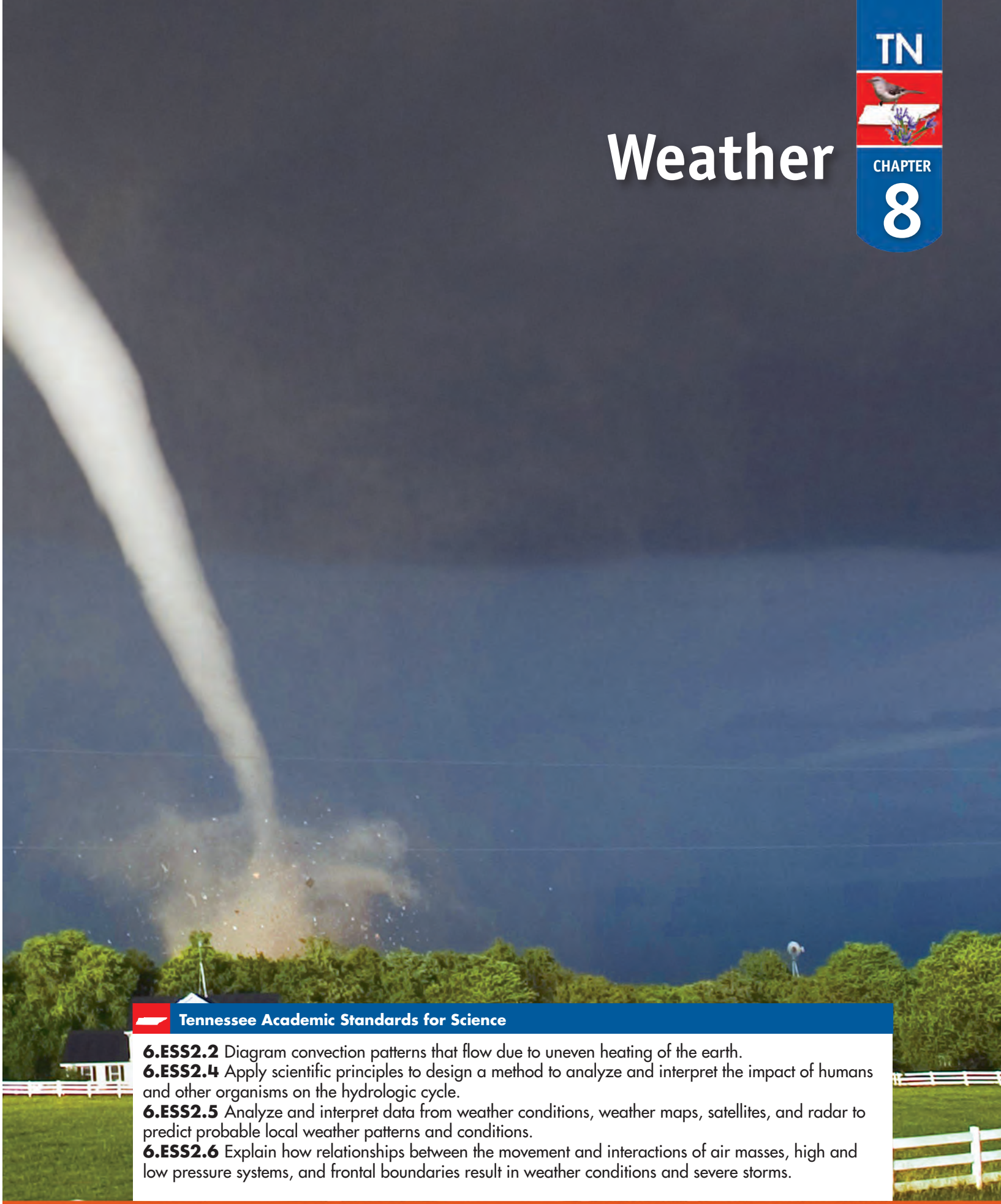
WHAT CLUES CAN PREDICT A STORM?

How do meteorologists predict the weather?

This tornado bearing down on this home in Kansas in June of 2004 reached wind speeds of 254–331 km/h. The state of Kansas had 124 tornadoes that year. Although tornadoes can occur anywhere, the United States leads the world with more than 1,000 tornadoes per year.

Observe **How could you predict a tornado was coming?**

Watch the **Untamed Science** video to learn more about weather.



TN

CHAPTER 8

Weather

Tennessee Academic Standards for Science

6.ESS2.2 Diagram convection patterns that flow due to uneven heating of the earth.
6.ESS2.4 Apply scientific principles to design a method to analyze and interpret the impact of humans and other organisms on the hydrologic cycle.
6.ESS2.5 Analyze and interpret data from weather conditions, weather maps, satellites, and radar to predict probable local weather patterns and conditions.
6.ESS2.6 Explain how relationships between the movement and interactions of air masses, high and low pressure systems, and frontal boundaries result in weather conditions and severe storms.

CHAPTER 8

Getting Started

Check Your Understanding

1. **Background** Read the paragraph below and then answer the question.

> "Is that smoke over the baseball field?" Eddie asked Cara in the park. "No," she replied. "It's **fog.**" "Ah, water **vapor,**" Eddie said. "No," Cara said. "If you can see it, it's water droplets suspended in the **atmosphere.** Water vapor is an invisible gas and can't be seen."

Fog is made up of clouds that form near the ground.

Vapor is water in the form of a gas.

The **atmosphere** is the envelope of gases surrounding Earth.

- What does water vapor in the atmosphere look like?

Vocabulary Skill

Prefixes A prefix is a word part that is added at the beginning of a word to change its meaning. For example, the prefix *anti-* means "against" or "opposed to" and is used frequently in science. In the word *antivenom*, the prefix *anti-* is added to the word *venom* to form *antivenom*, meaning "against poison."

Prefix	Meaning	Example
psychro-	cold	psychrometer, *n.*
alto-	high	altocumulus, *n.*; altostratus, *n.*
anti-	against or opposed to	anticyclone, *n.*

2. **Quick Check** **Review the prefixes above. Then predict what the word *altocumulus* means using what you know about the prefix *alto-*. After reading the chapter, revise your definition as needed.**

Chapter Preview

LESSON 1

- water cycle
- evaporation
- condensation
- humidity
- relative humidity
- psychrometer

Sequence
Interpret Data

LESSON 2

- dew point
- cirrus
- cumulus
- stratus

Summarize
Predict

LESSON 3

- precipitation
- rain gauge
- flood
- drought

Relate Cause and Effect
Calculate

LESSON 4

- wind
- anemometer
- windchill factor
- local winds
- sea breeze
- land breeze
- global winds
- Coriolis effect
- latitude

Identify Supporting Evidence
Draw Conclusions

LESSON 5

- air mass
- tropical
- polar
- maritime
- continental
- jet stream
- front
- occluded
- cyclone
- anticyclone

Relate Text and Visuals
Classify

LESSON 6

- storm
- thunderstorm
- lightning
- hurricane
- storm surge
- tornado
- evacuate

Outline
Infer

LESSON 7

- meteorologist
- isobar
- isotherm

Compare and Contrast
Predict

CCC: Cause and Effect

Scenario Investigation

Predicting the Weather Is No Sport

SEP: Analyzing and Interpreting Data

Purpose To predict weekend weather by following the movement of weather systems across the United States

Materials

- daily weather maps for one week (Monday–Friday)
- tracing paper
- two blank maps of the United States

Scenario

You are the sports reporter for the newspaper in your town. The paper's weather forecaster is going on vacation this Friday, and it's your turn to forecast the weekend weather. This is a real problem because you're not a meteorologist! You can't even forecast the winner of your town's high school football games.

The forecaster tries to calm you: "Don't worry. A few days of weather maps will show you what's coming. Watch the low- and high-pressure systems and fronts as they move across the United States." The forecaster also recommends that you ask yourself the following questions:

- What direction do the fronts move?
- How fast do they move?
- Is colder or warmer weather coming?
- Is rain moving your way?

The forecaster's last piece of advice is "Just pay attention, and forecasting is easy."

Procedure

1. **Five Days of Maps** Each day for the next five days your teacher will give you a copy of the day's weather map from the local newspaper.
2. **Panic on Monday** Don't panic yet. All you can do today is examine the map and make a copy of it. Notice the position of high- and low-pressure systems and fronts, the daily high temperatures, and the type and amount of precipitation. Pay attention to anything you think might be helpful in predicting your weekend weather. Trace the map onto tracing paper.
3. **Tuesday** Trace Tuesday's map and compare it to Monday's map. Notice that the weather moves. Pay close attention to the direction and speed of that movement. Based on movement alone, try to predict tomorrow's high temperature and precipitation for your town.

Procedure *(continued)*

☑ **4. Wednesday** Trace Wednesday's map. Was your prediction right? Is it raining? How hot will it be today? Is the weather still moving the same direction? Is it still moving at the same speed? Take what you learn and use Wednesday's map to predict Thursday's weather.

☑ **5. Thursday** Trace Thursday's map. Ask yourself the same questions from Step 4 and use Thursday's map to predict Friday's weather.

Conclusion

Let's see what you learned about the movement of weather across the country.

☑ **1.** According to the weather maps, does precipitation seem to come with high pressure or low pressure?

☑ **2.** In what direction does weather usually move across the United States? What causes weather to move in this direction?

☑ **3.** If a front passed through your town during the week, name the type of front, the day it came through, and tell how the weather changed. If a front didn't pass through your town, choose another city and answer the questions.

Friday is the big day. Time has run out, and you have learned everything you could. Your paper's regular weather forecaster left for vacation. It's time for you to write the weather forecast for the weekend edition of the paper. What will the weather be on Saturday and Sunday? Use two blank maps of the United States to show where you think the pressure systems and fronts will be this weekend. Where will it be raining or snowing? Provide a key for any symbols you use.

Prepare a more detailed forecast for the weather in your town for each day. Predict the high and low temperatures. Will it rain or snow where you live? Will it be cloudy or sunny? You can present your forecast in a chart or in complete sentences. Over the weekend, pay attention to the weather to see how you did.

TN

LESSON 1

6.ESS2.4

Water in the Atmosphere

UNLOCK THE BIG ?

- How Does Water Move Through the Atmosphere?
- What Is Relative Humidity and How Is It Measured?

MY PLANET DIARY

The Driest Place on Earth

The Atacama Desert in Chile is so dry that there are places where humans have never measured a single drop of rain. But even the Atacama has some moisture in the air. A dense fog along the coastline, known as *camanchaca*, often flows inland from the Pacific Ocean. At one point, the people of the fishing village Chungungo set up nets above the mountains to catch the fog. Water condensed on the nets and then was collected and sent through pipes that brought the water to the village.

FUN FACT

Write your answers to each question below. Then discuss your answers with a partner.

1. Why did the people of Chungungo need to use nets to catch moisture in the air?

2. What would be one way of collecting water where you live?

Lab zone® Do the Inquiry Warm-Up *Where Did the Water Go?*

How Does Water Move Through the Atmosphere?

During a rainstorm, the air feels moist. On a clear, cloudless day, the air may feel dry. As the sun heats the land and oceans, the sun provides energy to change the amount of water in the atmosphere. Water is always moving between Earth's atmosphere and surface.

The movement of water through Earth's systems, powered by the sun's energy, is the **water cycle.** **In the water cycle, water vapor enters the atmosphere by evaporation from the oceans and other bodies of water and leaves by condensation.** **Evaporation** is the process by which molecules of liquid water escape into the air after becoming water vapor. **Condensation** is the process by which water vapor becomes liquid water.

Vocabulary

- water cycle
- evaporation
- condensation
- humidity
- relative humidity
- psychrometer

Skills

Reading: Sequence

Inquiry: Interpret Data

Water vapor is also added to the air by living things. Water enters the roots of plants, rises to the leaves, and is released into the air as water vapor. Animals also release water vapor into the air every time they exhale.

As part of the water cycle, shown in **Figure 1,** some of the water vapor in the atmosphere condenses to form clouds. Rain and snow fall from the clouds toward the surface as precipitation. The water then runs off the surface or moves through the ground, back into lakes, streams, and eventually the oceans. Then the water cycle starts all over again with evaporation.

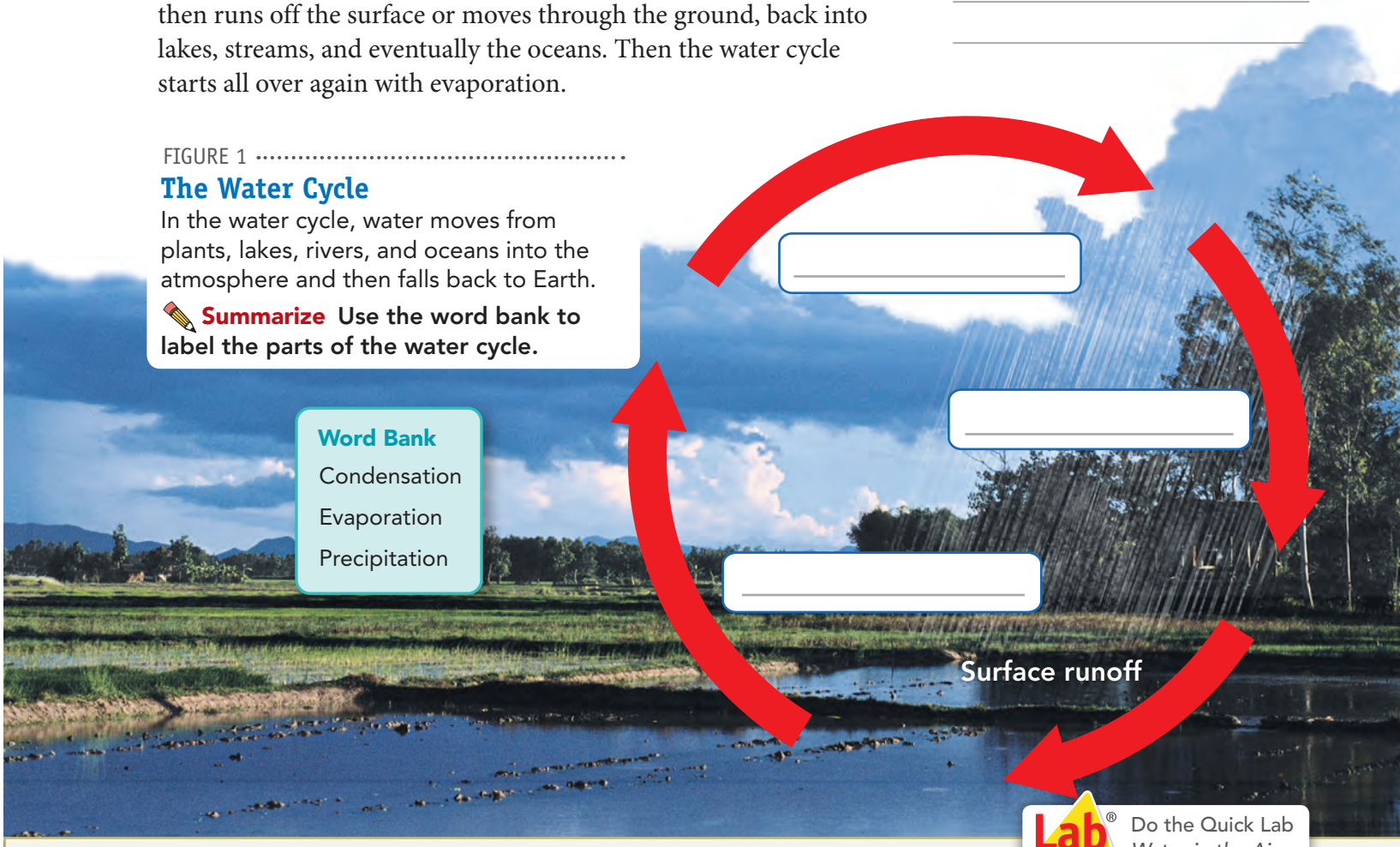
Sequence Starting with precipitation, list the order of the steps of the water cycle.

FIGURE 1

The Water Cycle

In the water cycle, water moves from plants, lakes, rivers, and oceans into the atmosphere and then falls back to Earth.

Summarize **Use the word bank to label the parts of the water cycle.**



Lab zone® Do the Quick Lab *Water in the Air.*

Assess Your Understanding

got it?

- I get it! Now I know that in the water cycle _____
- I need extra help with _____

What Is Relative Humidity and How Is It Measured?

How is the quantity of water vapor in the atmosphere measured? **Humidity** is a measure of the amount of water vapor in the air. The ability of air to hold water vapor depends on its temperature. Warm air can hold more water vapor than cool air.

Relative Humidity

Weather reports usually refer to the water vapor in the air as relative humidity. **Relative humidity** is the percentage of water vapor that is actually in the air compared to the maximum amount of water vapor the air can hold at a particular temperature. For example, at 10°C, 1 cubic meter of air can hold at most 8 grams of water vapor. If there were 8 grams of water vapor in the air, then the relative humidity of the air would be 100 percent. Air with a relative humidity of 100 percent is said to be saturated. If the air had 4 grams of vapor, the relative humidity would be 50 percent.

Measuring Relative Humidity

Relative humidity can be measured with an instrument called a psychrometer. A **psychrometer** (sy KRAHM uh tur) has two thermometers, a wet-bulb thermometer and a dry-bulb thermometer. As shown in **Figure 2,** the wet bulb is covered by a moist cloth. When the psychrometer is "slung," or spun, air blows over both thermometers. Because the wet-bulb thermometer is cooled by evaporation, its reading drops.

If the relative humidity is high, the water on the wet bulb evaporates slowly, and the wet-bulb temperature does not change much. If the relative humidity is low, the water on the wet bulb evaporates rapidly, and the wet-bulb temperature drops by a large amount. The relative humidity can be found by comparing the temperatures of the wet-bulb and dry-bulb thermometers.

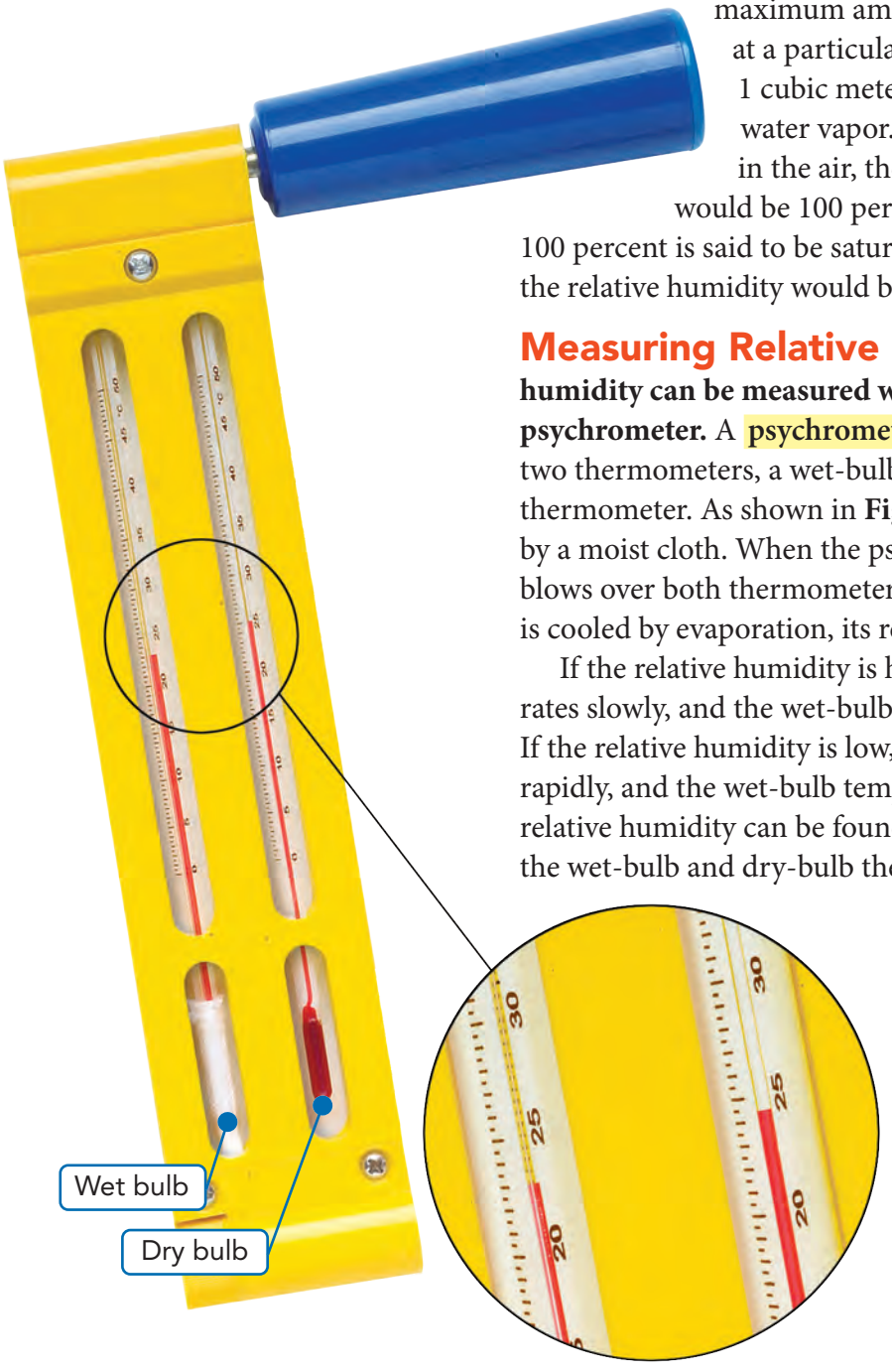


FIGURE 2

Sling Psychrometer

Relate Text and Visuals Read the psychrometer and compare the two Celsius temperatures. Is the relative humidity low or high? How do you know?

do the math!

