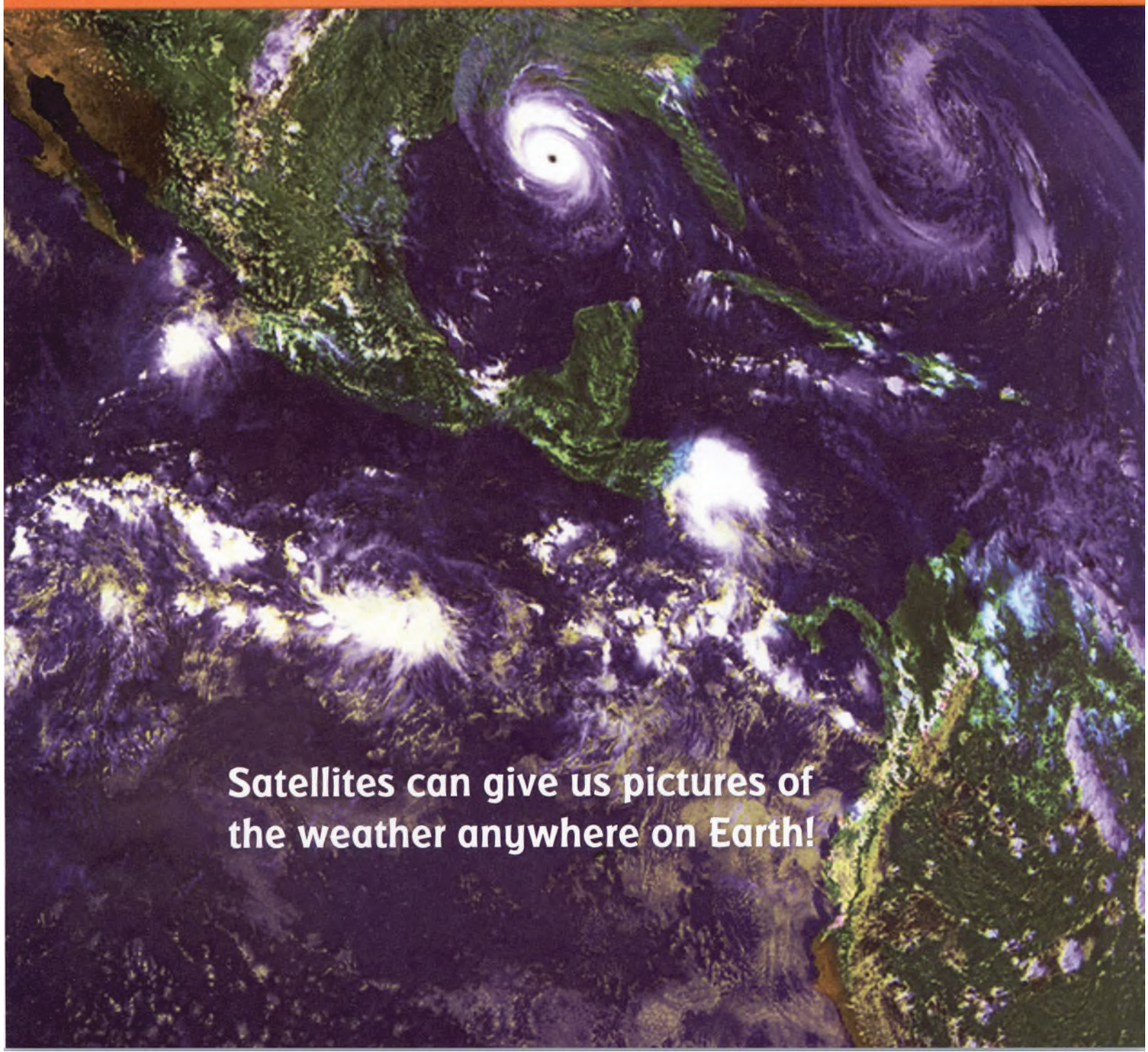
UNIT D

Weather and Space



Satellites can give us pictures of the weather anywhere on Earth!


Literature
TIME FOR KIDS
Magazine Article

Tornado

from *Time for Kids*

Tears through Midwest

FUJITA SCALE	
F0	branches broken off some trees
F1	surfaces peeled off roofs
F2	whole roofs torn from some houses
F3	most trees in the forest uprooted
F4	well-constructed houses destroyed
F5	houses and trucks hurled through the air

Every day you feel the effects of weather. Sometimes the weather changes powerfully. When tornadoes form, the effects might not be forgotten for years. In 2005, one such tornado took Indiana and Kentucky by storm.

Officials estimate its destructive path was about three-fourths of a mile wide and 20 miles long.

Tornadoes are made of strong, spinning winds. The churning storm first struck Evansville. There, it destroyed part of the Eastbrook Mobile Home Park. Indiana officials said that 100 of the 320 mobile homes had been destroyed and 125 others were damaged.

The tornado was rated a severe F3 on what is called the Fujita Scale. Its winds ranged from 158 miles per hour (mph) to 206 mph. The Fujita Scale is named after its creator, Dr. Theodore Fujita. The scale ranges from the weakest, F0, to F5, which is the strongest.

Tornadoes are created when the warm air of a giant storm system rises and hits a current of downward-moving cool air. The crash can cause the wind to start spinning and form a tornado. The center of a tornado is called a vortex. It sucks in air and carries it upward. Most tornadoes are black from picking up dust.

Write About It

Response to Literature What would happen if a tornado struck your community? Write a fictional story. Describe how your community would stay safe. How would it rebuild after the disaster?

LOG ON e-Journal Write about it online at www.macmillanmh.com

CHAPTER 7

Weather and Climate

The Big Idea: What are weather and climate?

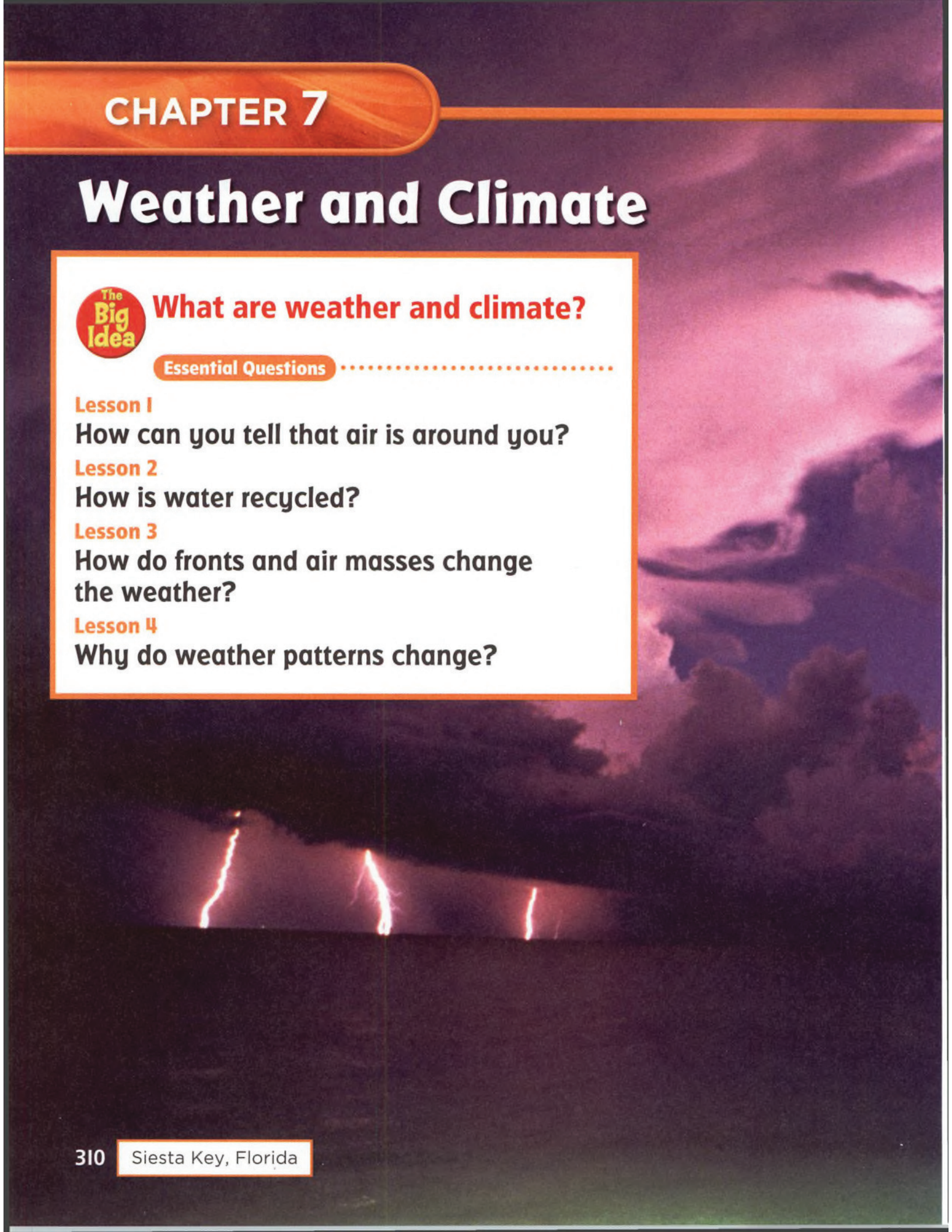
Essential Questions

Lesson 1
How can you tell that air is around you?

