CHAPTER

16 Weather Patterns

the BIG idea

Some features of weather have predictable patterns.

Key Concepts

SECTION 1 **The atmosphere's air pressure changes.**
Learn how air pressure changes and how it is measured.

SECTION 2 **The atmosphere has wind patterns.**
Learn how wind develops and about different types of wind.

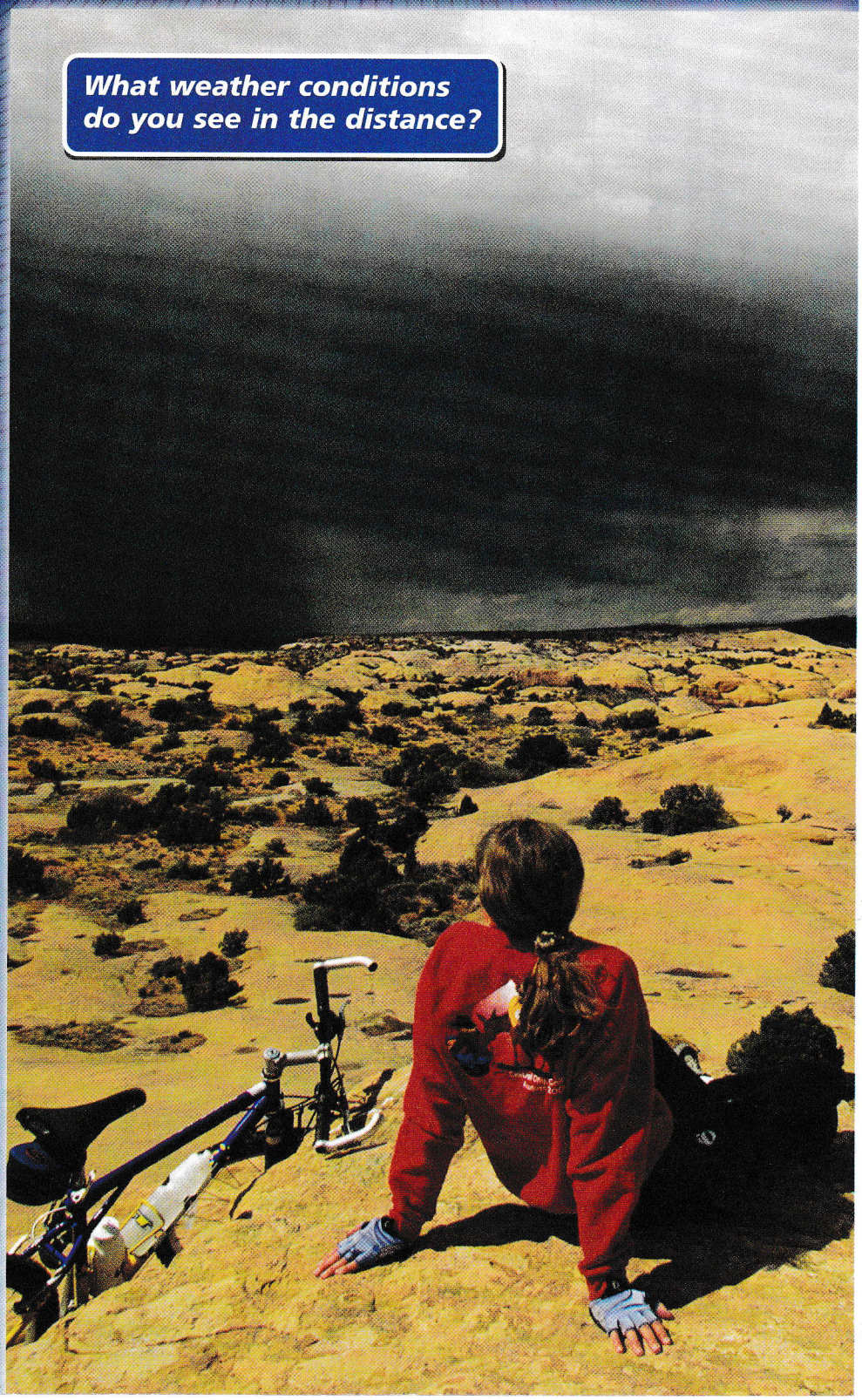
SECTION 3 **Most clouds form as air rises and cools.**
Learn how water changes form in the atmosphere and about different types of clouds.

SECTION 4 **Water falls to Earth's surface as precipitation.**
Learn about the different types of precipitation and about acid rain.

Internet Preview

CLASSZONE.COM

Chapter 16 online resources: Content Review, two Visualizations, four Resource Centers, Math Tutorial, Test Practice

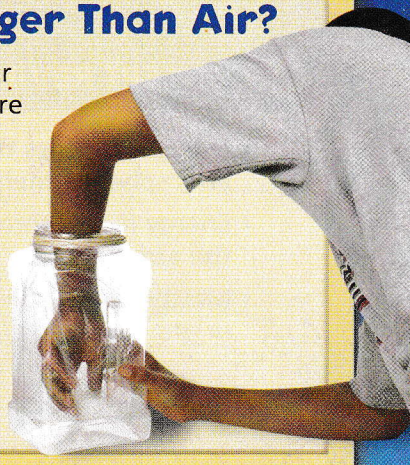


What weather conditions do you see in the distance?

EXPLORE the BIG idea

Are You Stronger Than Air?

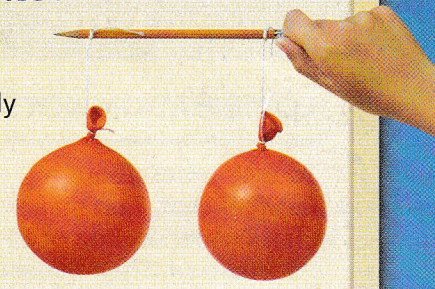
Line a wide-mouthed jar with a plastic bag. Secure the bag tightly with a rubber band. Reach in and try to pull the bag out of the jar.



Observe and Think
How easy was it to move the plastic bag? What was holding the bag in place?

How Does Air Motion Affect Balloons?

Tie two balloons to a pencil 5 centimeters apart as shown. Gently blow air between the balloons.



Observe and Think
How did the balloons move? Why did the air make them move this way?

Internet Activity: Wind

Go to **ClassZone.com** to explore how breezes blowing over land and water change over the course of an entire day.

Observe and Think
What patterns can you see in winds that occur near water?

NSTA SCILINKS
scilinks.org
Atmospheric Pressure and Winds **Code: MDL010**

CHAPTER 16

Getting Ready to Learn

CONCEPT REVIEW

- The Sun supplies the atmosphere's energy.
- Energy moves throughout the atmosphere.
- Matter can be solid, liquid, or gas.

VOCABULARY REVIEW

atmosphere p. 505
altitude p. 506
density p. 506
convection p. 515

CONTENT REVIEW
CLASSZONE.COM
Review concepts and vocabulary.

TAKING NOTES

COMBINATION NOTES

To take notes about a new concept, first make an informal outline of the information. Then make a sketch of the concept and label it so that you can study it later.

VOCABULARY STRATEGY

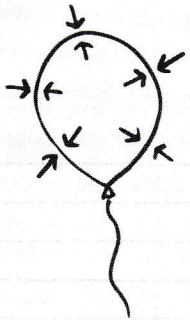
Place each vocabulary term at the center of a **description wheel.** Write some words describing it on the spokes.

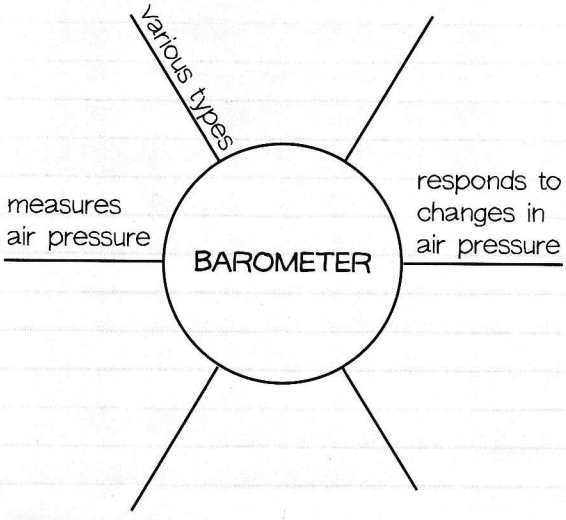
See the Note-Taking Handbook on pages R45–R51.

SCIENCE NOTEBOOK

NOTES

Air pressure
- is the force of air molecules pushing on an area
- pushes in all directions





KEY CONCEPT

16.1 The atmosphere's air pressure changes.

BEFORE, you learned

- Density is the amount of mass in a given volume of a substance
- Air becomes less dense as altitude increases
- Differences in density cause air to rise and sink

NOW, you will learn

- How the movement of air molecules causes air pressure
- How air pressure varies
- How differences in air pressure affect the atmosphere

VOCABULARY

air pressure p. 539
barometer p. 542

EXPLORE Air Pressure

What does air do to the egg?

PROCEDURE

1. Set a peeled hard-boiled egg in the mouth of a bottle. Make sure that the egg can't slip through.
2. Light the matches. Remove the egg, and drop the matches into the bottle. Quickly replace the egg.
3. Watch carefully, and record your observations.

MATERIALS

- peeled hard-boiled egg
- glass bottle
- 2 wooden matches

WHAT DO YOU THINK?

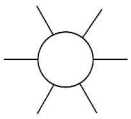
- What happened when you placed the egg back on top of the bottle?
- What can your observations tell you about the air in the bottle?

Air exerts pressure.

Air molecules move constantly. As they move, they bounce off each other like rubber balls. They also bounce off every surface they hit. As you read this book, billions of air molecules are bouncing off your body, the book, and everything else around you.

Each time an air molecule bounces off an object, it pushes, or exerts a force, on that object. When billions of air molecules bounce off a surface, the force is spread over the area of that surface. **Air pressure** is the force of air molecules pushing on an area. The greater the force, the higher the air pressure. Because air molecules move in all directions, air pressure pushes in all directions.

VOCABULARY
Add a description wheel for *air pressure* to your notebook.



CHECK YOUR READING How does the number of air molecules relate to air pressure?

Air pressure is related to altitude and density.

COMBINATION NOTES
Record details about how air pressure varies.

The air pressure at any area on Earth depends on the weight of the air above that area. If you hold out your hand, the force of air pushing down on your hand is greater than the weight of a bowling ball. So why don't you feel the air pushing down on your hand? Remember that air pushes in all directions. The pressure of air pushing down is balanced by the pressure of air pushing up from below.

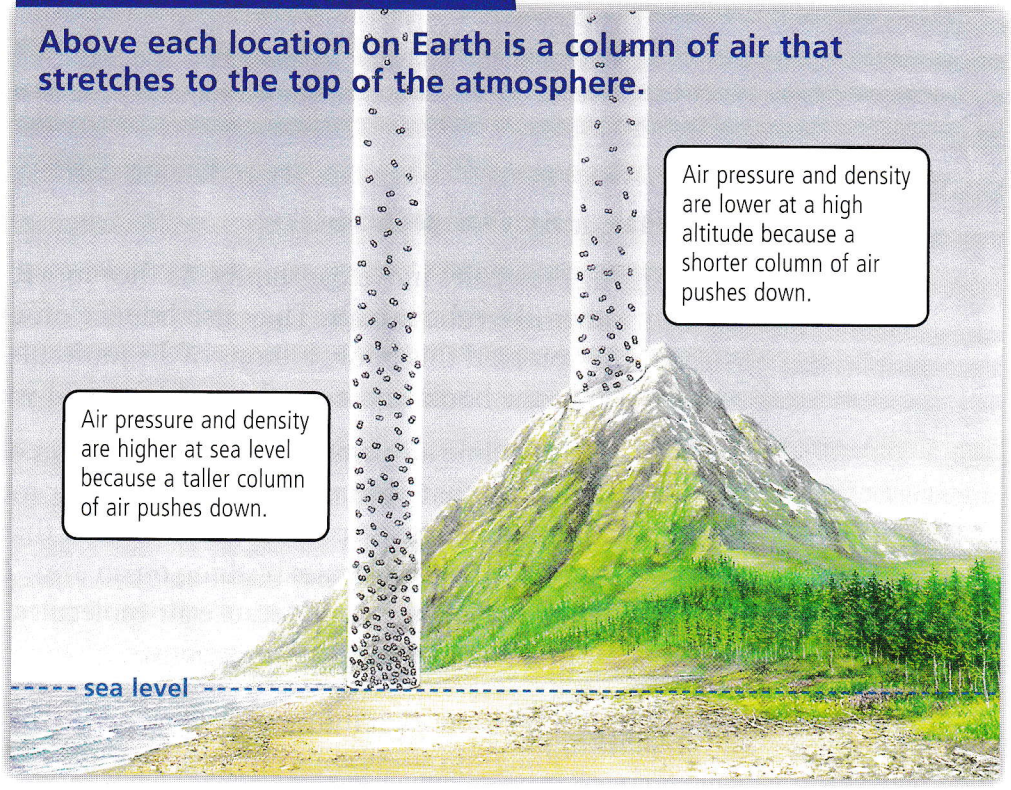
Air pressure decreases as you move higher in the atmosphere. Think of a column of air directly over your body. If you stood at sea level, this column would stretch from where you stood to the top of the atmosphere. The air pressure on your body would be equal to the weight of all the air in the column. But if you stood on a mountain, the column of air would be shorter. With less air above you, the pressure would be lower. At an altitude of 5.5 kilometers (3.4 mi), air pressure is about half what it is at sea level.

