_________ 12. The water current that flows parallel to the shore is called a longshore current.

_________ 13. Fine-grained materials, such as clay, fall to the bottom of moving water and are pushed along the bottom by the current.

_________ 14. Rip currents move large amounts of sediment along the shore.

_________ 15. Rip currents flow through gaps of longshore bars and up onto beaches.
**SECTION 16.1  Shoreline Features, continued**

In your textbook, read about depositional features of seashores.
Use each of the terms below just once to complete the passage.

<table>
<thead>
<tr>
<th>barrier islands</th>
<th>deposit</th>
<th>sand dunes</th>
<th>seashores</th>
</tr>
</thead>
<tbody>
<tr>
<td>sediment</td>
<td>spit</td>
<td>storm waves</td>
<td>wave erosion</td>
</tr>
</tbody>
</table>

Most (16) ________ are constantly changing due to (17) ____________, longshore transport, and (18) ____________ deposition. Large storm waves pick up sediments and (19) ____________ them wherever waves and currents move more slowly. Sometimes the transported sediments build a narrow bank of sand called a (20) ________ that projects into the water from a bend in the coastline. Longshore currents may also deposit long ridges of sediment to form a chain of (21) ____________. Tides and (22) ____________ can help currents build features that rise well above sea level. Also, winds blow dry, exposed sediment into (23) ____________ along shorelines.

Answer the following questions.

24. How are a spit and a tombolo alike?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

25. Do you think the shore of a barrier island is a good or bad place to build a house? Why?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
SECTION 16.1  **Shoreline Features, continued**

*In your textbook, read about protective structures.*

*Use the terms below to label each drawing.*

breakwater  groin  seawall

29. What happens to the beach in front of a seawall?

________________________________________________________________________

30. What happens to a beach located down the coast from a groin?

________________________________________________________________________

31. Why does the anchorage behind a breakwater have to be dredged?

________________________________________________________________________

32. About 10,000 years ago, Earth’s seas were (higher, lower) than they are today.

33. The seas are still rising. Many researchers believe the cause is (global warming, lower temperatures on Earth’s surface).

34. Coastal valleys scooped out by glaciers and later flooded produce (barrier islands, fjords).

35. Local sea levels can be affected by (tectonic movement, coastal cities).

36. A rising coastline produces a relative (rise, drop) in sea level.
SECTION 16.2  Seafloor Features

In your textbook, read about oceanic and continental crust, continental shelves, and continental slopes.

Use the terms below to label the diagram.

- continental crust
- continental margin
- continental rise
- continental shelf
- continental slope
- oceanic crust
- submarine canyons

Write the name of the topographic feature of the seafloor to the left of its description.

8. Thin crust associated with deep ocean basins
9. Submerged parts of continents
10. Shallowest part of a continental margin reaching seaward from shore
11. Area beyond the continental shelf where the seafloor drops sharply
12. Gentle slope at the base of the continental slope that is formed by sediments deposited by turbidity currents
13. Feature cut into the continental slope by turbidity currents
14. Crust associated with higher elevations on land
SECTION 16.2  Seafloor Features, continued

In your textbook, read about ocean basins.
Answer the following questions.

15. About what percent of Earth’s surface is ocean floor?

16. What is an abyssal plain? What kind of sediment is found there?

17. What are six identifying features of deep-sea trenches?

18. What are four identifying characteristics of mid-ocean ridges?

19. What is a hydrothermal vent?

20. What are two types of hydrothermal vents?
 SECTION 16.2  Seafloor Features, continued

In your textbook, read about seafloor volcanoes and marine sediments.
Use each of the terms below just once to complete the passage.

continents  extinct volcanoes  guyots
nODULES  ooze  SEAMOUNTS

Thousands of solitary mountains on the seafloor are not near areas of active volcanism.
Researchers believe that these mountains are (21) _________________. There are two
types of volcanoes on the seafloor. One type, submerged basaltic volcanoes more than
1 kilometer high, are called (22) _________________. The other type is tablemounts,
also called (23) _________________, which are large, extinct basaltic volcanoes with
flat, submerged tops.

Sedimentation is the only process that changes structures on the seafloor. Most of the
sediments come from (24) _________________ and other sources. These sediments
include mud, sand, dust, and volcanic ash. (25) _________________ is a source of
sediment that is formed by the shells and hard parts of marine organisms. Another type
of deep-sea sediment is manganese (26) _________________, which are formed when
metals precipitate from seawater.

If the statement is true, write true. If it is not true, rewrite the italicized word or
phrase to make it true.

__________ 27. Once they are formed, seafloor structures last practically forever.
__________ 28. The deep ocean floor is covered with mud made of silt, clay, and other
fine-grained materials.
__________ 29. Sandy sediments sometimes reach the abyssal plains riding on gentle
turbidity currents.
__________ 30. Deep-sea mud has a reddish color because of manganese in
the sediment.
__________ 31. Sediments with a large percentage of particles from once-living
organisms are called oozes.
__________ 32. Oozes are found in the deeper parts of the ocean.
__________ 33. Oozes and deep-sea muds accumulate grain by grain to reach the
depth of only a few millimeters per thousand years.
The Marine Environment

Reviewing Vocabulary

Circle the letter of the choice that best completes the statement.

1. The bending of wave crests as they reach shallow water is
   a. a longshore current.  b. wave refraction.  c. a rip current.  d. erosion.

2. The submerged parts of continents are called
   a. continental shelves.  b. continental slopes.  c. continental crust.  d. continental margins.

3. A rapid, flowing current along the bottom of the ocean is a(n)
   a. longshore current.  b. rip current.  c. estuary.  d. turbidity current.

4. The smooth part of the ocean floor at 5 or 6 km below sea level is the
   a. mid-ocean ridge.  b. deep-sea trench.  c. abyssal plain.  d. continental rise.

5. As a headland is eroded, the flat surface formed is called a
   a. wave-cut platform.  b. sea stack.  c. sea cave.  d. barrier island.

Compare and contrast each pair of related terms.

6. longshore bar, longshore current

   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________

7. ooze, deep-sea mud

   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________

8. seawalls, groins

   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________
Understanding Main Ideas (Part A)

Write the term that best completes the statement.

abyssal plains  barrier islands  beach erosion
hydrothermal vent  ooze  turbidity currents

1. ________________ are long ridges separated from the mainland and are made of sediment deposited by longshore currents.

2. Seawalls, groins, jetties, and breakwaters are built to prevent ________________.

3. ________________ are perhaps the flattest places on Earth and are covered with hundreds of meters of fine-grained sediments and sedimentary rocks.

4. Deep-sea sediments formed by shells and hard parts of marine organisms are called ________________.

5. Submarine canyons are formed by ________________.

6. A hole in the seafloor through which fluid heated by magma erupts is a(n) ________________.

In the space at the left, write true if the statement is true; if the statement is false, change the italicized word or phrase to make it true.

______________  7. Once a seafloor structure, such as a seamount, is formed, the only process that modifies it is erosion.

______________  8. Black and white smokers are submerged basalt volcanoes.

______________  9. Deep-sea sediment from a land source is called terrigenous sediment.

______________ 10. A ridge of sand called a tombolo connects an island to the mainland to form the tip of a peninsula.
Understanding Main Ideas (Part B)

Write the letter of the effect in the second column next to the action that causes it in the first column.