Lesson 2
How is water recycled?

Lesson 3
How do fronts and air masses change the weather?

Lesson 4
Why do weather patterns change?



Big Idea Vocabulary

atmosphere the blanket of gases that surrounds Earth (p. 314)

condensation the process of a gas changing into a liquid (p. 325)

cloud a collection of tiny water droplets or ice crystals that hangs in the air (p. 325)

air mass a large region of the atmosphere where the air has similar properties throughout (p. 336)

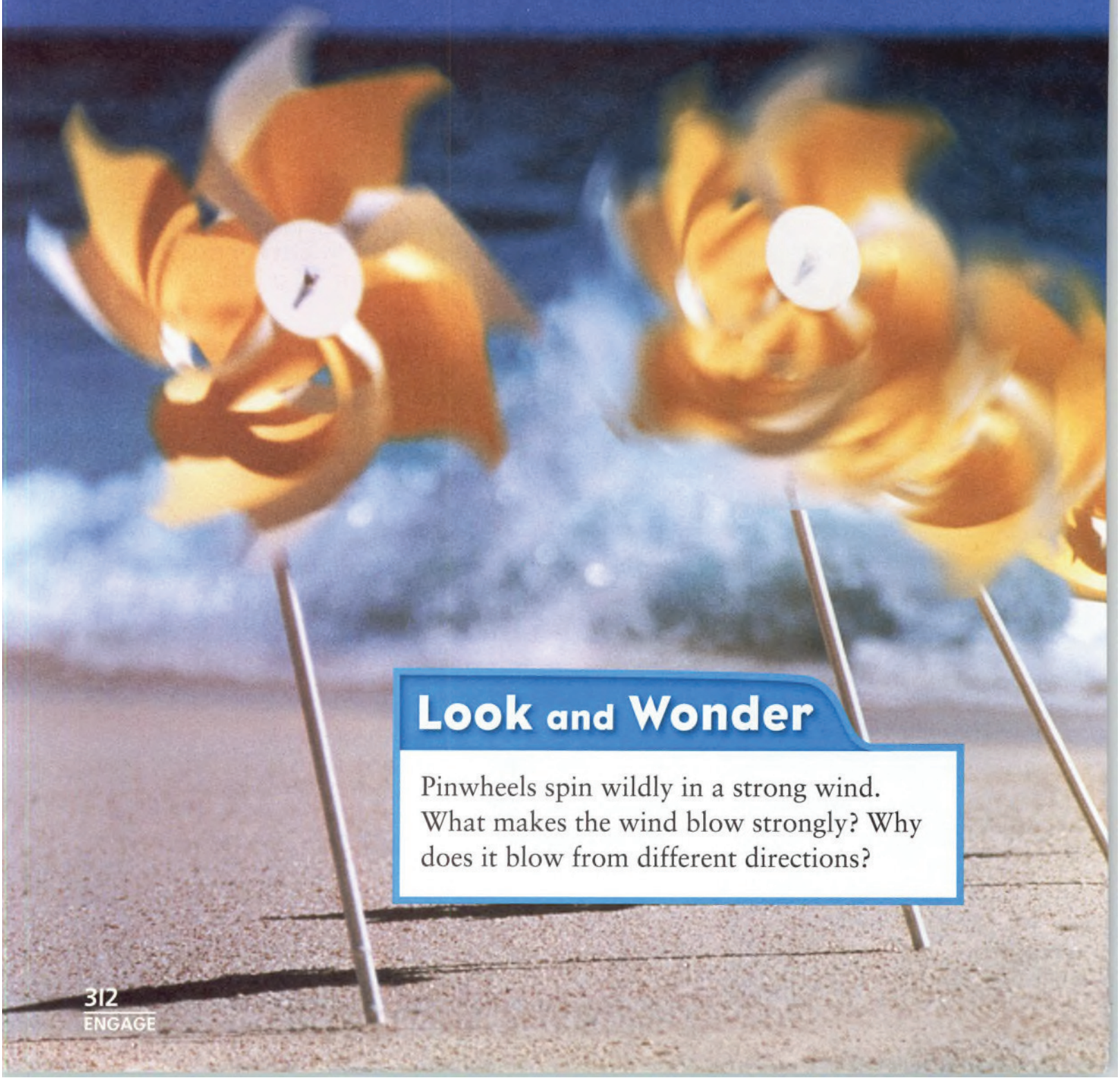
front a boundary between air masses with different temperatures (p. 337)

climate the average weather pattern of a region over time (p. 346)

LOG ON Visit www.macmillanmh.com for online resources.

Lesson 1

Air and Weather



Look and Wonder

Pinwheels spin wildly in a strong wind. What makes the wind blow strongly? Why does it blow from different directions?

Explore

Inquiry Activity

How does the wind move?

Make a Prediction

Air can move from place to place. When you open a sealed bottle of liquid that is under pressure, air moves. Does the air move into or out of the bottle? Why? Make a prediction.

Test Your Prediction

1. **Make a Model** Fill an empty plastic bottle halfway with very warm water from a faucet.
2. **Be Careful.** Pour warm liquids carefully. Place the cap on the bottle. Shake the bottle several times. Pour the water out. Replace the cap and set the bottle on a table. Observe it for several minutes.
3. **Observe** Hold the bottle near your ear. Remove the cap slowly. Listen carefully.

Draw Conclusions

4. Did air move into or out of the bottle? What happened to the pressure inside the bottle before the cap came off? After it came off?
5. **Infer** How might air pressure affect the direction from which winds blow? Use evidence from your model in your answer.

Materials

- bottle with cap
- funnel
- very warm water

Explore More

Suppose you warm the air inside a capped bottle. What will happen to the air pressure inside the bottle? Write a prediction. Try it!

Read and Learn

Essential Question

How can you tell that air is around you?

Vocabulary

atmosphere, p. 314

temperature, p. 316

humidity, p. 316

air pressure, p. 317

thermometer, p. 318

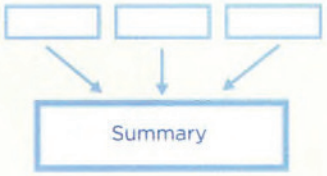
wind vane, p. 318

barometer, p. 318

rain gauge, p. 318

Reading Skill

Summarize



Technology

e-Glossary and e-Review online at www.macmillanmh.com

What is in the air?

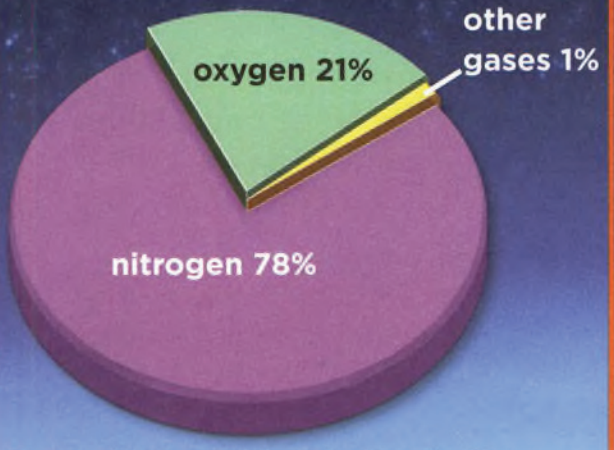
Air surrounds Earth like a thin blanket. This blanket of air is the **atmosphere** (AT•muh•sfeer). How is the atmosphere important to people and other living things?

Gases

The atmosphere is a mix of different gases. You can tell from the circle graph that most of the atmosphere is made of nitrogen (NI•truh•jun) and oxygen. The atmosphere also has carbon dioxide and other important gases.

Animals and most other organisms need oxygen to live. Plants also need carbon dioxide. The atmosphere allows living things to survive on Earth.

Layers of Earth's Atmosphere



Most of the air we breathe in the troposphere is oxygen and nitrogen.

The Troposphere

Earth's atmosphere is made up of layers. The layer closest to Earth's surface is the *troposphere* (TROH•puh•sfeer). Compared to the rest of the atmosphere, the troposphere is very thin. Yet all of Earth's life exists here.

The troposphere is also where all of Earth's weather takes place. Here the air is always on the move. Air that moves from place to place is called *wind*. Wind can be as gentle as a light breeze. It can be as fierce as a tornado. Any change in the wind brings a change in the weather.

Other Layers of the Atmosphere

The diagram shows three other layers of Earth's atmosphere. The stratosphere (STRA•tuh•sfeer) is the layer above the troposphere. The troposphere has few air particles. The air gets even lighter in the mesosphere (ME•zuh•sfeer) and thermosphere (THUR•muh•sfeer).

Quick Check

Summarize How are the troposphere and the atmosphere related?

Critical Thinking In what way is Earth's atmosphere like an orange peel? How is it different?

Read a Diagram

Which layer of the atmosphere is thickest?

Clue: Use subtraction. The numbers tell you the height of each layer above Earth's surface.

What is weather?

Weather is the condition of the atmosphere at a given time and place. Weather can vary depending on the time of day, season, or place.

Air Temperature

Temperature (TEM•puh•ruh•chur) describes how hot or cold something is. When the Sun's energy heats Earth's surface, the surface warms the air above it. The air moves.