REMINDER
Density is the amount of mass in a given volume of a substance.

Air pressure and density are related. Just as air pressure decreases with altitude, so does the density of air. Notice in the illustration that air molecules at sea level are closer together than air molecules over the mountain. Since the pressure is greater at sea level, the air molecules are pushed closer together. Therefore, the air at sea level is denser than air at high altitudes.

Air Pressure and Density

Above each location on Earth is a column of air that stretches to the top of the atmosphere.



Pressure and Air Motion

RESOURCE CENTER
CLASSZONE.COM
Find out more about air pressure.

You've read that air pressure decreases as you move to higher altitudes. Air pressure also often varies in two locations at the same altitude. You can observe how such pressure differences affect air when you open a new can of tennis balls. You may hear a hiss as air rushes into the can. The air inside the sealed can of tennis balls is at a lower pressure than the air outside the can. When you break the seal, air moves from outside the can toward the lower pressure inside it.

Air pressure differences in the atmosphere affect air in a similar way. If the air pressure were the same at all locations, air wouldn't move much. Because of differences in pressure, air starts to move from areas of higher pressure toward areas of lower pressure. The air may move only a short distance, or it may travel many kilometers. You will learn more about how air moves in response to pressure differences in Section 16.2.

CHECK YOUR READING How do differences in air pressure affect the movement of air?

INVESTIGATE Air Pressure

How can you measure changes in air pressure?

SKILL FOCUS
Collecting data

MATERIALS
- scissors
- round balloon
- metal can
- rubber band
- thin straw
- tape
- ruler

TIME
15 minutes

PROCEDURE

1. Cut open a balloon along one side until you get close to the end. Stretch the balloon across the open top of the can. Secure it tightly in place with a rubber band.
2. Cut the straw on an angle to make a pointer. Tape the other end of the straw to the center of the balloon.
3. Tape a ruler against a wall or a box so that the end of the pointer almost touches the ruler. Record the position of the pointer against the ruler.
4. Record the position of the pointer at least once a day for the next five days. Look for small changes in its position. For each day, record the air pressure printed in a local newspaper.

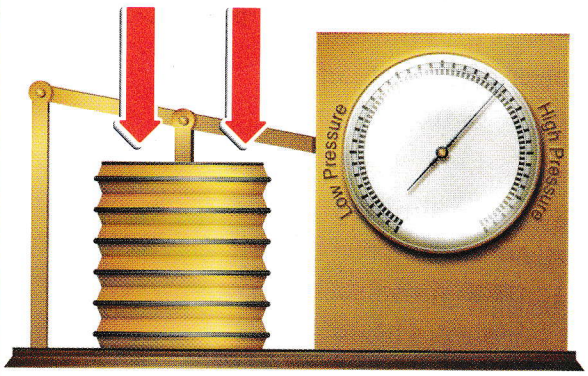
WHAT DO YOU THINK?

- In what direction did the pointer move when the air pressure went up? when the air pressure went down?
- Explain how your instrument worked.

CHALLENGE Predict what would happen to the pointer if you repeated this experiment but poked some small holes in the balloon.

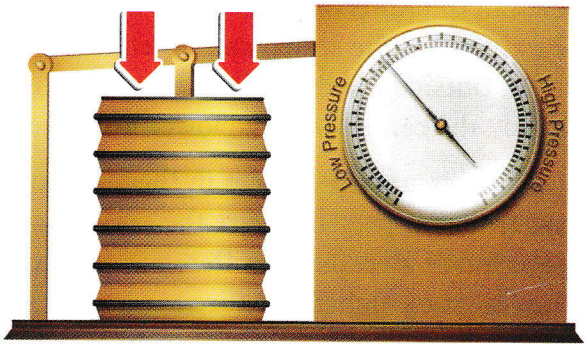
How a Barometer Works

High Air Pressure



The flexible chamber on the barometer contracts when the air pressure increases.

Low Air Pressure



The chamber expands when the air pressure decreases.

READING VISUALS Which of these barometer readings would be the more likely one on a mountain? Explain why.

Barometers and Air Pressure

Air pressure can be measured in different ways. A **barometer** is any instrument that measures air pressure. The illustrations above show a simplified version of a common type of barometer. This type contains a sealed flexible chamber that has little air inside. The chamber contracts when the outside air pressure is high and expands when the air pressure is low. A series of levers or other devices turns the motion of the chamber into something that can be read—the movement of a needle on a dial or a jagged line on a strip of graph paper.

16.1 Review

KEY CONCEPTS

1. How does the movement of air molecules cause pressure?
2. How does altitude affect air pressure?
3. How is air density related to air pressure?

CRITICAL THINKING

4. **Apply** Would you expect the air pressure in a valley that's below sea level to be higher or lower than air pressure at sea level? Explain.
5. **Predict** Two barometers are placed one kilometer apart. One shows higher pressure than the other. What will happen to air between them?

CHALLENGE

6. **Infer** The eardrum is a thin sheet of tissue that separates air in the middle part of your ear from air outside your ear. What could cause your eardrum to make a popping sound as you ride up a tall building in an elevator?

KEY CONCEPT

16.2 The atmosphere has wind patterns.

BEFORE, you learned

- Solar energy heats Earth's surface and atmosphere
- Differences in density cause air to move
- Air pressure differences set air in motion

NOW, you will learn

- About forces that affect wind
- About global winds
- About patterns of heating and cooling

VOCABULARY

weather p. 543
wind p. 543
global wind p. 544
Coriolis effect p. 545
jet stream p. 548
monsoon p. 550

EXPLORE Solar Energy

How does Earth's shape affect solar heating?

PROCEDURE

1. Place a globe on a desk in a darkened room.
2. Point a flashlight at the equator on the globe from a distance of about 15 centimeters. Keep the flashlight level. Observe the lighted area on the globe.
3. Keeping the flashlight level, raise it up and point it at the United States. Observe the lighted area.

MATERIALS

- globe
- flashlight
- ruler

WHAT DO YOU THINK?

- How were the two lighted areas different?
- What might have caused the difference?

Uneven heating causes air to move.

On local news broadcasts, weather forecasters often spend several minutes discussing what the weather will be like over the next few days. **Weather** is the condition of Earth's atmosphere at a particular time and place. Wind is an important part of weather. You will read about other weather factors later in this chapter.

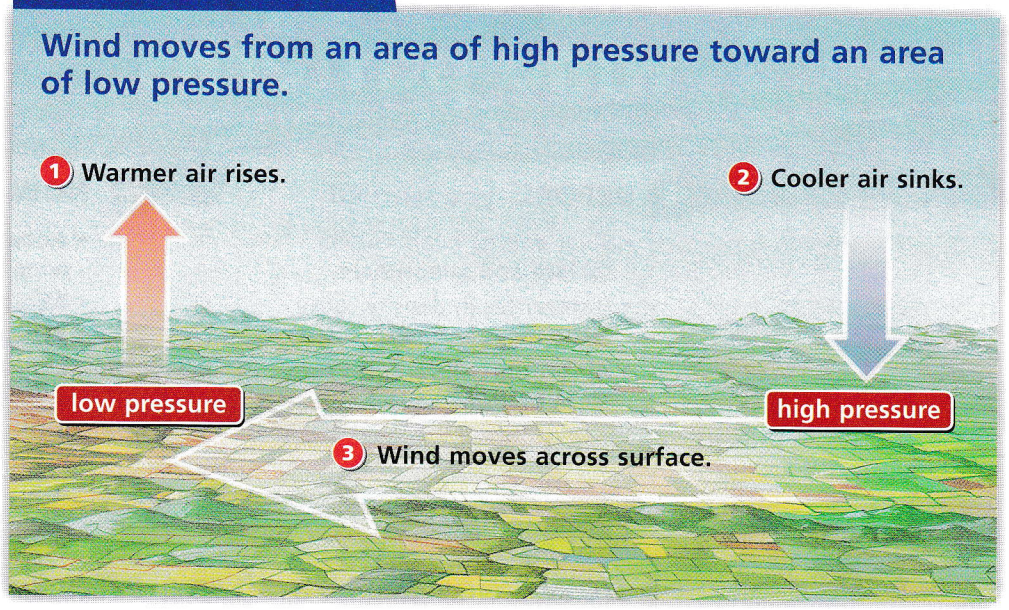
Wind is air that moves horizontally, or parallel to the ground. Remember that air pressure can differ from place to place at the same altitude. Uneven heating of Earth's surface causes such pressure differences, which set air in motion. Over a short distance, wind moves directly from higher pressure toward lower pressure.

REMINDER
Remember that air pressure is the force that air molecules exert on an area.

CHECK YOUR READING What is the relationship between air pressure and wind?

VISUALIZATION
CLASSZONE.COM
View an animation of the Coriolis effect.

How Wind Forms

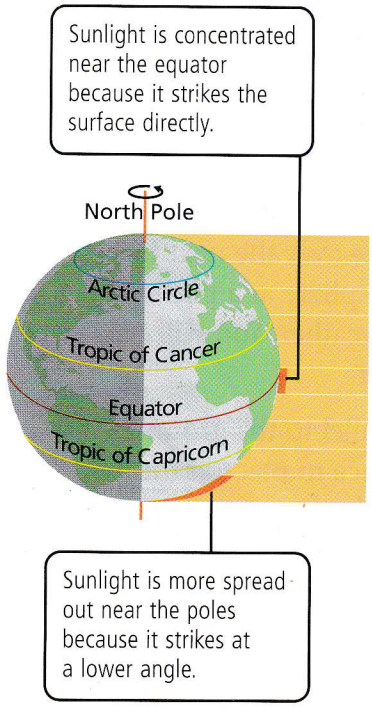


The illustration above shows a common pattern of air circulation caused by uneven heating of Earth's surface:

1. Sunlight strongly heats an area of ground. The ground heats the air. The warm air rises, and an area of low pressure forms.
2. Sunlight heats an area of ground less strongly. The cooler, dense air sinks slowly, and an area of high pressure forms.
3. Air moves as wind across the surface, from higher toward lower pressure.

When the difference in pressure between two areas is small, the wind may move too slowly to be noticeable. A very large pressure difference can produce wind strong enough to uproot trees.

CHECK YOUR READING What factor determines the strength of wind?



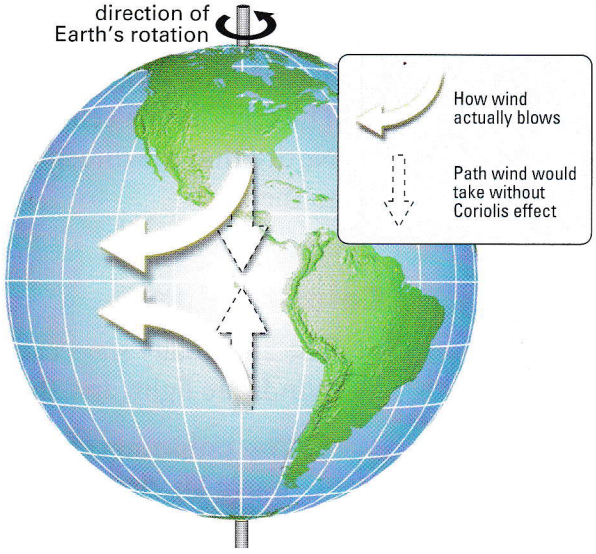
The distance winds travel varies. Some winds die out quickly after blowing a few meters. In contrast, **global winds** travel thousands of kilometers in steady patterns. Global winds last for weeks.