Relative Humidity

Relative humidity is affected by temperature. Use the data table to answer the questions below. First, find the dry-bulb temperature in the left column of the table. Then find the difference between the wet- and dry-bulb temperatures across the top of the table. The number in the table where these two readings intersect indicates the percentage of relative humidity.

Relative Humidity

Dry-Bulb Reading (°C)	Difference Between Wet- and Dry-Bulb Readings (°C)				
	1	2	3	4	5
10	88	76	65	54	43
12	88	78	67	57	48
14	89	79	69	60	50
16	90	80	71	62	54
18	91	81	72	64	56
20	91	82	74	66	58
22	92	83	75	68	60

1. **Interpret Data** At noon the readings on a sling psychrometer are 18°C for the dry bulb and 14°C for the wet bulb. What is the relative humidity?

2. **Interpret Data** At 5 P.M. the reading on the dry bulb is 12°C and the reading on the wet bulb is 11°C. Determine the new relative humidity.

3. **CHALLENGE** What was the difference in relative humidity between noon and 5 P.M.? How was the relative humidity affected by air temperature?

Lab zone® Do the Quick Lab *Measuring to Find the Dew Point.*

Assess Your Understanding

1a. Review What is humidity?

b. Calculate Suppose a sample of air can hold at most 10 grams of water vapor. If the sample actually has 2 grams of water vapor, what is its relative humidity?

c. Compare and Contrast How are humidity and relative humidity different?

got it?

- ○ **I get it!** Now I know that relative humidity is _____ and it can be measured with _____
- ○ I need extra help with _____

TN

LESSON 2

Related to 6.ESS2: Earth's Systems

Clouds

UNLOCK THE BIG ?

- How Do Clouds Form?
- What Are the Three Main Types of Clouds?

my planet diary

BLOG

Posted by: Chase

Location: Marshfield, Massachusetts

The first time I flew to visit my grandparents, I learned something that really surprised me. When we got above the clouds, I was amazed that something as big as a cloud could float in the sky! I was gazing at the clouds when I asked my mom what they were made of. I was shocked to discover that clouds were mostly fog and mist! I thought they looked like giant piles of mashed potatoes.

Communicate Write your answers to each question below. Then discuss your answers with a partner.

1. Why do you think large clouds can float in the sky?

2. How might you describe what clouds look like?

Lab zone® Do the Inquiry Warm-Up *How Does Fog Form?*

How Do Clouds Form?

When you look at a cloud, you are seeing millions of tiny water droplets or ice crystals. **Clouds form when water vapor in the air condenses to form liquid water or ice crystals.** Molecules of water vapor in the air become liquid water in a process called condensation. How does water in the atmosphere condense? Two conditions are required for condensation: cooling of the air and the presence of particles in the air.

Vocabulary

- dew point
- cirrus
- cumulus
- stratus

Skills

- Reading: Summarize
- Inquiry: Predict

The Role of Cooling

As you have learned, cold air holds less water vapor than warm air. As air cools, the amount of water vapor it can hold decreases. The water vapor condenses into tiny droplets of water or ice crystals. The temperature at which condensation begins is called the **dew point.** If the dew point is above freezing, the water vapor forms droplets. If the dew point is below freezing, the water vapor may change directly into ice crystals.

Summarize What is the difference between dew and frost?

The Role of Particles

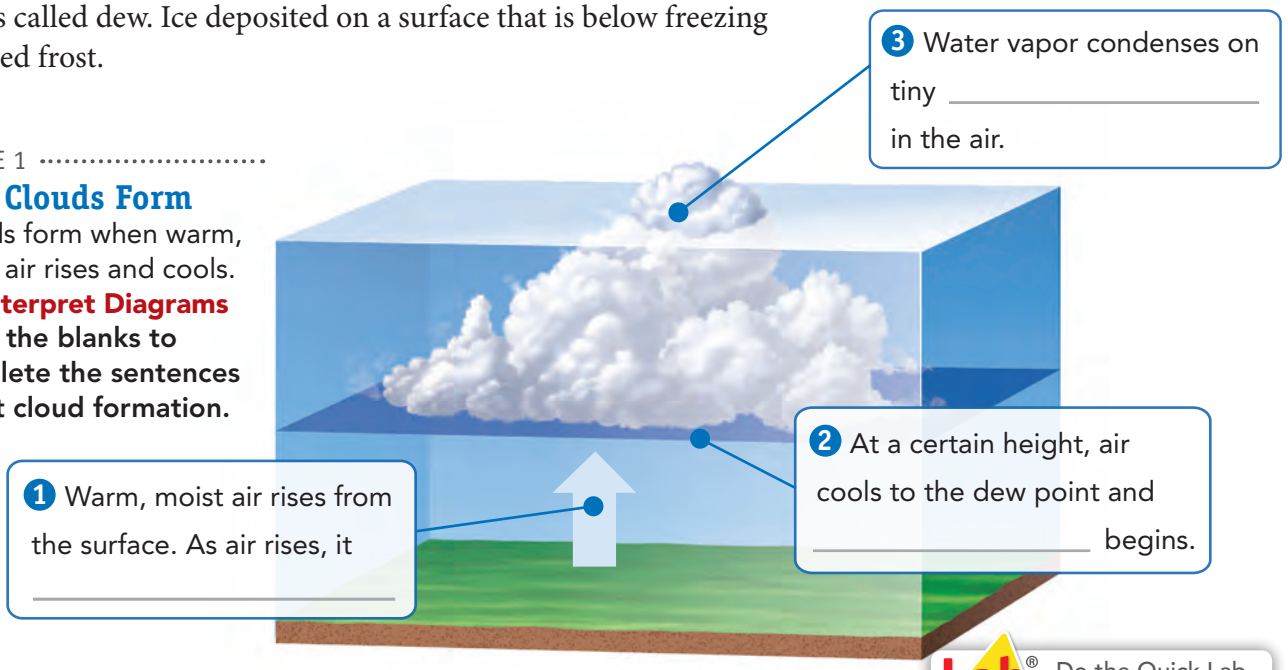
For water vapor to condense and form clouds, tiny particles must be present in the atmosphere so that the water has a surface on which to condense. Most of these particles are salt crystals, dust from soil, or smoke. Water vapor also condenses on solid surfaces, such as blades of grass or window panes. Liquid water that condenses from the air onto a cooler surface is called dew. Ice deposited on a surface that is below freezing is called frost.

FIGURE 1

How Clouds Form

Clouds form when warm, moist air rises and cools.

Interpret Diagrams **Fill in the blanks to complete the sentences about cloud formation.**



Lab zone® Do the Quick Lab *How Clouds Form.*

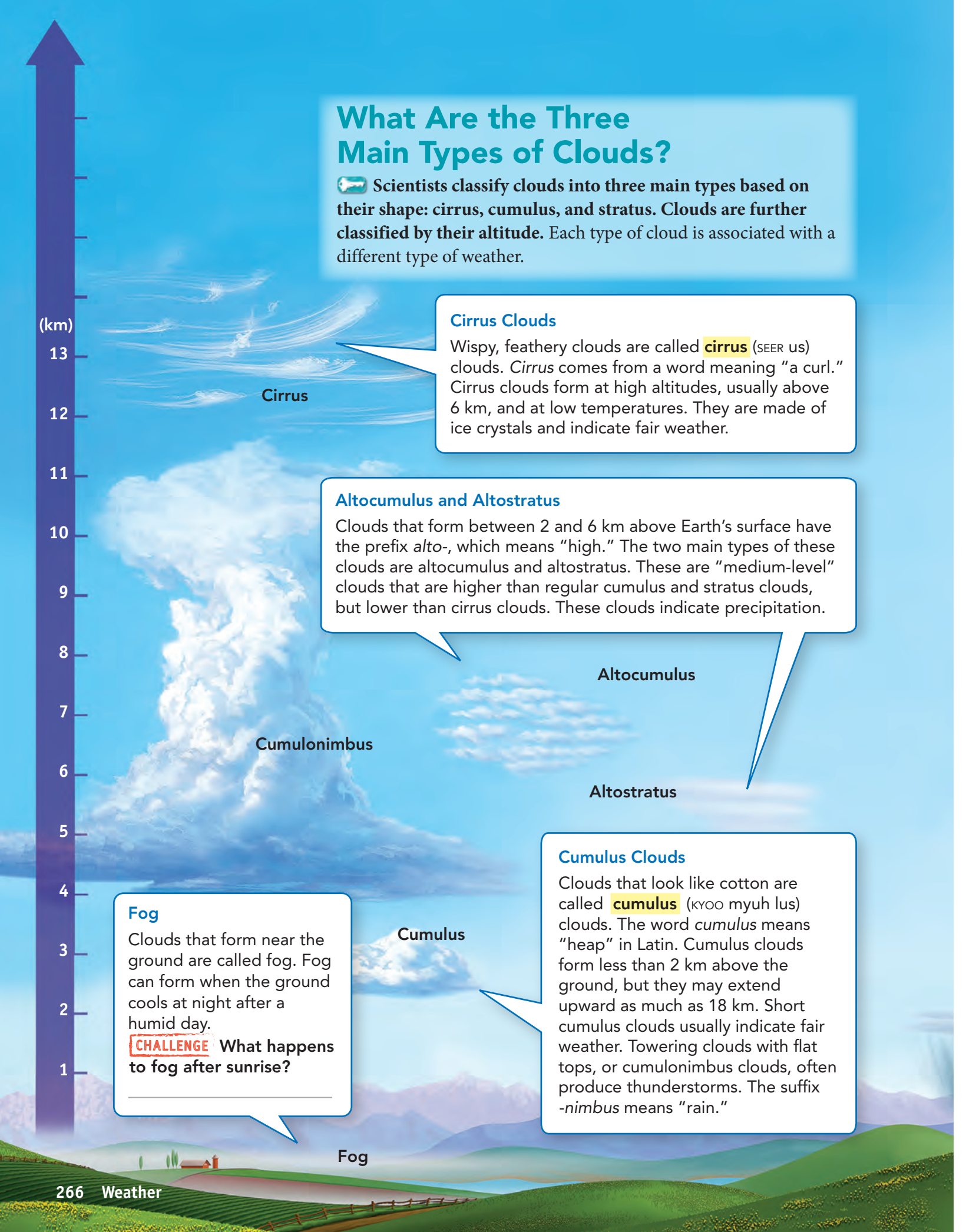
Assess Your Understanding

got it?

- I get it! Now I know that clouds form when _____
- I need extra help with _____

What Are the Three Main Types of Clouds?

Scientists classify clouds into three main types based on their shape: cirrus, cumulus, and stratus. Clouds are further classified by their altitude. Each type of cloud is associated with a different type of weather.



Cirrus Clouds

Wispy, feathery clouds are called **cirrus** (SEER us) clouds. *Cirrus* comes from a word meaning "a curl." Cirrus clouds form at high altitudes, usually above 6 km, and at low temperatures. They are made of ice crystals and indicate fair weather.

Altocumulus and Altostratus

Clouds that form between 2 and 6 km above Earth's surface have the prefix *alto-*, which means "high." The two main types of these clouds are altocumulus and altostratus. These are "medium-level" clouds that are higher than regular cumulus and stratus clouds, but lower than cirrus clouds. These clouds indicate precipitation.

Cumulus Clouds

Clouds that look like cotton are called **cumulus** (KYOO myuh lus) clouds. The word *cumulus* means "heap" in Latin. Cumulus clouds form less than 2 km above the ground, but they may extend upward as much as 18 km. Short cumulus clouds usually indicate fair weather. Towering clouds with flat tops, or cumulonimbus clouds, often produce thunderstorms. The suffix *-nimbus* means "rain."

Fog

Clouds that form near the ground are called fog. Fog can form when the ground cools at night after a humid day.

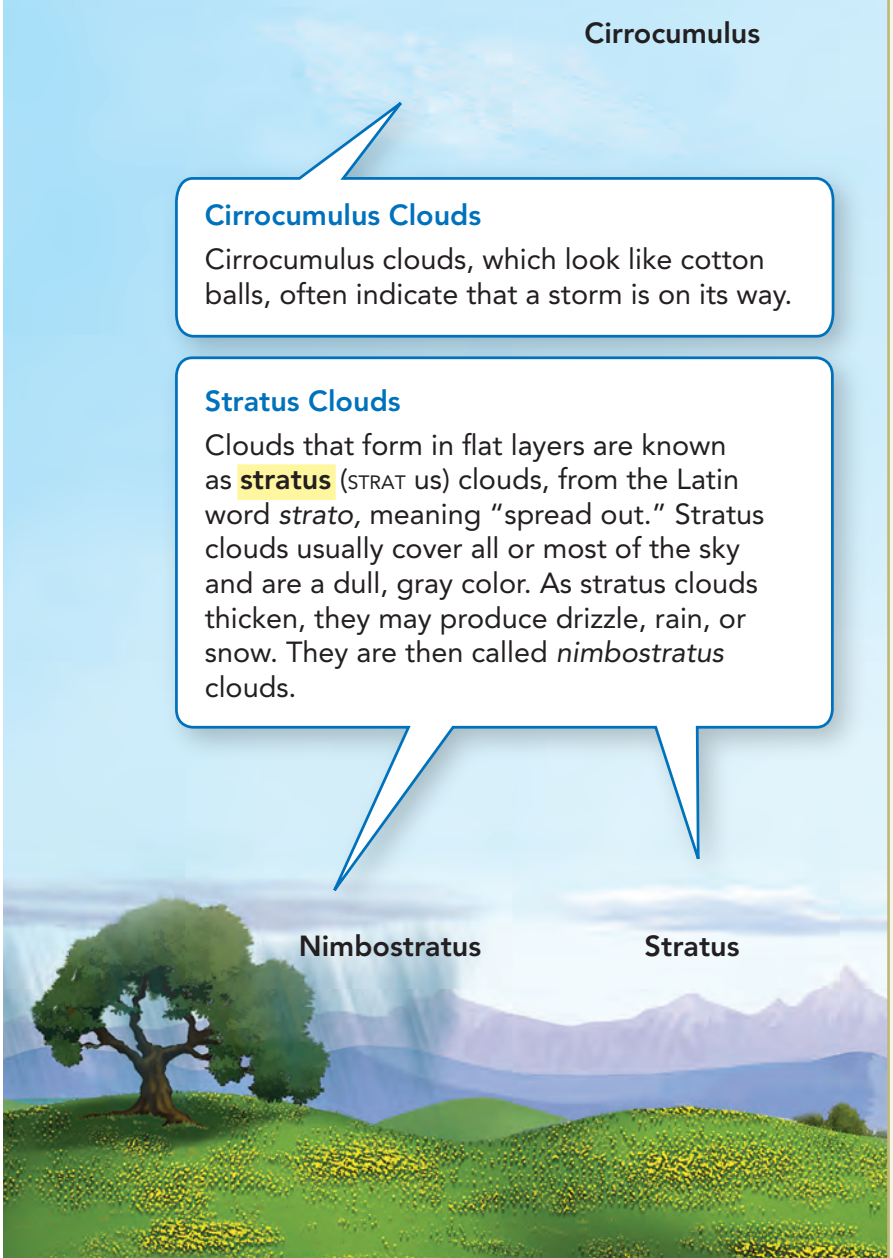
CHALLENGE **What happens to fog after sunrise?**

FIGURE 2

Cloud Types

There are many different types of clouds. **Predict Read about clouds in the text. Then fill in the table to predict the weather that you would expect with each type of cloud.**

Cloud	Weather
Cirrus	
Cirrocumulus	
Cumulus	
Cumulonimbus	
Stratus	
Nimbostratus	



Cirrocumulus

Nimbostratus

Stratus

Cirrocumulus Clouds

Cirrocumulus clouds, which look like cotton balls, often indicate that a storm is on its way.

Stratus Clouds

Clouds that form in flat layers are known as **stratus** (STRAT us) clouds, from the Latin word *strato*, meaning "spread out." Stratus clouds usually cover all or most of the sky and are a dull, gray color. As stratus clouds thicken, they may produce drizzle, rain, or snow. They are then called *nimbostratus* clouds.

apply it!

1 **Observe** Look out your window and identify the clouds you see. What kind of clouds are they? Circle a cloud on the page that looks most like one of the clouds you see.

2 **Predict** From what you know about this type of cloud, what sort of weather would you expect over the next 24 hours? Why?

Lab zone® Do the Quick Lab *Identifying Clouds.*

Assess Your Understanding

1a. Describe Briefly describe the shapes of the three main types of clouds.

b. Classify Classify each of the following cloud types as low-level, medium-level, or high-level.

Altocumulus _____

Altostratus _____

Cirrocumulus _____

Cirrus _____

Cumulus _____

Nimbostratus _____

Stratus _____

got it?

○ **I get it!** Now I know that the three main types of clouds are _____

○ I need extra help with _____

TN

LESSON 3

Related to 6.ESS2: Earth's Systems

Precipitation

UNLOCK THE BIG ?

- What Are the Common Types of Precipitation?
- What Are the Causes and Effects of Floods and Droughts?

MY PLANET DIARY

Cloud Seeding

Is that a space weapon you see in this photo? Not at all. This scientist in China is launching tiny crystals of silver iodide into the air to make rain. Clouds often contain water droplets that have cooled below 0°C. But the droplets do not freeze unless they can condense onto solid particles. When the silver iodide crystals reach the clouds, the droplets can condense onto them. Once that happens, the droplets can fall as rain.

Some scientists think that cloud seeding can increase rainfall by 10 percent. Others think that this is unlikely. In the United States, several western states are trying cloud seeding. Dry states, such as Wyoming and Utah, need as much rainfall as they can get.

TECHNOLOGY

Write your answer to each question below. Then discuss your answers with a partner.

1. Why would scientists want to find a way to make it rain?

2. Name a situation when you would want it to rain.

Lab zone® Do the Inquiry Warm-Up *How Can You Make Hail?*

Vocabulary

- precipitation
- rain gauge
- flood
- drought

Skills

Reading: Relate Cause and Effect

Inquiry: Calculate

What Are the Common Types of Precipitation?

Suppose you could control the weather. If you wanted it to rain, you would have to get the water from somewhere.

Water evaporates from every water surface on Earth and eventually falls back to the surface. **Precipitation** is any form of water that falls from clouds and reaches Earth's surface. It is a vital part of the water cycle. In warm climates, precipitation is almost always rain. In colder regions, it may fall as snow or ice. **Common types of precipitation include rain, sleet, freezing rain, snow, and hail.**

Rain The most common kind of precipitation is rain. As shown in **Figure 1,** drops of water are called rain if they are at least 0.5 millimeters in diameter. Precipitation made up of smaller drops of water is called drizzle. Precipitation of even smaller drops is called mist.

Measuring Rain What if scientists need to measure how much rain has fallen? An open-ended tube that collects rain is called a **rain gauge.** The amount of rain is measured by dipping a ruler into the water or by reading a scale. For rainfall to be measured more accurately, a rain gauge may have a funnel at the top that collects ten times as much rain as the tube alone would without it. The depth is easier to measure. To get the actual depth of rain, it is necessary to divide by ten.