<table>
<thead>
<tr>
<th>Cause</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Melting ice-age glaciers</td>
<td>a. submarine canyons</td>
</tr>
<tr>
<td>2. Rising coastline</td>
<td>b. rise in sea level</td>
</tr>
<tr>
<td>3. Rapidly flowing turbidity currents</td>
<td>c. turbidity currents</td>
</tr>
<tr>
<td>4. Underwater landslides, earthquakes, or large storm waves</td>
<td>d. harbor entrance closes</td>
</tr>
<tr>
<td>5. Sand drifting around jetties</td>
<td>e. drop in sea level</td>
</tr>
</tbody>
</table>

Write the terms to complete the network tree concept map.

abyssal plain  warm water  volcanic activity  fractures
mid-ocean ridges  deep-sea trench  black smoker  hydrothermal vent

Ocean Basin

- smooth ocean floor
- prominent feature of ocean floor
- narrow, long depressions in ocean floor

- white smoker
- earthquake activity

metal oxides and sulfides
Thinking Critically

Answer the following questions.

1. Researchers find that sediments along the ocean bottom seem to be sorted by size. Coarse gravel and sand are found close to shore. Fine particles are deposited at a greater distance from shore. What can you infer about the movement of sediments from these observations?

2. What observations support the fact that turbidity currents help form the topography of the seafloor?

3. How would the data in this graph change if the polar ice sheets melted?
Applying Scientific Methods

Research has shown that the temperature of the ocean varies with ocean depth. Use data from the table and graph to help you with the activities that follow.

<table>
<thead>
<tr>
<th>Ocean depth (m)</th>
<th>100</th>
<th>200</th>
<th>300</th>
<th>400</th>
<th>500</th>
<th>600</th>
<th>700</th>
<th>800</th>
<th>900</th>
<th>1000</th>
<th>1100</th>
<th>1200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water temperature (°C)</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>15</td>
<td>5.5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>4.5</td>
<td>4.5</td>
<td>4</td>
</tr>
</tbody>
</table>

1. Describe the relationship between water temperature and ocean depth.

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

2. Formulate a hypothesis to explain why water temperature decreases as water depth increases.

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
Applying Scientific Methods, continued

3. Plan an experiment to prove your hypothesis. Your plan should include variables, controls, and expected results.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

4. Once the cause of the temperature difference has been identified, researchers may want to determine what effect, if any, the temperature difference has on ocean organisms. Suggest questions or phenomena that might be investigated.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

5. Which question or phenomenon that you wrote for question 3 would you like to investigate? Why?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Standardized Test Practice

Multiple Choice

Select the best answer from the choices given, and fill in the corresponding circle.

1. A B C D
2. A B C D
3. A B C D
4. A B C D
5. A B C D
6. A B C D
7. A B C D
8. A B C D
9. A B C D
10. A B C D

Short Answer

Answer each question with complete sentences.

11. 
12. 
13. 
14. 
15. 
16. 
17. 

Reading for Comprehension

Select the best answer from the choices given, and fill in the corresponding circle.

18. A B C D
19. A B C D
20. A B C D
CHAPTER 11

MiniLab 11 – Investigate Dew Formation

Analysis
1. In both cases condensation will form. The glasses may differ if the relative humidity differs in the two locations. The more humid air produces the greater amount of condensation.
2. The rising, warm air models evaporation, the water droplets model condensation, and the falling droplets model precipitation.

GeoLab 11 – Interpret Pressure–Temperature Relationships

Analyze and Conclude
1. Average temperatures will differ. However, in all cases, temperature should have decreased when pressure was released.
2. Graphs will vary, but all should show that temperature increased when pressure was applied and decreased when pressure was released.
3. As pressure increases, the molecules are packed more tightly together. This creates more collisions and produces more heat.
4. Air would escape when pressure was applied on the bottle. There would be no change in pressure and thus no change in temperature.
5. Low pressure; in the atmosphere, the hot desert air would be less dense than the air around it and therefore would rise. When air rises, it pushes down with less force, which lowers atmospheric pressure.

Writing in Earth Science: Research Students should discuss how low pressure creates uplift, causing more clouds and precipitation. High pressure creates clear skies, low wind, and dry conditions.

Teaching Transparency 28 – Energy Transfer Throughout the Atmosphere
1. the Sun
2. convection, conduction, radiation
3. A small percentage of solar radiation is absorbed by the atmosphere, heating it directly. A larger percentage of solar radiation is absorbed by Earth’s surface. The surface then radiates energy, which is absorbed by the atmosphere, heating it.
4. Energy from heated particles of air near Earth’s surface is transferred when these particles collide with air particles in the very lowest layer of the atmosphere.
5. Energy transferred by conduction to pockets of air near the surface is transferred by convection higher into the atmosphere.
6. Answers will vary. Without convection, energy would not reach the higher levels of the atmosphere, so the middle and upper sections of the troposphere would be colder. Most of the warmth would be concentrated near Earth’s surface.

Teaching Transparency 29 – Temperature Changes in the Atmosphere
1. Temperature decreases with altitude in the troposphere.
2. Temperature remains stable in the lower part of the stratosphere, then increases with altitude to the top of the stratosphere.
3. In the lowermost parts of both layers, temperature remains stable. Throughout most of the stratosphere, temperature generally increases with altitude. In contrast, throughout most of the mesosphere, temperature generally decreases with altitude.
4. The temperature profile in the thermosphere is more like that of the stratosphere because in both of these layers, temperature generally increases with altitude. In the troposphere, temperature decreases with altitude.
5. Major shifts in temperature occur at the boundaries between atmospheric layers.
6. No; the temperatures are all generally below freezing (0 degrees C), so they are too cold for people.
Teaching Transparency 30 – The Water Cycle

1. The water cycle is the constant movement of water between the atmosphere and Earth’s surface.

2. Water evaporates from surface waters such as oceans, streams, and lakes and becomes water vapor in the atmosphere.

3. Water that evaporates from Earth’s surface rises, cools, and condenses, forming cloud droplets and clouds.

4. Water droplets in clouds combine and grow in size. Then they fall to Earth as precipitation.

5. It flows along the surface and then into streams, rivers, and other water bodies as runoff. It also soaks into the ground and becomes groundwater, which eventually flows into surface water bodies.

6. the Sun

7. Possible response: The water cycle allows Earth to continuously recycle its limited water supply, which is essential to life on Earth.

Study Guide – Chapter 11 – Atmosphere

Section 11.1 Atmospheric Basics

1. c
2. a
3. d
4. c
5. b
6. stratosphere
7. mesosphere
8. troposphere
9. exosphere
10. thermosphere
11. the Sun
12. 50%
13. About 30%; lost energy is scattered by the atmosphere, reflected from clouds, and reflected from Earth’s surface.
14. Particles of air on Earth’s surface collide with and transfer energy to particles of air in the very lowest part of the atmosphere by conduction.
15. Convection is the transfer of energy by the flow of a heated substance. Heated air near Earth’s surface rises, expands, and starts to cool. When it cools below the temperature of surrounding air, it increases in density and sinks, creating a convection current.

Section 11.2 Properties of the Atmosphere

1. Temperature
2. heat
3. Fahrenheit
4. water vapor
5. condensation
6. dew point
7. altitude
8. lifted condensation level
9. true
10. true
11. false
12. true
13. false
14. true
15. A temperature inversion is an increase in temperature with height in an atmospheric layer. On a clear, winter night where there is a rapid cooling of land, the lower layers of the atmosphere lose heat to Earth’s surface. As a result, the lower layers of air become cooler than the air above.

16. Relative humidity is the ratio of water vapor in a volume of air relative to how much water vapor that volume of air is capable of holding at saturation. 17.100 percent

Section 11.3 Clouds and Precipitation

1. Air is rising, expanding, and cooling, which leads to water vapor condensing to form clouds.
2. the collision of the warm air mass with a colder one
3. The air encounters a mountain, forcing the air upward.
4. orographic lifting
5. These particles in the atmosphere provide objects around which water vapor can condense to form cloud droplets.