Uneven heating between the equator and the north and south poles causes global winds. Notice in the illustration at left how sunlight strikes Earth's curved surface. Near the equator, concentrated sunlight heats the surface to a high temperature. Warm air rises, producing low pressure.

In regions closer to the poles, the sunlight is more spread out. Because less of the Sun's energy reaches these regions, the air above them is cooler and denser. The sinking dense air produces high pressure that sets global winds in motion.

Earth's rotation affects wind direction.

If Earth did not rotate, global winds would flow directly from the poles to the equator. However, Earth's rotation changes the direction of winds and other objects moving over Earth. The influence of Earth's rotation is called the **Coriolis effect** (KAWR-ee-OH-lihs). Global winds curve as Earth turns beneath them. In the Northern Hemisphere, winds curve to the right in the direction of motion. Winds in the Southern Hemisphere curve to the left. The Coriolis effect is noticeable only for winds that travel long distances.



Because the Coriolis effect causes global winds to curve, they cannot flow directly from the poles to the equator. Instead, global winds travel along three routes in each hemisphere. These routes, which circle the world, are called global wind belts.

CHECK YOUR READING In which direction do winds curve in the Northern Hemisphere?

INVESTIGATE Coriolis Effect

How does Earth's rotation affect wind?

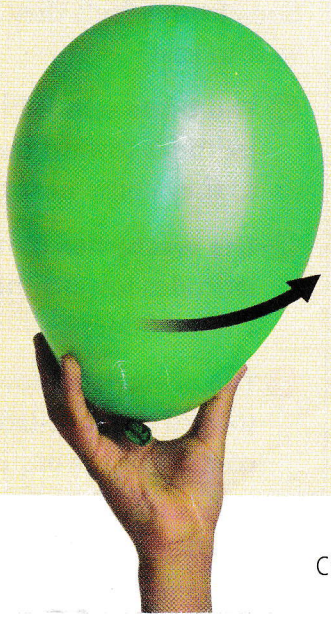
SKILL FOCUS
Modeling

MATERIALS
- round balloon
- felt-tip pen

TIME
10 minutes

PROCEDURE

1. Blow up a balloon and tie it off.
2. Have a classmate slowly rotate the balloon to the right. Draw a line straight down from the top of the balloon to the center as the balloon rotates.
3. Now draw a line from the bottom of the balloon straight up to the center as the balloon rotates.



WHAT DO YOU THINK?

- How did the rotation affect the lines that you drew?
- How does this activity demonstrate the Coriolis effect?

CHALLENGE How might changing the speed at which the balloon is rotated affect your results? Repeat the activity to test your prediction.

Bands of calm air separate global wind belts.

RESOURCE CENTER
CLASSZONE.COM
Learn more about global winds.

Earth's rotation and the uneven heating of its surface cause a pattern of wind belts separated by calm regions. Each calm region is a zone of either high pressure or low pressure. The illustration on page 547 shows how each wind belt and the calm regions that border it form a giant loop of moving air. These loops are called circulation cells. The section of a cell that flows along Earth's surface is global wind. Notice that the direction of airflow changes from one circulation cell to the next.

Calm Regions

The air usually stays calm in high-pressure and low-pressure zones. Winds are light, and they often change direction.

READING TiP
As you read about each region or wind belt, locate it in the diagram on page 547.

1. **The doldrums** are a low-pressure zone near the equator. There, warm air rises to the top of the troposphere, which is the atmosphere's lowest layer. Then the air spreads out toward the poles. The rising, moist air produces clouds and heavy rain. During the hottest months, heavy evaporation from warm ocean water in the region fuels tropical storms.
2. **The horse latitudes** are high-pressure zones located about 30° north and 30° south of the equator. Warm air traveling away from the equator cools and sinks in these regions. The weather tends to be clear and dry.

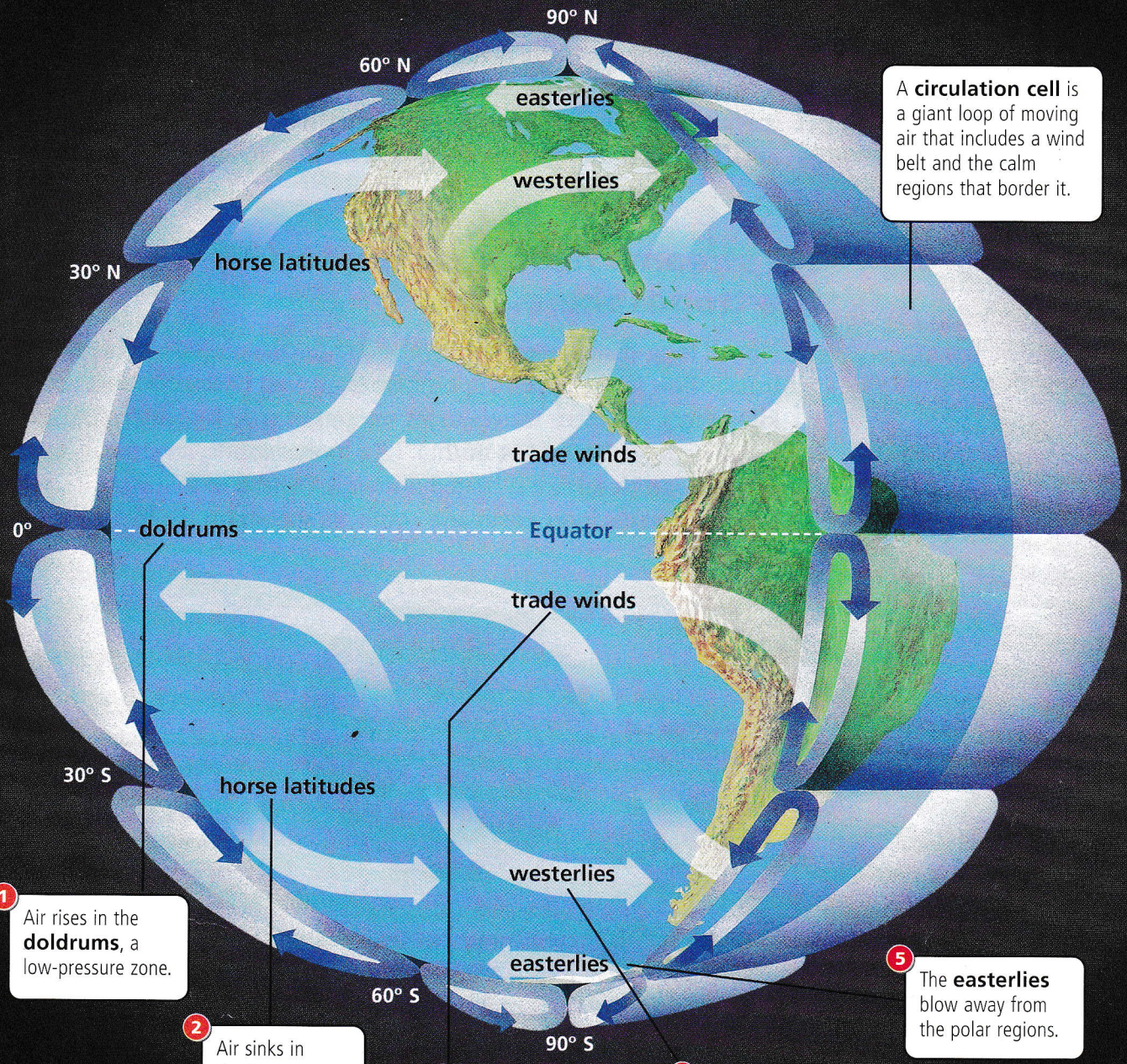
Wind Belts

As dense air sinks to Earth's surface in the horse latitudes and other high-pressure zones, it flows out toward regions of low pressure. This pattern of air movement produces three global wind belts in each hemisphere. Because of the Coriolis effect, the winds curve toward the east or toward the west. Some global winds are named for the directions from which they blow. The westerlies, for example, blow from west to east.

3. **The trade winds** blow from the east, moving from the horse latitudes toward the equator. These strong, steady winds die out as they come near the equator.
4. **The westerlies** blow from the west, moving from the horse latitudes toward the poles. They bring storms across much of the United States.
5. **The easterlies** blow from the east, moving from the polar regions toward the mid-latitudes. Stormy weather often occurs when the cold air of the easterlies meets the warmer air of the westerlies.

Global Winds

Belts of global wind circle Earth. Because of the Coriolis effect, the winds in these belts curve to the east or the west. Between the global wind belts are calm areas of rising or falling air.



A **circulation cell** is a giant loop of moving air that includes a wind belt and the calm regions that border it.

1. Air rises in the **doldrums**, a low-pressure zone.
2. Air sinks in the **horse latitudes,** a high-pressure zone.
3. The **trade winds** blow from the horse latitudes toward the equator.
4. The **westerlies** blow from the horse latitudes toward the poles.
5. The **easterlies** blow away from the polar regions.

READING VISUALS What are the positions of the calm regions and the wind belts in the circulation cells?

Effects of Wind on Travel

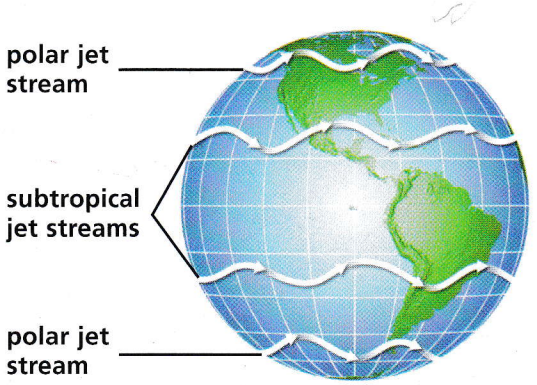
Before the invention of steam engines, sailors used to dread traveling through the doldrums and the horse latitudes. There often wasn't enough wind to move their sailing ships. A ship might stall for days or even weeks, wasting precious supplies of food and fresh water.

To avoid the calm regions, sailors sought out global wind belts. The trade winds got their name because traders used them to sail from east to west. For centuries, sailors relied on the trade winds to reach North America from Europe. They would return by sailing north to catch the westerlies and ride them across the Atlantic.

Jet streams flow near the top of the troposphere.

COMBINATION NOTES
Record information about how jet streams flow and their effects on weather and travel.

Not all long-distance winds travel along Earth's surface. **Jet streams** usually flow in the upper troposphere from west to east for thousands of kilometers. Air often moves in jet streams at speeds greater than 200 kilometers per hour (124 mi/hr). Like global winds, jet streams form because Earth's surface is heated unevenly. Instead of following a straight line, jet streams loop north and south, as shown on the globe below.



Jet streams flow in a wavy pattern from west to east around the world. They change positions during the year.

Each hemisphere usually has two jet streams, a polar jet stream and a subtropical jet stream. The polar jet streams flow closer to the poles in summer than in winter.

The polar jet stream has a strong influence on weather in North America. It can pull cold air down from Canada into the United States and pull warm air up toward Canada. In addition, strong storms tend to form along its loops. Scientists must know where the jet stream is flowing to make accurate weather predictions.

Jet streams also affect air-travel times. They usually flow 10 to 15 kilometers (6–9 mi) above Earth's surface. Since airplanes often fly at these altitudes, their travel times can be lengthened or shortened by the strong wind of a jet stream.