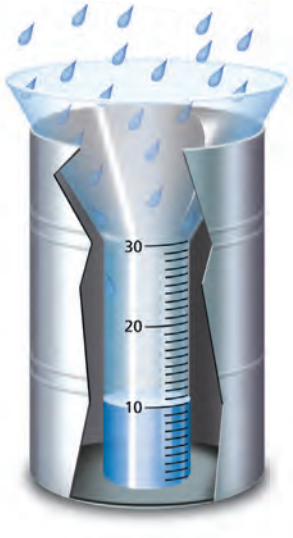


FIGURE 2

Rain Gauge

The rain gauge, measuring in centimeters, collects ten times the actual depth of rain that falls.

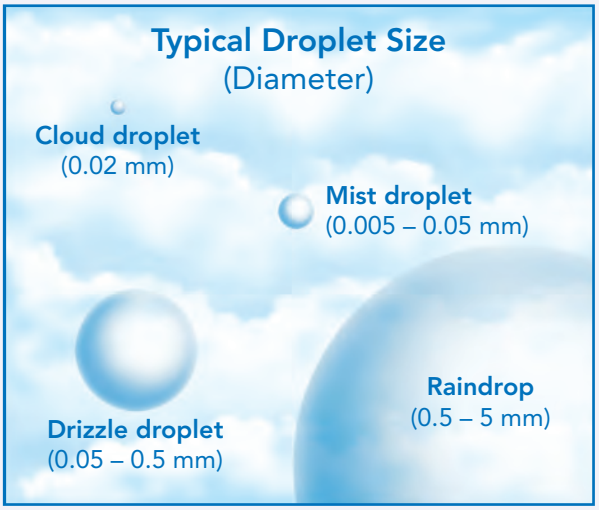
Calculate **How much rain has fallen so far?**

FIGURE 1

Water Droplets

Cloud droplets condense to become larger droplets.

Calculate **Determine how many times larger the diameter of a large (5 mm) raindrop is than the diameter of a cloud droplet.**



Freezing Rain

On a cold day, raindrops can sometimes fall as liquid water but freeze when they touch a cold surface. This kind of precipitation is called freezing rain.

Snow

You probably know that snowflakes have an endless number of different shapes and patterns, many with six sides or branches. A snowflake forms when water vapor in a cloud is converted directly into ice crystals. Snowflakes often join together into large clumps of snow in which the crystals are hard to see.

FIGURE 3

Freezing Precipitation

There are four types of freezing precipitation: freezing rain, snow, sleet, and hail.

Review Circle the temperature range in the air and on the ground for which you would expect each kind of precipitation. In some cases, more than one choice may be correct.

Precipitation	Air Temperature	Ground Temperature
Rain	Above 0 °C / At or below 0 °C	Above 0 °C / At or below 0 °C
Freezing rain	Above 0 °C / At or below 0 °C	Above 0 °C / At or below 0 °C
Sleet	Above 0 °C / At or below 0 °C	Above 0 °C / At or below 0 °C
Snow	Above 0 °C / At or below 0 °C	Above 0 °C / At or below 0 °C
Hail	Above 0 °C / At or below 0 °C	Above 0 °C / At or below 0 °C

Hail

A hailstone is a round pellet of ice larger than 5 millimeters in diameter. If you cut a hailstone in half, you would see layers of ice, like the layers of an onion. Hail forms only inside cumulonimbus clouds during thunderstorms. A hailstone starts as an ice pellet inside a cold region of a cloud. Strong updrafts carry the hailstone up through the cold region many times. Each time the hailstone goes through the cold region, a new layer of ice forms around it. Eventually the hailstone becomes heavy enough to fall to the ground. Because hailstones can grow large, hail can cause damage to crops, buildings, and vehicles.

Sleet

Sometimes raindrops fall through a layer of air that is below 0°C, the freezing point of water. As they fall, the raindrops freeze into solid particles of ice. Ice particles smaller than 5 millimeters in diameter are called sleet.

Measuring Snow Rain is not the only kind of precipitation meteorologists measure. Have you ever walked through a large snowstorm and wanted to know exactly how much snow had fallen?

Snowfall is usually measured in two ways: by using a simple measuring stick or by melting collected snow and measuring the depth of water it produces. On average, 10 centimeters of snow contains about the same amount of water as 1 centimeter of rain. However, light, fluffy snow contains far less water than heavy, wet snow does.

apply it!

A rain gauge with a wide funnel collects ten times the actual depth of rain that falls. After the rain ends, the water level is at 15 centimeters.

1. How much rain actually fell?

2. **Calculate** If snow had fallen instead, how deep would that snow have been?

Lab zone® Do the Quick Lab *Types of Precipitation.*

Assess Your Understanding

1a. Define What is precipitation?

b. Draw Conclusions What factors determine if precipitation falls as freezing rain or as sleet?

got it?

- ○ **I get it!** Now I know that the common types of precipitation are _____
- ○ I need extra help with _____

What Are the Causes and Effects of Floods and Droughts?

In September 2008, just three years after Hurricane Katrina, Hurricane Gustav blasted the coasts of Louisiana and Mississippi. Lakes and rivers overflowed. The result was severe flooding.

Floods

A **flood** is an overflowing of water in a normally dry area. The floods caused by Gustav fortunately were not as devastating as those caused by Katrina. Because of the flooding caused by Katrina, more than 100,000 homes and businesses were destroyed, along with many bridges and highways.

Causes and Effects of Floods

Not all floods are as severe as those caused by a hurricane. **Small or large, many floods occur when the volume of water in a river increases so much that the river overflows its channel.** As rain and melting snow add more water, a river gains speed and strength. A flooding river can uproot trees and pluck boulders from the ground. It can even wash away bridges and buildings.

People who live near rivers try to control floods with dams and levees. A dam is a barrier across a river that may redirect the flow of the river to other channels or store floodwaters so they can be released slowly. A levee is an embankment built along a river to prevent flooding of the surrounding land. People sometimes strengthen levees with sandbags or stones and concrete. But powerful floodwaters can sometimes break through dams and levees.

FIGURE 4

Flooding Caused by Hurricane Gustav

Hurricane Gustav hit the Gulf Coast in September 2008, causing severe flooding. **Answer the questions below.**

1. **Infer** What sort of damage would you expect to your home if this flood took place in the area where you live?

2. CHALLENGE A "100-year flood" is the flooding elevation that has a 1% chance of happening each year. Why is the name misleading?

FIGURE 5

Drought in Texas
In July 1998, a drought hit Wharton County, Texas. This farmer lost about 50 percent of his normal cereal crop to the drought.

Relate Cause and Effect
What causes a flood? A drought?

Lab zone® Do the Quick Lab *Floods and Droughts.*

Droughts

If you went away for a month and no one was around to water your plants, what would happen to them? They would probably die from lack of water. A long period of scarce rainfall or dry weather is known as a **drought** (drowt). A drought reduces the supplies of groundwater and surface water. A drought can result in a shortage of water for homes and businesses.

Causes and Effects of Droughts

Droughts are usually caused by dry weather systems that remain in one place for weeks or months at a time. Long-term droughts can devastate a region. Droughts can cause crop failure. A drought can even cause famine in places where people must grow their own food. Streams and ponds dry up, and people and animals suffer.

People can prepare for droughts in several ways. When dry conditions first occur, people can begin conserving water. Farmers can grow drought-resistant plants that have been bred to withstand dry conditions. By practicing water and soil conservation, people can ensure that when droughts do occur, people will be prepared for their effects.

Assess Your Understanding

2a. Explain What are two ways to help reduce the dangers of floods?

b. Make Judgments Your community is considering building a dam on a nearby river to reduce flooding. Would you support this proposal? Explain.

got it?

○ **I get it!** Now I know that floods are caused by _____ and droughts are caused by _____

○ **I need extra help with** _____

TN

LESSON 4

6.ESS2.2

Winds

UNLOCK THE BIG ?

- What Causes Winds?
- How Do Local Winds and Global Winds Differ?

my planet Diary

Windsurfing

Imagine being able to ride a wave at almost 81 km/h—not in a boat powered by a motor but on a board powered only by the wind. That's what windsurfing is all about.

Windsurfers stand on a sailboard, which is similar to a surfboard. But the sailboard has a mast and a sail that the surfer can control with his or her hands. It uses a sail to capture wind and move the surfer along the surface of the water. Jim Drake, one of the first inventors of windsurfing, points out:

"It's the simplicity of standing up so you can adjust your weight and move quickly, as well as actively participate in transmitting the sail's forces to the board."

EXTREME SPORTS

Discuss these questions with a classmate. Write your answers below.

1. How does wind move the sail?

2. How have you experienced the effects of wind?

Lab zone® Do the Inquiry Warm-Up *Does the Wind Turn?*

Vocabulary

- wind
- anemometer
- windchill factor
- local winds
- sea breeze
- land breeze
- global winds
- Coriolis effect
- latitude

Skills

Reading: Identify Supporting Evidence

Inquiry: Draw Conclusions

What Causes Winds?

Air is a fluid, so it can move easily from place to place. But how does it do that? **Differences in air pressure cause the air to move.** **Wind** is the movement of air parallel to Earth's surface. Winds move from areas of high pressure to areas of lower pressure.

Most differences in air pressure are caused by the unequal heating of the atmosphere. Recall that convection currents form when an area of Earth's surface is heated by the sun's rays. Air over the heated surface expands and becomes less dense. As the air becomes less dense, its air pressure decreases. If a nearby area is not heated as much, the air above the less-heated area will be cooler and denser. The cool, dense air with a higher pressure flows underneath the warm, less dense air. This forces the warm air to rise.

FIGURE 1

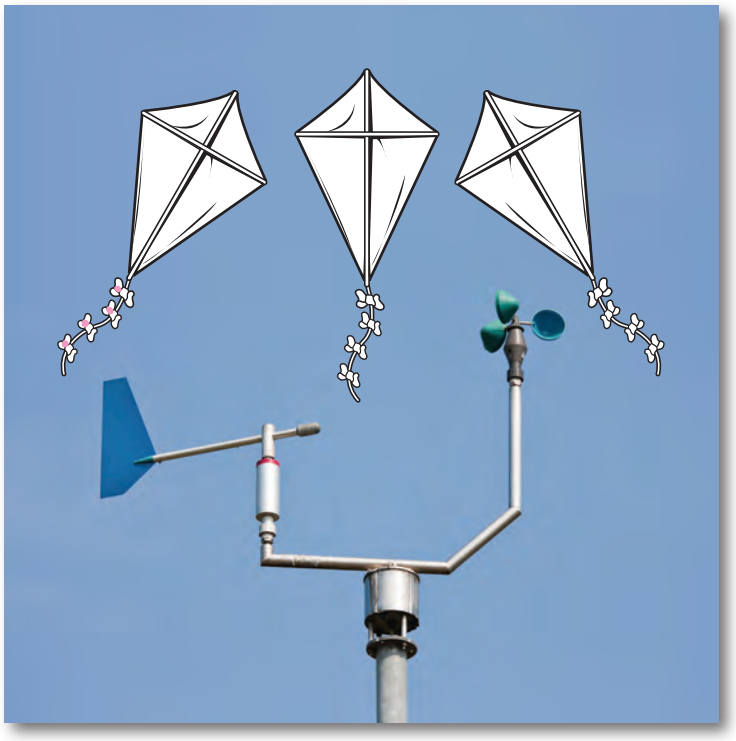
Moving Air

Windsurfers need wind in order to move across the water. **Explain** **How do differences in air pressure cause wind?**

FIGURE 2

Wind Direction and Speed

Identify Based on the direction of the wind vane, which direction would your kite be flying? Indicate your answer by shading in your kite.



Measuring Wind

Winds are described by their direction and speed. Winds can blow from all directions: north, south, east, and west. Wind direction is determined with a wind vane. The wind swings the wind vane so that one end points into the wind. The name of a wind tells you where the wind is coming from. For example, a south wind blows from the south toward the north. A north wind blows to the south.

Wind speed can be measured with an **anemometer** (an uh MAHM uh tur). An anemometer has three or four cups mounted at the ends of spokes that spin on an axle. The force of the wind against the cups turns the axle. A meter connected to the axle shows the wind speed. **Figure 2** shows a wind vane and an anemometer.

Windchill Factor

On a warm day, a cool breeze can be refreshing. But during the winter, the same breeze can make you feel uncomfortably cold. The wind blowing over your skin removes body heat. The stronger the wind, the colder you feel. The increased cooling that a wind can cause is called the **windchill factor.** A weather report may say, "The temperature outside is 20 degrees Fahrenheit. But with a wind speed of 30 miles per hour, the windchill factor makes it feel like 1 degree above zero."

Lab zone® Do the Quick Lab *Build a Wind Vane.*

Assess Your Understanding

1a. Define What is wind?

b. Relate Cause and Effect How is wind related to air pressure and temperature?

got it?

- ○ **I get it!** Now I know that wind is _____
- ○ I need extra help with _____

How Do Local Winds and Global Winds Differ?

Have you ever noticed a breeze at the beach on a hot summer day? Even if there is no wind inland, there may be a cool breeze blowing in from the water. This breeze is an example of a local wind.

Local Winds Winds that blow over short distances are called **local winds.** **The unequal heating of Earth's surface within a small area causes local winds.** These winds form only when large-scale winds are weak. Two types of local winds are sea breezes and land breezes, as shown in **Figure 3.**

FIGURE 3

Local Winds

Relate Text and Visuals Read about sea breezes. Add arrows to the bottom diagram to indicate how a land breeze develops. Then summarize the process.

Sea Breeze During the day, the land warms up faster than the water. The air over the land gets warmer than the air over the water. This warm air is less dense. It expands and rises, creating a low-pressure area. Cool air blows inland from over the water and moves underneath the warm air, causing a sea breeze. A **sea breeze** or a lake breeze is a local wind that blows from an ocean or lake.

Land Breeze At night, the process is reversed. The flow of air from land to a body of water forms a **land breeze.**

Global Winds

Global winds are winds that blow steadily from specific directions over long distances. **Like local winds, global winds are created by the unequal heating of Earth's surface. But unlike local winds, global winds occur over a large area.** In **Figure 4,** you can see how the sun's radiation strikes Earth. In the middle of the day near the equator, the sun is almost directly overhead. The direct rays from the sun heat Earth's surface intensely. Near the poles, the sun's rays strike Earth's surface at a lower angle. The sun's energy is spread out over a larger area, so it heats the surface less. As a result, temperatures near the poles are much lower than they are near the equator.

Global Convection Currents

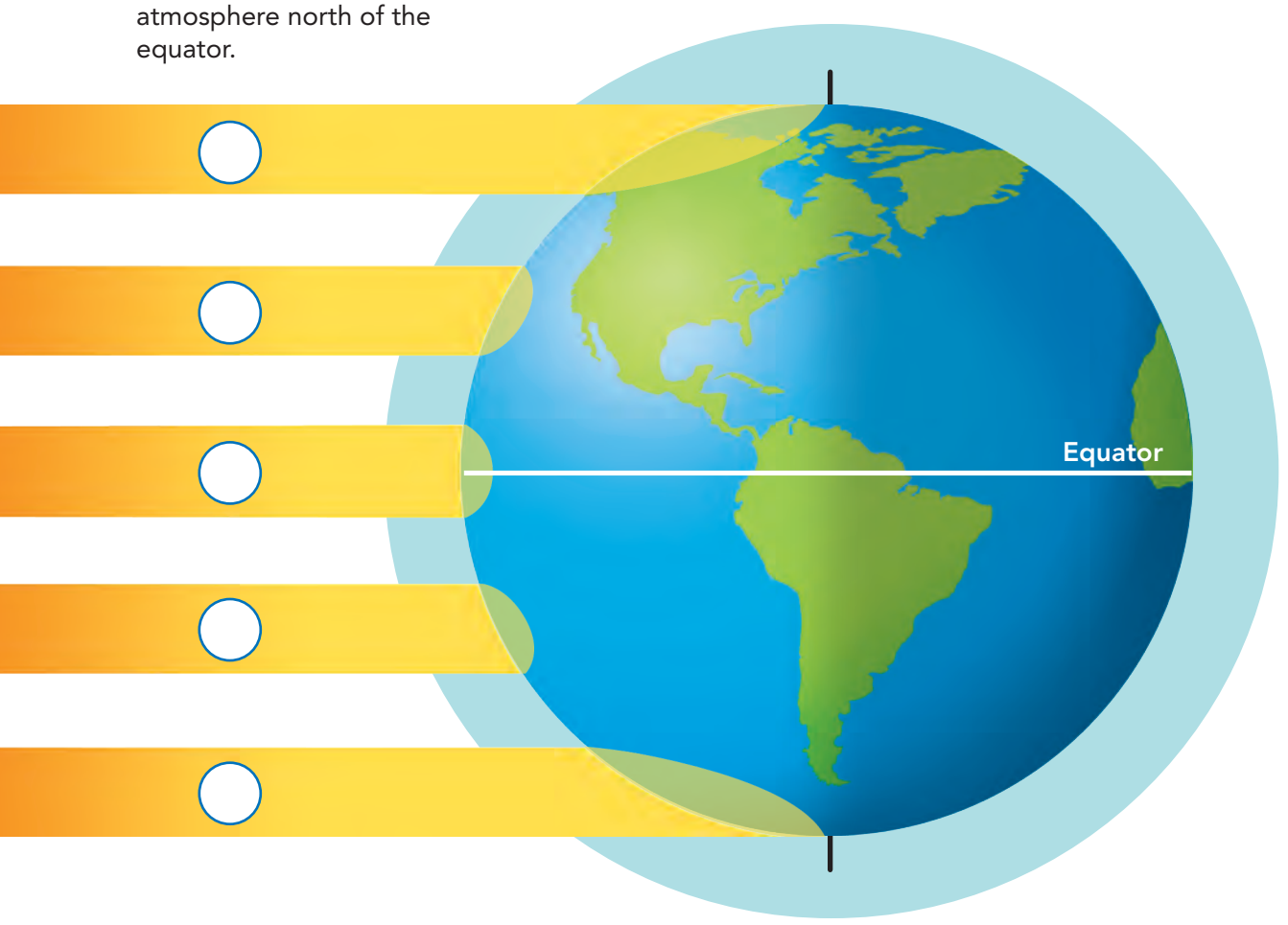
How do global winds develop? Temperature differences between the equator and the poles produce giant convection currents in the atmosphere. Warm air rises at the equator, and cold air sinks at the poles. Therefore air pressure tends to be lower near the equator and greater near the poles. This difference in pressure causes winds at Earth's surface to blow from the poles toward the equator. Higher in the atmosphere, however, air flows away from the equator toward the poles. Those air movements produce global winds.

FIGURE 4

Heating of Earth's Surface

Interpret Diagrams **The angle of the sun's rays causes temperature differences at Earth's surface.**

1. Label the areas where the sun hits Earth most directly (M) and least directly (L).
2. CHALLENGE Draw a convection current in the atmosphere north of the equator.



The Coriolis Effect If Earth did not rotate, global winds would blow in a straight line from the poles toward the equator. Because Earth is rotating, however, global winds do not follow a straight path. As the winds blow, Earth rotates from west to east underneath them, making it seem as if the winds have curved. The way Earth's rotation makes winds curve is called the **Coriolis effect** (kawr ee OH lis). Because of the Coriolis effect, global winds in the Northern Hemisphere gradually turn toward the right. A wind blowing toward the south gradually turns toward the southwest. In the Southern Hemisphere, winds curve toward the left.

Identify Supporting Evidence Underline the text that describes how winds blow due to the Coriolis effect.