6. c
7. a
8. d
9. b
10. b
11. d
12. c
13. c
14. a

Chapter Assessment – Chapter 11
Reviewing Vocabulary
1. e
2. c
3. a
4. b
5. f
6. d
7. Both are related to energy. Heat is the transfer of energy that occurs because of a difference in temperature. Temperature is the measurement of how rapidly or slowly molecules move around.
8. Both are related to water vapor in air. Humidity is the amount of water vapor in air. Relative humidity is the ratio of the amount of water vapor in air to how much water vapor that volume of air can hold at saturation.
9. Both are changes of state. Condensation is the change of state from gas to liquid. Evaporation is the change of state from liquid to gas.
10. Both are ways in which energy is transferred. Conduction is energy transfer by the collision of molecules. Convection is energy transfer by the flow of a heated substance, such as water or air.

Understanding Main Ideas (Part A)
1. nitrogen
2. ozone
3. true
4. humidity
5. true
6. increase
7. b
8. c
9. a
10. b

Understanding Main Ideas (Part B)
1. Cumulus clouds are puffy and white. Cirrus clouds are wispy, indistinct clouds made up of ice crystals. Cumulus clouds form lower in the atmosphere than cirrus clouds do.
2. Moving air is called wind. Air moves in response to density imbalances created by the unequal heating and cooling of Earth’s surface. These imbalances create areas of high and low pressure. Air moves from areas of higher pressure or density to areas of lower pressure or density.
3. Because of the rapid cooling of land, the lower layers of the atmosphere lose heat to the surface. As a result, lower layers of air become cooler than the air above.
4. No; the inversion would block rising air, so towering clouds would not form.
5. Both are layers of the atmosphere. The troposphere is the lowest layer of the atmosphere. The stratosphere is the layer above the troposphere. The troposphere contains most of the mass of the atmosphere. It is characterized by a general decrease in temperature with height. The stratosphere, which contains the ozone layer, gradually increases in temperature with height.

Thinking Critically
1. No; air pressure decreases with altitude. Temperature decreases and increases depending on the layer of the atmosphere.
2. Temperature decreases with altitude in the troposphere. In the stratosphere, temperature begins to increase with altitude. In the mesosphere, temperature begins to decrease again. Then between the mesosphere and thermosphere, temperature starts to increase with altitude.
3. The stratosphere contains concentrated ozone. Ozone easily absorbs ultraviolet radiation from
the Sun. Thus, temperature increases in the stratosphere.

**Applying Scientific Methods**

1. A “cloud” of small water droplets formed. The hot water in the bottom of the jar evaporated and the resulting water vapor rose. The air at the top of the jar cooled from contact with the ice-filled tray. In turn, the rising warm air cooled and condensed at the top, forming water droplets that made a mist or cloud.

2. It decreases with height. The air at the bottom of the jar is warmed by the water. The air at the top is cooled by the ice.

3. Possible response: The warm air would rise and escape, so water vapor would not have condensed and droplets of water would not have formed.

4. An area of mist would not have formed because there would have been no warm, moist air rising in the jar.

5. The hot water at the bottom of the jar represents liquid water on the surface of Earth that has been heated by the Sun’s radiation, causing it to evaporate. It then rises in the atmosphere. The atmospheric layer nearest Earth’s surface cools with altitude, as does the air in the jar as a result of the ice cubes at the top. Just as rising air cools and condenses in the atmosphere, the rising moist air cooled and condensed in the jar. The mist that formed in the jar is similar to cloud droplets that form in the atmosphere.

6. Answers will vary. Students might suggest adding a heat source under the water supply to keep the water heated. Then water would continuously warm up, evaporate, rise, condense, and fall as rain or drop down the sides of the jar.

**CHAPTER 12**

**MiniLab 12 – Compare the Angles of Sunlight to Earth**

**Analysis**

1. The outline of the light was larger in Step 5, because the light covered a larger area.

2. The amount of light received at any one place decreases when the light covers a larger area due to the lower soler angle.

**GeoLab 12 – Interpret a Weather Map**

**Analyze and conclude**

1. 4 mb

2. The highest isobar is 1040 mb and is around the high-pressure center in South-central Canada. The lowest isobar is 988 mb and is around the low = pressure center off the coast of Oregon.

3. They are blowing mainly from the south or southeast

4. The coldest is −12° F at Fargo, North Dakota. The warmest is 65° at both Miami and Key West, Florida.

5. It would probably be clear because the high-pressure system along the coast would cause air to sink and dry out.

6. The low-pressure system would cause air to rise and produce clouds and rain.

**Forecasting** Using today’s weather map, have students use the extrapolation method to predict tomorrow’s weather. How does their forecast compare to the official forecast for your area? Have a discussion tomorrow about how accurate the forecast was.

**Teaching Transparency 31 – Air Mass Source Regions**


2. Polar air masses originate over cold polar areas. Tropical air masses originate over warm tropical areas.

3. The maritime polar (Pacific) air masses influence weather in the Northwest. They bring cool and humid weather.

4. continental polar

5. A continental polar air mass over the area might get replaced by a continental tropical air mass.

6. They are both maritime air masses, so they both bring humid weather. However, the maritime polar air mass brings cool weather, while the maritime tropical air mass brings warm weather.

7. The air mass would warm up as it moves south over warmer land surfaces.
Teaching Transparency 32 – Global Wind Systems

1. the northeast trade winds in the northern hemisphere and the southeast trade winds in the southern hemisphere

2. Air rises at the equator and then flows northward. At about 30 degrees north latitude, the air sinks. When it reaches the surface, it flows south, back toward the equator. At the equator, the air rises again and the cycle starts all over.

3. Clouds form as air rises at the equator. Clouds often bring rain, and the presence of clouds and rainfall makes tropical rain forests possible.

4. prevailing westerlies

5. Air sinks at 30 degrees, then moves south along the surface. At about 60 degrees, air rises and then moves north toward the equator. At 30 degrees, the air sinks again and the cycle starts all over.

6. High pressure; air sinks at the poles.

7. polar easterlies

Teaching Transparency 33 – Weather Data

1. barometer, hygrometer, thermometer

2. anemometer, rain gauge, wind vane

3. The weather shack protects some of the instruments from strong sunlight, rain, and wind that could damage them or influence the data they collect.

4. These instruments record data on precipitation, wind speed, and wind direction, so must be out in the open to collect their data.

5. A thermometer measures temperature. A maximum-minimum thermometer measures and records the maximum and minimum temperatures during a certain period of time.

6. The two types of barometers are the mercury barometer and the aneroid barometer. A mercury barometer indicates changes in air pressure by changes in the height of a column of mercury. In an aneroid barometer, a metal chamber containing a vacuum contracts and expands, depending on the air pressure.

7. Possible response: The wind vane, because it would be fairly easy to observe objects around you to tell the direction from which the wind is blowing. There is no easy way to measure rainfall without an instrument. There also is no easy way to observe or determine humidity without a hygrometer.

Study Guide – Chapter 12 – Meteorology

Section 12.1 The Causes of Weather

1. true

2. atmosphere

3. true

4. directly

5. b

6. a

7. b

8. b

Section 12.2 Weather Systems

1. Coriolis effect

2. rotation

3. trade winds

4. low pressure

5. intertropical convergence zone

6. prevailing westerlies

7. North America

8. polar easterlies

9. northeast

10. southwest

11. jet streams

12. polar jet stream

13. cold front

14. front

15. warm front

16. low-pressure system

17. occluded front

18. stationary front

19. High-Pressure System

20. Low-Pressure System

21. Low-Pressure System

22. High-Pressure System
23. High-Pressure System
24. Low-Pressure System
25. High-Pressure System
26. Low-Pressure System

Section 12.3 Gathering Weather Data
1. e
2. c
3. a
4. b
5. f
6. d

7. The Doppler effect is the change in wave frequency that occurs in energy, such as sound or light, as the energy moves toward or away from an observer. Meteorologists use Doppler radar (based on the Doppler effect) to find areas of precipitation and associated wind speeds by measuring the speed at which raindrops move toward or away from a radar station.