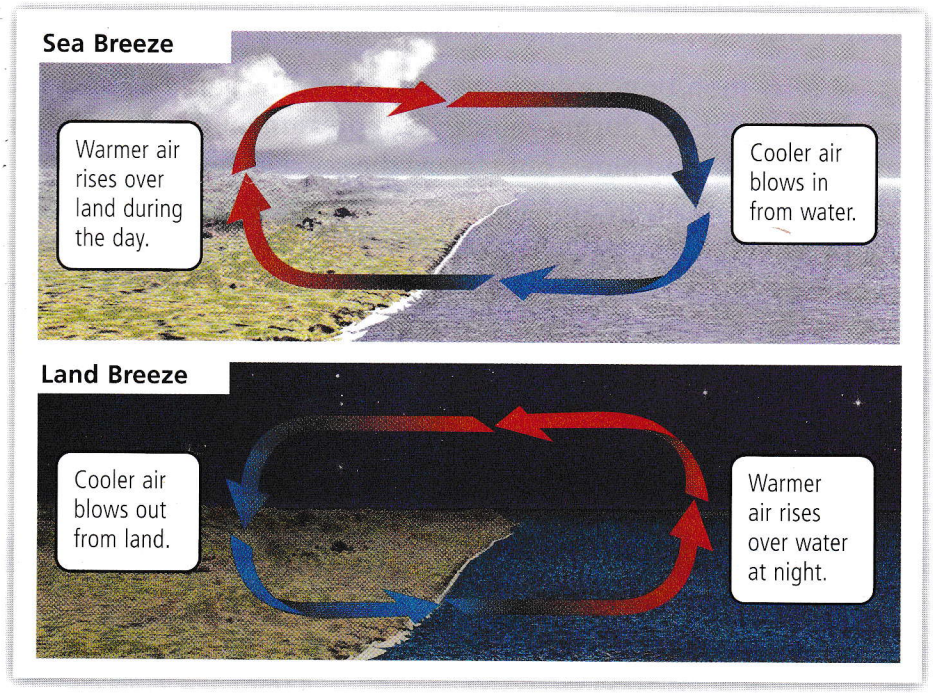
Patterns of heating and cooling cause local winds and monsoons.

Have you ever noticed how the wind can change in predictable ways? For example, at the beach on a hot day you will often feel a cool breeze coming off the water. At night a breeze will flow in the opposite direction. The change in the breeze occurs because water and land heat up and cool down at different rates.

Local Winds

Some winds change daily in a regular pattern. These local winds blow within small areas.

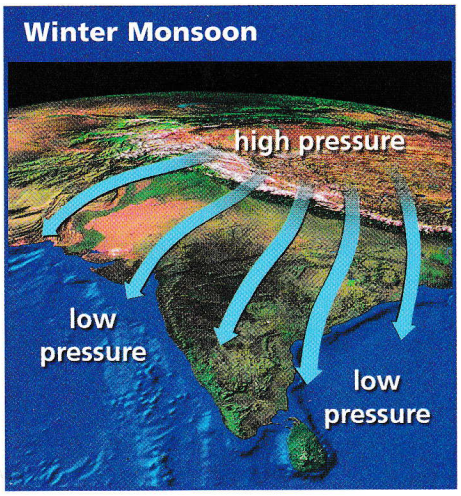
- Sea breezes and land breezes occur near shorelines. During the day, land heats up faster than water. The air over the land rises and expands. Denser ocean air moves into the area of low pressure, producing a sea breeze. As the illustration below shows, this pattern is reversed at night, when land cools faster than water. Warm air rises over the ocean, and cooler air flows in, producing a land breeze.



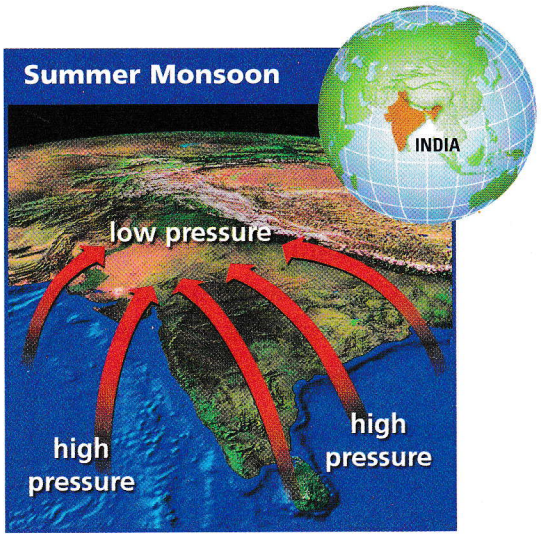
REMINDER
Red arrows stand for warmer air. Blue arrows stand for cooler air.

- Valley breezes and mountain breezes are caused by a similar process. Mountain slopes heat up and cool faster than the valleys below them. During the day, valley breezes flow up mountains. At night mountain breezes flow down into valleys.

CHECK YOUR READING How do mountains and bodies of water affect patterns of heating and cooling?



Dry air blows from the high-pressure area over the continent to the low-pressure areas over the ocean.



Moist air blows from the high-pressure areas over the ocean to the low-pressure area over the continent.

VOCABULARY
Add a description wheel for *monsoon* to your notebook.

Monsoons

Winds that change direction with the seasons are called **monsoons.** Like sea breezes and land breezes, monsoons are caused by the different heating and cooling rates of land and sea. However, monsoons flow longer distances and affect much larger areas.

Winter monsoons occur in regions where the land becomes much cooler than the sea during winter. High pressure builds over the land, and cool, dry wind blows out toward the sea. During summer this pattern reverses as the land becomes much warmer than the sea. Moist wind flows inland, often bringing heavy rains. The most extreme monsoons occur in South Asia and Southeast Asia. Farmers there depend on rain from the summer monsoon to grow crops.

CHECK YOUR READING How do monsoon winds affect rainfall?

16.2 Review

KEY CONCEPTS

1. How does the uneven heating of Earth's surface cause winds to flow?
2. How does Earth's rotation influence the movement of global winds?
3. Why do some winds change direction in areas where land is near water?

CRITICAL THINKING

4. **Compare and Contrast** How are global winds and local winds similar? How are they different?
5. **Analyze** Make a table that shows the causes and effects of local winds and monsoons.

CHALLENGE

6. **Predict** Suppose that a city is located in a valley between the sea and a mountain range. What kind of wind pattern would you predict for this area?

MATH in SCIENCE

SKILL: ADDING MEASUREMENTS

Navigate the Jet Stream

When an airplane is flying in the same direction as a jet stream, the airplane gets a boost in its speed. Pilots can save an hour or more if they fly with the jet stream. On the other hand, flying against the jet stream can slow an airplane down.

MATH TUTORIAL
CLASSZONE.COM
Click on Math Tutorial for more help with adding measures of time.

High clouds show the location of the jet stream in this satellite image.

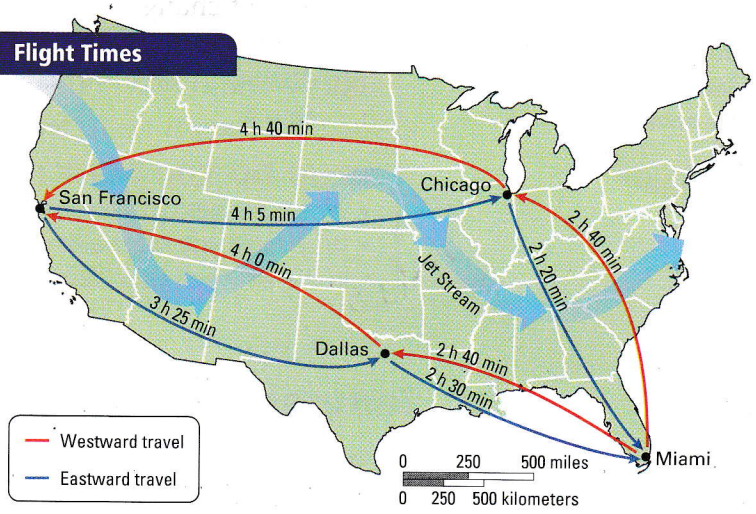
Example

To determine the total flight time between San Francisco and Chicago, with a stop in Denver, you need to add the hours and minutes separately. Set up the problem like this:

San Francisco to Denver:	2 h	10 min
Denver to Chicago:	1 h	45 min
Total flight time:	3 h	55 min

ANSWER The total flight time is 3 hours 55 minutes.

Flight Times



Use the map to answer the following questions.

1. What is the total flight time for an airliner flying from San Francisco to Miami through Chicago?
2. What is the total flight time for an airliner flying from San Francisco to Miami through Dallas?
3. How much time will the fastest possible trip from Miami to San Francisco take?
4. Compare the flight time from Chicago to San Francisco with the flight time from San Francisco to Chicago.

CHALLENGE What is the total flight time from Miami to San Francisco through Chicago? Convert minutes to hours if necessary.

KEY CONCEPT

16.3 Most clouds form as air rises and cools.

BEFORE, you learned

- Water vapor circulates from Earth to the atmosphere
- Warm air is less dense than cool air and tends to rise

NOW, you will learn

- How water in the atmosphere changes
- How clouds form
- About the types of clouds

VOCABULARY

evaporation p. 552
condensation p. 552
precipitation p. 553
humidity p. 554
saturation p. 554
relative humidity p. 554
dew point p. 554

EXPLORE Condensation

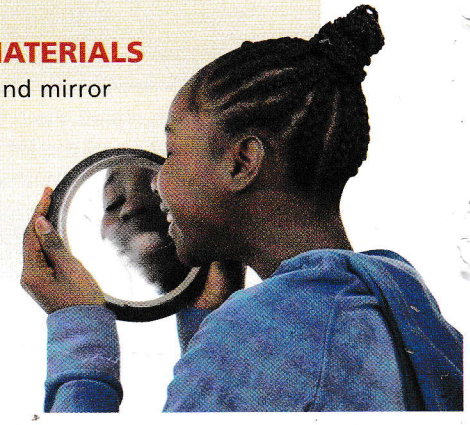
How does condensation occur?

PROCEDURE

1. Observe the air as a classmate breathes out.
2. Observe a mirror as a classmate breathes onto it.

MATERIALS

hand mirror



WHAT DO YOU THINK?

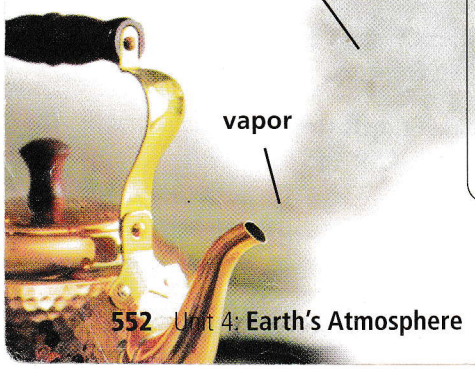
- What changes did you observe on the mirror?
- Why could you see water on the mirror but not in the air when your classmate breathed out?

Temperature affects water in the air.

Water is always in the atmosphere. You may see water in solid form, such as falling snow. Water may also be present as liquid water droplets. Even if you can't see any water, it is still part of the air as water vapor, an invisible gas. When temperatures change, water changes its form.

- **Evaporation** is the process by which a liquid changes into a gas. For water to evaporate, it needs extra energy.
- **Condensation** is the process by which a gas, such as water vapor, changes into a liquid. Condensation occurs when moist air cools.

The picture on the left shows the processes of evaporation and condensation at work. Water in a teakettle absorbs heat. It gets enough energy to evaporate into water vapor. The invisible water vapor rises and escapes from the kettle. When the vapor hits the cooler air outside the kettle, it cools and condenses into tiny but visible water droplets.



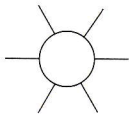
Water in the Air

Vast amounts of Earth's water are recycled. The oceans hold most of the water. Water is also stored in lakes, rivers, and ice sheets; in plants; and underground. Energy from sunlight causes molecules to evaporate from the surface of a body of water. These molecules become part of the air in the form of water vapor.

As air rises in the atmosphere, it cools. The loss of heat causes water vapor to condense into tiny water droplets or ice crystals. If the droplets or crystals grow and become heavy enough, they fall as rain, snow, sleet, or hail. Any type of liquid or solid water that falls to Earth's surface is called **precipitation.** Earth's water goes through a never-ending cycle of evaporation, condensation, and precipitation.