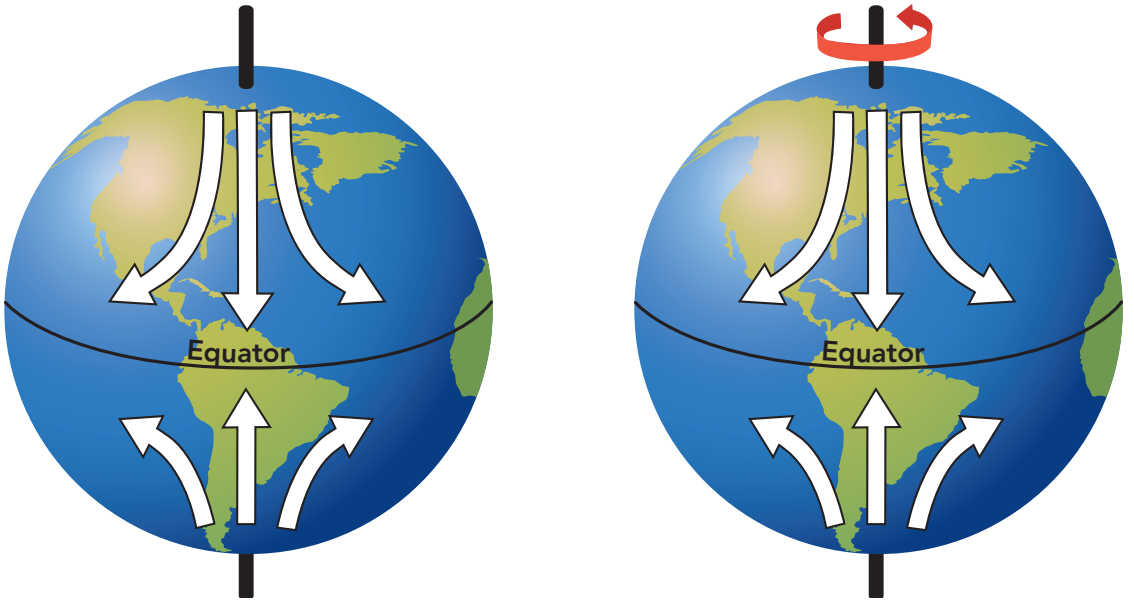
apply it!

The Coriolis effect determines the direction of global winds.

1. Look at the globe on the left. Shade in the arrows that show the direction the global winds would blow without the Coriolis effect.

2. Look at the globe on the right. Shade in the arrows that show the direction the global winds blow as a result of the Coriolis effect.

3. **Draw Conclusions** Based on your last answer, what direction do global winds blow in the Northern Hemisphere? In the Southern Hemisphere?



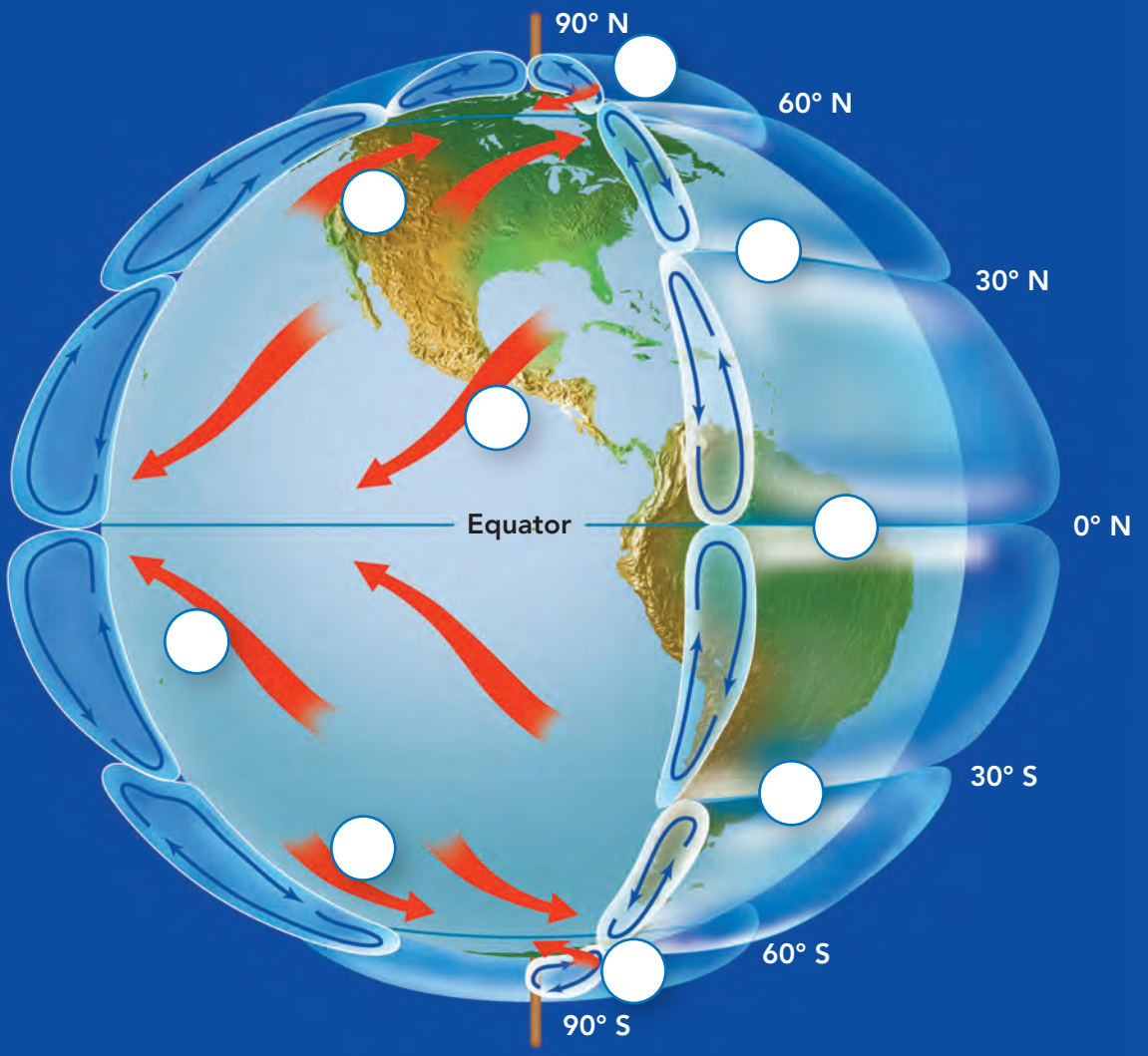


FIGURE 5

Global Wind Belts

The Coriolis effect and other factors combine to produce a pattern of wind belts and calm areas around Earth.

Relate Text and Visuals
Match the descriptions of the global winds with their location on the globe.

A **Doldrums** are a calm area where warm air rises. They occur at the equator where the sun heats the surface strongly. Warm air rises steadily, creating an area of low pressure. Cool air moves into the area, but is warmed rapidly and rises before it moves very far.

B **Horse Latitudes** are two calm areas of sinking air. **Latitude** is the distance from the equator, measured in degrees. At about 30° north and south latitudes, the air stops moving toward the poles and sinks.

C **Trade Winds** blow from the horse latitudes toward the equator. As cold air over the horse latitudes sinks, it forms a region of high pressure. This causes surface winds to blow. The winds that blow toward the equator are turned west by the Coriolis effect.

D **Prevailing Westerlies** blow from west to east, away from the horse latitudes. In the mid-latitudes, between 30° and 60° north and south, winds that blow toward the poles are turned toward the east by the Coriolis effect.

E **Polar Easterlies** blow cold air away from the poles. Air near the poles sinks and flows back toward lower latitudes. The Coriolis effect shifts these polar winds to the west, producing the polar easterlies.

Parts of the Atmosphere

How does the sun's energy affect Earth's atmosphere?

FIGURE 6

Earth's atmosphere is a system made up of many different parts.

Communicate **In the space below, draw a picture or a diagram that helps you understand the relationship between the concepts in the word bank. Explain your diagram to a classmate.**

Word Bank

atmosphere
air pressure
convection
radiation
global winds

Lab zone® Do the Quick Lab *Modeling Global Wind Belts.*

Assess Your Understanding

2a. Summarize What causes local winds?

b. Identify What is a global wind?

c. How does the sun's energy affect Earth's atmosphere?

got it?

- I get it! Now I know that winds blow locally and globally due to _____
- I need extra help with _____

TN

LESSON 5

6.ESS2.6

Air Masses

UNLOCK THE BIG ?

- What Are the Major Air Masses?
- What Are the Main Types of Fronts?
- What Weather Do Cyclones and Anticyclones Bring?

MY PLANET DIARY

Cyclones and Tornadoes

Misconception: A cyclone is another name for tornado.

Fact: Both cyclones and tornadoes are spinning storm systems. Both rotate around an area of low pressure. However, tornadoes cover a much smaller area than cyclones do. And tornado winds reach much higher speeds.

Evidence: Outside the tropics, cyclones can be 1,000 to 4,000 kilometers across. Tropical cyclones, which are powerful hurricanes, are smaller, ranging from 100 to 1,000 kilometers across. But tornadoes are smaller still. Tornadoes range in size from a few meters to 1,600 meters across. Tornado winds are the fastest known winds on Earth. They can reach speeds of 480 km/h, but are usually much slower. Cyclone winds are strong, but do not move as fast as the fastest tornado winds. Tropical cyclone winds rarely reach more than 320 km/h.

MISCONCEPTION

Think about the cyclones and tornadoes you have heard about as you answer the following questions.

1. Which kind of storm do you think would cause damage over a larger area, a cyclone or a tornado? Why?

2. Have you ever seen water swirl down a drain? How is it related to a tornado?

Lab zone® Do the Inquiry Warm-Up *How Do Fluids of Different Densities Move?*

Vocabulary

- air mass
- tropical
- polar
- maritime
- continental
- jet stream
- front
- occluded
- cyclone
- anticyclone

Skills

- Reading: Relate Text and Visuals
- Inquiry: Classify

What Are the Major Air Masses?

When you have a certain type of weather taking place outside, that's because a certain type of air mass is influencing the weather. An **air mass** is a huge body of air in the lower atmosphere that has similar temperature, humidity, and air pressure at any given height. Scientists classify air masses according to temperature and humidity. **Four major types of air masses influence the weather in North America: maritime tropical, continental tropical, maritime polar, and continental polar.**

As shown in **Figure 1,** the characteristics of an air mass depend on the temperatures and moisture content of the region over which the air mass forms. Remember that temperature affects air pressure. Cold, dense air has a higher pressure, while warm, less-dense air has a lower pressure. **Tropical,** or warm, air masses form in the tropics and have low air pressure. **Polar,** or cold, air masses form north of 50° north latitude and south of 50° south latitude. Polar air masses have high air pressure.

Whether an air mass is humid or dry depends on whether it forms over water or land. **Maritime** air masses form over oceans. Water evaporates from the oceans, so the air can become very humid. **Continental** air masses form over land. Continental air masses have less exposure to large amounts of moisture from bodies of water. Therefore, continental air masses are drier than maritime air masses.

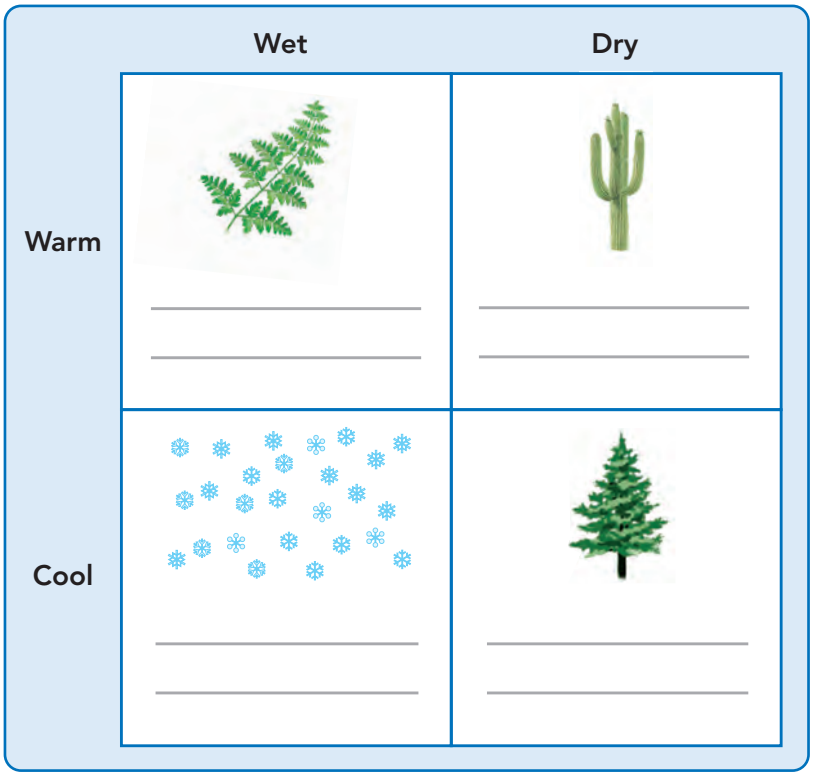


FIGURE 1

Types of Air Masses

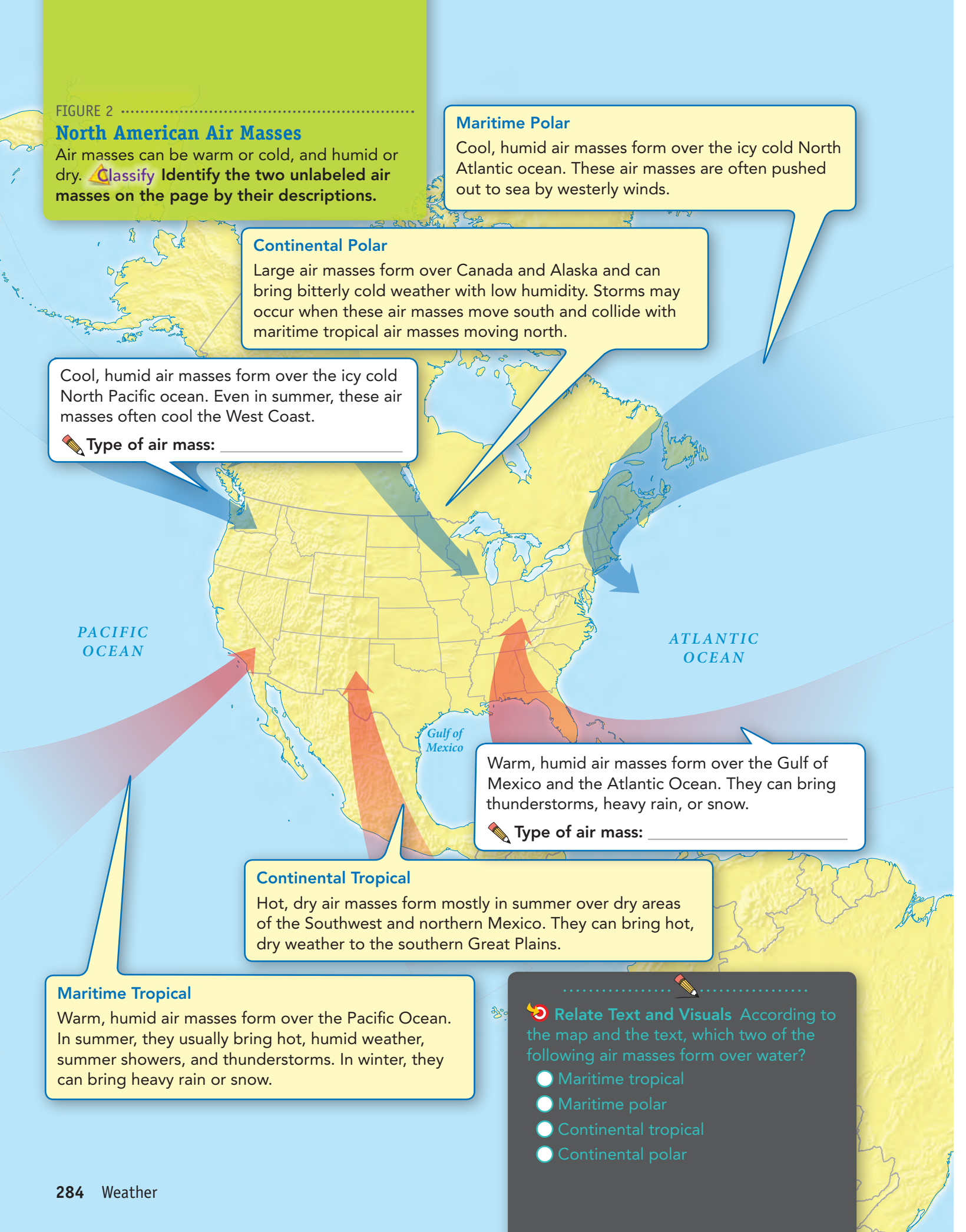
Air masses can be classified according to temperature and humidity.

Classify Fill in the table. Classify each type of air mass as *maritime* or *continental* and as *tropical* or *polar*.

FIGURE 2

North American Air Masses

Air masses can be warm or cold, and humid or dry. Classify **Identify the two unlabeled air masses on the page by their descriptions.**



Maritime Polar

Cool, humid air masses form over the icy cold North Atlantic ocean. These air masses are often pushed out to sea by westerly winds.

Continental Polar

Large air masses form over Canada and Alaska and can bring bitterly cold weather with low humidity. Storms may occur when these air masses move south and collide with maritime tropical air masses moving north.

Cool, humid air masses form over the icy cold North Pacific ocean. Even in summer, these air masses often cool the West Coast.

Type of air mass: _____

Warm, humid air masses form over the Gulf of Mexico and the Atlantic Ocean. They can bring thunderstorms, heavy rain, or snow.

Type of air mass: _____

Continental Tropical

Hot, dry air masses form mostly in summer over dry areas of the Southwest and northern Mexico. They can bring hot, dry weather to the southern Great Plains.

Maritime Tropical

Warm, humid air masses form over the Pacific Ocean. In summer, they usually bring hot, humid weather, summer showers, and thunderstorms. In winter, they can bring heavy rain or snow.

Relate Text and Visuals According to the map and the text, which two of the following air masses form over water?

- Maritime tropical
- Maritime polar
- Continental tropical
- Continental polar

How Air Masses Move

When an air mass moves into an area and interacts with other air masses, it causes the weather to change, sometimes drastically. In the continental United States, air masses are commonly moved by the prevailing westerlies and jet streams.

Prevailing Westerlies The prevailing westerlies, the major wind belts over the continental United States, generally push air masses from west to east. For example, maritime polar air masses from the Pacific Ocean are blown onto the West Coast, bringing low clouds and showers.

Jet Streams Embedded within the prevailing westerlies are jet streams. **Jet streams** are bands of high-speed winds about 10 kilometers above Earth's surface. As jet streams generally blow from west to east, air masses are carried along their tracks.

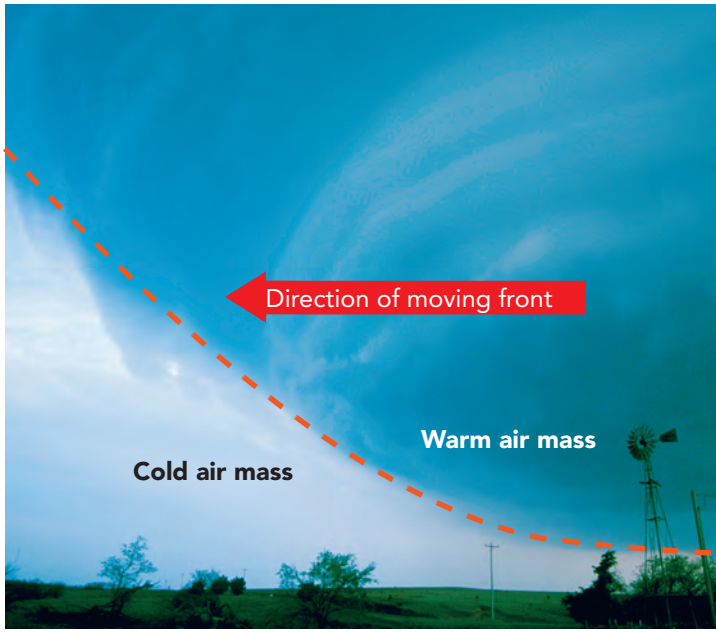
Fronts As huge masses of air move across the land and the oceans, they collide with each other, but do not easily mix. Think about a bottle of oil and water. The less-dense oil floats on top. Something similar happens when two air masses of different temperature and humidity collide. They do not easily mix. The boundary where the air masses meet becomes a **front.** Storms and changeable weather often develop along fronts like the one in **Figure 3.**

FIGURE 3

How a Front Forms

The boundary where unlike air masses meet is called a front. A front may be 15 to 600 km wide and extend high into the troposphere.

Relate Text and Visuals **What kind of weather would develop along the front shown in the photo?**



Lab zone® Do the Quick Lab *Tracking Air Masses.*

Assess Your Understanding

1a. Review What two characteristics are used to classify air masses?

b. Apply Concepts What type of air mass would form over the northern Atlantic Ocean?

c. Classify Classify the four major types of air masses according to moisture content.

got it?

- ○ **I get it!** Now I know that the four major types of air masses are
- ○ I need extra help with

What Are the Main Types of Fronts?