8. Meteorologists use weather radar to track precipitation and weather satellite images to track clouds. By combining data from these two types of technology, meteorologists can determine where both clouds and precipitation are occurring.

9. Infrared imagery detects differences in thermal energy. These differences are used to map either cloud cover or surface temperatures. Objects that radiate warmth at slightly different frequencies show up in an infrared image as different colors. Infrared imagery is especially useful in detecting thunderstorms that show up as very cold areas on an infrared image.

Section 12.4 Weather Analysis and Prediction
1. It is a record of weather data for a particular site at a particular time.

2. Station models allow meteorologists to fit a good amount of data into a small space. They also give meteorologists a uniform way of communicating weather data.

3. Answers may include any of the following: types of clouds, temperature, type of precipitation, dew point temperature, barometric pressure, wind speed and direction.

4. 208°C
5. It has decreased by .12 mb.
6. true
7. true
8. true
9. false
10. true
11. digital forecast
12. analog forecast
13. short term
14. long-term

Chapter Assessment – Chapter 12
Reviewing Vocabulary
1. Both refer to the conditions of the atmosphere. However, weather refers to current atmospheric conditions, while climate refers to long-term weather patterns for an area.

2. Both are global wind systems. The trade winds are easterlies that occur between 30° and the equator in both the northern and southern hemispheres. The prevailing westerlies are westerlies that flow between 30° and 60° latitude north and south of the equator. The two systems have opposite circulation patterns.

3. Both involve the movement of weather systems. However, an air mass is a large body of air that takes on the characteristics of the area over which it forms, while a front is a narrow region separating two air masses of different densities.

4. Both are weather instruments. A thermometer measures temperature, while a barometer measures air pressure.

5. Both are weather instruments. An anemometer measures wind speed and direction, while a hygrometer measures relative humidity.

6. Both are methods of weather forecasting. The digital forecast relies on numerical data collected by many weather instruments and analyzed by computers, while the analog forecast relies on comparing past and current weather patterns.

Understanding Main Ideas (Part A)
1. b
2. c
3. a
4. b
5. d
6. c
7. a.
8. b
9. b

**Understanding Main Ideas (Part B)**

1. A large mass of air takes on the temperature and humidity characteristics of the land or water under it. An air mass redistributes energy by moving from place to place, transferring energy from one area to another.

2. Jet streams are narrow bands of fast, high-altitude westerly winds that form as a result of great differences in temperature and pressure between the boundaries of the major wind systems. They form in the midlatitudes between the polar easterlies and the prevailing westerlies, and between the prevailing westerlies and the trade winds.

3. Cold fronts are associated with clouds, showers, and thunderstorms. Warm fronts are characterized by extensive cloudiness and light precipitation. Stationary fronts usually are associated with light precipitation and light winds, and, less frequently, weather similar to that of warm fronts. Occluded fronts are characterized by strong winds and heavy precipitation.

4. Both are air masses that have taken on the characteristics of the area over which they formed. A continental polar air mass is cold and dry, having formed over polar land. A maritime tropical air mass is warm and humid, having formed over tropical oceans.

5. Forecasts become less reliable when they attempt to predict long-term changes in weather. This is because many factors affect the weather and, over time, all these factors interact to create progressively more complicated scenarios that are difficult to predict.

**Thinking Critically**

1. Isobars that are closely spaced indicate a large pressure difference over a small area and strong winds. Isobars that are far apart indicate a small pressure difference over an area and light winds.

2. Wind systems exist because differences in temperature and air pressure create moving air. With equal temperature and pressure all over the surface, there would be no global wind systems.

3. Most likely, there is a high-pressure system over the area. High-pressure systems are characterized by sinking air, which works against the formation of clouds and precipitation.

4. Possible response: Anemometer, thermometer, or hygrometer; these instruments would give you data on wind speed, temperature, or relative humidity, which would be useful in choosing clothing. The data from the barometer (air pressure) and radiosonde (high-level data) would be much less useful.

5. It allows meteorologists to determine the temperature of a cloud. From this, they can infer the cloud type and estimate its height. Because the strength of a thunderstorm is related to its height, infrared imagery gives data that can predict a storm’s potential severity. When people have advance warning of a severe storm, they can take precautions.

**Applying Scientific Methods**

1. Wednesday

2. On Wednesday there was rainfall and the associated increase in humidity and decrease in temperature.

3. Clouds form at cold fronts, so clouds would have been visible as the front arrived.

4. The pressure would have been lower on Wednesday, when the front was passing through with clouds and precipitation.

5. The high relative humidity indicates cloudy skies.

6. They would be able to make a digital forecast if they knew how to express mathematically the relationships between the atmospheric variables they have collected. However, the forecast probably would not be highly accurate because their data is not very dense.

7. Possible answer: The temperature might be 18 or 19˚C, since the trend seems to be rising temperatures. The relative humidity has been
falling for the past few days, so it is likely that Monday will have clear skies. Without air pressure data, however, it is difficult to make a guess as to whether a front is approaching.

CHAPTER 13

MiniLab 13 – Model Flood Conditions
Analysis
1. The average depth decreased in step 5 because the water fell over each compartment in a shorter amount of time.
2. Storms that move slowly can release more rain over any one place than can storms that move quickly.
3. Speed up or slow down the motion of the water bottle; open or close the twist top slightly to simulate heavier or lighter rainfall.

GeoLab 13 – Track a Tropical Cyclone
Analyze and Conclude
1. Answers will vary depending on the tropical cyclone students researched.
2. Answers will vary depending on the tropical cyclone students researched.
3. Answers will vary depending on the tropical cyclone students researched.
4. Answers will vary depending on the tropical cyclone students researched.
5. The storm surge would be strongest on the side of the storm where onshore winds developed as the storm center moved inland.
6. Wind speeds decrease rapidly when a storm center moves inland because the storm becomes cut off from its energy source and weakens.

Teaching Transparency 35 – Tornado Formation
1. Supercells
2. The horizontal rotation is caused by a sudden change in wind speed and direction with height, a phenomenon called wind shear.
3. Updrafts tilt the rotating column of wind from a horizontal to a vertical position.
4. The center of a tornado is an area of low pressure because air is removed from the center as rotation accelerates.
5. The intense, rotating updrafts of a supercell would contribute to tornado formation.
6. The swirling air picks up dust and debris. Condensation of water vapor also makes a visible cloud.
7. Updrafts accelerate the rotating motion, removing air from the center of the storm. This lowers air pressure at the center, and the resulting extreme pressure gradient between the inner and outer portion of the tornado produces the strong winds.

Teaching Transparency 36 – Hurricanes
1. The eye
2. The center is calm.
3. The winds circle the eye in a counterclockwise direction. Students should infer that this a northern hemisphere storm, since the winds would spin clockwise in the southern hemisphere.
4. The strongest winds are usually in the eyewall.
5. It is a low-pressure system because air is rising throughout the system.
6. Air sinks in the eye. The sinking motion makes it difficult for air to rise and clouds to form.

7. A hurricane gets its energy from the warm, moist air above the tropical ocean. When the storm moves over land or cooler water, it loses its energy source.

Teaching Transparency 37 – Wind Chill Index
1. The wind chill factor describes how the effects of cold air are worsened by wind.
2. It does not account for individual variations in sensitivity to cold, the effects of physical activity, or humidity.
3. Actual air temperatures
4. Wind speed
5. 3 degrees F
6. It decreases.
7. It decreases.
8. 15 mph
9. 0 degrees F

Study Guide – Chapter 13 – The Nature of Storms
Section 13.1 Thunderstorms
1. Cumulonimbus
2. Convection
3. Moisture
4. Unstable
5. Warmer
6. Condensation
7. Stable
8. b
9. c
10. a
11. A sea breeze
12. In a sea breeze, cool dense air over the water moves inland, forcing up the warm, less-dense air over the land. This process can produce strong updrafts that result in a thunderstorm.
13. Thunderstorms are often classified according to the mechanism that causes the air to rise. Air-mass thunderstorms result from unequal heating of Earth’s surface within one air mass. Interaction between warm air over land and cool air over the ocean is an example of such unequal heating and may lead to a sea-breeze thunderstorm.