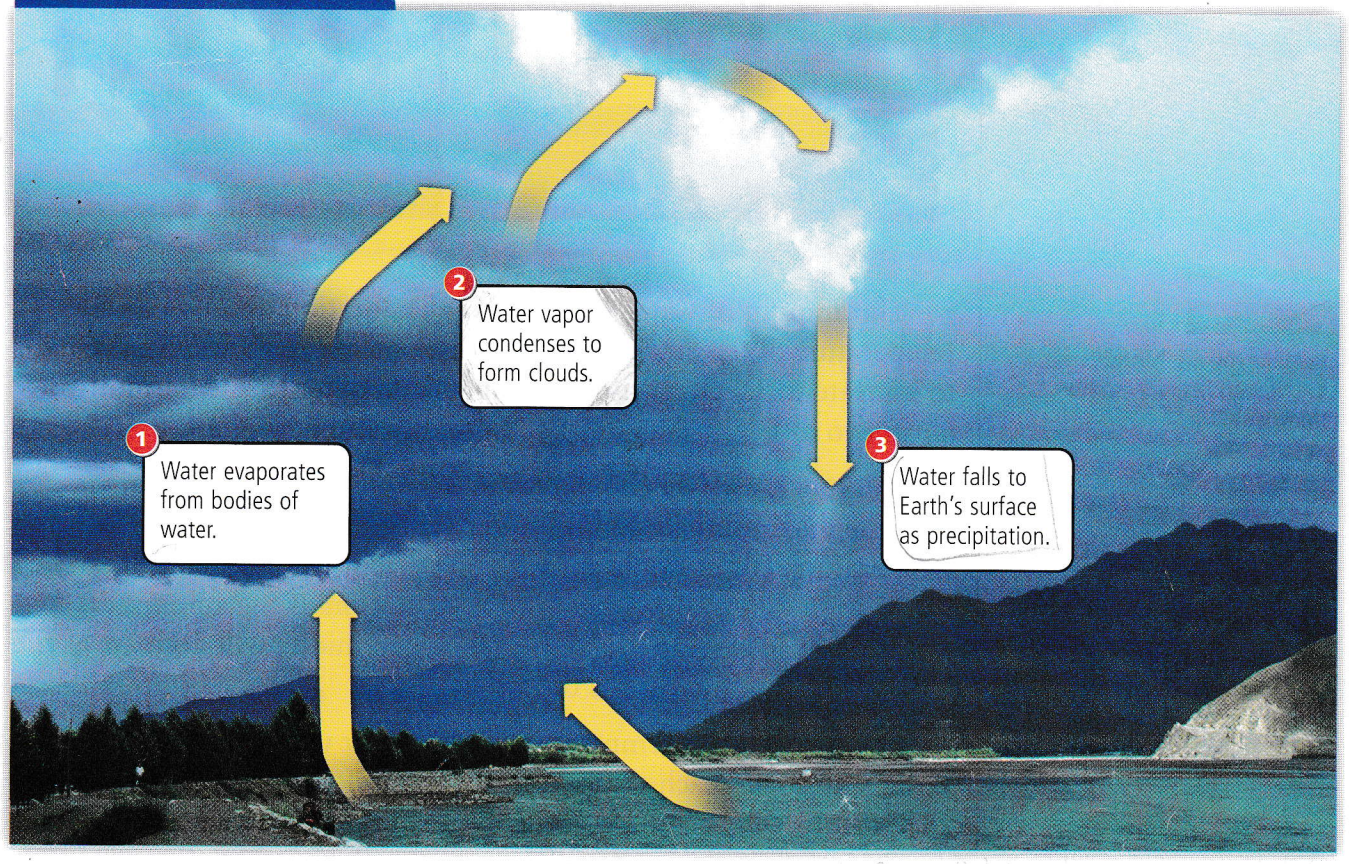
Water vapor can also condense on solid surfaces. Have you ever gotten your shoes wet while walking on grass in the early morning? The grass was covered with dew, which is water that has condensed on cool surfaces at night. If the temperature is cold enough, water vapor can change directly into a covering of ice, called frost.

VOCABULARY
Add a description wheel for *precipitation* to your notebook.



CHECK YOUR READING Summarize the way water moves in the water cycle. For each part of the cycle, specify whether water exists as a gas, liquid, or solid.

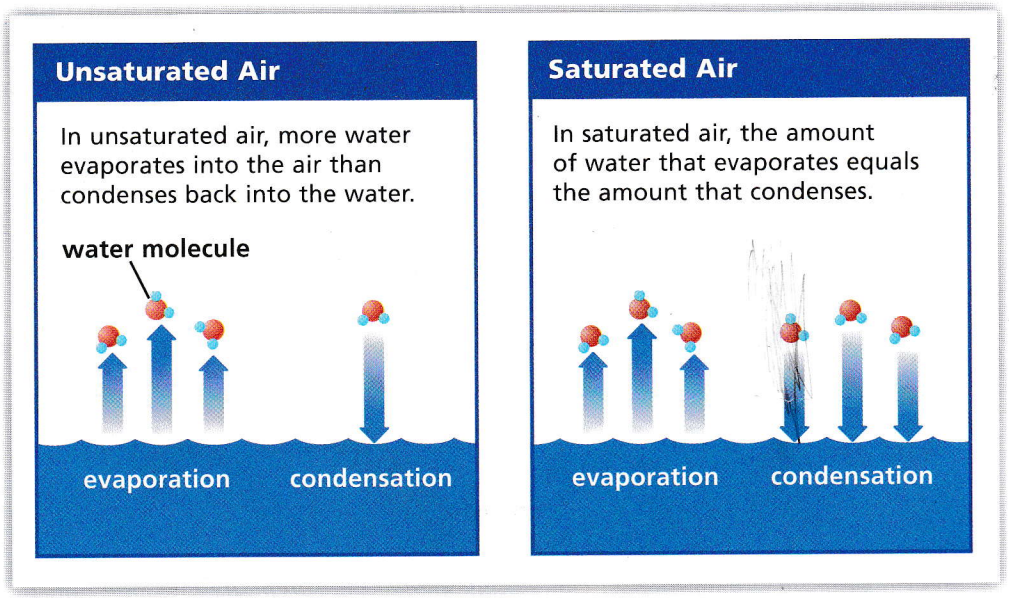
Water Cycle



Humidity and Relative Humidity

On a warm summer day, evaporation of moisture from your skin can help you feel comfortable. However, a lot of water vapor in the air can cause less moisture to evaporate from your skin. With less evaporation, the air will seem hotter and damper. **Humidity** is the amount of water vapor in air. Humidity varies from place to place and from time to time.

The illustration shows how humidity increases in a sealed container. As water molecules evaporate into the air, some start to condense and return to the water. For a while the air gains water vapor because more water evaporates than condenses. But eventually the air reaches **saturation,** a condition in which the rates of evaporation and condensation are equal. Any additional water that evaporates is balanced by water that condenses.



READING TiP

Relative means "considered in comparison with something else."

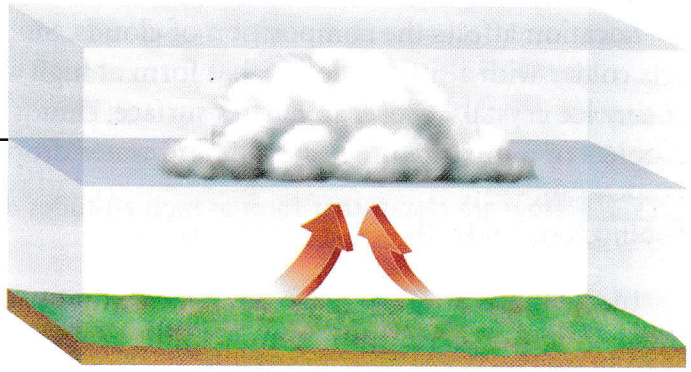
The amount of water vapor in air at saturation depends on the temperature of the air. The warmer air is, the more water vapor it takes to saturate it. Scientists use this principle to describe the humidity of air in two different ways: relative humidity and dew point.

Relative humidity compares the amount of water vapor in air with the maximum amount of water vapor that can be present at that temperature. For example, air with 50 percent relative humidity has half the amount of water needed for saturation. If the amount of water vapor in air stays the same, relative humidity will decrease as the air heats up and increase as the air cools.

Dew point is the temperature at which air with a given amount of water vapor will reach saturation. For example, air with a dew point of 26°C (79°F) will become saturated if it cools to 26°C. The higher the dew point of air, the more water vapor the air contains.

Water vapor condenses and forms clouds.

Clouds are made of condensed water vapor. As warm air rises in the atmosphere, it cools. When the air cools to its dew point—the temperature at which air reaches saturation—water vapor condenses into tiny droplets or ice crystals. These droplets and crystals are so light that they either float as clouds on rising air or fall very slowly.



Rising warm air can produce clouds. Water vapor begins to condense when the air cools to its dew point.

Recall how dew condenses on grass. Water must condense on something solid. There are no large solid surfaces in the air. However, the air is filled with tiny particles such as dust, smoke, and salt from the ocean. Water vapor condenses on these particles.

INVESTIGATE Condensation

How does a cloud form?

SKILL FOCUS
Observing

MATERIALS
- clear 1-liter plastic bottle with cap
- water at room temperature
- tablespoon
- matches

TIME
10 minutes

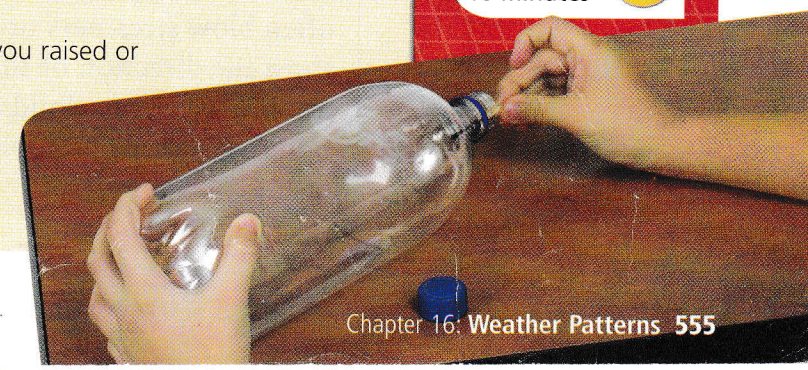
PROCEDURE

1. Add a spoonful of water to the bottle to increase the humidity inside it.
2. Lay the bottle on its side. Light a match, blow it out, and then stick the match into the bottle for a few seconds to let smoke flow in. Replace the cap.
3. Squeeze the bottle quickly and then release it. Observe what happens when the bottle is allowed to expand.

WHAT DO YOU THINK?

- What happened to the water vapor inside the bottle when you squeezed the bottle and then let it expand?
- How did the smoke affect what happened to the water vapor?

CHALLENGE How would the cloud change if you raised or lowered the temperature inside the bottle?



RESOURCE CENTER
CLASSZONE.COM
Observe different types of clouds.

Characteristics of Clouds

If you watch the sky over a period of time, you will probably observe clouds that do not look alike. Clouds have different characteristics because they form under different conditions. The shapes and sizes of clouds are mainly determined by air movement. For example, puffy clouds form in air that rises sharply or moves straight up and down. Flat, smooth clouds covering large areas form in air that rises gradually.

Location affects the composition of clouds. Since the troposphere gets colder with altitude, clouds that form at high altitudes are made of tiny ice crystals. Closer to Earth's surface, clouds are made of water droplets or a mixture of ice crystals and water droplets.

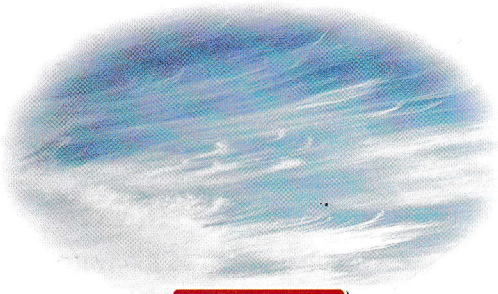
CHECK YOUR READING How are clouds that form at high altitudes different from clouds that form close to Earth's surface?

COMBINATION NOTES
Record information about the three main cloud types.

In the illustration on page 557, notice that some cloud names share word parts. That is because clouds are classified and named according to their altitudes, the ways they form, and their general characteristics. The three main types of clouds are cirrus, cumulus, and stratus. These names come from Latin words that suggest the clouds' appearances.

- ***Cirrus*** (SEER-uhs) means "curl of hair." Cirrus clouds appear feathery or wispy.
- ***Cumulus*** (KYOOM-yuh-luhs) means "heap" or "pile." Cumulus-type clouds can grow to be very tall.
- ***Stratus*** (STRAT-uhs) means "spread out." Stratus-type clouds form in flat layers.