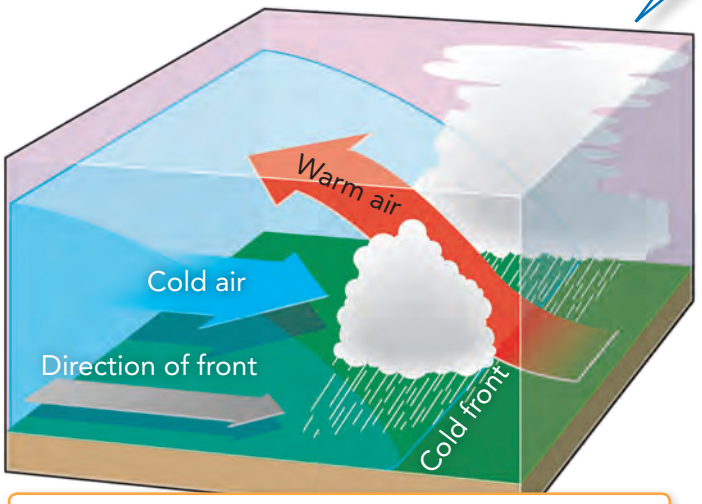
When you leave school in the afternoon, you may find that the weather is different from when you arrived in the morning. That might be because a front has just recently passed through the area.

Colliding air masses can form four types of fronts: cold fronts, warm fronts, stationary fronts, and occluded fronts. The kind of front that develops depends on the characteristics of the air masses and the direction in which they move.

FIGURE 4

Types of Fronts

Infer **Identify the type of weather brought by each front as it passes through an area.**



Cold Fronts

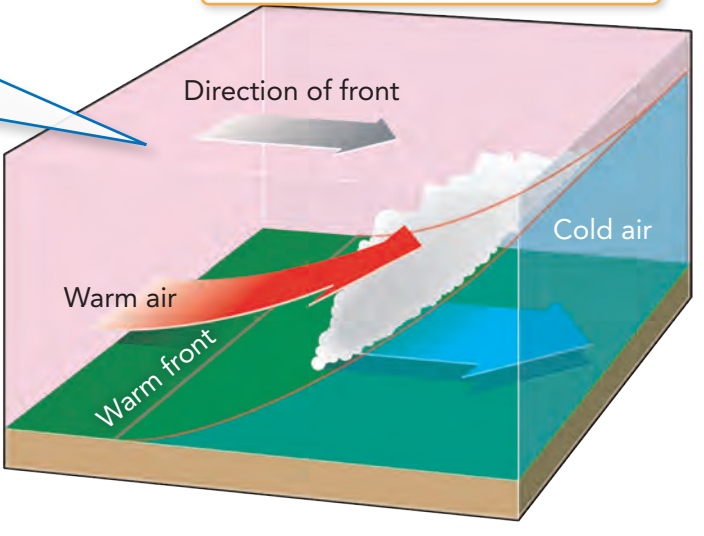
Cold air is dense and tends to sink. Warm air is less dense and tends to rise. When a faster cold air mass runs into a slower warm air mass, the denser cold air slides under the lighter warm air. The warm air is pushed upward along the leading edge of the colder air. A cold front forms.

As the warm air rises, it expands and cools. The rising air soon reaches the dew point, the temperature at which water vapor in the air condenses. Clouds form. Heavy rain or snow may fall.

Cold fronts tend to arrive quickly, because their leading edges move along the ground. They can cause abrupt weather changes, including thunderstorms. After a cold front passes, colder, drier air moves in, often bringing clear skies, a shift in wind direction, and lower temperatures.

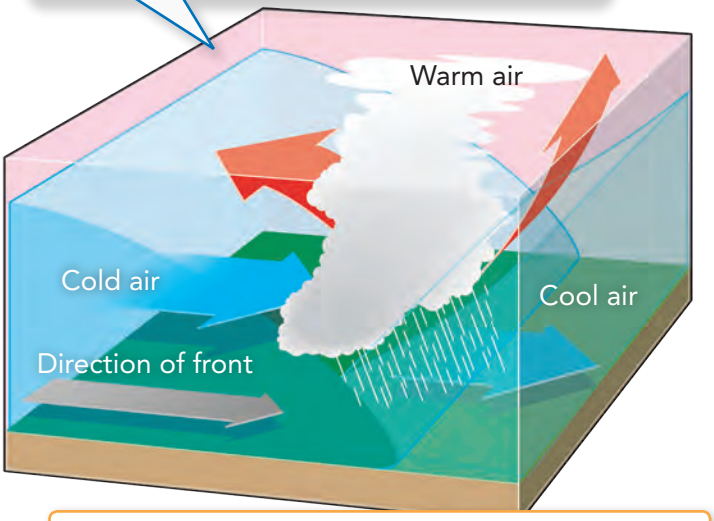
Warm Fronts

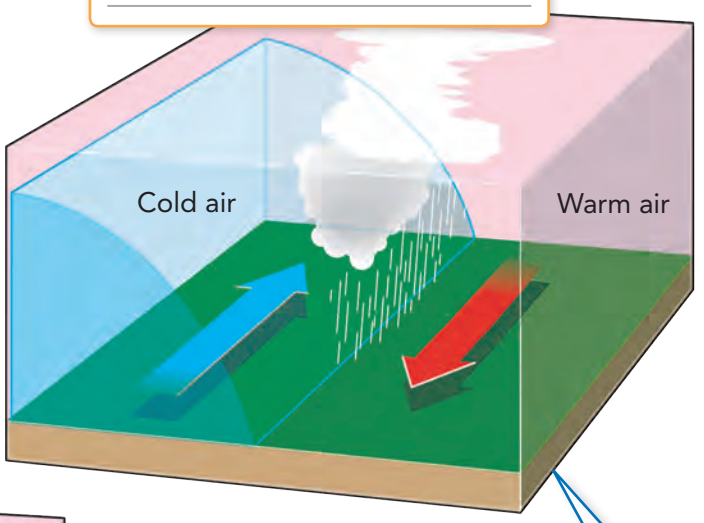
Clouds and precipitation also accompany warm fronts. At a warm front, a fast-moving warm air mass overtakes a slower cold air mass. Because cold air is denser than warm air, the warm air moves over the cold air. If the warm air is humid, light rain or snow falls along the front. If the air is dry, scattered clouds form. Because warm fronts arrive slowly, the weather may be rainy or cloudy for several days. After a warm front passes, the weather tends to be warmer and humid.



Occluded Fronts

The most complex weather situation occurs at an occluded front, where a warm air mass is caught between two cooler air masses. The denser cool air masses move underneath the less dense warm air mass and push the warm air upward. The two cooler air masses meet in the middle and may mix. The temperature near the ground becomes cooler. The warm air mass is cut off, or **occluded,** from the ground. As the warm air cools and its water vapor condenses, the weather may turn cloudy and rain or snow may fall.





Stationary Fronts

Sometimes cold and warm air masses meet, but neither one can move the other. In this case, the front is called a stationary front. Where the warm and cool air meet, water vapor in the warm air condenses into rain, snow, fog, or clouds. But if a stationary front stalls, it may bring many days of clouds and precipitation.

Lab zone® Do the Quick Lab *Weather Fronts.*

Assess Your Understanding

2a. Define What is a front?

b. Describe What type of weather occurs as a warm front moves through an area?

c. Classify What types of fronts would cause several days of rain and clouds?

got it?

○ **I get it!** Now I know that the four main types of fronts are

○ I need extra help with

What Weather Do Cyclones and Anticyclones Bring?

As air masses collide to form fronts, the boundary between the fronts sometimes becomes distorted. This distortion can be caused by surface features, such as mountains, or strong winds, such as the jet stream. When this happens, the air begins to swirl. The swirling air can cause a low-pressure center to form.

Cyclones

A circled *L* on a weather map stands for "low," and indicates an area of relatively low air pressure. A swirling center of low air pressure is a **cyclone,** from a Greek word meaning "wheel." You can see a cyclone in **Figure 5.**

As warm air at the center of a cyclone rises, the air pressure decreases. Cooler air blows inward from nearby areas of higher air pressure. Winds spiral inward toward the center. In the Northern Hemisphere, the Coriolis effect deflects winds to the right. So the cyclone winds spin counterclockwise when viewed from above.

As air rises in a cyclone, the air cools, forming clouds and precipitation. **Cyclones and decreasing air pressure are associated with clouds, wind, and precipitation.**

Anticyclones

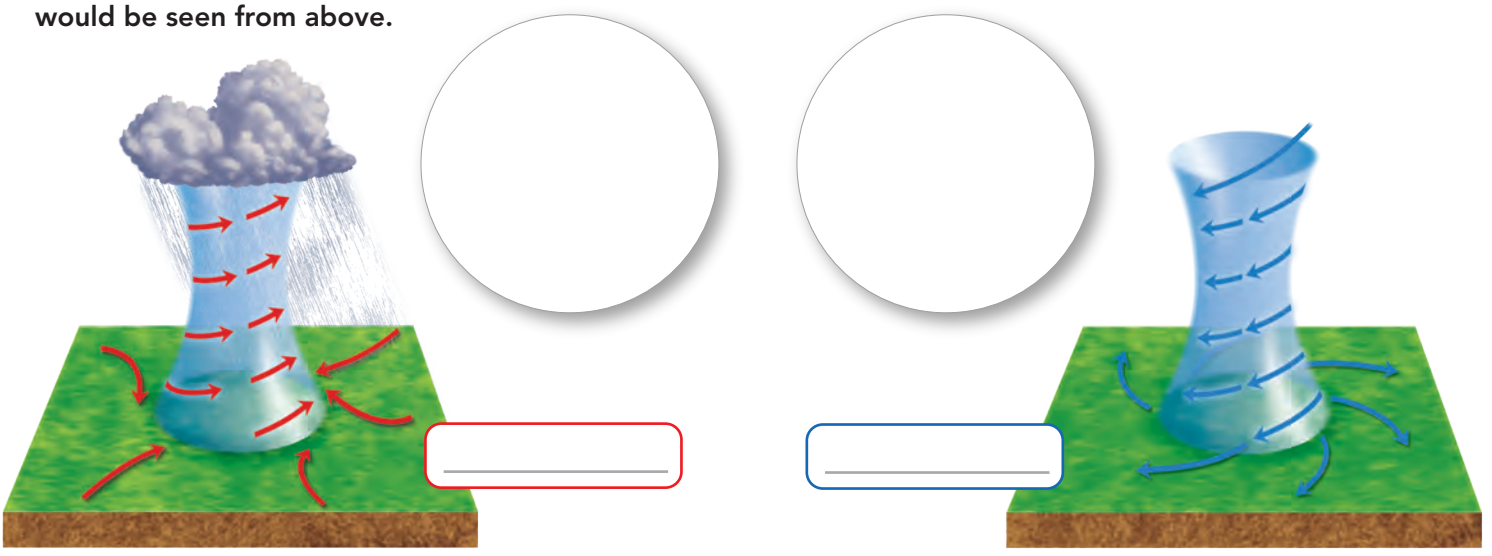
As its name suggests, an anticyclone is the opposite of a cyclone. **Anticyclones** are high-pressure centers of dry air, shown by an *H* on a weather map. Winds spiral outward from the center, moving toward areas of lower pressure. Because of the Coriolis effect, winds in an anticyclone spin clockwise in the Northern Hemisphere. As air moves out from the center, cool air moves downward from higher in the troposphere. The cool air warms up, so its relative humidity drops. **The descending air in an anticyclone generally causes dry, clear weather.**

Vocabulary Prefixes How does knowing the meaning of the prefix *anti-* help you remember how an anticyclone spins?

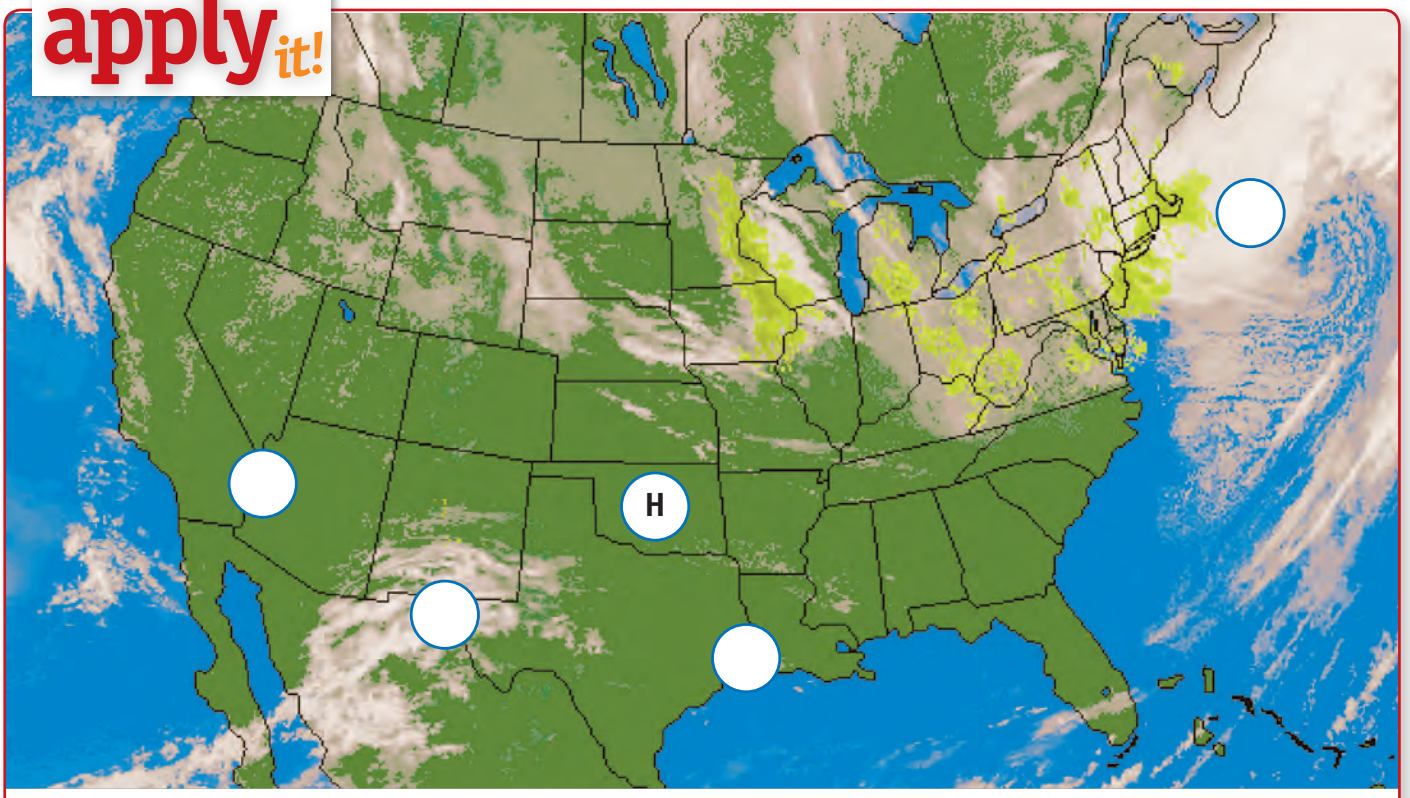
FIGURE 5

Cyclones and Anticyclones

Interpret Diagrams **Label each diagram as either a cyclone or an anticyclone. In each circle, draw an arrow to show the direction of air motion for the system as it would be seen from above.**



apply it!



1 **Classify** Fill in the empty circles with either *L* for a low-pressure center or *H* for a high-pressure center.

2 **CHALLENGE** What information on the map helped you decide if an area's air pressure was low or high?

_____

_____

Lab zone® Do the Quick Lab *Cyclones and Anticyclones.*

Assess Your Understanding

3a. Identify What is a cyclone?

_____

b. Relate Text and Visuals How does air move in a cyclone?

_____

_____

c. Compare and Contrast What kind of weather is associated with a cyclone? What kind of weather is associated with an anticyclone?

_____

_____

_____

got it?

○ **I get it!** Now I know that cyclones cause _____ and anticyclones cause _____

○ I need extra help with _____

_____

TN

LESSON 6

6.ESS2.6

Storms

UNLOCK THE BIG ?

- How Do the Different Types of Storms Form?
- How Can You Stay Safe in a Storm?

MY PLANET DIARY

DISASTERS

The Blizzard of 1978

In February 1978, a huge blizzard hit the northeastern United States. Weather stations recorded hurricane-force winds, and many cities received record-breaking amounts of snow. The storm hovered over New England, and heavy snow fell for almost 33 hours without letting up.

In Massachusetts, people driving on highways abandoned their cars when the snow became too deep to drive through. Rescuers used cross-country skis and snowmobiles to help evacuate the roads. Stranded drivers returned home any way they could. The governor of Massachusetts declared a state of emergency. He called in the National Guard to clear the roads of snow. It took almost a week until the roads opened again.

Communicate Write your answers to each question below. Then discuss your answers with a partner.

1. What do you think made the blizzard so dangerous?

2. Besides the hurricane-force winds and the roads filling with snow, what other hazards do you think the blizzard caused?

Lab zone® Do the Inquiry Warm-Up *Can You Make a Tornado?*

Vocabulary

- storm
- thunderstorm
- lightning
- hurricane
- storm surge
- tornado
- evacuate

Skills

Reading: Outline

Inquiry: Infer

How Do the Different Types of Storms Form?

The Blizzard of 1978 was one of the most intense storms ever to hit the northeastern United States. A **storm** is a violent disturbance in the atmosphere. Storms involve sudden changes in air pressure, which cause rapid air movements. There are several types of severe storms: winter storms, thunderstorms, hurricanes, and tornadoes.

Winter Storms In the winter in the northern United States, a large amount of precipitation falls as snow. **All year round, most precipitation begins in clouds as snow. If the air is colder than 0°C all the way to the ground, the precipitation falls as snow.** Heavy snow can block roads, trapping people in their homes and delaying emergency vehicles. Extreme cold can damage crops and cause water pipes to burst.

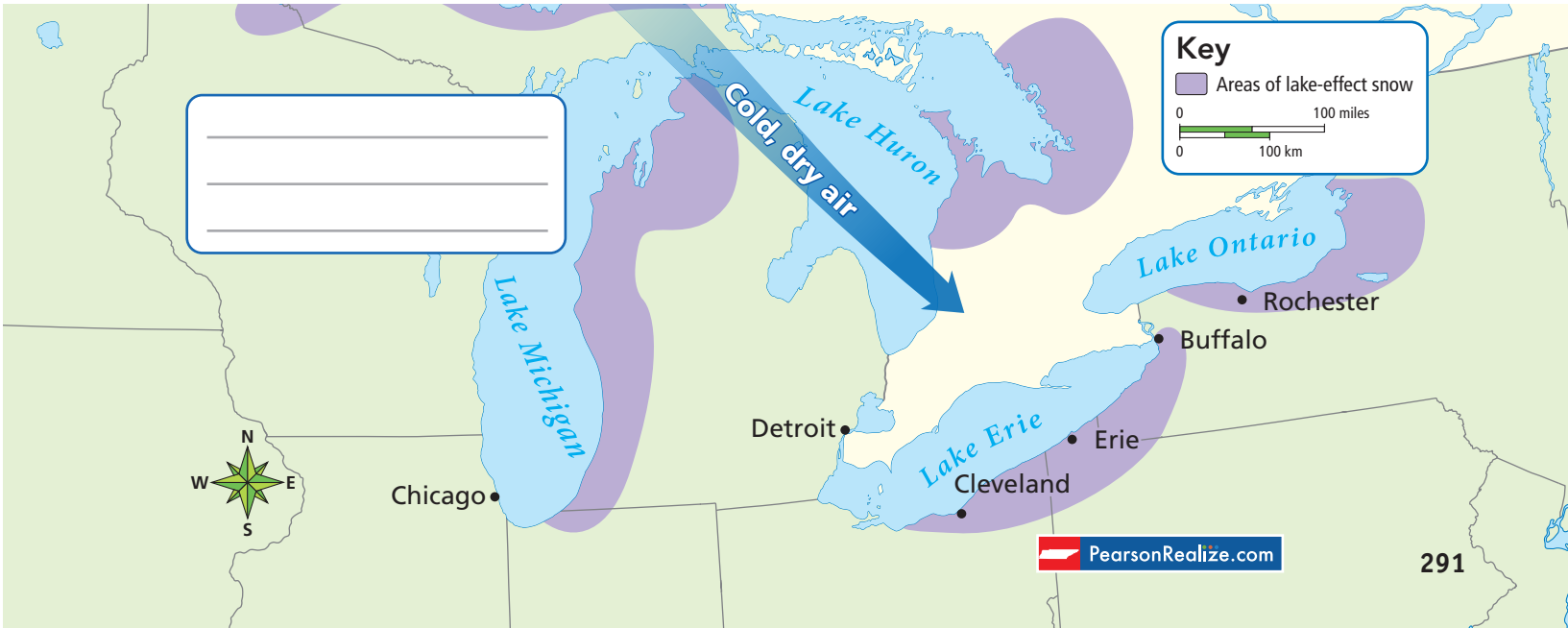
Some places, including Buffalo and Rochester in upstate New York, get a lot more snow than others. In an average winter, nearly three meters of snow fall on these cities due to lake-effect snow, as shown in **Figure 1.** Buffalo is located east of Lake Erie. Rochester is located south of Lake Ontario. In the fall and winter, the land near these lakes cools much more rapidly than the water in the lakes. When a cold, dry air mass moves southeast across one of the lakes, it picks up water vapor and heat. As soon as the air mass reaches the other side of the lake, the air rises and cools again. The water vapor condenses and falls as snow.