Some parts of Earth's surface heat up more than other parts. The uneven heating of Earth's surface causes air to move at different speeds. Moving air is called wind.

Humidity

If the air around us feels damp and sticky, we call the weather humid (HYEW•mud). **Humidity** (hyew•MIH•duh•tee) is a measure of how much moisture is in the air. Deserts usually have very low humidity. Rain forests have very high humidity.

Air always has some amount of moisture. Most of the moisture comes from ocean water that changes into a gas. The rest comes from bodies of water, soil, and plants.

Read a Photo

What can you infer about the weather in a tropical rain forest?

Clue: Look for clues that show humidity and air temperature.

Humidity in a Rain Forest

Mountain climbers use special equipment to deal with low temperature and low air pressure.

Air Pressure

We live at the bottom of the troposphere. Here, the weight of the entire atmosphere pushes down on us. The force of air pushing on an area is called **air pressure**.

Particles of cool air are closer together than particles of warm air. In the same amount of space, cool air weighs more than warm air. Warm air is less *dense*, or packed together, than cold air. As air warms, its pressure decreases. Air moves from an area of high pressure to an area of low pressure.

Precipitation

Any form of water that falls from clouds is *precipitation* (prih•sih•puh•TAY•shun). The term includes rain, snow, sleet, and hail.

Quick Lab

Humidity in a Cup

1. Pour 5 milliliters of water in each of two cups. Cover each cup with plastic wrap.
2. Place one cup in the refrigerator for ten minutes. Keep the other cup on a flat surface.
3. **Observe** Remove the cup from the refrigerator. Set it beside the other cup. Observe and compare the water in both cups. What differences do you notice?
4. **Infer** Which cup do you think has greater humidity—the warm cup or the cold cup? How do you know?

Quick Check

Summarize What properties can you use to describe the weather?

Critical Thinking What role does the Sun play in Earth's weather?

FACT Humidity on Earth's surface never reaches zero.

How can you measure weather?

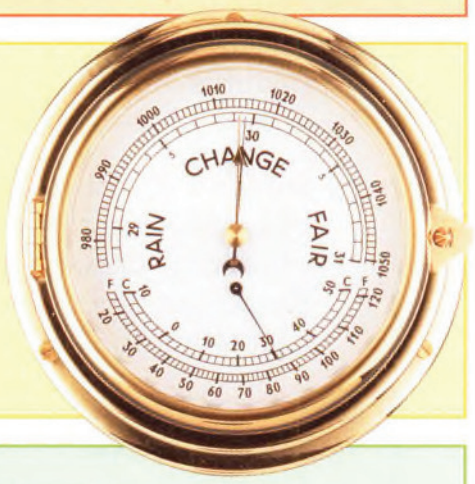
Weather scientists often collect data from a place called a weather station. You can set up your own weather station. All you need are a few of the tools shown on this page.

A *hygrometer* (hi•GRAH•muh•tur) measures humidity. ▲

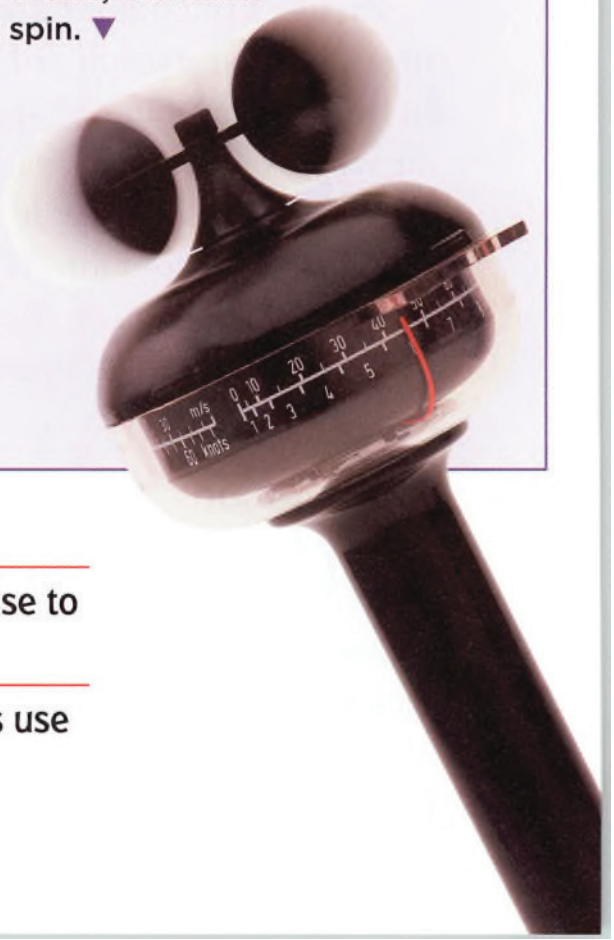
◀ A thermometer measures air temperature in degrees Celsius (°C) or degrees Fahrenheit (°F).

A wind vane points in the direction from which the wind is blowing. ▶

A barometer measures air pressure. ▶



An *anemometer* (a•nuh•MAH•muh•tur) measures wind speed. The faster the wind blows, the faster the cups spin. ▼



◀ A rain gauge (GAYJ) is a tube that collects water. It shows the amount of rainfall.

Quick Check

Summarize What tools could you use to measure the weather?

Critical Thinking Why do scientists use different tools to measure weather?

Lesson Review

Visual Summary

Earth's atmosphere is made of gases. It has several layers. The troposphere is the layer where weather forms.

We can describe the **properties of weather** using air temperature, humidity, air pressure, precipitation, and wind.

Scientists use many different **tools to measure weather,** such as hygrometers and thermometers.

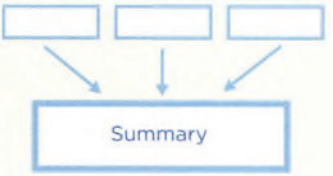
Make a FOLDABLES Study Guide

Make a three-tab book. Use it to summarize what you read about air and weather.

Think, Talk, and Write

1. **Vocabulary** A(n) _____ measures the speed of the wind.

2. **Summarize** What are the different parts of Earth's atmosphere?



3. **Critical Thinking** Compare and contrast two examples of weather that you have experienced. Your comparison should include the vocabulary terms from this lesson.

4. **Test Prep** **In which layer of the atmosphere do we experience weather?**

   A thermosphere
   B stratosphere
   C mesosphere
   D troposphere

5. **Essential Question** How can you tell that air is around you?

Math Link

Find the Average Rainfall
It rained 4 centimeters on Monday, 8 cm on Tuesday, and 6 cm on Wednesday. What is the average rainfall for the three days?

Health Link

Report on Staying Healthy
How do people stay healthy when the air temperature is very cold or very hot? Research the answers. Report on your findings.

Writing in Science

WATCHING SPRING WEATHER

Spring weather can be very different from day to day. Last week, we had a stretch of sunny and mild spring weather. Temperatures were in the seventies. At night, they dropped to the mid-60s. The air was mostly still, with a gentle breeze moving in every now and then.

Then the barometer started to fall rapidly. This signaled an approaching storm.

Yesterday strong winds swept in from the northwest. A heavy rain began to fall. The temperature was 41°F at noon. At night, it fell to the low 30s.

Today it is cloudy and overcast. The temperatures are in the high 40s. The wind speed is 23 miles per hour.

Don't put away your winter coat yet. The weather forecasters predict more cold weather to come. We might have a light snowfall tonight.

Expository Writing

Good expository writing

- develops the main idea with facts and details;
- uses transition words to connect ideas;
- draws a conclusion based on the information.

Write About It

Expository Writing Observe the weather in your area every day for two weeks. Record the temperature, air pressure, precipitation, clouds, and wind speed. Write a newspaper article about the changes you observe.

LOG ON e-Journal Research and write about it online at www.macmillanmh.com

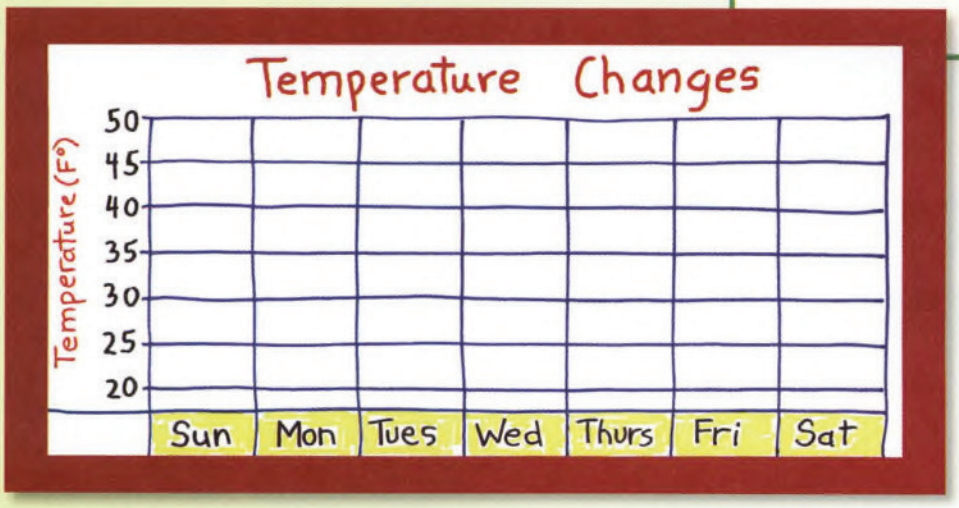
Graphing Weather Changes

You can use line graphs to show how things change over time. Record the high and low temperatures in your area every day for seven days. Use newspapers, television, or radio broadcasts to collect your data. Then plot the data on a line graph.