Word parts are used to tell more about clouds. For example, names of clouds that produce precipitation contain the word part *nimbo-* or *nimbus*. Names of clouds that form at a medium altitude have the prefix *alto-*.

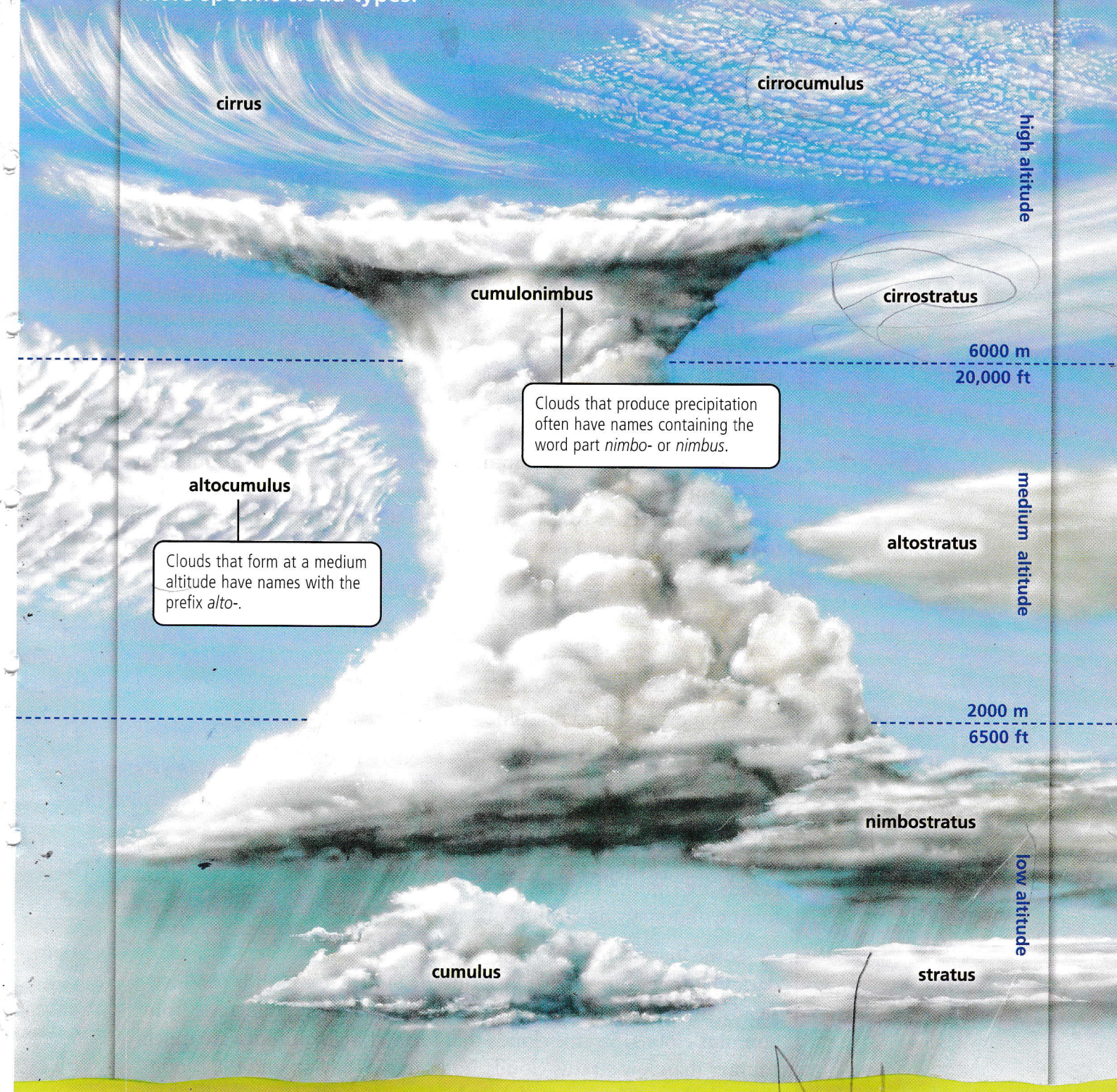

cirrus clouds

Cirrus Clouds

Cirrus clouds form in very cold air at high altitudes. Made of ice crystals, they have a wispy or feathery appearance. Strong winds often blow streamers or "tails" off cirrus clouds. These features show the direction of the wind in the upper troposphere. You will usually see cirrus clouds in fair weather. However, they can be a sign that a storm is approaching.

Cloud Types

The three main cloud types are cirrus, cumulus, and stratus. These names can be combined with each other and with other word parts to identify more specific cloud types.



READING VISUALS

Which cloud names are combinations of names of two main cloud types?

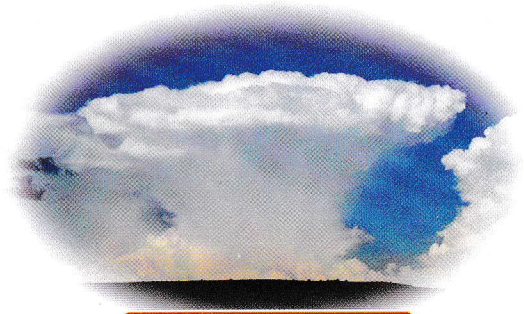
READING TiP

As you read each description of a main cloud type, look back at the visual on page 557. Notice the different clouds that have the main cloud type as part of their names.

Cumulus Clouds

cumulus clouds

Cumulus clouds are puffy white clouds with darker bases. They look like cotton balls floating in the sky. There are several varieties of cumulus clouds. Usually they appear in the daytime in fair weather, when warm air rises and its water vapor condenses. Cooler air sinks along the sides of the clouds, keeping cumulus clouds separate from one another.

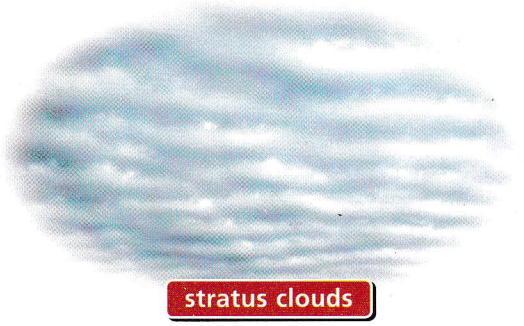


cumulonimbus clouds

If cumulus clouds keep growing taller, they can produce showers. The precipitation usually lasts less than half an hour because there are spaces between the clouds. The tallest clouds are cumulonimbus clouds, or thunderheads. These clouds produce thunderstorms that drop heavy rainfall. A cumulonimbus cloud can tower 18 kilometers (11 mi) above Earth's surface. By comparison, jet planes usually fly at about 10 kilometers (6 mi). Strong high-altitude winds often cause the top of the cloud to jut out sharply.

CHECK YOUR READING How are cumulonimbus clouds different from other cumulus clouds?

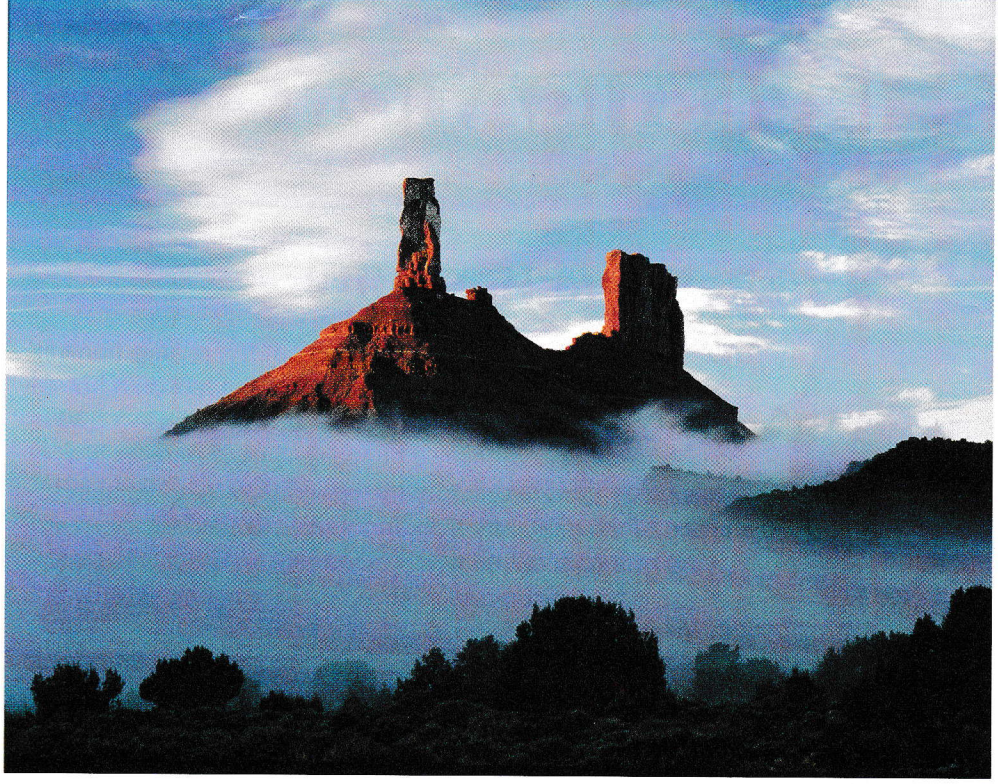
Stratus Clouds



stratus clouds

Have you ever noticed on some days that the whole sky looks gray? You were looking at stratus clouds. They form in layers when air cools over a large area without rising or when the air is gently lifted. Stratus clouds are smooth because they form without strong air movement.

Some low stratus clouds are so dark that they completely block out the Sun. These clouds produce steady, light precipitation—unlike the brief showers that come from cumulus clouds. Stratus clouds that form at high altitudes are much thinner than low stratus clouds. You can see the Sun and the Moon through them. The ice crystals in high stratus clouds can make it seem as if there's a circle of colored light around the Sun or the Moon.



This fog formed around Castleton Tower in Utah. The land cooled overnight, causing water vapor in the air above it to condense.

Fog

Fog is a cloud that rests on the ground or a body of water. Like stratus clouds, fog has a smooth appearance. It usually forms when a surface is colder than the air above it. Water vapor in the air condenses as it cools, forming a thick mist. Fog on land tends to be heaviest at dawn, after the ground has cooled overnight. It clears as the ground is heated up by sunlight.

Fog can look beautiful rolling over hills or partly covering structures such as bridges. However, it often makes transportation dangerous by limiting visibility. In the United States close to 700 people die each year in automobile accidents that occur in dense fog.

16.3 Review

KEY CONCEPTS

1. Describe the three forms in which water is present in the atmosphere.
2. How does altitude affect the composition of clouds?
3. How are clouds classified?

CRITICAL THINKING

4. **Summarize** Describe the main characteristics of cirrus, cumulus, and stratus clouds.
5. **Draw Conclusions** Why might cumulonimbus clouds be more likely to form on sunny days than on days with little sunlight?

CHALLENGE

6. **Apply** Imagine that the sky has turned very cloudy after a hot morning. You notice that the bread in your sandwich is soggy and the towels on the towel rack won't dry. Explain why these things are happening. Use the following terms in your answer: *condensation, evaporation, relative humidity.*

CHAPTER INVESTIGATION

Relative Humidity

OVERVIEW AND PURPOSE Finding out the relative humidity can help you predict how comfortable you will feel on a hot day or whether dew will form on the ground. You can use a psychrometer to measure relative humidity. A psychrometer is a device made from two thermometers—one with a wet bulb and the other with a dry bulb. In this activity you will

- make a milk-carton psychrometer
- use it to measure the relative humidity of the air at two locations in your school

Problem

Write It Up

Which location will have the greater relative humidity?

Hypothesize

Write It Up

Write a hypothesis in "If . . . , then . . . , because . . ." form to answer the problem.

Procedure

MATERIALS

- 2 thermometers
- cotton or felt cloth
- 3 rubber bands
- plastic bowl
- water at room temperature
- scissors
- pint milk carton
- ruler
- Relative Humidity Chart

1. Make a table like the one shown on the sample notebook page to record your data.

2. Check the two thermometers that you are using in this experiment to make sure they read the same temperature. Wrap a piece of cotton or felt cloth around the bulb of one thermometer. Hold the cloth in place with a rubber band as shown in the photograph. Dip this wet-bulb thermometer into a bowl of room-temperature water until the cloth is soaked.