FIGURE 1

Lake-Effect Snow

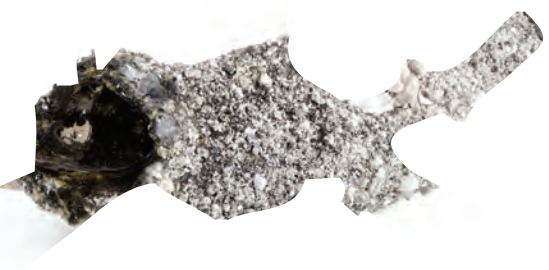
As cold, dry air moves across the warmer water, it becomes more humid as water vapor evaporates from the lake surface. When the air reaches land and cools, lake-effect snow falls.

Interpret Maps **Circle the cities that receive lake-effect snow. In the box on the map, name a city that does not get it and explain why.**



did you know?

A fulgurite forms when lightning strikes sand or sandy soil. The temperature of the lightning is so high that it melts the sand and forms a tube made of glass.



Thunderstorms

Do you find thunderstorms frightening? Exciting? As you watch the brilliant flashes of lightning and listen to long rolls of thunder, you may wonder what causes them.

How Thunderstorms Form

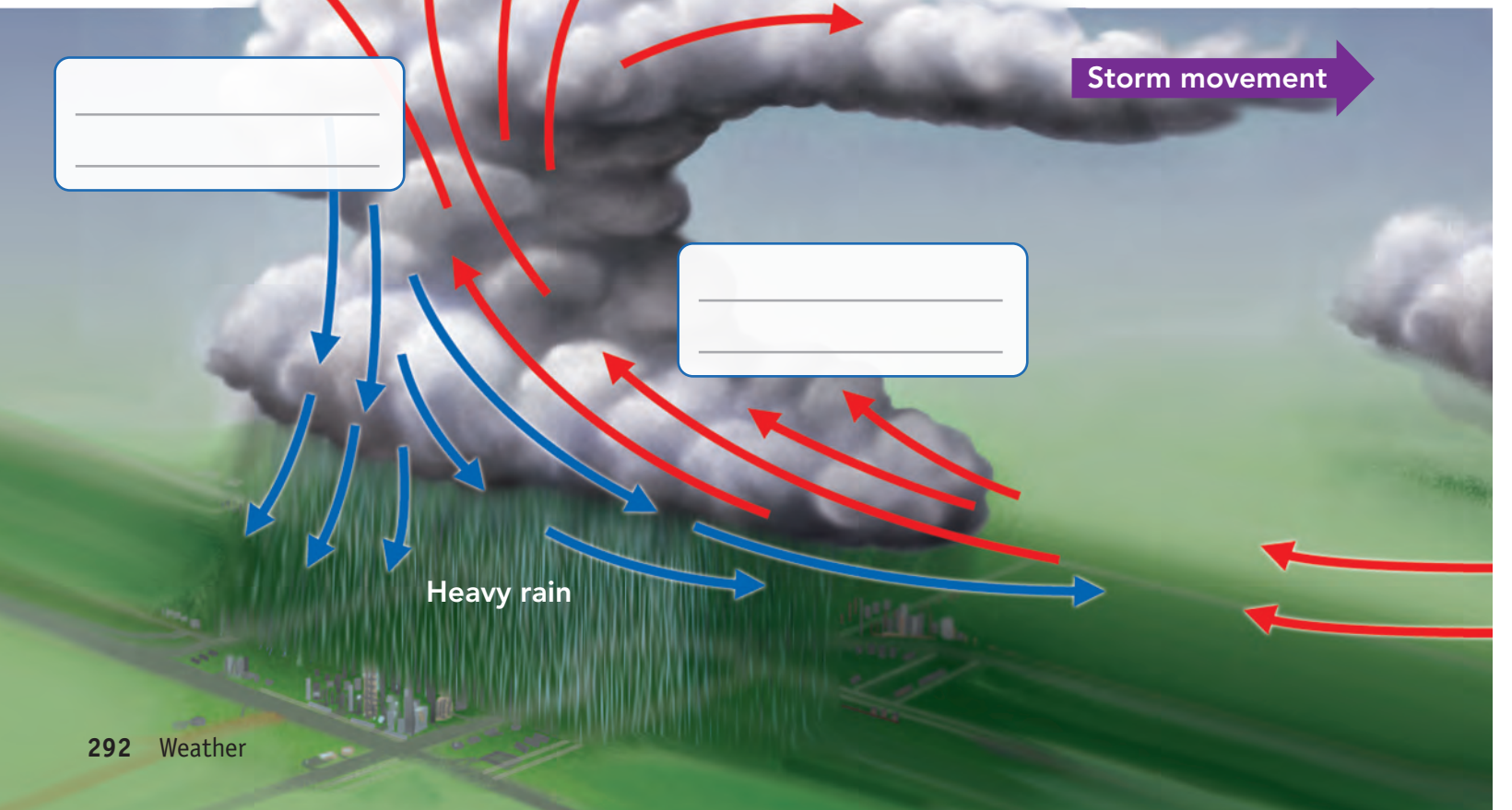
A **thunderstorm** is a small storm often accompanied by heavy precipitation and frequent thunder and lightning. **Thunderstorms form in large cumulonimbus clouds, also known as thunderheads.** Most cumulonimbus clouds form on hot, humid afternoons or evenings. They also form when warm air is forced upward along a cold front. In both cases, the warm, humid air rises rapidly, as shown in **Figure 2.** The air cools, forming dense thunderheads with water condensing into rain droplets. Heavy rain falls, sometimes along with hail. Within the thunderhead are strong upward and downward winds known as updrafts and downdrafts. Many thunderstorms form in the spring and summer in southern states or on the western plains.

FIGURE 2

How Thunderstorms Form

A thunderstorm forms when warm, humid air rises rapidly within a cumulonimbus cloud.

Interpret Diagrams **Fill in the captions noting the direction of the warm, humid air and the cold air.**



Lightning and Thunder During a thunderstorm, areas of positive and negative electrical charges build up in the storm clouds. **Lightning** is a sudden spark, or electrical discharge, as these charges jump between parts of a cloud, between nearby clouds, or between a cloud and the ground. Lightning is similar to the shocks you sometimes feel when you touch a metal object on a very dry day. Because lightning is electricity, it is easily conducted by metal.

What causes thunder? A lightning bolt can heat the air near it to as much as 30,000°C, much hotter than the sun's surface. The rapidly heated air expands explosively. Thunder is the sound of the explosion. Because light travels faster than sound, you see lightning before you hear thunder.

Thunderstorm Damage Thunderstorms can cause severe damage. The heavy rains associated with thunderstorms can flood low-lying areas. Lightning can also cause damage. When lightning strikes the ground, the hot, expanding air can shatter tree trunks or start forest fires. When lightning strikes people or animals, it acts like a powerful electric shock. Lightning can cause unconsciousness, serious burns, and heart failure.

Floods A major danger during severe thunderstorms is flooding. Some floods occur when so much water pours into a stream or river that its banks overflow, covering the surrounding land with water. In urban areas, floods can occur when the ground is already saturated by heavy rains. The water can't soak into the water-logged ground or the many areas covered with buildings, roads, and parking lots. A flash flood is a sudden, violent flood that occurs shortly after a storm.

FIGURE 3

Lightning Damage

Lightning can cause fires, serious damage, and injuries. Infer **Which is more likely to be hit by lightning, a metal or a wooden boat? Why?**

Outline After reading the text on this page, complete the outline by adding details about how a hurricane forms.

I. Hurricanes

A. How a Hurricane Forms

1. _____

2. _____

3. _____

Hurricanes

A **hurricane** is a tropical cyclone with winds of 119 km/h or higher. A typical hurricane is about 600 kilometers across. Hurricanes form in the Atlantic, Pacific, and Indian oceans. In the western Pacific, they are called typhoons. In the Indian ocean, they are simply called cyclones.

How Hurricanes Form

A typical hurricane that strikes the United States forms in the Atlantic Ocean north of the equator in August, September, or October. **A hurricane begins over warm ocean water as a low-pressure area, or tropical disturbance.** If the tropical disturbance grows in size and strength, it becomes a tropical storm, which may then become a hurricane.

Look at **Figure 4** to see how a hurricane forms. A hurricane draws its energy from the warm, humid air at the ocean's surface. As this air rises and forms clouds, more air is drawn into the system. Inside the storm are bands of very high winds and heavy rains. Winds spiral inward toward the area of lowest pressure at the center. The lower the air pressure at the center of a storm, the faster the winds blow toward the center. Hurricane winds may be as strong as 320 km/h.

Hurricane winds are strongest in a narrow band around the storm's center. At the center is a ring of clouds, called the eyewall, that encloses a quiet "eye." The wind gets stronger as the eye approaches. When the eye arrives, the weather changes suddenly. The air grows calm and the sky may clear. After the eye passes, the storm resumes, but the wind blows from the opposite direction.

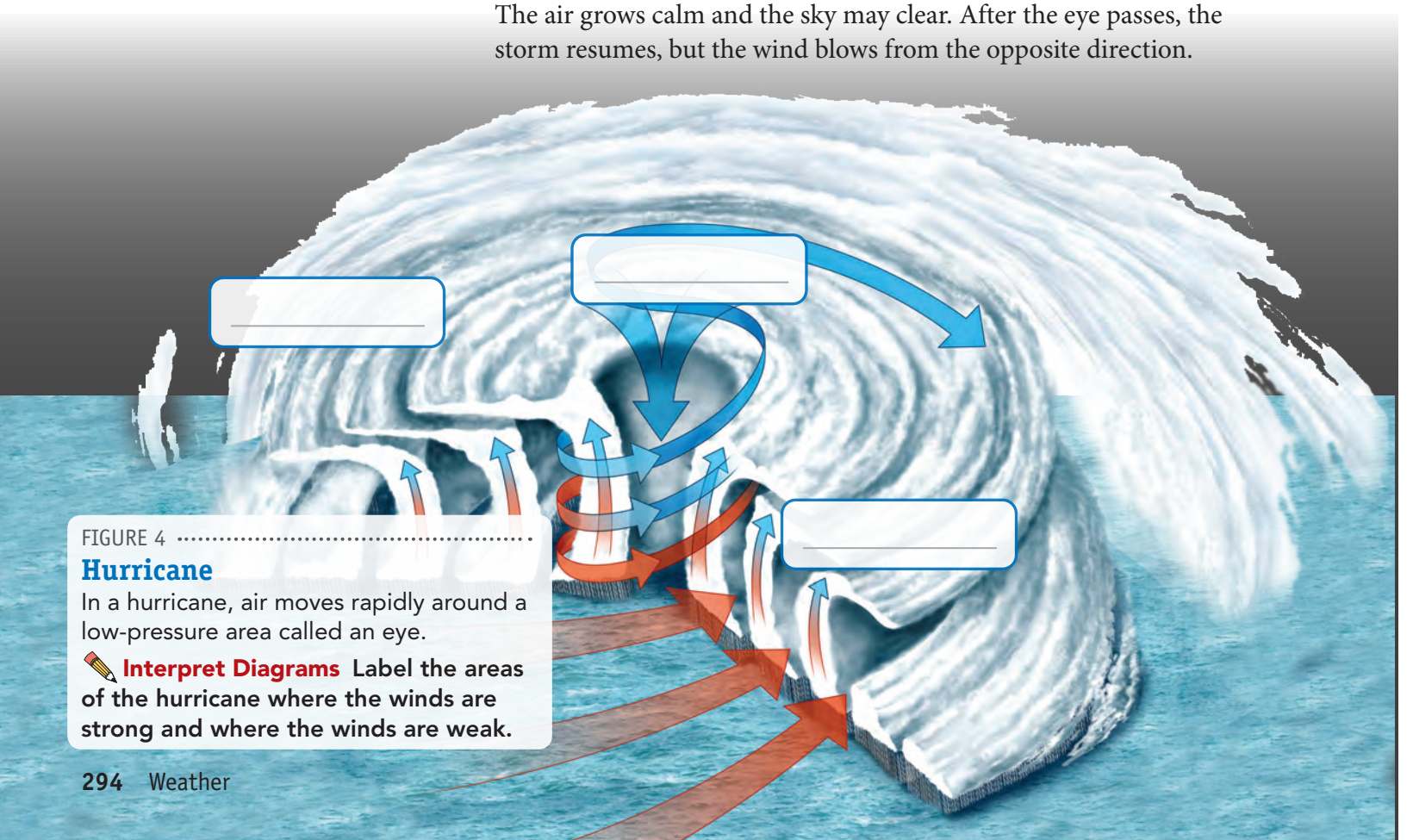


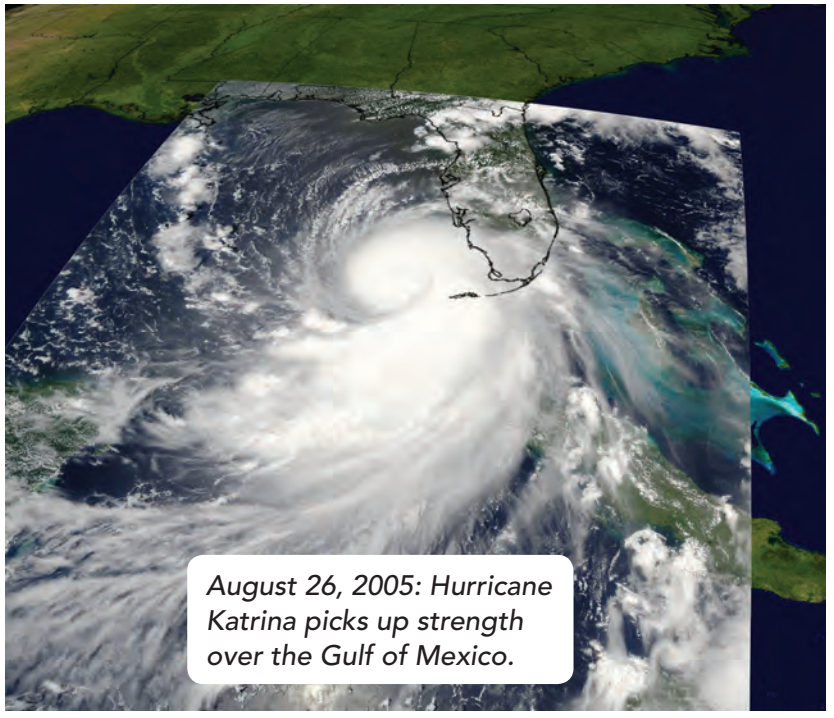
FIGURE 4

Hurricane

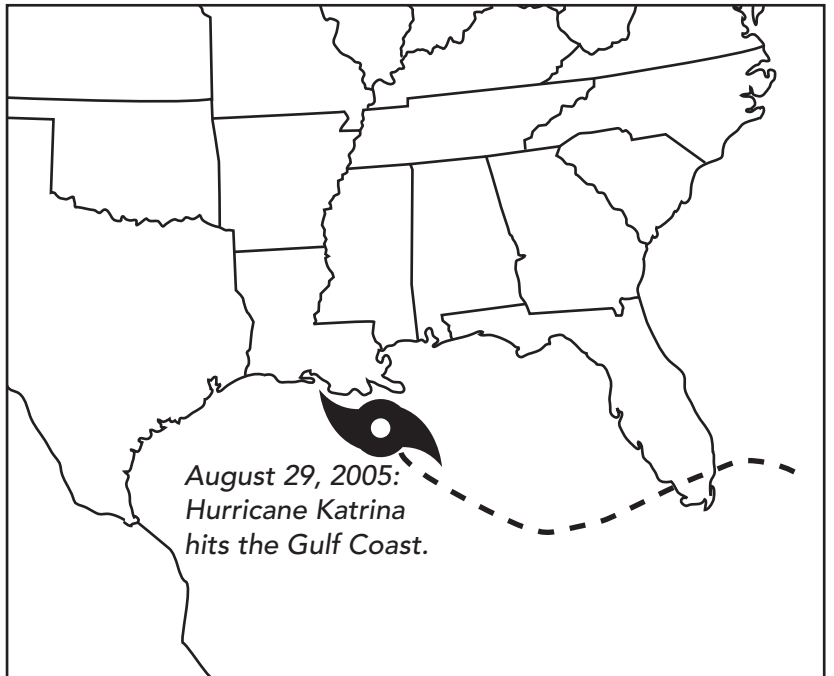
In a hurricane, air moves rapidly around a low-pressure area called an eye.

Interpret Diagrams **Label the areas of the hurricane where the winds are strong and where the winds are weak.**

August 24, 2005: Katrina approaches Florida.



August 26, 2005: Hurricane Katrina picks up strength over the Gulf of Mexico.



How Hurricanes Move Hurricanes can last longer than other storms—a week or more. During that period, they can travel thousands of kilometers. Hurricanes that form in the Atlantic Ocean are steered by easterly trade winds toward the Caribbean islands and the southeastern United States. After a hurricane passes over land, it no longer has warm, moist air to draw energy from. The hurricane gradually weakens, although heavy rainfall may continue for several days.

Hurricane Damage When a hurricane comes ashore, it brings high waves and severe flooding, as well as wind damage. The low pressure and high winds of the hurricane over the ocean raise the level of the water as much as 6 meters above normal sea level. The result is a **storm surge,** a "dome" of water that sweeps across the coast where the hurricane lands. Storm surges can cause great damage, washing away beaches, destroying coastal buildings, and eroding the coastline.

FIGURE 5

Hurricane Katrina

The picture shows the path of Hurricane Katrina.

Predict **On the picture, draw lines showing the possible paths the hurricane could have taken after reaching land. What happens to a hurricane after it reaches land?**

Tornadoes

A tornado is one of the most frightening and intense types of storms. A **tornado** is a rapidly whirling, funnel-shaped cloud that reaches down from a thunderstorm to touch Earth's surface. If a tornado occurs over a lake or ocean, the storm is called a waterspout. Tornadoes are usually brief, but can be deadly. They may touch the ground for 15 minutes or less and be only a few hundred meters across. But an intense tornado's wind speed may approach 500 km/h.

How Tornadoes Form

Tornadoes can form in any situation involving severe weather. **Tornadoes most commonly develop in thick cumulonimbus clouds—the same clouds that bring thunderstorms.** Tornadoes often occur when thunderstorms are likely—in spring and early summer, late in the afternoon when the ground is warm.