First, title your graph *Temperature Changes*. Label the bottom and left side as shown below. Start the temperature scale with a lower number than the lowest temperature you recorded. Then, mark off equal spaces in intervals of 5. Write the days of the week across the bottom.

Plotting Points on a Line Graph

- Use different colors for high and low temperatures.
- Find the high temperature for your first day. If it is between two markings, make an estimate. Slide your finger over to the day. Mark that spot with a point.
- Continue plotting all the high and low temperatures. Use straight lines to connect all the highs. Use another line to connect all the lows.



Solve It

Plot your data on the graph you made. Describe the temperature pattern shown on your graph.

Lesson 2

The Water Cycle

Jacques Cartier River, Quebec, Canada

Look and Wonder

Earth has had the same amount of water for billions of years. But not all of that water is in the liquid state. Some is solid ice. Some is even in the gas state. How can this be so?

Explore

Inquiry Activity

How does water change from a liquid to a gas?

Form a Hypothesis

What variables affect how water changes from a liquid to a gas? Write a hypothesis.

Test Your Hypothesis

1. **Communicate** Work in a small group. Discuss examples of water changing from a liquid to a gas. What might affect how fast this change occurs? Consider temperature, wind, area, and volume of water.
2. **Use Variables** Using the materials, design an experiment to test one of the variables you discussed. Use two water samples. One will test the independent variable. The other water sample is your control.
3. **Experiment** Conduct your experiment. Record your observations at each step.

Draw Conclusions

4. Was your hypothesis correct? Does the variable you tested affect how water changes from a liquid to a gas? Give evidence to support your conclusion.
5. **Classify** Share your results as a class. Classify the variables you tested into those that affect the change and those that do not.

Materials

- water
- 2 plastic containers with lids
- spoon
- salt

Explore More

Choose a different variable that might affect how liquid water changes to a gas. Form a new hypothesis. Design an experiment to test it. Then conduct your experiment. Share your findings with the class.

Read and Learn

Essential Question

How is water recycled?

Vocabulary

evaporation, p. 324

water vapor, p. 324

condensation, p. 325

cloud, p. 325

freeze, p. 325

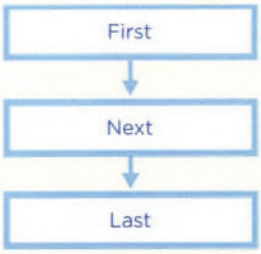
precipitation, p. 325

water cycle, p. 326

melt, p. 330

Reading Skill

Sequence



Technology

e-Glossary, e-Review, and animations online at www.macmillanmh.com

Why does water change state?

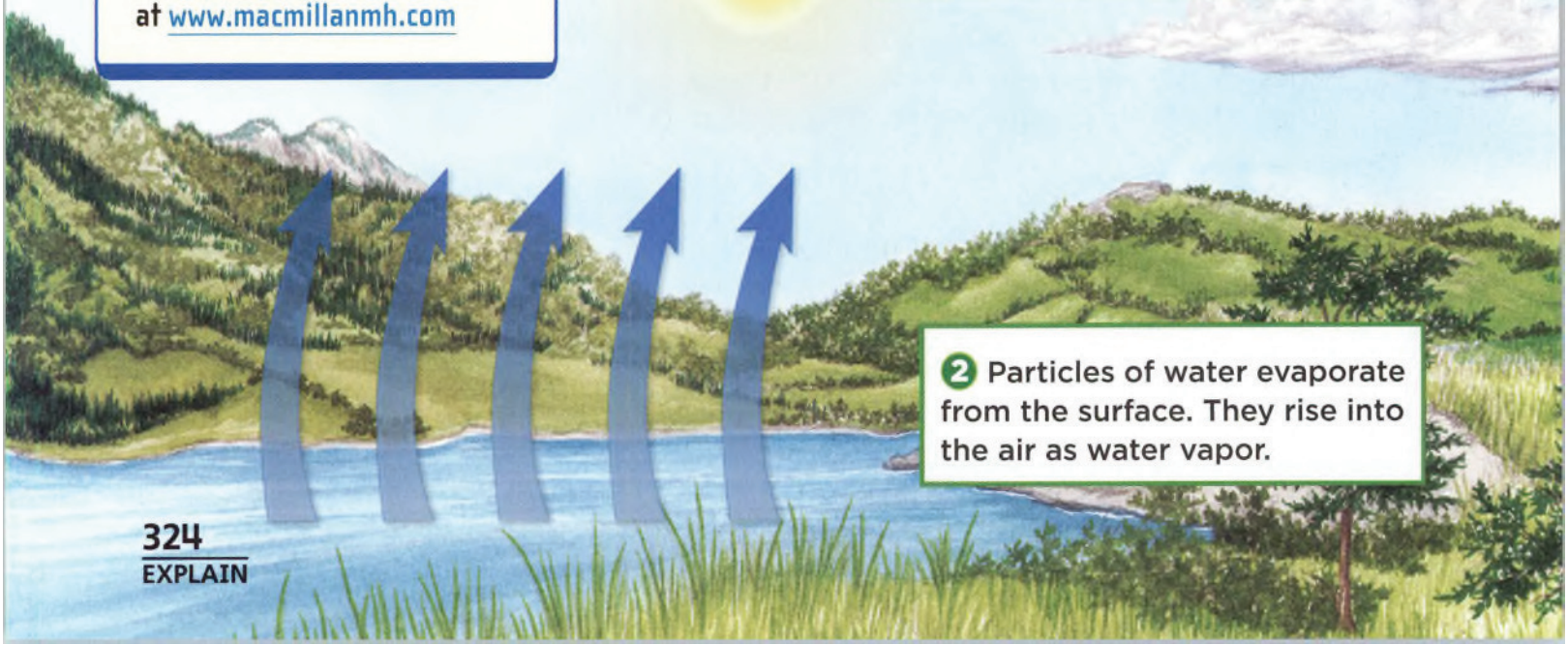
Water moves from Earth's surface into the atmosphere. Then it moves back to the surface. Water changes state, or form, as it moves.

Evaporation

Water seems to disappear when it evaporates (ih•VA•puh•rayts). **Evaporation** occurs when a liquid changes slowly into a gas. Liquid water does not really disappear. It just changes to a gas.

Water vapor is water in the gas state. You cannot see water vapor, but it is part of the air around you.

Water is always evaporating from oceans, streams, lakes, rivers, and ponds. The Sun's heat causes particles of water at the surface to move rapidly. The more heat they take in, the faster and farther apart they move. Some of the particles rise into the air as a gas—water vapor.

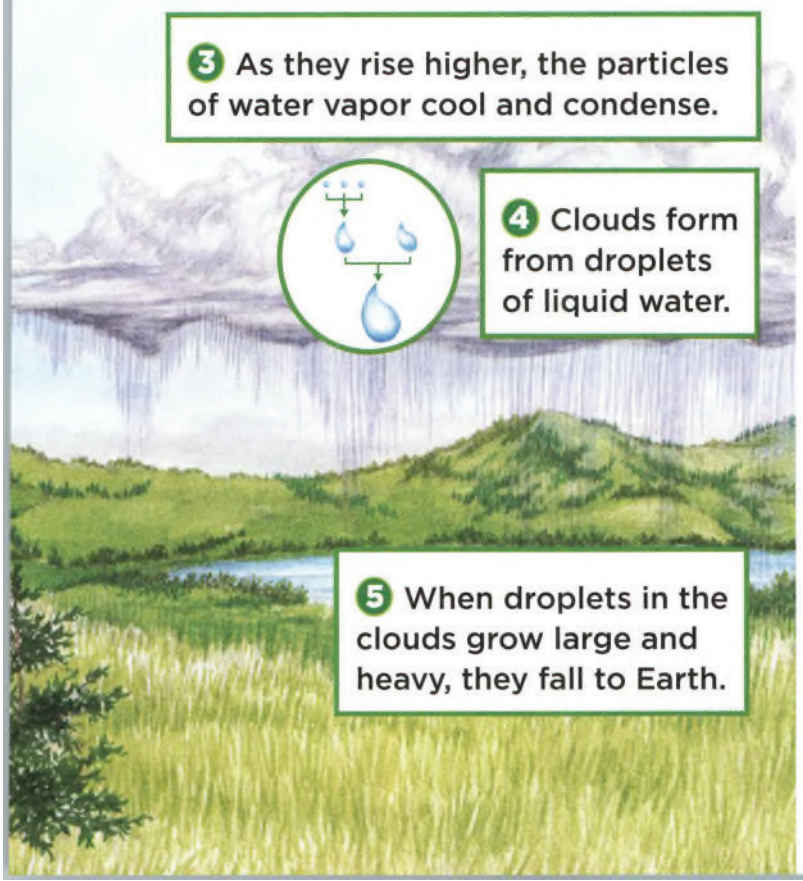


Condensation

As particles of water vapor rise into the air, they cool. The particles lose energy. They move more slowly. High in the atmosphere, the water vapor *condenses* (kun•DENS•ez) to liquid water. **Condensation** occurs when a gas changes to a liquid.