3. Use scissors to cut a small hole in one side of the milk carton, 2 centimeters from the bottom of the carton. Place the wet-bulb thermometer on the same side as the hole that you made in the milk carton, and attach it with a rubber band. Push the tail of the cloth through the hole. Attach the dry-bulb thermometer as shown.

4. Fill the carton with water to just below the hole so that the cloth will remain wet. Empty the bowl and place the completed psychrometer inside it.

5. Write "science room" under the heading "Location 1" in your data table. Take your first readings in the science classroom about 10 minutes after you set up your psychrometer. Read the temperatures on the two thermometers in degrees Celsius. Record the temperature readings for the first location in the first column of your table.

6. Choose a second location in your school, and identify it under the heading "Location 2" in the data table. Take a second set of temperature readings with your psychrometer in this location. Record the readings in the second column of your table.

7. Subtract the wet-bulb reading from the dry-bulb reading for each location. Record this information in the third row of your data table.

8. Use the relative humidity table your teacher provides to find each relative humidity (expressed as a percentage). In the left-hand column, find the dry-bulb reading for location 1 that you recorded in step 5. Then find in the top line the number you recorded in step 7 (the difference between the dry-bulb and wet-bulb readings). Record the relative humidity in the last row of your data table. Repeat these steps for location 2.

Observe and Analyze

Write It Up

1. **RECORD OBSERVATIONS** Draw the setup of your psychrometer. Be sure your data table is complete.
2. **IDENTIFY** Identify the variables and constants in this experiment. List them in your **Science Notebook.**
3. **COMPARE** How do the wet-bulb readings compare with the dry-bulb readings?
4. **ANALYZE** If the difference between the temperature readings on the two thermometers is large, is the relative humidity high or low? Explain why.

Conclude

Write It Up

1. **INTERPRET** Answer the question in the problem. Compare your results with your hypothesis.
2. **IDENTIFY LIMITS** Describe any possible errors that you made in following the procedure.
3. **APPLY** How would you account for the differences in relative humidity that you obtained for the two locations in your school?

INVESTIGATE Further

CHALLENGE Use the psychrometer to keep track of the relative humidity in your classroom over a period of one week. Make a new chart to record your data. What do you notice about how the changes in relative humidity relate to the weather conditions outside?

Relative Humidity

Problem Which location will have the greater relative humidity?

Hypothesize

Observe and Analyze

Table 1. Relative Humidity at Two Locations

	Location 1	Location 2
Dry-bulb temperature		
Wet-bulb temperature		
Difference between dry-bulb and wet-bulb readings		
Relative humidity		

Conclude

KEY CONCEPT

16.4 Water falls to Earth's surface as precipitation.

BEFORE, you learned

- Water moves between Earth's surface and the atmosphere
- Water vapor condenses into clouds

NOW, you will learn

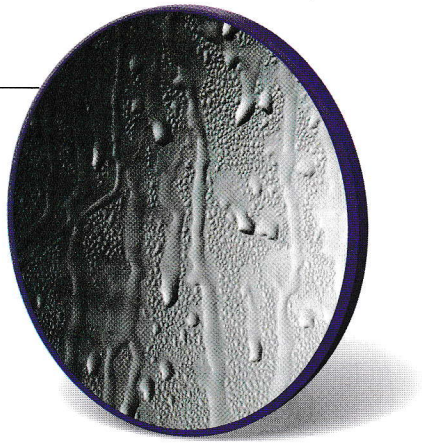
- How precipitation forms
- How precipitation is measured
- About acid rain

VOCABULARY

freezing rain p. 564
sleet p. 564
hail p. 564
acid rain p. 566

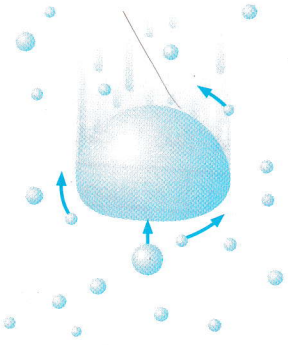
THINK ABOUT

Why does steam from a shower form large drops?



When you run a hot shower, the bathroom fills up with water vapor. The vapor condenses into tiny droplets that make it seem as if you are standing in fog. You may also see larger drops running down cool surfaces, such as a mirror. Why do some drops fall while others remain suspended?

Precipitation forms from water droplets or ice crystals.



Water droplets combining to form a raindrop

All precipitation comes from clouds. For example, rain occurs when water droplets in a cloud fall to the ground. Then why doesn't every cloud produce precipitation? Cloud droplets are much smaller than a typical raindrop. They weigh so little that it takes only a slight upward movement of air to hold them up. In order for rain to fall from a cloud and reach Earth's surface, the cloud droplets must become larger and heavier.

One way that precipitation can form is through the combining of cloud droplets. The tiny droplets of water move up and down in clouds. Some collide with each other and combine, forming slightly bigger droplets. As the droplets continue to combine, they grow larger and larger. Eventually they become heavy enough to fall. It takes about a million droplets to make a single raindrop.

Another way that precipitation can form is through the growth of ice crystals. When the temperature inside a cloud is below freezing, water vapor changes into tiny ice crystals. The crystals grow by collecting more water vapor or by colliding and merging with one another. When the crystals become heavy enough, they fall from the cloud. Snow isn't the only type of precipitation that forms this way. Most rain in the United States actually starts out as falling ice crystals. Before the crystals reach the ground, they melt in a layer of warm air.

CHECK YOUR READING How do cloud droplets become large enough to fall as precipitation?

Measuring Precipitation

Scientists use a rain gauge to measure rainfall. A funnel or opening at the top of the gauge allows rain to flow into a cylinder. By measuring the water collected, you can find out how much rain fell in a storm or over a period of time.

READING TiP A gauge (gayj) is an instrument used for measuring or testing.

Snow depth can be measured with a long ruler. Because the amount of water in snow varies, scientists use a special gauge to find out how much water the snow contains. A built-in heater melts the snow so that it can be measured just like rain.

go to very back of book

INVESTIGATE Precipitation

How much rain falls during a storm?

SKILL FOCUS
Measuring

MATERIALS
- scissors
- 1-liter plastic bottle
- gravel
- water
- permanent marker
- ruler

TIME
15 minutes

PROCEDURE

1. Cut off the top third of the bottle. Set this part aside.
2. Put some gravel at the bottom of the bottle to keep it from tipping over. Add water to cover the gravel. Draw a horizontal line on the bottle at the top of the water. Use a ruler to mark off centimeters on the bottle above the line that you drew. Now take the part of the bottle that you set aside and turn it upside down. Fit it inside the bottle to create a funnel.
3. Place the bottle outside when a rainstorm is expected. Make sure that nothing will block rain from entering it. Check your rain gauge after 24 hours. Observe and record the rainfall.

WHAT DO YOU THINK?
- How much rain fell during the time period?
- How do the measurements compare with your observations?

CHALLENGE Do you think you would measure the same amount of rain if you used a wider rain gauge? Explain.

When you watch weather reports on television, you often see storm systems passing across a weather map. Some of these images are made with Doppler radar. The radar shows which areas are getting precipitation and how fast it is falling. Forecasters use this information to estimate the total amount of precipitation an area will receive.

COMBINATION NOTES
Record information on precipitation in your combination notes.

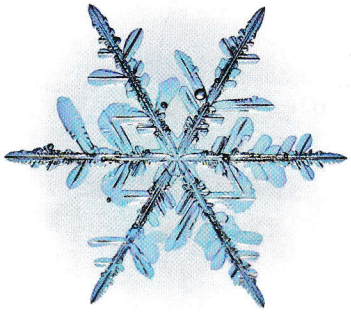
Types of Precipitation

Precipitation reaches Earth's surface in various forms. Some precipitation freezes or melts as it falls through the atmosphere.

1. **Rain and Drizzle** Rain is the most common type of precipitation. Raindrops form from liquid cloud droplets or from ice crystals that melt as they fall. A light rain with very small drops is called drizzle. Drizzle usually comes from stratus clouds, which don't have enough air movement to build up larger raindrops.

2. **Freezing Rain** Raindrops may freeze when they hit the ground or other surfaces in cold weather. **Freezing rain** covers surfaces with a coating of ice. During an ice storm, roads become slippery and dangerous. The weight of ice can also bring down trees and power lines.

3. **Sleet** When rain passes through a layer of cold air, it can freeze before hitting the ground. The small pellets of ice that form are called **sleet.**



Most snowflakes have six branches or sides.

4. **Snow** As ice crystals grow and merge in clouds, they become snowflakes. Snowflakes come in many different shapes and sizes. Usually they have six sides or branches. When snow falls through moist air that is near freezing, the flakes tend to join together in clumps. When snow falls through colder and drier air, snowflakes don't join together, and the snow is powdery.

5. **Hail** Surprisingly, the largest type of frozen precipitation often arrives in warm weather. Lumps or balls of ice that fall from cumulonimbus clouds are called **hail.** During a thunderstorm, violent air currents hurl ice pellets around the cloud. These pellets grow as water droplets freeze onto them at high elevations. Some start to fall and then are pushed back up again. They may repeat this process several times, adding a layer of ice each time. Eventually they fall to the ground.

   Large hailstones can damage property and injure people and animals. The biggest hailstone ever found in the United States weighed 1.7 pounds and was about as wide as a compact disc.

CHECK YOUR READING Which forms of precipitation undergo a change after they leave a cloud?

How Precipitation Forms

All precipitation forms from water droplets or ice crystals in clouds. Some precipitation freezes or melts after it falls from the clouds.

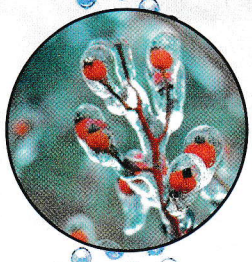
1. **Rain** and **drizzle** form from water droplets or ice crystals that melt as they fall.

2. **Freezing rain** is rain that freezes when it hits the ground or other surfaces.

3. **Sleet** is rain that freezes into ice pellets while falling through cold air.

4. **Snow** forms from ice crystals that merge in clouds.

5. **Hail** forms when ice pellets move up and down in clouds, growing larger as they gain layers of ice.



freezing rain

hail

READING VISUALS

What forms of precipitation occur most often where you live?

These trees have few needles because acid rain has damaged the trees.

Precipitation can carry pollution.

VOCABULARY
Add a description wheel for *acid rain* to your notebook.

Rainwater is naturally a little acidic. **Acid rain** is rain that has become much more acidic than normal because of pollution. Factories, power plants, automobiles, and some natural sources release sulfur dioxide and nitrogen oxides into the air. These gases can combine with water vapor to form sulfuric acid and nitric acid. The acids mix with cloud droplets or ice crystals that eventually fall to Earth's surface as precipitation.

Because wind can blow air pollution hundreds of kilometers, acid rain may fall far from the source of the pollution. Acid rain harms trees and raises the acidity of lakes, making it difficult for fish to live in them. Acid rain also damages the surfaces of buildings and sculptures.

CHECK YOUR READING How does acid rain form? Your answer should mention water vapor.

16.4 Review

KEY CONCEPTS

1. What are the two ways that rain can form?
2. How are rain and snow measured?
3. What human activities cause acid rain?

CRITICAL THINKING

4. **Compare and Contrast** How are sleet and freezing rain similar? How are they different?
5. **Draw Conclusions** When a large hailstone is cut open, four layers can be seen. What conclusions can you draw about the formation of the hailstone?

CHALLENGE

6. **Predict** Temperatures in a cloud and on the ground are below freezing. A warmer layer of air lies between the cloud and the ground. What type of precipitation do you predict will occur? Explain.