14. 4
15. 1
16. 3
17. 2
18. 6
19. 5

Section 13.2 Severe Weather
1. b
2. d
3. c
4. a
5. d
6. a
7. c
8. a
9. A tornado is a violent, whirling column of air in contact with the ground.
10. Tornadoes often form when wind speed and direction shift suddenly with height. This can produce a horizontal rotation near Earth’s surface. Updrafts can then shift the twisting column of wind from a horizontal to a vertical position, creating a tornado.
11. Most form in spring when the temperature contrast between polar air and tropical air is greatest.
12. Many occur in the central United States, where cold continental polar air and maritime tropical air collide to produce tornadoes.
13. Path of destruction, wind speed, and duration
14. More than 200 mph
15. 20 minutes or longer

Section 13.3 Tropical Storms
1. 1
2. 4
3. 3
4. 2
5. true
6. low-pressure
7. true
8. Saffir-Simpson hurricane scale
9. true
10. eyewall
11. true

Section 13.4 Recurrent Weather
1. flood
2. drought
3. heat wave
4. cold wave
5. cold wave
6. heat wave
7. drought
8. flood

Chapter Assessment – Chapter 13

Reviewing Vocabulary
1. They are both types of thunderstorms, but the process that makes air rise so condensation occurs is different for each. Air-mass thunderstorms are caused by the unequal heating of Earth’s surface. Frontal thunderstorms are produced by advancing cold fronts, and, more rarely, warm fronts.

2. Supercells and downdrafts are both characteristics of severe thunderstorms. Supercells are powerful storms characterized by intense, rotating updrafts. Updrafts transport moisture to the cool upper reaches of a cumulonimbus cloud, where the moisture condenses into cloud droplets. As these droplets fall, they cool the air around them. This cooled air then sinks, causing downdrafts that ultimately produce gusty surface winds. If these downdrafts become concentrated in a local area, they result in violent downdrafts called downbursts.

3. Both are scales that rank major storms. The Fujita tornado intensity scale ranks tornadoes according to their path of destruction, wind speed, and duration. The Saffir-Simpson hurricane scale ranks hurricanes according to wind speed, potential for flooding, and potential for property damage.

4. Both are major storms that swirl around areas of low pressure. Their high winds can cause great damage. A tornado is a whirling visible column of air in contact with the ground. A tropical cyclone is a larger, swirling system that forms over tropical oceans.

5. Both are structures at the centers of hurricanes. The eye is the calm center of a hurricane. The eyewall is the band of strongest hurricane winds that surrounds the eye.

Understanding Main Ideas (Part A)
1. c
2. b
3. c
4. c
5. unstable air
6. lightning; tornadoes
7. tropical Pacific Ocean; tropical Atlantic Ocean

Understanding Main Ideas (Part B)
1. The storm starts when unequal heating or an advancing front causes warm, moist air to rise vertically, creating updrafts that transport moisture upward. Condensation creates cloud droplets, and cloud droplets grow in size, forming precipitation. As precipitation falls, it cools the air around it, creating downdrafts. The rising updrafts and falling downdrafts produce a convection cell in the cloud that causes gusty winds, but the downdrafts eventually cool the surface, and the storm’s supply of warm, moist air is gone. Updrafts stop and precipitation can no longer form, bringing an end to the storm.

2. Occasionally, there is a continuous supply of surface moisture, so storms can continually regenerate themselves. Also, cold fronts, which cause some thunderstorms to form, are usually accompanied by upper-level, low-pressure systems with pools of cold air. This cold air can increase the temperature difference between the upper and lower parts of the storm, which increases the strength of updrafts and downdrafts, and makes the storm more severe.
3. Hurricanes form when a weak low-pressure area called a tropical disturbance develops over a tropical ocean. When the disturbance begins a cyclonic circulation around the low-pressure center, it becomes a tropical depression. When winds exceed 65 km/h, the system becomes a tropical storm. If air pressure keeps dropping and winds reach at least 120 km/h, the system is classified as a hurricane.

4. Droughts are caused by large high-pressure systems that persist for a long time over continental areas. The sinking air in the systems prevent condensation from occurring. Heat waves are also caused by large high-pressure systems. Heat increases as the air under the system sinks and is warmed by compression, causing above-normal temperatures. The system blocks cooler air masses from moving into an area and also prevents condensation from occurring.

Thinking Critically

1. The broadcasts should occur before spring because that is when most violent tornadoes form. It is the time of year when the temperature contrast is greatest between colliding polar and tropical air masses over the central United States.

2. No, because conditions would not be right. Hurricanes form over warm ocean waters. The waters of the northern Atlantic would be too cold.

3. Much of a hurricane’s damage is due to flooding of low-lying areas that results from torrential rains and storm surges that push mounds of water onto the coast.

4. Air pressure has become lower, and the strength of the winds has increased, making the storm much stronger.

5. No; droughts form when large, high-pressure systems characterized by sinking air remain over an area for a long time. The high pressure would prevent the formation of a supercell, which needs intense updrafts to form.

6. Answers will vary. Students may say that because the wind chill factor estimates heat loss from skin caused by the combination of cold and wind, the information gives people a more accurate idea of how cold it feels outside (and how they should dress) than does temperature alone.

Applying Scientific Methods

1. It caused the river to rise above its normal level.

2. noon

3. 2.2 m

4. There was likely flooding at houses Y and Z. House Y is at an elevation of 3.5 m and Z is at 4 m, and the river level rose above these elevations after 1:00 p.m. House X would not have flooded because it is at an elevation of 8 m, and the river did not rise that high during the time shown in the table.

5. If the storm had moved faster, less rain would have had a chance to fall in Wilson Bend, so there would have been less chance for flooding to occur there. However, wind speed would have been greater, and thus some wind-related damage might have occurred.

6. Accurate forecasting makes it possible to issue advanced warnings, and this is crucial in saving people from the hazards of flooding caused by storms.

CHAPTER 14

MiniLab 14 – Model the Greenhouse Effect

Analyze and Conclude

1. The independent variable is the treatment of the thermometer, whether it is covered with a glass jar or not. The dependent variable is the temperature.

2. Graphs will vary depending on student measurements.

3. The thermometer in the jar should show higher readings. Air was trapped inside the jar.

4. In the atmosphere, greenhouse gases absorb and trap solar radiation, much like the glass jar absorbed and trapped energy from the Sun.

GeoLab 14 – Identify a Microclimate

Analyze and Conclude

1. Students should find that darker and denser surfaces are generally warmer and less humid than are lighter and less dense surfaces.
2. With increasing height, temperature should decrease, and humidity and wind speed should increase.

3. Answers will vary depending on individual results. If the weather variables showed appropriate changes with different heights and surfaces, student hypotheses were likely supported.

4. Darker and denser surfaces absorb more sunlight and therefore warm up faster. This higher rate of absorption also affects relative humidity. Areas protected from the wind likely experienced the most variation.

5. Answers will vary depending on the exposure of individual locations. Any of the variables might show the most change, but normally, temperature varies most.

6. Wind is least likely to change, but again, this depends on the exposure of the location.

7. Answers will vary but could include ideas such as the influence of conduction close to the ground or convection currents.

**Plan or Experiment** Experiments will vary but should include the use of scientific methods. The scale of the experiment would be much larger.