Tornado Alley

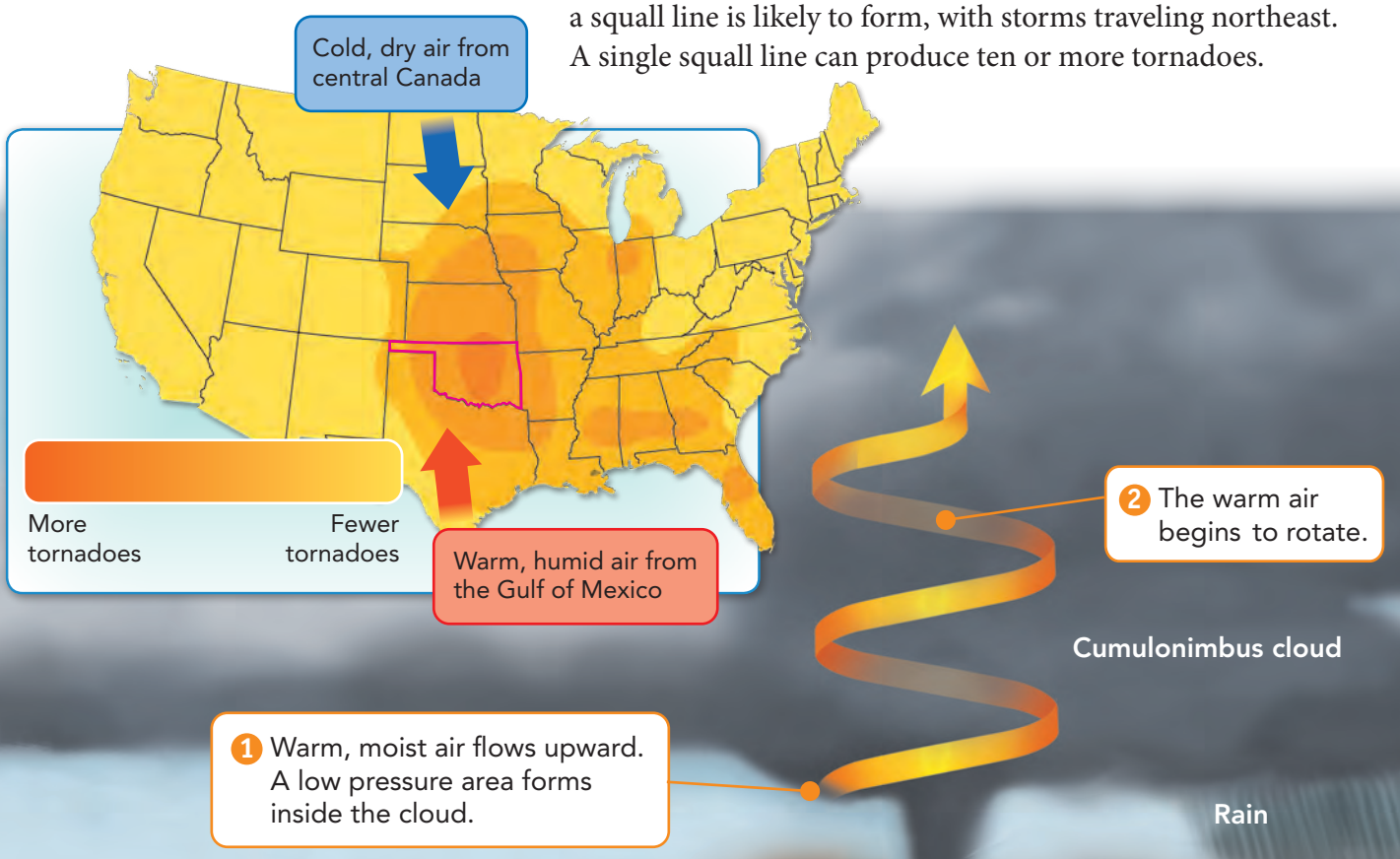
Tornadoes occur in nearly every part of the United States. However, the Great Plains often have the kind of weather pattern that is likely to create tornadoes: A warm, humid air mass moves north from the Gulf of Mexico into the lower Great Plains, and a cold, dry air mass moves south from Canada. When the air masses meet, the cold air moves under the warm air, forcing it to rise. A line of thunderstorms called a squall line is likely to form, with storms traveling northeast. A single squall line can produce ten or more tornadoes.

FIGURE 6

Tornado Formation

About 1,200 tornadoes occur in the United States every year. Weather patterns on the Great Plains result in a "tornado alley."

Interpret Maps **Pick a state on the map (or your home state) and indicate whether its risk of tornadoes is low or high.**



Tornado Damage Tornado damage comes from both strong winds and flying debris. The low pressure inside the tornado sucks objects into the funnel. Tornadoes can move large objects and scatter debris many miles away. One tornado tore a sign off in Oklahoma and dropped it 50 km away in Arkansas! A tornado can level houses on one street but leave neighboring houses standing.

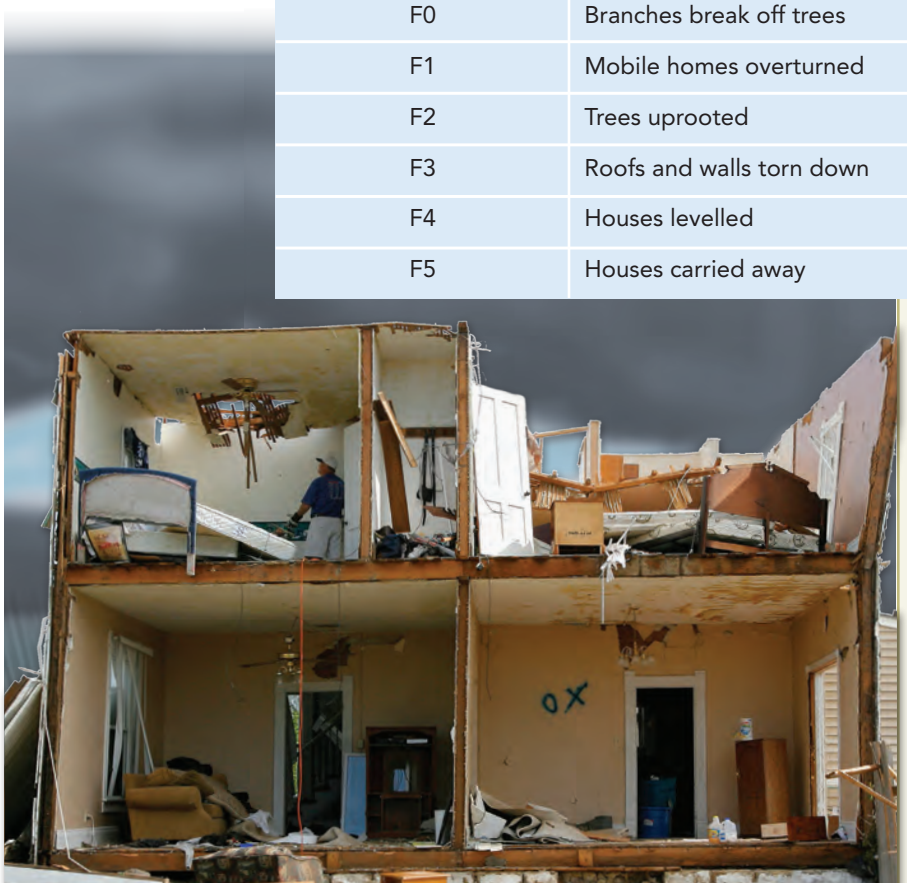
Tornadoes are ranked on the Enhanced Fujita scale by the amount of damage they cause. The scale was named for the scientist who devised the original scale, Dr. T. Theodore Fujita. As shown in **Figure 7,** the scale goes from light damage (EF0) to extreme damage (EF5). Only about one percent of tornadoes are ranked as EF4 or EF5.

FIGURE 7

Tornado Damage

CHALLENGE **How would you rank this tornado damage on the Enhanced Fujita scale? Why?**

Enhanced Fujita Scale	Types of Damage
F0	Branches break off trees
F1	Mobile homes overturned
F2	Trees uprooted
F3	Roofs and walls torn down
F4	Houses levelled
F5	Houses carried away



Lab zone® Do the Quick Lab *Where Do Hurricanes Come From?*

Assess Your Understanding

1a. Identify What is a hurricane?

b. Explain How do hurricanes form?

c. Compare and Contrast How do hurricanes differ from tornadoes?

got it?

○ **I get it!** Now I know that the main kinds of storms are _____

○ I need extra help with _____

How Can You Stay Safe in a Storm?

A winter storm or a thunderstorm can be fun to watch if you're in a safe place. But you don't want to be near a hurricane or tornado if you can avoid it.

Winter Storm Safety Imagine being caught in a snowstorm when the wind suddenly picks up. High winds can blow falling snow sideways or pick up snow from the ground and suspend it in the air. This situation can be dangerous because the blowing snow limits your vision and makes it easy to get lost. Also, strong winds cool a person's body rapidly. **If you are caught in a snowstorm, try to find shelter from the wind.** Cover exposed parts of your body and try to stay dry. If you are in a car, keep the engine running only if the exhaust pipe is clear of snow.

Thunderstorm Safety The safest place to be during a thunderstorm is indoors. Avoid touching telephones, electrical appliances, or plumbing fixtures. It is usually safe to stay in a car. The electricity will move along the metal skin of the car and jump to the ground. However, do not touch any metal inside the car. **During thunderstorms, avoid places where lightning may strike. Also, avoid objects that can conduct electricity, such as metal objects and bodies of water.**

How can you remain safe if you are caught outside during a thunderstorm? Do not seek shelter under a tree, because lightning may strike the tree. Instead, find a low area away from trees, fences, and poles. Crouch with your head down. If you are swimming or in a boat, get to shore and find shelter away from the water.

Hurricane Safety Today, weather satellites can track the paths of hurricanes. So people now receive a warning well in advance of an approaching hurricane. A "hurricane watch" indicates that hurricane conditions are possible in an area within the next 36 hours. You should be prepared to **evacuate** (ee VAK yoo ayt), or move away temporarily. A "hurricane warning" means that hurricane conditions are expected within the next 24 hours. **If you hear a hurricane warning and are told to evacuate, leave the area immediately.**

FIGURE 8

Evacuation Site
In September 2005, the city of Dallas opened up shelters such as the Reunion Arena for people who fled Hurricane Katrina.

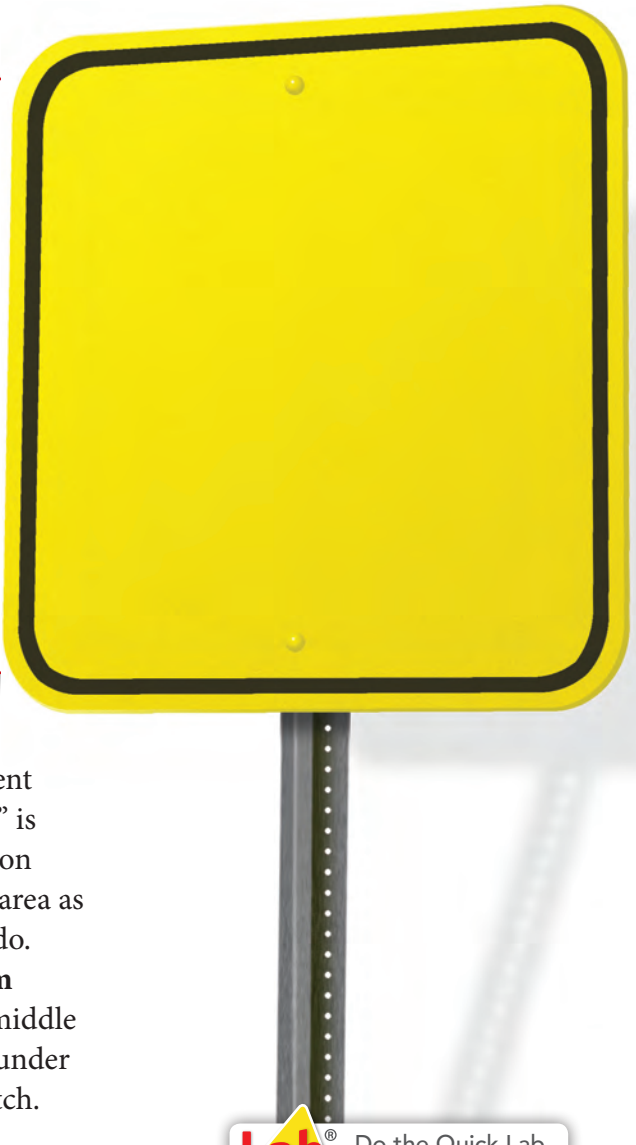
Explain **What is the difference between a hurricane watch and a hurricane warning?**

apply it!

The two signs in the pictures show warnings about possible storms.

1 **Infer** Match each safety sign to the appropriate storm.

2 In the space to the right, draw a sign to show how one could stay safe in a thunderstorm or winter storm.



Tornado Safety A "tornado watch" is an announcement that tornadoes are possible in your area. A "tornado warning" is an announcement that a tornado has been seen in the sky or on weather radar. If you hear a tornado warning, move to a safe area as soon as you can. Do not wait until you actually see the tornado.

The safest place to be during a tornado is in a storm shelter or a basement. If there is no basement, move to the middle of the ground floor. Stay away from windows and doors. Lie under a sturdy piece of furniture. If you are outdoors, lie flat in a ditch.

Lab zone® Do the Quick Lab *Storm Safety.*

Assess Your Understanding

2a. List Based on the safety steps, list the four storms from least to most dangerous.

b. Solve Problems How can a community make sure people stay safe in a storm?

got it?

○ **I get it!** Now I know that to stay safe in a storm I should either _____ or, in the case of a hurricane, I should _____

○ I need extra help with _____

TN

LESSON 7

6.ESS2.5

Predicting the Weather

UNLOCK THE BIG ?

- How Do You Predict the Weather?
- What Can You Learn From Weather Maps?

MY PLANET DIARY

CAREERS

Meteorologist Mish Michaels

Mish Michaels uses computers in her work every day to sort data from weather satellites, radar, and weather stations from all over the world. Then she shares her weather forecasts with television viewers in Boston, Massachusetts.

Michaels became interested in weather while in kindergarten in Maryland. She watched a tornado damage her family's apartment complex. Since then, she has been fascinated by storms. Michaels went on to major in meteorology at Cornell University.

Michaels is devoted to educating others about weather. She supports the WINS program (Women in the Natural Sciences) of Blue Hill Weather Observatory in Milton, Massachusetts. The program inspires girls to pursue careers in math, science, and technology.

Communicate After you read about Mish Michaels, answer these questions with a partner.

1. Why do you think that meteorologists depend so heavily on computers?

2. What subjects do you think future meteorologists need to study in school?

Lab zone® Do the Inquiry Warm-Up *Predicting Weather.*

Vocabulary

- meteorologist
- isobar
- isotherm

Skills

Reading: Compare and Contrast

Inquiry: Predict

How Do You Predict the Weather?

The first step in weather forecasting is to collect data, either from direct observations or through the use of instruments. For example, if a barometer shows that the air pressure is falling, you can expect an approaching low-pressure area, possibly bringing rain or snow.

Making Simple Observations You can read weather signs in the clouds, too. Cumulus clouds often form on warm days. If they grow larger and taller, they can become cumulonimbus clouds, which may produce a thunderstorm. If you can see thin cirrus clouds high in the sky, a warm front may be approaching.

Even careful weather observers often turn to meteorologists for weather information. **Meteorologists** (mee tee uh RAHL uh jists) are scientists who study and try to predict weather.

Interpreting Complex Data Meteorologists interpret information from a variety of sources. **Meteorologists use maps, charts, computers, and other technology to analyze weather data and to prepare weather forecasts.**

Weather reporters get their information from the National Weather Service, which uses balloons, satellites, radar, and surface instruments to gather data.

FIGURE 1

Red Sky

Many people have their own weather sayings. Many of these sayings are based on long-term observations.

Write your own weather poem in the space below.

Red sky at night,
Sailors delight;
Red sky at morning,
Sailors take warning.

Evening red and morning gray
Will send the travelers on their way;
Evening gray and morning red
Will bring down rain upon their head.

Using Technology Techniques for predicting weather have changed dramatically in recent years. Short-range forecasts—forecasts for up to five days—are now fairly reliable. Meteorologists can also make somewhat accurate long-range predictions. Technological improvements in gathering weather data and using computers have improved the accuracy of weather forecasts.

FIGURE 2

Weather Technology

Explain why better technology leads to improved weather forecasting.

Automated Weather Stations

Weather stations gather data from surface locations for temperature, air pressure, relative humidity, rainfall, and wind speed and direction. The National Weather Service has established a network of more than 1,700 surface weather observation sites.

Weather Balloons

Weather balloons carry instruments into the troposphere and lower stratosphere. The instruments measure temperature, air pressure, and humidity.

Weather Satellites

Satellites orbit Earth in the exosphere, the uppermost layer of the atmosphere. Cameras on weather satellites can make images of Earth's surface, clouds, storms, and snow cover. Satellites also collect data on temperature, humidity, solar radiation, and wind speed and direction.

Computer Forecasts

Computers process weather data quickly to help forecasters make predictions. The computer works through thousands of calculations using equations from weather models to make forecasts.

Lab zone® Do the Quick Lab *Modeling Weather Satellites.*

Assess Your Understanding

got it?

- I get it! Now I know that meteorologists prepare weather forecasts using _____
- I need extra help with _____

What Can You Learn From Weather Maps?

A weather map is a "snapshot" of conditions at a particular time over a large area. There are many types of weather maps.

Weather Service Maps Data from many local weather stations all over the country are assembled into weather maps at the National Weather Service. The way maps display data is shown in the Apply It feature below. The simplified weather map at the end of this lesson includes a key that shows weather station symbols.

On some weather maps you see curved lines. These lines connect places with similar conditions of temperature or air pressure. **Isobars** are lines joining places on the map that have the same air pressure. (*Iso* means "equal" and *bar* means "weight.") The numbers on the isobars are the pressure readings. These readings may be given in inches of mercury or in millibars.

Isotherms are lines joining places that have the same temperature. The isotherm may be labeled with the temperature in degrees Fahrenheit, degrees Celsius, or both.

Compare and Contrast
How are isobars and isotherms alike? How do they differ?

apply it!

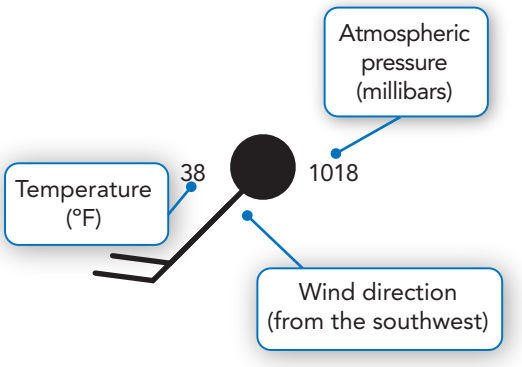
The tables below show what various weather symbols represent.

1 Apply Concepts According to the weather map symbol below, what are the amount of cloud cover and the wind speed?

2 Predict Would you expect precipitation in an area marked by this weather symbol? Why?

Cloud Cover (%)	Symbol
0	○
10	◔
20–30	◔
40	◑
50	◑
60	◕
70–80	◕
90	●
100	●

Weather Map Symbol



Wind Speed (mi/h)	Symbol
1–2	
3–8	
9–14	
15–20	
21–25	
26–31	
32–37	
38–43	
44–49	
50–54	
55–60	
61–66	
67–71	
72–77	

FIGURE 3

Newspaper Weather Map

The symbols on this map show fronts, high- and low-pressure areas, the high and low temperature readings for different cities, and precipitation. The color bands indicate different temperature ranges.

Answer the questions below.

1. **Interpret Maps** Identify the weather that will occur in Denver according to this map.

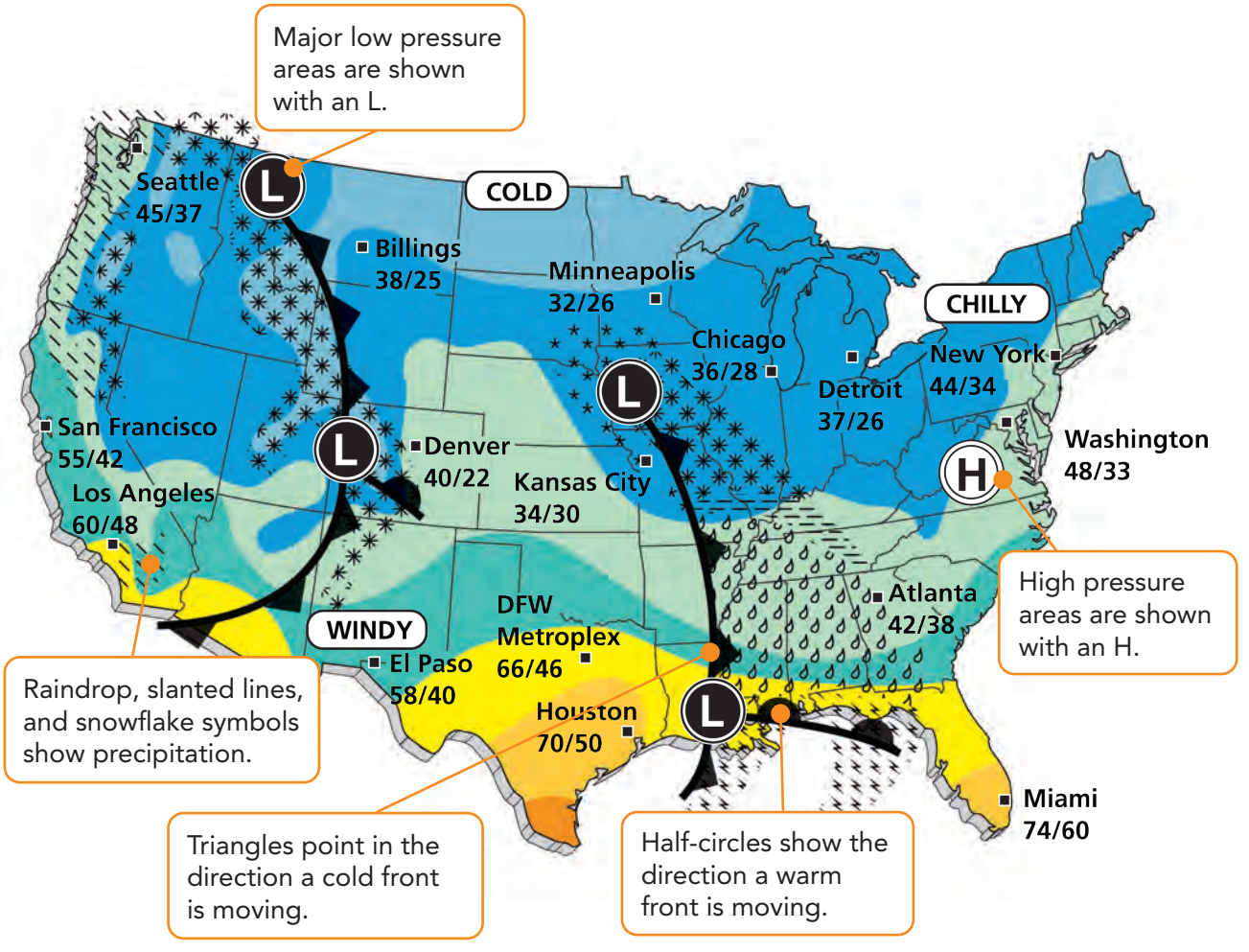
2. CHALLENGE Can you predict the weather in Denver a week later? Explain.