Dew is a familiar kind of condensation. Dew forms when water vapor cools and condenses onto a surface. Have you ever seen drops of water cover the grass on a cool morning? Those drops are dew.

Water vapor can also condense onto dust particles in the air. The tiny drops, or *droplets*, form clouds. A **cloud** is a group of water droplets in the atmosphere. The droplets are pure water in liquid form.



Dew can form on spiderwebs in the early morning.

Precipitation

Inside a cloud, small water droplets may join together and form larger ones. If it is very cold, some droplets freeze into ice. To **freeze** is to change from a liquid to a solid.

The droplets and bits of ice grow larger and heavier. When they are too heavy, they fall to Earth's surface. **Precipitation** (prih•sih•puh•TAY•shun) is the water that falls from clouds down to Earth.

Quick Check

Sequence Explain the steps in evaporation and condensation.

Critical Thinking What happens to a puddle of water on a sunny day? Why?

Where does water go?

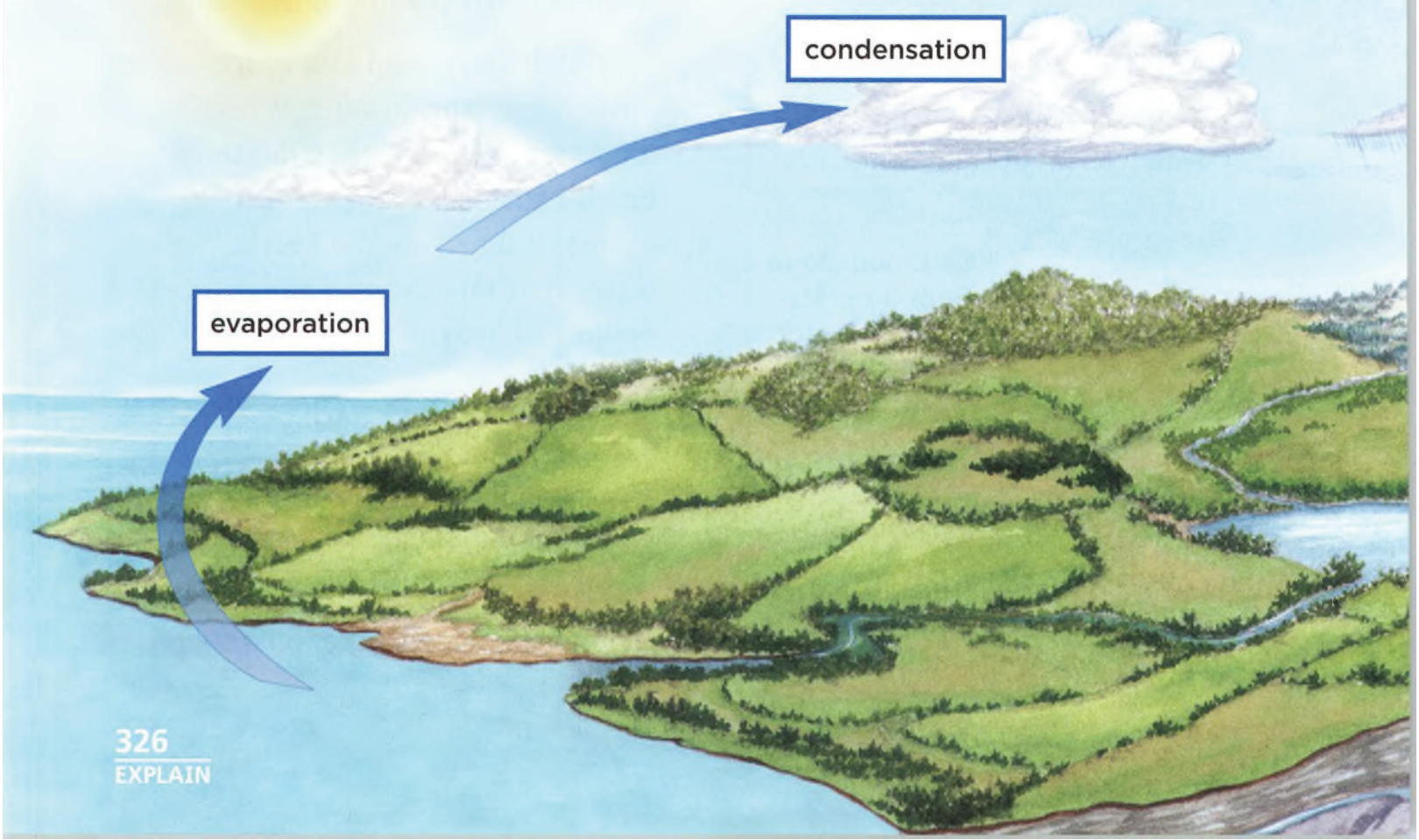
By now you know a lot about water. You know that water can be found in many places. You know it has three different states.

Water is always moving from place to place, in one form or another. The **water cycle** is the movement of water between Earth's surface and the air. Evaporation, condensation, and precipitation help water move through the cycle. The diagram shows you how.

In the Air

In the water cycle, water changes state among liquid, gas, and solid. The Sun is the energy source for this cycle. The Sun's energy causes water to evaporate from lakes, oceans, and other bodies of water. Water also evaporates from the leaves of plants. This is called *transpiration* (trans•puh•RAY•shun). As it rises in the air, the water vapor condenses. Clouds form. During precipitation, water falls from the clouds over land and water.

The Water Cycle



On and Below the Ground

Precipitation can fall as rain, snow, sleet, or hail. When it rains, water flows over Earth's surface as *runoff*. Runoff gathers in lakes, oceans, and streams. Water also collects in glaciers and ice caps.

Water that soaks into the ground moves downward through small cracks and spaces. Some of this water becomes groundwater that flows to wells, rivers, and lakes. Plants take up some water and some evaporates. Water is always moving and recycling.

Quick Check

Sequence How does water enter and leave the atmosphere?

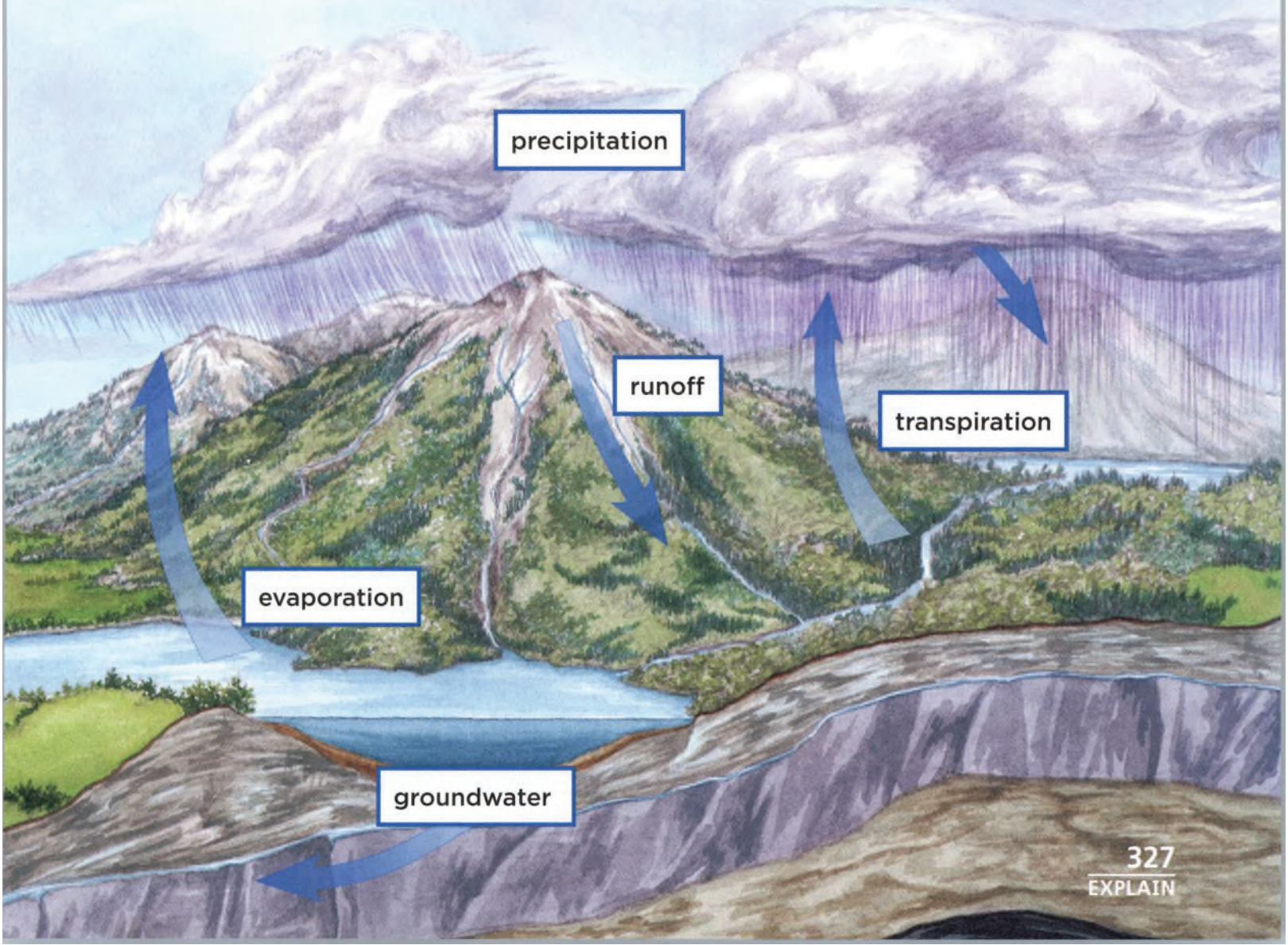
Critical Thinking How does the Sun's energy affect Earth's weather?