### Teaching Transparency 38 – Mountains and Climate

1. It is more abundant on the windward side.

2. Because of orographic lifting, the moist air moves upward as it encounters the mountain. As the moist air rises, it cools, condenses, and drops its moisture on that side of the mountain.

3. The air warms as it descends.

4. It is drier on the leeward side. It has already dropped most of its moisture on the windward side of the mountain.

5. You would most likely find it on the windward side because that side gets most of the rainfall.

6. You would most likely find a desert on the leeward side because the climate on that side is dry.

7. The mountaintop climate would be cooler because temperatures generally decrease with altitude.

### Teaching Transparency 39 – World Climate Map

1. continental, dry, high elevation, mild, polar, tropical

2. Both types of tropical climate are between the equator and 30° latitude north and south. In both cases, average temperatures are high. The tropical wet climate is wet year-round, while alternating wet and dry seasons characterize the tropical wet and dry climate.

3. subarctic

4. humid subtropical

5. ice cap

6. arid climate

7. They occur between about 55 degrees N and 55 degrees S.

8. in the western part of the United States

9. polar and high elevation climates

### Teaching Transparency 40 – El Niño

1. Normally, the cold Peruvian current flows north along the coast and the warm Equatorial currents flow west away from the coast along the equator.

2. The current flows in the opposite direction of the Equatorial current, bringing warm water east along the equator toward western South America.

3. During normal periods, there is a high-pressure system off the west coast of South America and a low-pressure system north of Australia. During El Niño, this situation reverses—a low-pressure system is present off the west coast of South America and a high-pressure system is located north of Australia.

4. The polar jet stream’s path becomes less straight, with waves that dip farther south into North America than normal.

5. wetter-than-average winters in the southeast and warmer-than-average winters in the north

6. Australia becomes drier than normal.

7. They would be easier to catch during normal periods because cold water ocean currents are more extensive along the northwest coast of South America at these times.
Teaching Transparency 41 –
The Greenhouse Effect

1. the Sun

2. The energy from the Sun is absorbed by soil and other material inside the greenhouse and is released as infrared radiation, which gets trapped inside the greenhouse.

3. the Sun

4. Some energy from the Sun penetrates Earth’s atmosphere and reaches the planet’s surface. It is absorbed and then released to the atmosphere as infrared radiation that is trapped by the gases of the atmosphere.

5. Both the greenhouse and the atmosphere get their energy from the Sun. In both, the energy enters as sunlight, or solar radiation, and is absorbed and released as infrared radiation. In the greenhouse, glass walls hold in the heat. In the atmosphere, atmospheric gases trap the radiation.

6. Earth would be colder because much of the energy that is released from its surface would escape into space. Life as we know it could not exist on Earth.

7. the Sun and the atmosphere

Study Guide – Chapter 14 – Climate

Section 14.1 Defining Climate

1. ✓

2.

3. ✓

4. ✓

5.

6.

7. The amount of solar radiation received at any place varies with latitude. Areas near the equator are warm because they receive the most direct solar radiation. Areas near the poles are cold because the Sun strikes them at a lower, less-direct angle.

8. A large body of water affects the climate of a coastal area by making it warmer in winter and cooler in summer than an inland area at the same latitude.

9. Because temperature decreases with altitude in the lower atmosphere, mountain climates are cooler than those at lower elevations at the same latitude. The climate can also be wetter and cooler on the windward side of a mountain than on the leeward side, where deserts can form.

10. The climate in and near regions of air-mass formation is fairly similar to that exhibited by the air masses themselves. For example, if a city is located where maritime tropical (warm and humid) air masses dominate the weather, the city’s climate will have maritime tropical characteristics.

Section 14.2 Climate Classification

1. dry climate

2. continental climate

3. mild climate

4. Mean temperature of warmest month is less than 108°C and precipitation is generally low

5. polar climate

6. microclimate

7. heat island

8. precipitation

9. temperatures

Section 14.3 Climatic Changes

1. true

2. true

3. false

4. true

5. true

6. true

7. false

8. Because Earth is tilted, seasonal climatic changes occur as Earth revolves around the Sun and different areas of the planet receive varying amounts of solar radiation. During summer in the northern hemisphere, for example, the north pole is tilted toward the Sun, and the northern hemisphere has longer hours of daylight and warmer temperatures. At the same time, the south pole is tilted away from the Sun, causing the southern hemisphere to experience longer hours of darkness and colder temperatures. Also, the angle of the tilt varies every 41,000 years.
Scientists theorize that these changes in angle cause seasons to become more severe.

9. Seasons on Earth will be reversed, meaning that winter will come in the northern hemisphere when Earth is farthest from the Sun and summer will come when it is closest. That is the opposite of what happens now. The result will be colder winters and warmer summers than we now experience.

10. d
11. a
12. a
13. b
14. b
15. c
16. b
17. d
18. d

Section 14.4 Impact of Human Activities

1. d
2. e
3. a
4. c
5. b
6. d
7. a
8. a
9. fossil fuels
10. true
11. deforestation
12. true
13. decreasing
14. temperature
15. To conserve energy, which reduces the consumption of fossil fuels, people can turn off appliances and lights when a room is not in use. (Answers for questions 15 through 17 can be in any order. Accept all reasonable answers.)
16. Turning down thermostats in winter conserves energy and reduces fossil fuel consumption.
17. Recycling conserves resources such as trees, decreasing deforestation.

Chapter Assessment – Chapter 14

Reviewing Vocabulary

1. Both terms involve long-term weather patterns. Climate is the long-term weather pattern of an area, while a normal is a standard value (such as daily high and low temperature and amount of rainfall) that describes an area’s climate.

2. Each describes a different climate zone on Earth. The tropics are located between 23.58 south and north of the equator. Temperate zones are between 23.58 and 66.58 north and south of the equator, while polar zones stretch from 66.58 north and south of the equator to the poles.

3. Both are climates that occur in small areas. A microclimate is a localized climate that differs from the main regional climate. A heat island is a type of microclimate wherein a city is warmer than surrounding rural areas.

4. Both involve the heating of Earth. The greenhouse effect is the natural heating of Earth’s surface caused by atmospheric gases, while global warming is the abnormal rise in global temperatures due to the increased concentration of greenhouse gases in the atmosphere.

5. c
6. a
7. b
8. d

Understanding Main Ideas (Part A)

1. true
2. warmer
3. sunspot
4. c
5. a
6. c
7. a

Understanding Main Ideas (Part B)

1. Earth’s elliptical orbit elongates, then becomes more circular in a 100,000-year cycle. When the orbit is more elongated, Earth passes closer to the Sun and receives more solar energy overall. When the orbit is more circular, Earth is farther from the Sun and its average temperature is lower.
2. Both are cooler than tropical climates. But a continental climate has seasons with distinct cool or cold winters and warm or hot summers. Polar climates are cold all year round.

3. These could include solar activity, changes in Earth’s orbit or the tilt of its axis, and volcanic eruptions.

4. Volcanic dust from an eruption can remain suspended in the atmosphere for several years, blocking incoming solar radiation and thus lowering global temperatures.

5. Without the greenhouse effect, Earth’s climate would be much colder. The greenhouse gases in Earth’s atmosphere, such as carbon dioxide, trap heat from the Sun that is absorbed and released by Earth’s surface. Much of this heat would otherwise escape into space.

6. Students can list any two of the following: location on Earth’s surface in either the tropical, temperate, or polar zone; location near or far from a large body of water; altitude.

Thinking Critically

1. Possible response: The climate of an area would influence the way buildings are designed and constructed. For example, houses in a polar climate might need to withstand heavy snows and protect its inhabitants against cold temperatures, while homes in tropical climates might need to withstand heavy rainfall and provide ventilation for cooling because of the high temperatures.

2. The area is likely located at a high altitude. Because temperature in the lower atmosphere decreases with altitude, areas at the tops of mountains are colder than areas at the same latitude that are at lower elevations. A high mountain in the tropics could be cold enough to have snow.