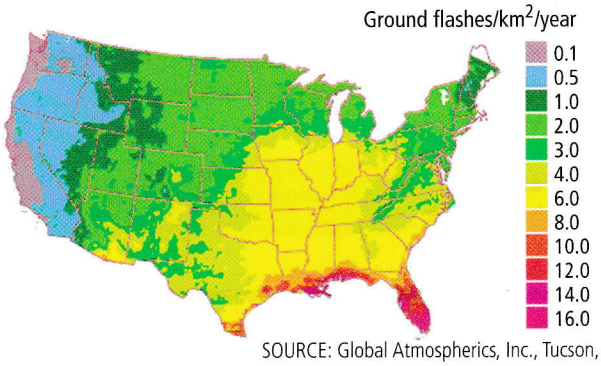
Caught Inside a Thunderhead

In 1959, engine failure forced Lieutenant Colonel William Rankin to eject from his plane at a high altitude. When his parachute opened, he thought he was out of danger. However, he soon realized that he was caught inside a cumulonimbus cloud during a fierce thunderstorm.

As Rankin hung by his parachute, violent air movement inside the cloud tossed him "up, down, sideways, clockwise." The rain was so heavy that he feared he would drown in midair. Lightning flashed all around him. Rankin finally landed 40 minutes after his adventure began. He had many injuries, including bruises from hailstones. Fortunately, none of the storm's lightning had struck him.

Lightning flashes to the ground from a thunderhead, or cumulonimbus cloud.

Where Lightning Strikes



SOURCE: Global Atmospherics, Inc., Tucson, AZ

Water, Wind, Hail, and Lightning

- A cumulonimbus cloud, or thunderhead, can rise to over 18 kilometers above Earth's surface. That's about twice the elevation of Mount Everest.
- A cumulonimbus cloud may contain 500,000 tons of water.
- Thunderstorm clouds cause 8 million lightning flashes each day.

EXPLORE

1. **ANALYZE** Find where you live on the map. Use the color key to figure out how often lightning strikes each square kilometer in your area.
2. **CHALLENGE** Use information from the Resource Center to propose an explanation for the pattern of lightning frequencies shown on the map.

RESOURCE CENTER
CLASSZONE.COM
Learn more about lightning.

16 Chapter Review

the BIG idea

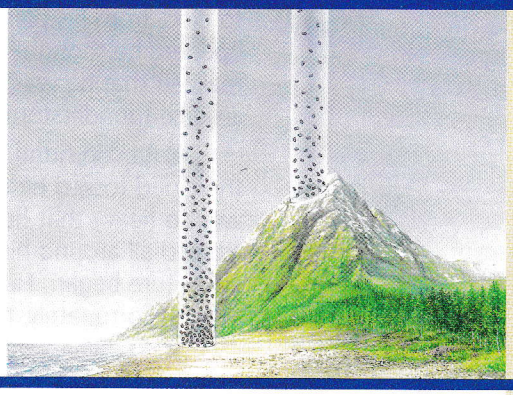
Some features of weather have predictable patterns.

CONTENT REVIEW
CLASSZONE.COM

KEY CONCEPTS SUMMARY

1 The atmosphere's air pressure changes.

Air pressure is the force of air molecules pushing on an area. Air pressure decreases as you move higher in the atmosphere. Air pressure can also differ in two locations at the same altitude.



VOCABULARY
air pressure p. 539
barometer p. 542

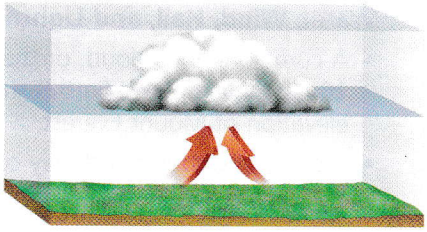
2 The atmosphere has wind patterns.

Wind blows from areas of high pressure toward areas of low pressure. Earth's rotation causes long-distance winds to curve.

VOCABULARY
weather p. 543
wind p. 543
global wind p. 544
Coriolis effect p. 545
jet stream p. 548
monsoon p. 550

3 Most clouds form as air rises and cools.

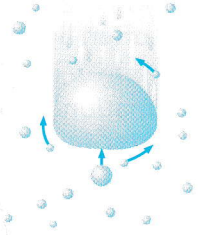
Clouds are made of tiny water droplets or ice crystals that condense from water vapor in rising air.



VOCABULARY
evaporation p. 552
condensation p. 552
precipitation p. 553
humidity p. 554
saturation p. 554
relative humidity p. 554
dew point p. 554

4 Water falls to Earth's surface as precipitation.

Water droplets in clouds merge to form raindrops.



Ice crystals in clouds can form snow, rain, and other types of precipitation.

VOCABULARY
freezing rain p. 564
sleet p. 564
hail p. 564
acid rain p. 566

Reviewing Vocabulary

Write a definition of each term. Use the meaning of the underlined root to help you.

Word	Root Meaning	Definition
EXAMPLE air pressure	to apply force	the force of air molecules pushing on an area
1. barometer	weight	
2. saturation	to fill	
3. global wind	sphere	
4. monsoon	season	
5. evaporation	steam	
6. condensation	thick	
7. humidity	moist	
8. precipitation	thrown down	

Reviewing Key Concepts

Multiple Choice *Choose the letter of the best answer.*

9. The movement of air molecules causes
- **a.** air density
- **b.** air pressure
- **c.** humidity
- **d.** relative humidity

10. Winds curve as they move across Earth's surface because of
- **a.** the Coriolis effect
- **b.** air pressure
- **c.** humidity
- **d.** relative humidity

11. Jet streams generally flow toward the
- **a.** north
- **b.** south
- **c.** east
- **d.** west

12. Condensation increases with greater
- **a.** relative humidity
- **b.** air temperature
- **c.** air pressure
- **d.** wind speed

13. Any type of liquid or solid water that falls to Earth's surface is called
- **a.** precipitation
- **b.** dew
- **c.** a monsoon
- **d.** humidity

14. What are low-altitude clouds composed of?
- **a.** snowflakes
- **b.** raindrops
- **c.** water droplets
- **d.** water vapor

15. Clouds made of ice crystals form under conditions of
- **a.** strong winds
- **b.** high altitude
- **c.** low humidity
- **d.** high pressure

16. Which type of cloud is most likely to bring thunderstorms?
- **a.** stratus
- **b.** altostratus
- **c.** cumulonimbus
- **d.** cirrus

17. Over short distances wind blows toward areas of
- **a.** high pressure
- **b.** high density
- **c.** low temperature
- **d.** low pressure

18. The doldrums and the horse latitudes are both regions of
- **a.** high air pressure
- **b.** light winds
- **c.** heavy rains
- **d.** low temperatures

19. As altitude increases, air pressure usually
- **a.** decreases
- **b.** increases
- **c.** varies more
- **d.** varies less

Short Answer *Write a short answer to each question.*

20. What causes land breezes to flow at night?

21. Why does hair take longer to dry after a shower on days with high relative humidity?

22. How does air pressure affect air density?

23. Why are dust and other particles necessary for precipitation?

24. How did global wind belts and calm regions affect transportation in the past?

Thinking Critically

The soil in this terrarium was soaked with water two weeks ago. Then the box was sealed so that no moisture could escape. Use the diagram to answer the next six questions.

25. **IDENTIFY EFFECTS** How does sunlight affect conditions inside the terrarium?

26. **ANALYZE** Draw a diagram of the water cycle inside the terrarium.

27. **INFER** What do the water drops on the glass indicate about the temperatures inside and outside the terrarium?

28. **PREDICT** Explain how long you think the plants will live without being watered.

29. **PREDICT** What would happen if you placed the terrarium on top of a block of ice?

30. **HYPOTHESIZE** How would conditions inside the terrarium change if there were a hole in one side of it?

31. **COMPARE AND CONTRAST** How are sea breezes and monsoon winds alike, and how are they different?

32. **PREDICT** A cumulus cloud is growing taller. What will happen to the density of the air beneath it? Explain.

33. **INFER** Imagine that a group of factories and power plants lies 200 kilometers to the west of a forest where trees are dying. Describe three steps in a process that could be causing the trees to die.

IDENTIFY EFFECTS Write the type of precipitation that would form under each set of conditions.

Conditions	Precipitation
34. above-freezing air inside a cloud and freezing air beneath it	
35. above-freezing air beneath a cloud and freezing temperatures on the ground	
36. below-freezing air inside a cloud and above-freezing temperatures in the air beneath it and on the ground	
37. below-freezing air inside a cloud and beneath it	
38. ice pellets hurled around by air currents inside a cloud	

the BIG idea

39. **APPLY** Look again at the photograph on pages 536–537. Now that you have finished the chapter, how would you change your response to the question on the photograph?

40. **WRITE** Write one or more paragraphs explaining how energy from the Sun influences the weather. In your discussion, include at least three of the following topics:

- global wind belts
- high- and low-pressure areas
- local winds
- monsoons
- the water cycle
- cloud formation

UNIT PROJECTS

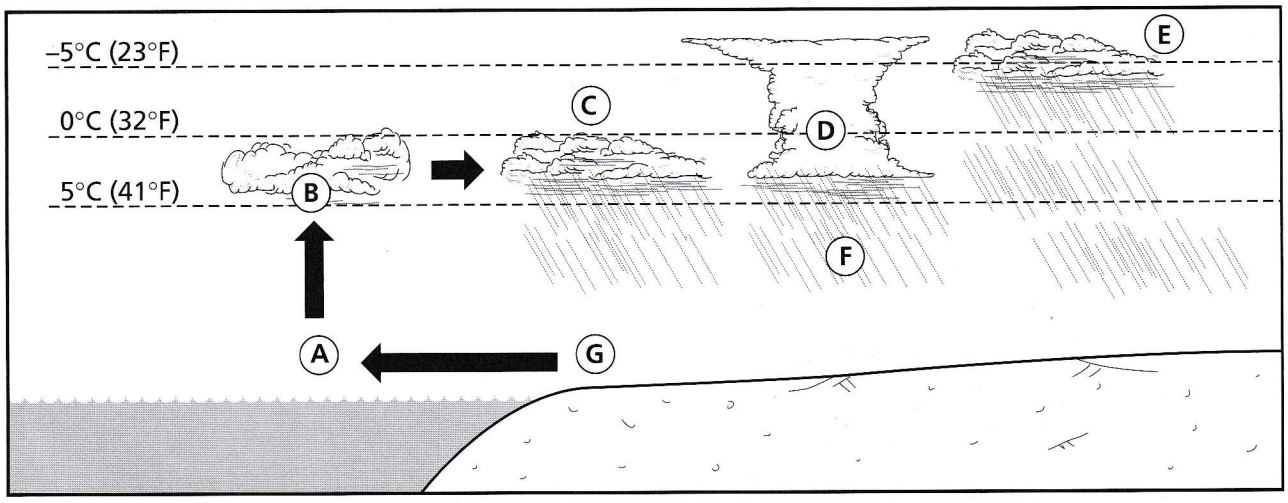
If you need to do an experiment for your unit project, gather the materials. Be sure to allow enough time to observe results before the project is due.

Standardized Test Practice

For practice on your state test, go to . . .
TEST PRACTICE
CLASSZONE.COM

Analyzing a Diagram

This diagram shows the water cycle. Use it to answer the questions below.



1. Where is evaporation occurring?
- **a.** A
- **b.** D
- **c.** F
- **d.** G

2. Where is condensation occurring?
- **a.** A
- **b.** B
- **c.** F
- **d.** G

3. Where is precipitation shown?
- **a.** A
- **b.** C
- **c.** E
- **d.** F

4. Where is hail most likely to form?
- **a.** C
- **b.** D
- **c.** E
- **d.** F

5. From which cloud will precipitation fall as snow and then turn to rain?
- **a.** B
- **b.** C
- **c.** D
- **d.** E

6. Which is the best estimate for the temperature in B?
- **a.** 8°C (46°F)
- **b.** 3°C (37°F)
- **c.** –3°C (27°F)
- **d.** –8°C (17°F)

7. What does the arrow pointing up between A and B indicate?
- **a.** the movement of moisture
- **b.** the direction of the wind
- **c.** a low pressure area
- **d.** a reflection off the water

Extended Response

Answer the two questions below in detail. Include some of the terms shown in the word box. In your answers underline each term you use.

low air pressure	cool air	west
high air pressure	warm air	east
Coriolis effect		

8. Whenever Richard rides in an elevator to the top of a skyscraper, he feels a pop inside his ears. Explain what is happening in the air to produce the pop in Richard's ears.

9. Winds tend to blow from west to east across the United States. If Earth spun in the other direction, how might the winds across the United States be different? Use the terms *east, west,* and *Coriolis effect* in your answer.