Read a Diagram

Describe one path through the water cycle.

Clue: Follow the arrows.

LOG ON *Science in Motion* Watch how the water cycle works at www.macmillanmh.com



Quick Lab

Cloud in a Jar

1. Pour very warm water into a jar until it is about 1 cm deep. Seal the jar tightly. Then shake it several times.
2. Open the jar and quickly place a plastic sandwich bag inside it. Using a rubber band, seal the bag tightly around the mouth of the jar.
3. **Observe** Reach into the bag. Gently pull it up. Then release the bag. Observe and describe what happens in the jar. Repeat this step several times.
4. **Interpret Data** When does the cloud form? When does it disappear? Why do you think this happens?

What are some types of clouds?

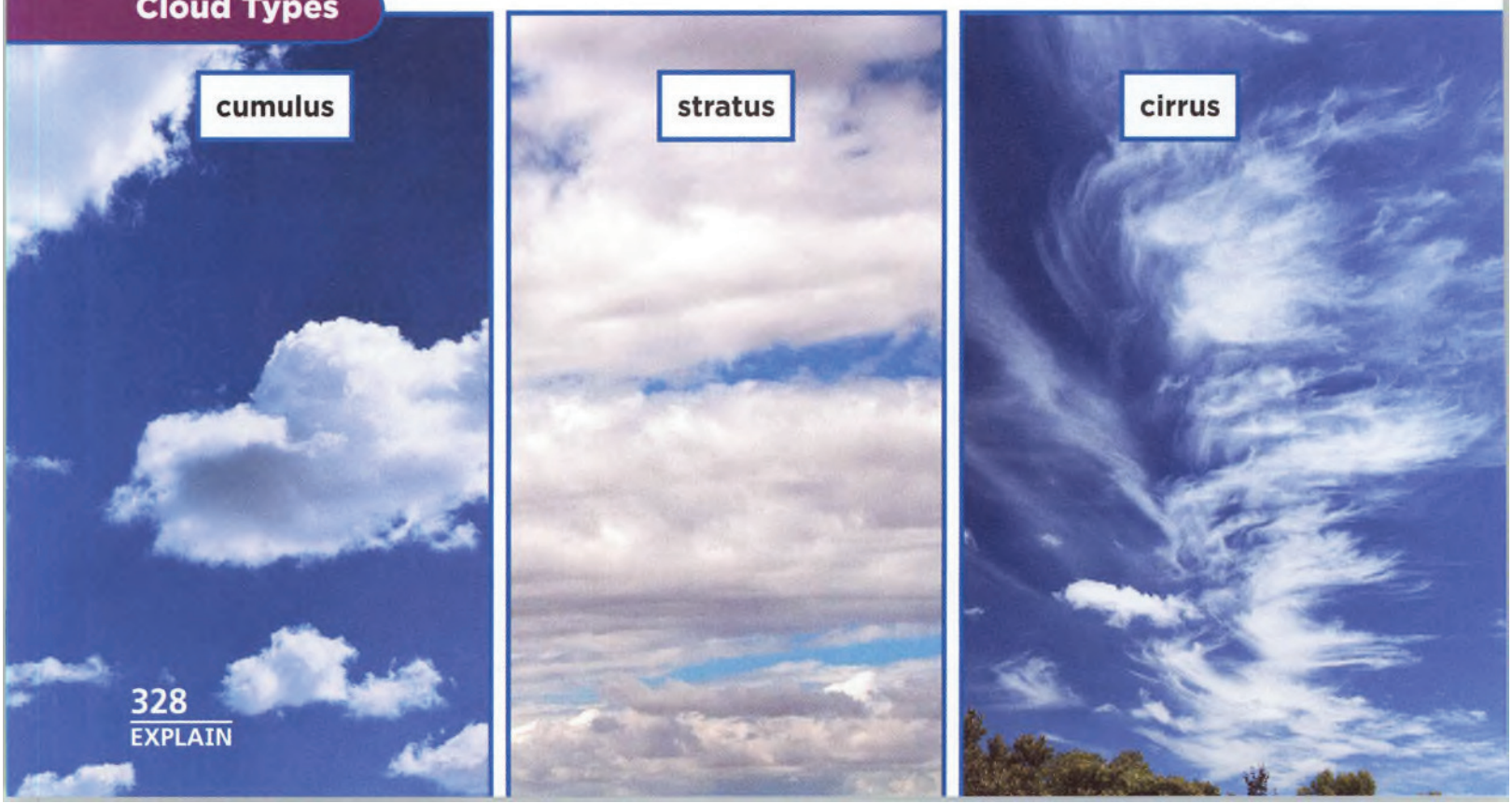
Clouds form at different heights above Earth's surface. Scientists classify clouds into three main types based on how and where they form.

Cumulus

Cumulus (KYEW•myuh•lus) clouds are puffy, white clouds that look like cotton balls. They often have a flat bottom.

You have probably seen clouds grow dark before a rainstorm. If a cumulus cloud becomes dark and thick, it is called a *cumulonimbus* (kyew•myuh•loh•NIM•bus) cloud. This kind of cloud produces precipitation.

Cloud Types



Stratus

Stratus (STRA•tus) clouds form in layers. The layers look like sheets or blankets. Stratus clouds are often the lowest clouds in the sky. What we call fog is really a stratus cloud near Earth's surface. Like cumulonimbus clouds, stratus clouds can form precipitation.

Cirrus

Cirrus (SEER•us) clouds look thin, wispy, or feathery. They are made of tiny bits of ice. Cirrus clouds are usually found very high in the sky.

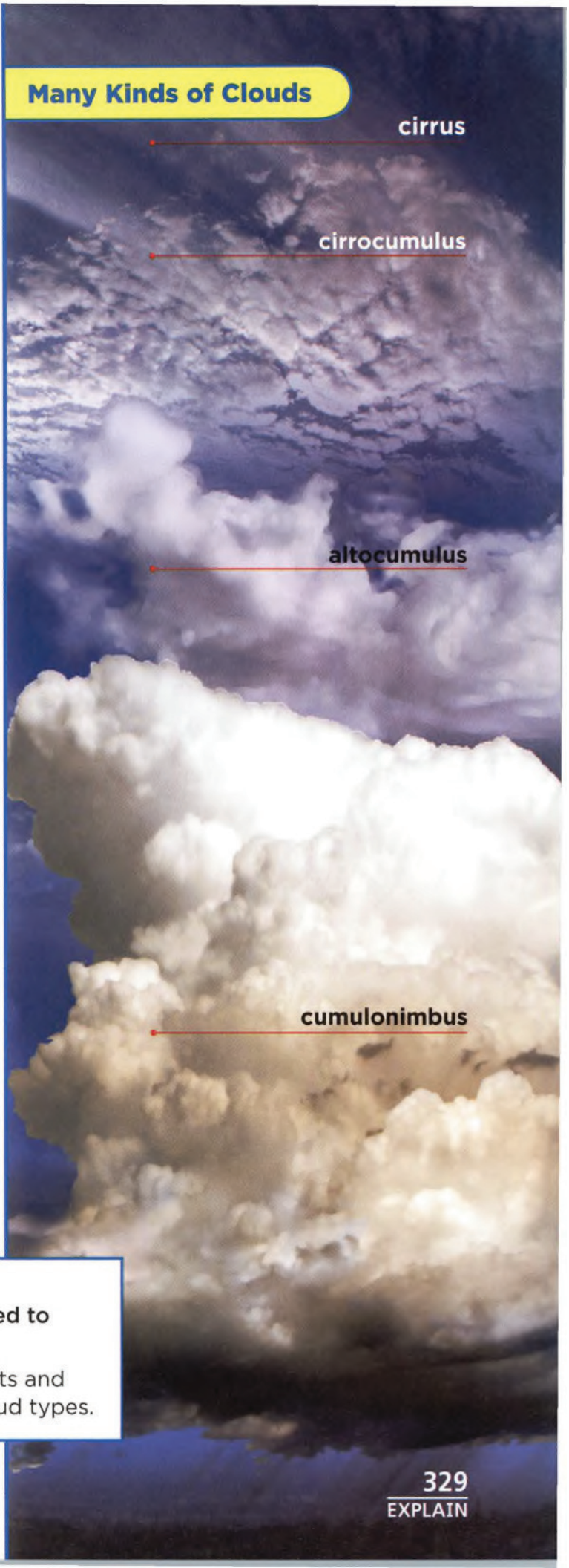
Observing Clouds

In the diagram at right, you can see other cloud types. Often, you can find more than one cloud type in the sky at one time.

Quick Check

Sequence How might clouds change as a morning rain shower turns into a sunny day?

Critical Thinking Classify the types of clouds you see in the sky today.