3. Normals are standard values for weather in an area. They include average readings for characteristics such as temperature and rainfall. On any given day, the temperature or amount of precipitation can vary greatly from that average.

4. There would be scarcely any seasonal climatic changes if Earth were not tilted because each part of Earth’s surface would receive the same amount of solar radiation all year round.

5. Vehicles run on gasoline, a fossil fuel that produces carbon dioxide emissions when burned. The buildup of carbon dioxide in the atmosphere is one cause of global warming. If many people left their cars at home and took buses instead, the number of vehicles on the road would be reduced and thus the amount of carbon dioxide emissions would decrease.

6. City buildings and expanses of asphalt can create heat islands where the climate is warmer than in surrounding rural areas.

Applying Scientific Methods

1. Temperature was hot year-round, averaging about 27°C. Precipitation averaged about 51 cm per month and was plentiful all year.

2. City X’s climate is classified as a tropical wet climate because it has high temperatures and plentiful rainfall year-round.

3. It is probably located in the tropics, where temperatures are high and precipitation is plentiful.

4. Temperatures were hot year-round, averaging about 32°C. There was abundant precipitation during May through August (about 51 cm per month). October through March was drier, with average precipitation measuring less than 10 cm per month.

5. City Y has a tropical wet and dry climate because it is hot year-round and has a distinct dry winter season.

6. The main difference would be much lower average monthly precipitation. The temperature data could vary significantly because dry climates are defined by the amount of precipitation, not the temperature.

7. It would be a polar climate. An average yearly temperature of less than 08°C would place it below freezing year-round. An annual average of less than 2 cm of precipitation would be fairly low, which also is a characteristic of polar climates.

8. City X likely would have very lush tropical vegetation and might be located in or near a tropical rain forest. City Y would probably be located in or near tropical grasslands called savannas.
CHAPTER 15

MiniLab 15 – Model Seawater
Analyze and Conclude
1. 34.43 g of salt + 965.57 g of water = 1000 g of saltwater; 34.43 g /1000 g = 0.03443 or 3.443 percent
2. 3.443 percent = 34.43 ppt
3. Cl\(^{-}\), Na\(^{+}\), SO\(_4\)^{2-}, Mg\(^{2+}\), Ca\(^{2+}\), K\(^{+}\), HCO\(_3\)^{-}, Br\(^{-}\)
4. The solution doesn’t contain the trace elements and nutrients dissolved in seawater.

GeoLab 15 – Model Water Masses
Analyze and Conclude
1. Cold saltwater sinks in warm saltwater; cold freshwater floats in warm saltwater. Cold saltwater is denser than warm saltwater; cold freshwater is less dense than warm or cold saltwater. The amount of salinity in the water accounts for the differences observed.
2. clear, blue, yellow, red
3. clear, blue, yellow, red
4. Student graphs should show that the first layer extends to a depth of 100 m and has a temperature of 20°C. The second layer extends to 1100 m and has a temperature of 5°C. The third layer extends to 1200 m and has a temperature of 20°C. The fourth layer extends to 2200 m and has a temperature of 5°C.

Infer The high-temperature layer is saltier than the colder thermocline above it. It is therefore denser than the thermocline because salinity causes an increase in density.

Teaching Transparency 42 – Sonar
1. sound navigation and ranging
2. the time it takes for a sonar signal sent from a ship to return to the ship (the return time of an echo) and the known velocity of sound in water
3. A sonar signal is sent from a ship, and it bounces off the ocean floor and returns to the ship. The time it takes for this to happen is multiplied by 1454 m/s (the velocity of sound in water) and then divided by 2 to determine the distance to the ocean floor.
4. 1454 m/s x 4s = 5816 m ÷ 2 = 2908 m
5. 1817.5 m x 2 = 3635 m ÷ 1454 m/s = 2.5 s
6. Side-scan sonar sends sonar signals to the ocean floor at an angle and is used to map the topographic features of the ocean floor. Ordinary sonar sends signals straight down to determine the ocean depth at a particular place.

Teaching Transparency 43 – Processes that Add and Remove Sea Salts
1. Chlorine and sulfur dioxide are present in volcanic gases, and after eruption they dissolve in seawater to form chlorine and sulfate ions.
2. Through the weathering of rocks on land, these minerals are dissolved in water. They are then flushed into rivers and transported to oceans.
3. Processes remove salts from seawater at the same rate as they are added.
4. The wind carries small spray droplets from breaking waves and deposits them inland.
5. Marine organisms remove ions from seawater to form their shells, teeth, and bones. When they die, these parts sink to the bottom and become incorporated into the sediments.
6. The formation of evaporites along coasts removes immense quantities of salts from ocean water.
7. Possible response: Ocean salinity would likely increase because there would be less salt-removal taking place.

Teaching Transparency 44 – Solar and Lunar Tides
1. A spring tide is a large tidal range in which high tides are higher than normal and low tides are lower than normal. It occurs during a full or new Moon.
2. During a spring tide, the Sun, the Moon, and Earth are aligned.
3. A neap tide is a small tidal range in which lower high tides than normal and higher low tides than normal occur. It occurs during a first-quarter or third-quarter Moon.
4. During a neap tide, the Sun, the Moon, and Earth form a right angle.
5. Lunar high tides are higher because the Moon is much closer to Earth and therefore exerts a greater gravitational force.
6. The Sun enhances a lunar tide during new moons and full moons because the Sun and the Moon are aligned and both exert a gravitational force in the same direction.

7. because the Sun and the Moon exert gravitational forces in different directions, thus offsetting each other

8. during first-quarter and third-quarter moons

Study Guide – Chapter 15 – Earth’s Oceans

Section 15.1 An Overview of Oceans

1. e
2. b
3. c
4. d
5. a
6. b
7. c
8. c
9. b
10. a
11. d
12. oceans
13. frozen ice caps
14. sea level
15. Tectonic
16. rising
17. because about 71 percent of its surface is covered by oceans
18. 3800 m
19. 61 percent
20. 81 percent
21. Indian
22. true
23. true
24. arctic
25. southern

Section 15.2 Seawater

1. c
2. a
3. a
4. d
5. b
6. c
7. b
8. b
9. c
10. surface layer
11. thermocline
12. bottom layer
13. C
14. A
15. D
16. B

Section 15.3 Ocean Movements

1. As an ocean wave passes, the water moves up and down in a circular pattern and returns to its original position. The energy moves forward.
2. crest
3. trough
4. wave height
5. wavelength
6. Wave speed increases with wavelength.
7. As ocean waves reach the shallow water near shorelines, they begin to lose energy because of friction with the ocean bottom. This causes the waves to slow down. As the water becomes shallower, incoming wave crests gradually catch up with the slower wave crests ahead. As a result, the crest-to-crest wavelength decreases. The incoming waves become higher, steeper, and unstable, and their crests collapse forward.
8. d
9. e
10. a
11. b
12. c
13. density current
14. true
15. clockwise
16. true.
17. vertically
18. upwelling
19. cold
20. trade-wind
21. offshore
22. nutrients

Chapter Assessment – Chapter 15

Reviewing Vocabulary
1. d
2. k
3. b
4. m
5. j
6. e
7. i
8. l
9. h
10. a
11. c
12. n
13. g
14. f

Understanding Main Ideas (Part A)
1. volcanism.
2. freshwater
3. melting,
4. 4.56
5. removed from
6. lower
7. 100 m
8. thermocline
9. Antarctic Bottom Water
10. Moon
11. gyres
12. nutrients

Understanding Main Ideas (Part B)
1. Different wavelengths, or colors, of light penetrate ocean water to different depths.

Blue light penetrates the deepest; red light the shallowest.