Newspaper Weather Maps

Maps in newspapers are simplified versions of maps produced by the National Weather Service. **Figure 3** shows a typical newspaper weather map. From what you have learned in this lesson, you can probably interpret most symbols on this map. **Standard symbols on weather maps show fronts, areas of high and low pressure, types of precipitation, and temperatures.** Note that the high and low temperatures are given in degrees Fahrenheit instead of Celsius.

Limits of Weather Forecasts

As computers have grown more powerful, and new satellites and radar technologies have been developed, scientists have been able to make better forecasts. But even with extremely powerful computers, it is unlikely that forecasters will ever be able to predict the weather accurately a month in advance. This has to do with the so-called "butterfly effect." The atmosphere works in such a way that a small change in the weather today can mean a larger change in the weather a week later! The name refers to a scientist's suggestion that even the flapping of a butterfly's wings causes a tiny disturbance in the atmosphere. A tiny event might cause a larger disturbance that could—eventually—grow into a large storm.



EXPLORE THE BIG Q

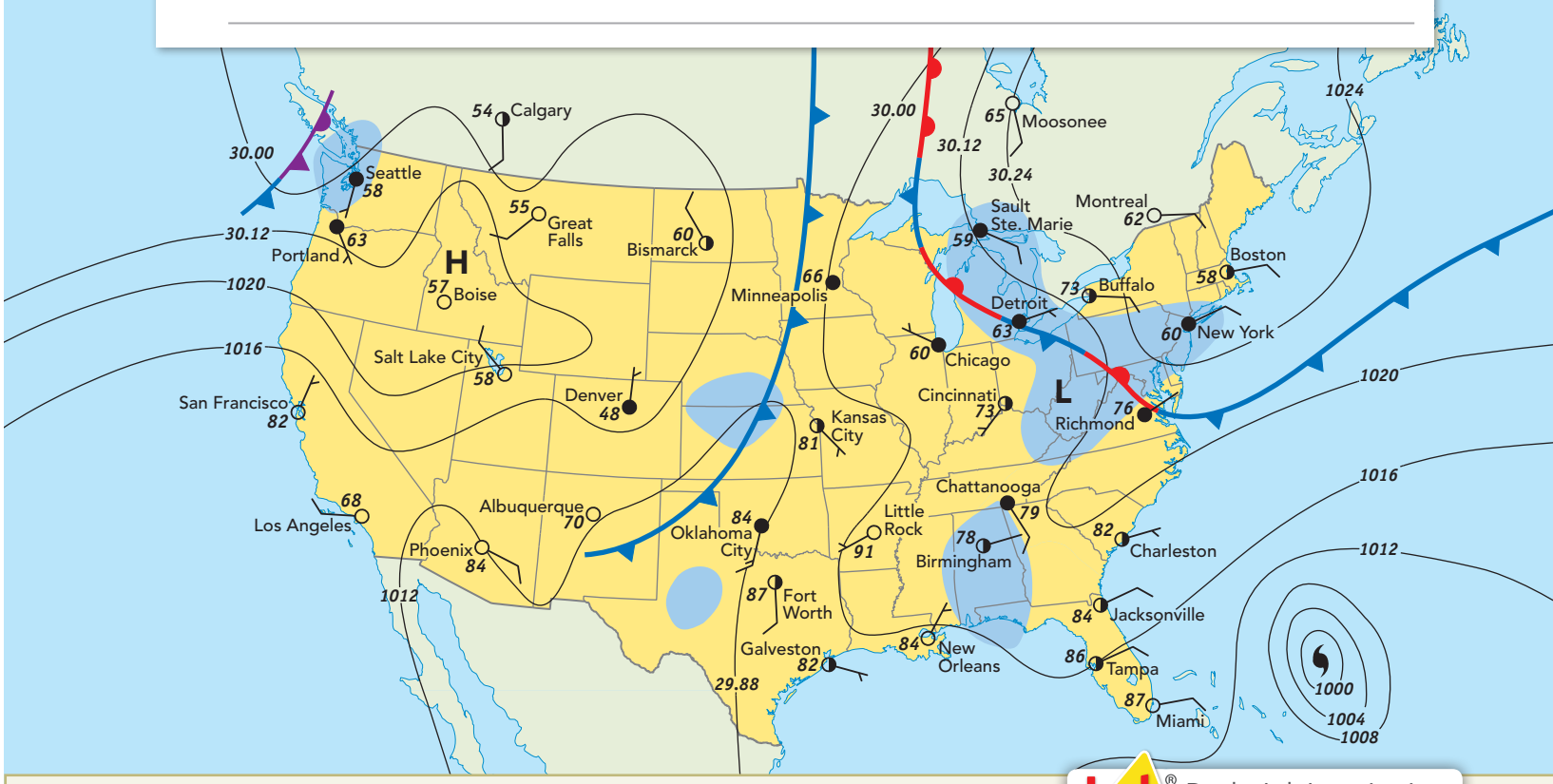
Predicting the Weather

How do meteorologists predict the weather?

FIGURE 4

Using a Weather Map

What would you tell the people of Miami, Kansas City, and Seattle about tomorrow's weather? Explain why.



Lab zone® Do the Lab Investigation *Reading a Weather Map.*

Assess Your Understanding

1a. Explain What is a weather map?

b. ANSWER THE BIG Q How do meteorologists predict the weather?

got it?

- ○ **I get it!** Now I know that standard symbols on weather maps show _____
- ○ I need extra help with _____

CHAPTER 8

Study Guide

REVIEW THE BIG ?

Meteorologists predict the weather by collecting data about _____.

LESSON 1 Water in the Atmosphere

- In the water cycle, water vapor enters the atmosphere by evaporation leaves by condensation.
- Relative humidity can be measured with a psychrometer.

Vocabulary

- water cycle
- evaporation
- condensation
- humidity
- relative humidity
- psychrometer

LESSON 2 Clouds

- Clouds form when water vapor in the air condenses to form ice crystals.
- Scientists classify clouds into three main types based on their shape: cirrus, cumulus, and stratus.

Vocabulary

- dew point
- cirrus
- cumulus
- stratus

LESSON 3 Precipitation

- Common types of precipitation include rain, sleet, freezing rain, snow, and hail.
- Many floods occur when the volume of water in a river increases and it overflows its channel.
- Droughts are usually caused by dry weather systems that stay in one place for weeks or months.

Vocabulary

- precipitation
- rain gauge
- flood
- drought

LESSON 4 Winds

- Winds are caused by differences in air pressure.
- The unequal heating of Earth's surface within a small area causes local winds.
- Global winds are caused by the unequal heating of Earth's surface over a large area.

Vocabulary

- wind
- anemometer
- windchill factor
- local winds
- sea breeze
- land breeze
- global winds
- Coriolis effect
- latitude

LESSON 5 Air Masses

- The major air masses are classified as maritime or continental and as tropical or polar.
- The four types of fronts are cold, warm stationary and occluded.
- Cyclones come with wind and precipitation.

Vocabulary

- air mass
- tropical
- polar
- maritime
- continental
- jet stream
- front
- occluded
- cyclone
- anticyclone

LESSON 6 Storms

- Most precipitation begins in clouds as snow.
- Thunderstorms and tornadoes form in cumulonimbus clouds.
- A hurricane begins over warm ocean water as a low-pressure area, or tropical disturbance.
- Always find proper shelter from storms.

Vocabulary

- storm
- thunderstorm
- lightning
- hurricane
- storm surge
- tornado
- evacuate

LESSON 7 Predicting the Weather

- Meteorologists use maps, charts, computers, and other technology to prepare weather forecasts.
- Standard symbols on weather maps show fronts, air pressure, precipitation, and temperature.

Vocabulary

- meteorologist
- isobar
- isotherm

Review and Assessment

LESSON 1 Water in the Atmosphere

1. **Infer** What is the energy source for the water cycle?

2. **math!** At 3 P.M., a dry-bulb thermometer reading is 66°F. The wet-bulb reading is 66°F. What is the relative humidity? Explain.

LESSON 2 Clouds

3. What type of cloud forms at high altitudes and appears wispy and feathery?

a. stratus **b.** altocumulus

c. cumulus **d.** cirrus

4. One type of cloud is a nimbostratus, which is

5. **Infer** Why do clouds usually form high in the air instead of near Earth's surface?

LESSON 3 Precipitation

6. What is the name for raindrops that freeze as they fall through the air?

a. dew **b.** sleet

c. hail **d.** frost

7. Rain and hail are both precipitation, which is

8. **Write About It** It is winter where Jenna lives. It's been snowing all day, but now the snow has changed to sleet and then to freezing rain. What is happening to cause these changes? In your answer, explain how snow, sleet, and freezing rain form.

LESSON 4 Winds

9. The calm areas near the equator where warm air rises are

a. horse latitudes. **b.** trade winds.

c. doldrums. **d.** polar easterlies.

10. Nights often feature land breezes, which blow

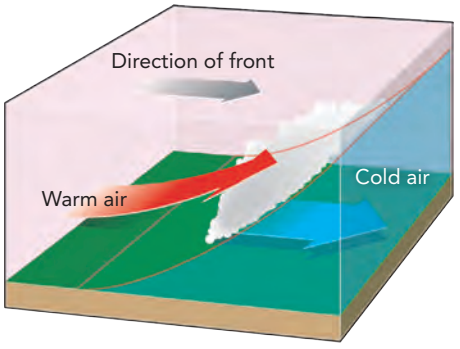
CHAPTER 8

Review and Assessment

LESSON 5 Air Masses

11. What do you call a hot air mass that forms over land?

12. Predict What type of weather is most likely to form at the front shown below?



LESSON 6 Storms

13. What are very large tropical cyclones with high winds called?

a. storm surges **b.** tornadoes

c. hurricanes **d.** thunderstorms

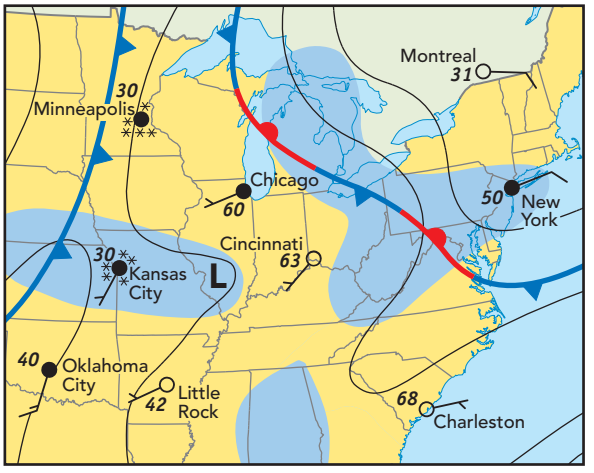
14. Make Judgments What do you think is the most important thing people should do to reduce the dangers of storms?

LESSON 7 Predicting the Weather

15. Apply Concepts How does the butterfly effect keep meteorologists from accurately forecasting the weather a month in advance?

APPLY THE BIG Q How do meteorologists predict the weather?

16. Meteorologists use information from many sources to make predictions about the weather. The weather map shows that right now it is sunny in Cincinnati, but the weather report for tomorrow shows a major snowstorm. Using the map, explain how a meteorologist is able to make this prediction. Include details on weather technology used and the atmospheric conditions that lead to a snowstorm. Make sure to discuss clouds, air masses, fronts, temperature, and pressure.



TNReady Prep

6.ESS2.2, 6.ESS2.4, 6.ESS2.5, 6.ESS2.6

Read each question and choose the best answer.

1. The table below shows the amount of rainfall in different months.

Average Monthly Rainfall			
Month	**Rainfall**	**Month**	**Rainfall**
January	1 cm	July	49 cm
February	1 cm	August	57 cm
March	1 cm	September	40 cm
April	2 cm	October	20 cm
May	25 cm	November	4 cm
June	52 cm	December	1 cm

Which two months had the most rainfall?

A June and August **B** January and March
C June and July **D** August and May

2. When the temperature equals the dew point, what is the relative humidity?

A zero **B** 10%
C 50% **D** 100%

3. How does the jet stream influence weather?

A by elevating temperature and pressure
B by lowering pressure and humidity
C by reducing temperature and density
D by moving air masses to produce fronts

4. Low pressure over warm ocean water may produce which of the following conditions?

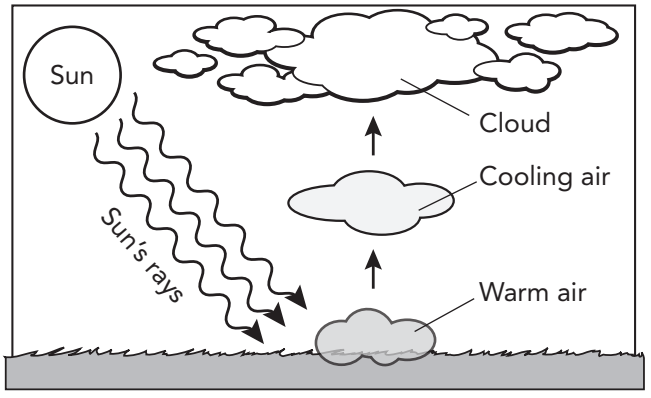
A fair weather
B a thunderstorm
C a hurricane
D a tornado

5. Which of the following map symbols identifies a place likely to experience fair weather?

A isobars
B H for *high pressure*
C isotherms
D H for *high temperature*

Constructed Response

Use the diagram below and your knowledge of science to help you answer Question 6. Write your answer on a separate piece of paper.

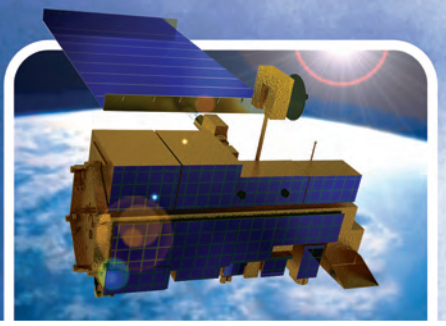


6. Describe the process by which a cloud forms. What two conditions are necessary for this process to occur? How does this process compare to the process by which dew or frost form?

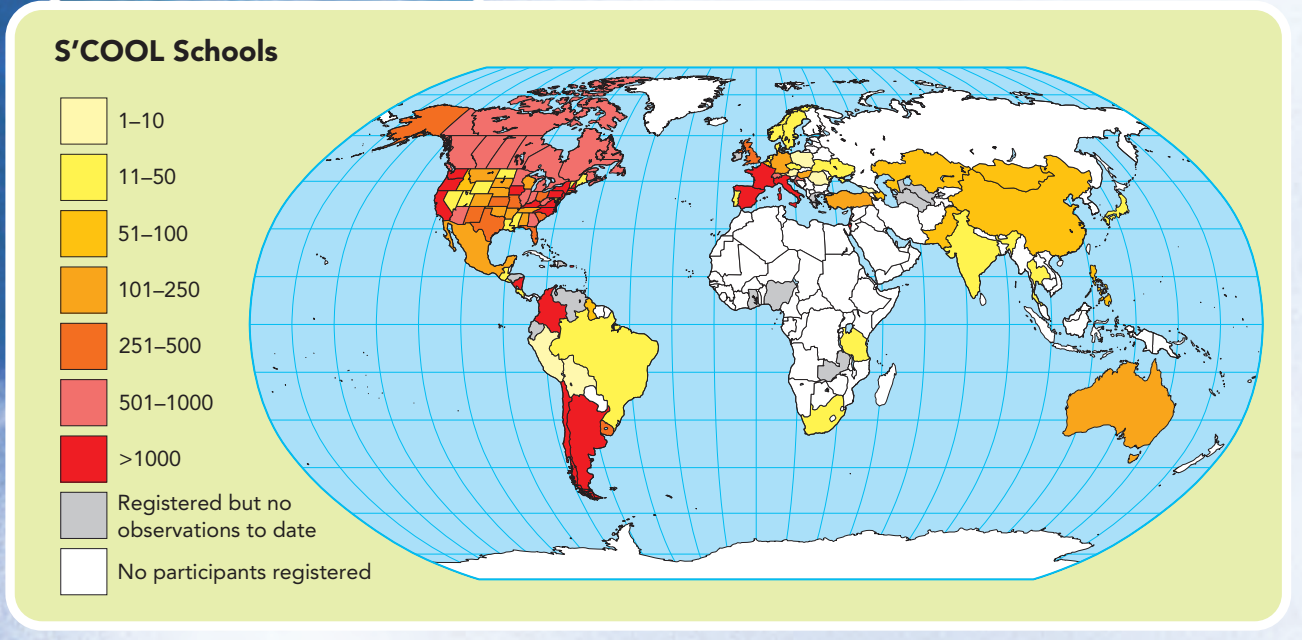
The S'COOL Project

Schools around the world are teaming up to help scientists at the National Aeronautics and Space Administration (NASA). Since 1998, students have been helping NASA check satellite observations through a project called Students' Cloud Observations On-Line (S'COOL).

NASA tells schools in the program the date and time when the project satellites will be passing over different regions of the world. When a satellite passes over their school, students observe the clouds in the sky. Students can also measure weather data such as temperature and relative humidity. These observations are uploaded to the project Web site. Then NASA scientists compare the satellite data with the students' observations. This process, called ground truthing, helps scientists determine how accurate the satellite data are.



◀ Students' observations are compared to data collected by satellites like this one.



▲ Schools around the world participate in the S'COOL program. The map above shows where they are. If you had to recruit schools to help NASA get complete data, where would you look for schools?

Research It Make a record book. Use it to keep a weeklong log of cloud formations and weather conditions, including photos or sketches, at a specific time each day.

Tracking Hurricanes

with Latitude and Longitude

Do you understand the important bulletin on the computer screen? Lines of latitude and longitude are imaginary lines that crisscross Earth's surface. Because the lines cross, they can help you describe any location on Earth, including the location of hurricanes. A location's latitude is always written before its longitude.

Hurricane Hilda is located in the Atlantic Ocean off the southeastern coast of the United States.

Write About It Assume that Hurricane Hilda is following a straight path. Using the information in the bulletin and the map, try to predict the path the hurricane will take to reach land, and how long it will take to get there. Compare your predicted path with the path of a real hurricane. Evaluate your prediction. Does the bulletin provide enough information for you to make a precise prediction? Write a paragraph explaining why or why not.

ATTENTION

HURRICANE HILDA IS CURRENTLY
LOCATED AT 30°N, 74°W.
IT IS MOVING 21 KM/H NW.
ALL RESIDENTS OF NEARBY
COASTAL AREAS ARE ADVISED
TO EVACUATE IMMEDIATELY.

Hurricane Hilda is currently located at 30° N, 74° W. You can plot the hurricane's location on a map. What information do you need to predict where it will reach land? ▶