Read a Diagram

Which cloud types are related to one another?

Clue: Compare the word parts and pictures for the different cloud types.

What are other forms of precipitation?

Rain is just one form of precipitation. Water can change state as it moves through the air. When this happens, other types of precipitation may fall.

Snow

When water reaches a temperature below 0°C (32°F), it freezes into ice. Remember, to freeze is to change from a liquid to a solid. Bits of ice can collect in a cloud. If they get too heavy, they fall as snow.

Snow may melt as it falls to the ground. To **melt** is to change from a solid to a liquid. Melting happens when sunshine or warm air heats the snowflakes. The heat makes the snow change to rain.

Sleet and Hail

Sometimes rain falls from clouds as a liquid but freezes along the way. The rain turns into small chunks of ice. The ice that falls to the ground is called *sleet*.

Hail is made of ice too. The ice chunks are much larger than sleet. Hail forms inside the tall clouds of a thunderstorm. Most hailstones are the size of peas. However, some are bigger than baseballs!

Quick Check

Sequence How does snow form?

Critical Thinking Do all pieces of ice that fall to the ground come from icy clouds? Explain.

Most hailstones are small. Large ones can be dangerous! How big is the hailstone to the left?

FACT Hail can fall in spring and summer.

Lesson Review

Visual Summary

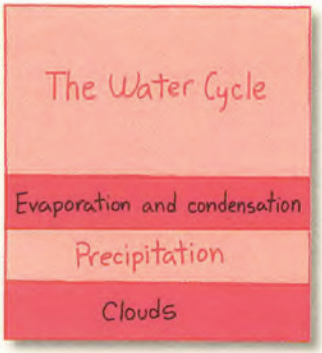
Water changes from a liquid to a gas through **evaporation.** It changes from a gas to a liquid through **condensation.**

In the **water cycle,** water travels by runoff, evaporation, condensation, and **precipitation.**

Clouds form at different heights above Earth's surface. They are classified by how and where they form.

Make a FOLDABLES® Study Guide

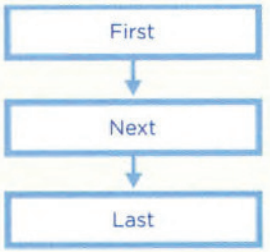
Make a layered-look book. Use it to summarize what you read about the water cycle.



Think, Talk, and Write

1. **Vocabulary** Water vapor becomes liquid water through _____.

2. **Sequence** Describe the path of water from the ocean to a raindrop.



3. **Critical Thinking** How are hail and sleet alike? How are they different?

4. **Test Prep** **Clouds form when water vapor**
   - **A** evaporates.
   - **B** condenses.
   - **C** precipitates.
   - **D** transpires.

5. **Test Prep** **Puffy, white clouds with flat bottoms are**
   - **A** cumulus clouds.
   - **B** cirrus clouds.
   - **C** stratus clouds.
   - **D** cirrostratus clouds.

6. **Essential Question** How is water recycled?

Writing Link

Write a Cloud Poem
Write a poem about clouds. Choose ones you have seen or ones you would like to see. Include several different cloud types in your poem.

Art Link

Water Cycle Diorama
Make a diorama that shows how the water cycle works. Label the places where water goes. Write captions to describe how water changes state.

Focus on Skills

Inquiry Skill: Make a Model

You have seen water collect in puddles during a heavy rainstorm. You have learned that evaporation causes puddles to dry up. Does the size of a puddle affect how fast it evaporates? To answer this question and still stay dry, you can **make a model.**

▶ Learn It

When you **make a model,** you build something to represent an object or event. A model helps you learn more about the real object or event you are investigating. It is important to record your observations about your model. Then you can make inferences about the real thing.

▶ Try It

Make a model to study how the size of a puddle affects evaporation.

Materials **whole kitchen sponge, half kitchen sponge, two-pan balance, paper clips, water, measuring cup, lamp**

1. Place the whole sponge in one balance pan and the half sponge in the other. The sponges represent puddles.
2. Add paper clips to the pan with the half sponge until both sides of the balance are equal in mass.
3. Add equal amounts of water to each sponge.
4. Place the lamp so it will shine on both puddles. Turn on the lamp. This models the Sun.
5. Observe the sponges after 5 minutes. Read the measurement on the balance. Record your observations in a data table like the one shown.

6. Continue to read the balance every 5 minutes for 15 more minutes. Record your observations.
7. Look at your results. Which sponge became lighter first? Why do you think it did?
8. How are your model puddles similar to real rain puddles? How are they different?

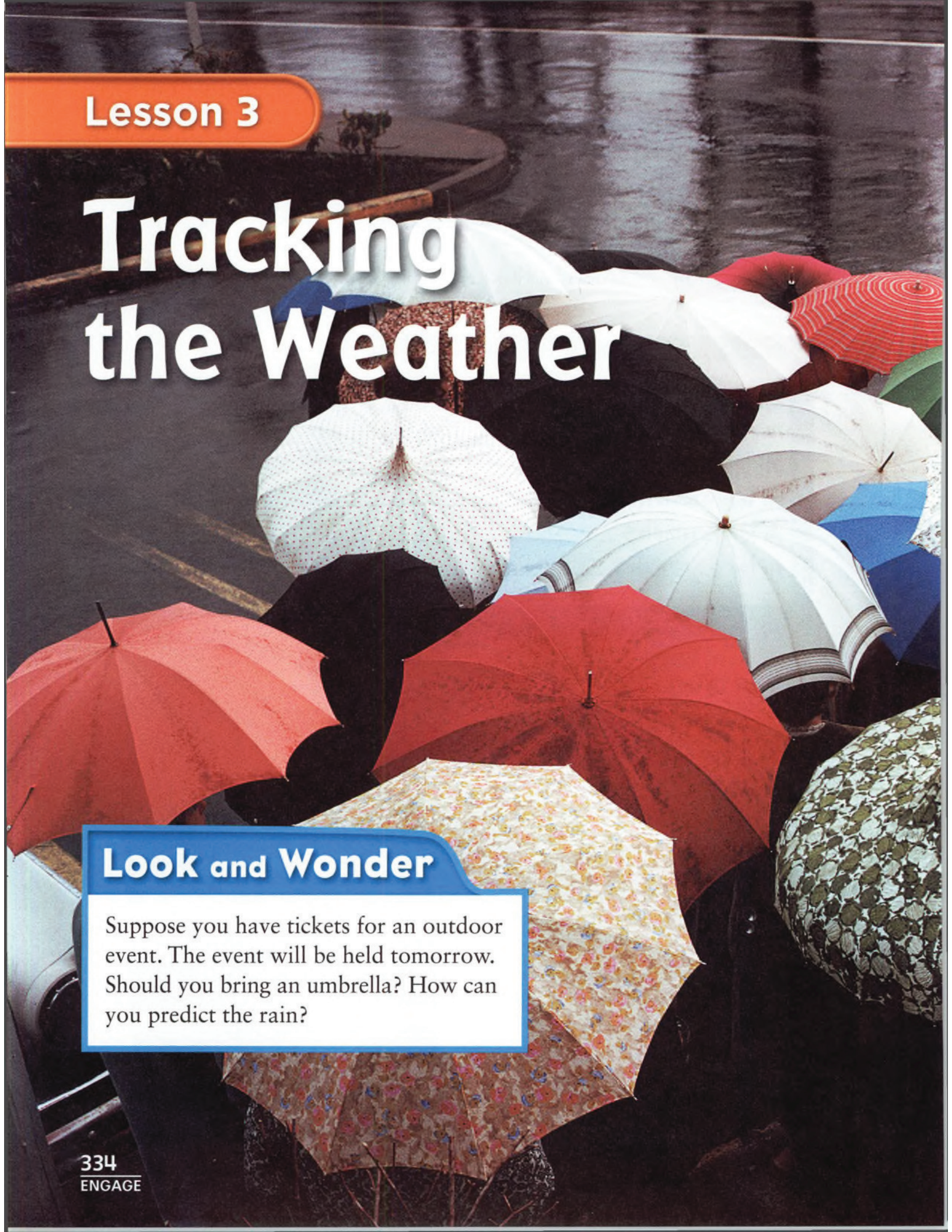
My Observations

	Whole Sponge	Half Sponge
After 5 minutes		
After 10 minutes		
After 15 minutes		
After 20 minutes		

▶ Apply It

Now **make a model** to test the effect of wind on evaporation. Use two rectangular plastic containers.

1. Pour the same amount of water into each container. Place a fan so it will blow across the surface of only one container. Turn the fan on. Use a low setting.
2. Wait 10–15 minutes. Then measure the amount of water in each container.
3. How much water evaporated from each container? What does this tell you about wind and evaporation?



Lesson 3

Tracking the Weather

Look and Wonder

Suppose you have tickets for an outdoor event. The event will be held tomorrow. Should you bring an umbrella? How can you predict the rain?

Explore

Inquiry Activity

How do raindrops form?

Form a Hypothesis

How do changes in air temperature affect water in the liquid and gas states? Write a hypothesis.