2. High tides are caused mainly by the gravitational pull of the Moon on Earth’s ocean waters.

3. Volcanic eruptions send gases into the atmosphere. These gases contribute chloride and sulfate ions to seawater. Rivers add salts to the ocean from rock weathering. Sea spray, evaporation, and biological processes remove salt from sea water.

Thinking Critically
1. It might flow eastward until it arrived at Australia, and then it would flow southward.

2. They might be combined into one large gyre that would flow counterclockwise along the equator, the east coast of Australia, and the west coast of Africa.

3. The ocean currents would flow in a west-to-east direction, too.

Applying Scientific Methods
1. You could compare the colors of the actual estuary samples with the colors of the samples made with river water and seawater. The reference sample that most closely matches the estuary sample in color will help determine the ratio of river water to seawater in the estuary sample.

2. No; a visual comparison would only give an approximate idea of the percentages in each sample. The amount of salt present in each sample would have to be measured to determine the actual ratio.

3. Density; because the salt content of seawater makes its density higher than that of freshwater, the densities of the samples could be calculated to determine the actual ratio of river water to seawater in each sample.

4. There should be variations in the samples because the concentration of river water would decrease as it mixed with more and more ocean water.

5. The salt concentration should be higher in deep water samples because salt water is denser and heavier and most likely layered below the less-dense freshwater.
CHAPTER 16

MiniLab 16 – How fast do sediment grains sink?

Analyze and Conclude
1. Settling speeds is calculated by dividing distance by time.
2. Graphs will vary based on data collected.
3. Settling speeds decrease with decreasing size.

GeoLab 16 – Identify Coastal Landforms

Analyze
1. tombolo
2. sea stack; formed by differential erosion
3. baymouth bar; formed when a spit crosses a bay
4. sand dunes
5. To the north; sand is piling up on the south side of the breakwater.
6. an elevated marine terrace; formed by uplifting of a wave-cut platform
7. The shoreline would move 2000 ft seaward and become more regular. Morro Bay would dry up.
8. Morro Rock would become an island, most of the coastal communities would be flooded, the coastline would become more irregular, and Morro Bay would become a large, branching estuary extending almost 2 mi further inland.

Compare and Contrast The Gulf Coast is dominated by low topography, large barrier islands, large lagoons and estuaries, and baymouth bars. There are no rocky headlands with sea stades or elevated marine terroces. The Gulf Coast is a submergent coast.

Teaching Transparency 45 – Depositional Shoreline Features
1. a narrow bank of sand that projects into the water from a bend in the coastline
2. the baymouth bar
3. In the wave shadow of the island, slow-moving ocean water deposited sand to form a ridge connecting the island and mainland.
4. the lagoons; the barrier islands and baymouth bar
5. the bay; the spit
6. The sediment was carried by moving ocean water from another section of the coastline.
7. They are temporary features. Wave erosion, longshore transport, storm erosion, and deposition keep shoreline features in a constant state of change.

Teaching Transparency 46 – Features of the Continental Margin
1. the submerged parts of continents where continents meet the oceans
2. the continental shelf
3. along the boundary between the continent and the continental margin (or the continental shelf)
4. They are eroded by turbidity currents.
5. the continental slope
6. at the edge of the continental slope
7. the abyssal plain
8. It is the gently sloping accumulation of deposits from turbidity currents that forms at the base of the continental slope.

Study Guide – Chapter 16 – The Marine Environment

Section 16.1 Shoreline Features
1. false
2. true
3. true
4. true
5. false
6. true
7. true
8. false
9. true
10. false
11. true
12. true
13. false
14. false
15. false
16. seashores
17. wave erosion
18. sediment
19. deposit
20. spit
21. barrier islands
22. storm waves
23. sand dunes
24. Both are formed by sediments deposited by longshore currents, and both are connected to the mainland.
25. A barrier island shore would be a bad choice for a building a house because depositional coastal landforms, such as barrier islands, are unstable and temporary. Storms and waves erode the land and change the shoreline.
26. groin
27. breakwater
28. seawall
29. It is eroded by the waves that are reflected back toward the beach.
30. The beach is deprived of sand and is eroded.
31. The breakwater slows the current, and the sediment in the water is deposited, filling the anchorage.
32. lower
33. global warming
34. fjords.
35. tectonic movement
36. drop

Section 16.2  Seafloor Features
1. submarine canyons
2. continental margin
3. continental rise
4. continental crust
5. continental slope
6. oceanic crust
7. continental shelf
8. oceanic crust
9. continental margin
10. continental shelf
11. continental slope
12. continental rise
13. submarine canyons
14. continental crust
15. about 60 percent
16. An abyssal plain is the smooth, flat, deep part of the ocean floor, 5 to 6 km below sea level. It is made up of sedimentary rock covered with fine-grained, muddy sediments.
17. Deep-sea trenches are the deepest parts of the ocean basins. They are elongated, relatively narrow depressions in the seafloor. They may be several kilometers deep and extend for thousands of kilometers. Most are located around the Pacific Ocean.
18. Answers may include any four of the following: most prominent ocean-basin feature; have a total length of more than 65,000 km; average height of 1500 m; may be thousands of kilometers wide; sites of frequent volcanic and earthquake activity; highest peaks reach above sea level as volcanic islands; breaks in the ridge produce fracture zones.
19. A hydrothermal vent is a hole in the seafloor through which fluid heated by magma erupts.
20. black smoker, white smoker
21. extinct volcanoes
22. seamounts
23. guyots
24. continents
25. Ooze
26. nodules
27. true
28. true
29. strong
30. iron
31. true
32. true
33. true
Chapter Assessment – Chapter 16
Reviewing Vocabulary
1. b
2. d
3. d
4. c
5. a
6. Both occur just offshore. The longshore bar is a sandbar that forms in front of most beaches. The longshore current is a current that flows parallel to the shore. Water from incoming breakers spills over the longshore bar and produces the longshore current.
7. Both are deep-sea sediments that accumulate slowly on the ocean floor. Ooze is made up of the shells and hard parts of marine organisms. Deep-sea mud is made up of fine silt, clay, and volcanic ash.
8. Both are protective structures meant to prevent beach erosion, but actually cause beach erosion. A seawall protects property from storm waves, but reflects the energy of waves back toward the beach, causing beach erosion. A groin is a wall-like structure built perpendicular to the shoreline to trap beach sand, but causes beach erosion down the coast.

Understanding Main Ideas (Part A)
1. Barrier Islands
2. beach erosion
3. Abyssal plains
4. ooze
5. turbidity currents
6. hydrothermal vent
7. sediment
8. hydrothermal vents
9. true
10. true

Understanding Main Ideas (Part B)
1. b
2. e
3. a
4. c
5. d

Thinking Critically
1. Heavier rocks and sediments carried to the ocean by rivers and other waters are too heavy to be carried far into the ocean by waves and currents. However, finer particles can be carried by ocean currents great distances from the shore.
2. Turbidity currents cut into the continental slope, eroding bottom sediments and bedrock and forming submarine canyons. Sediments cut from the slope are carried downward and are deposited at the bottom of the continental slope to form the continental rise.
3. The percentage of land would decrease, percentage of ocean would increase, average elevation of continents would decrease, average depth of ocean would increase.

Applying Scientific Methods
1. Water temperature is relatively constant near the ocean surface. Between 300 m and 500 m below the surface, the temperature drops sharply. It remains fairly constant again from 600 m to 900 m below the surface. Then it drops slowly at depths greater than 900 m.
2. Answers will vary but should attempt to provide reasonable explanations, such as heat transfer from landmass or heat absorbed from the Sun’s radiation.
3. Answers will vary but should identify variables to be studied, controls used, and expected results.
4. Answers will vary but should include questions such as: Where do the majority of marine organisms thrive? Is temperature a limiting factor for marine organisms? How is the temperature related to production of food for marine animals?
5. Accept reasonable responses.