Test Your Hypothesis

1. Pour just enough water into each jar to cover the bottom of the jars.
2. **Use Variables** Place one lid upside down on one jar. Put three or four ice cubes in that lid. Place the other lid upside down on the second jar. Do not add ice cubes to that lid.
3. **Observe** Wait two minutes. Then look closely at the parts of the lids inside the jars. Record your observations every two minutes over the next ten minutes.
4. Draw a diagram that shows what happened to the water inside the jars. Add labels and arrows to explain how the water changed.

Draw Conclusions

5. Why did water droplets form mostly underneath the lid? Why didn't they form inside the jar or on the upside-down lid?
6. **Predict** What if you shined a heat lamp on the water in the jars before step 3? Predict how your results would change.

Materials

- 2 jars with lids
- water
- ice cubes

Explore More

What would happen if you used ice instead of water in step 1? Make a prediction. Then repeat the activity with the ice. Explain your results.

Read and Learn

Essential Question

How do fronts and air masses change the weather?

Vocabulary

air mass, p. 336

front, p. 337

warm front, p. 337

cold front, p. 337

stationary front, p. 337

forecast, p. 339

Reading Skill

Predict

My Prediction	What Happens

Technology

e-Glossary and e-Review online at www.macmillanmh.com

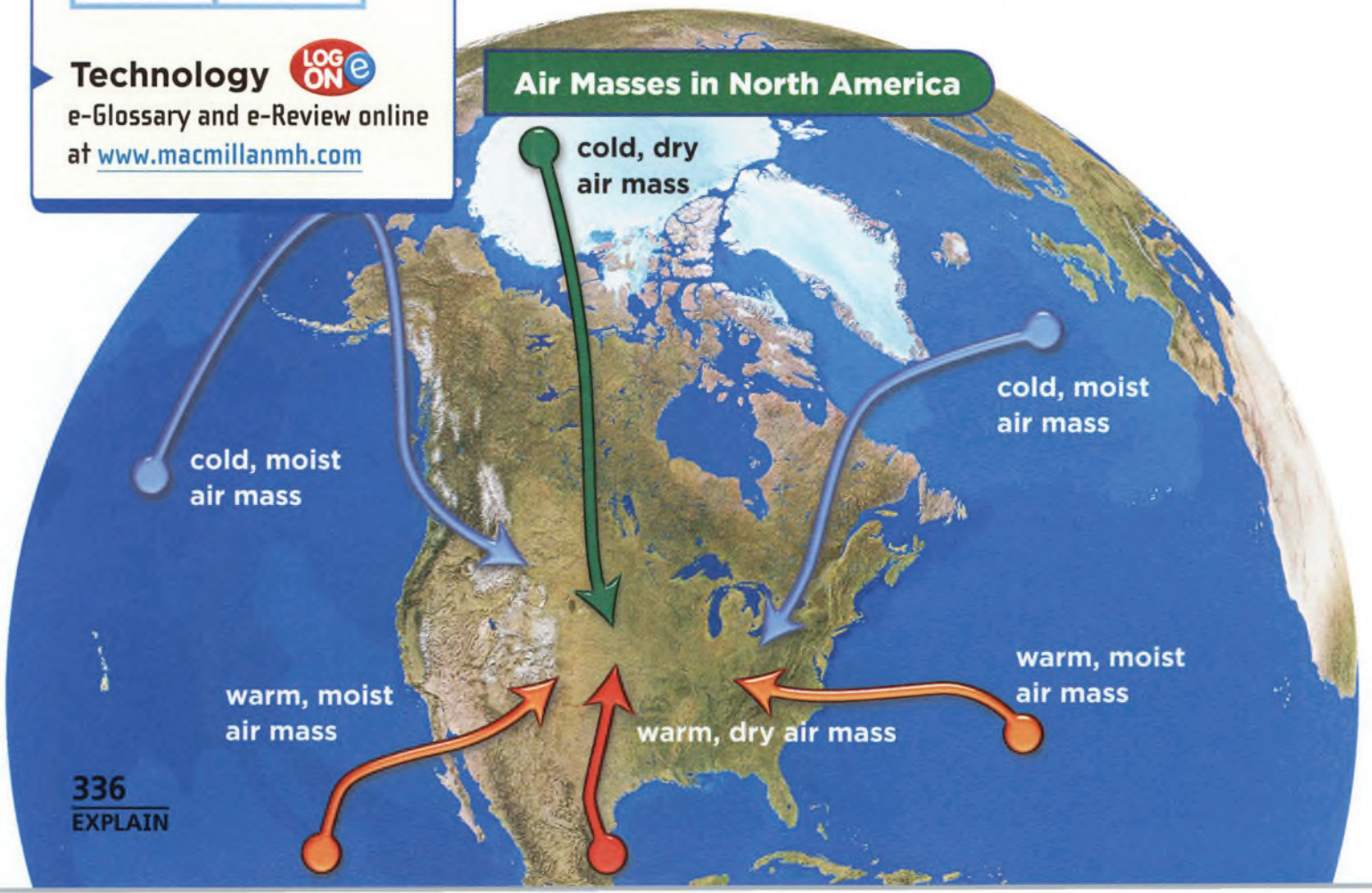
What are air masses and fronts?

The wettest place on Earth is in the state of Hawaii. Rain falls over one of the islands about 350 days of the year. One of the driest places in the world is a desert in South America. Why is it rainy in some places and dry in others?

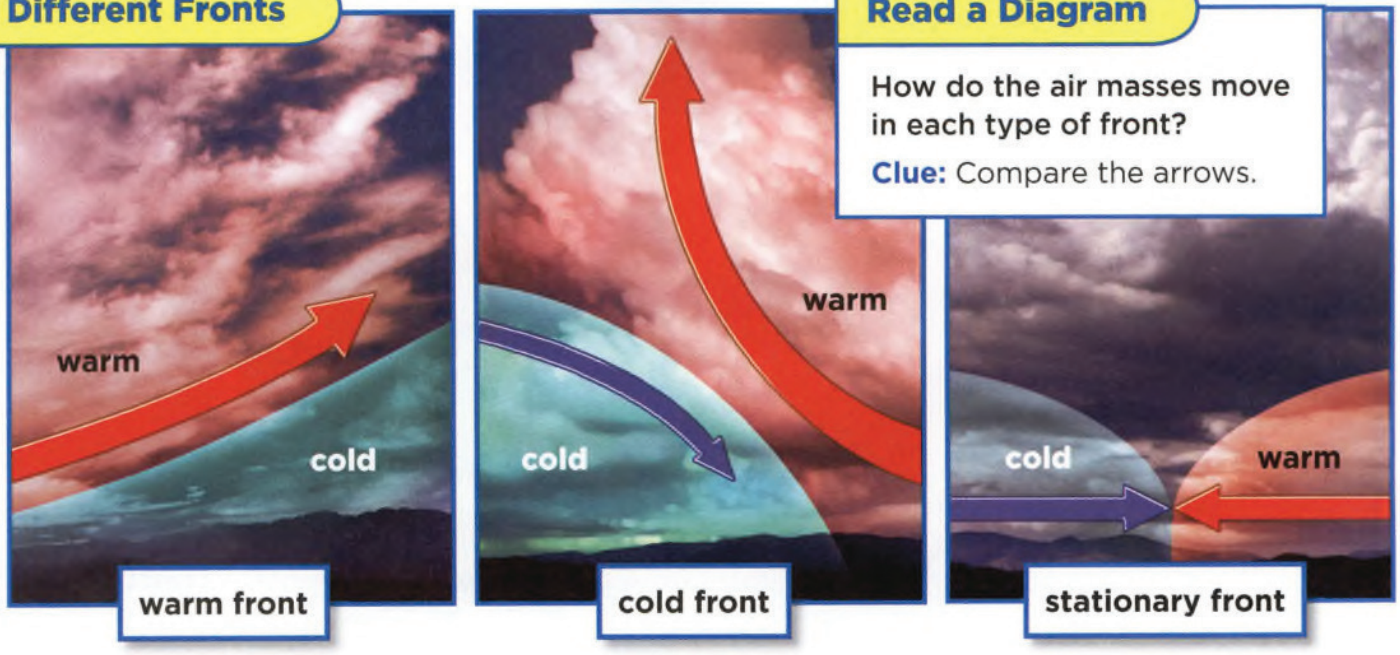
Air Masses

The properties of the air in different places on Earth vary. Some large regions of air have nearly the same properties throughout. These regions are called **air masses**. Weather in one part of an air mass is like the weather throughout the rest of the air mass.

Air masses form all the time, usually near the poles or the equator. They move across Earth, covering it like an ever-changing blanket. The map shows some of the common paths they take.



Different Fronts



Read a Diagram

How do the air masses move in each type of front?

Clue: Compare the arrows.

Fronts

As an air mass moves, it brings weather with it. What happens when different air masses meet? Like two cars in a crash, the air masses slam into each other. The area where they meet is called a front.

A **front** is the boundary between two air masses that have different temperatures. Fronts usually cause a change in the weather.

Warm Fronts

When a warm air mass pushes into a cold air mass, a **warm front** forms. As the diagram shows, the warm air mass slides up and over the cold air mass. Layers of clouds form. The cold air retreats.

A warm front often brings light, steady rain. After the front passes, the air temperature rises.

Cold Fronts

A **cold front** forms when a cold air mass pushes under a warm air mass. The cold air mass forces the warm air mass upward quickly. Thick clouds form as the warm air rises and cools. Cold fronts often bring stormy weather.

Stationary Fronts

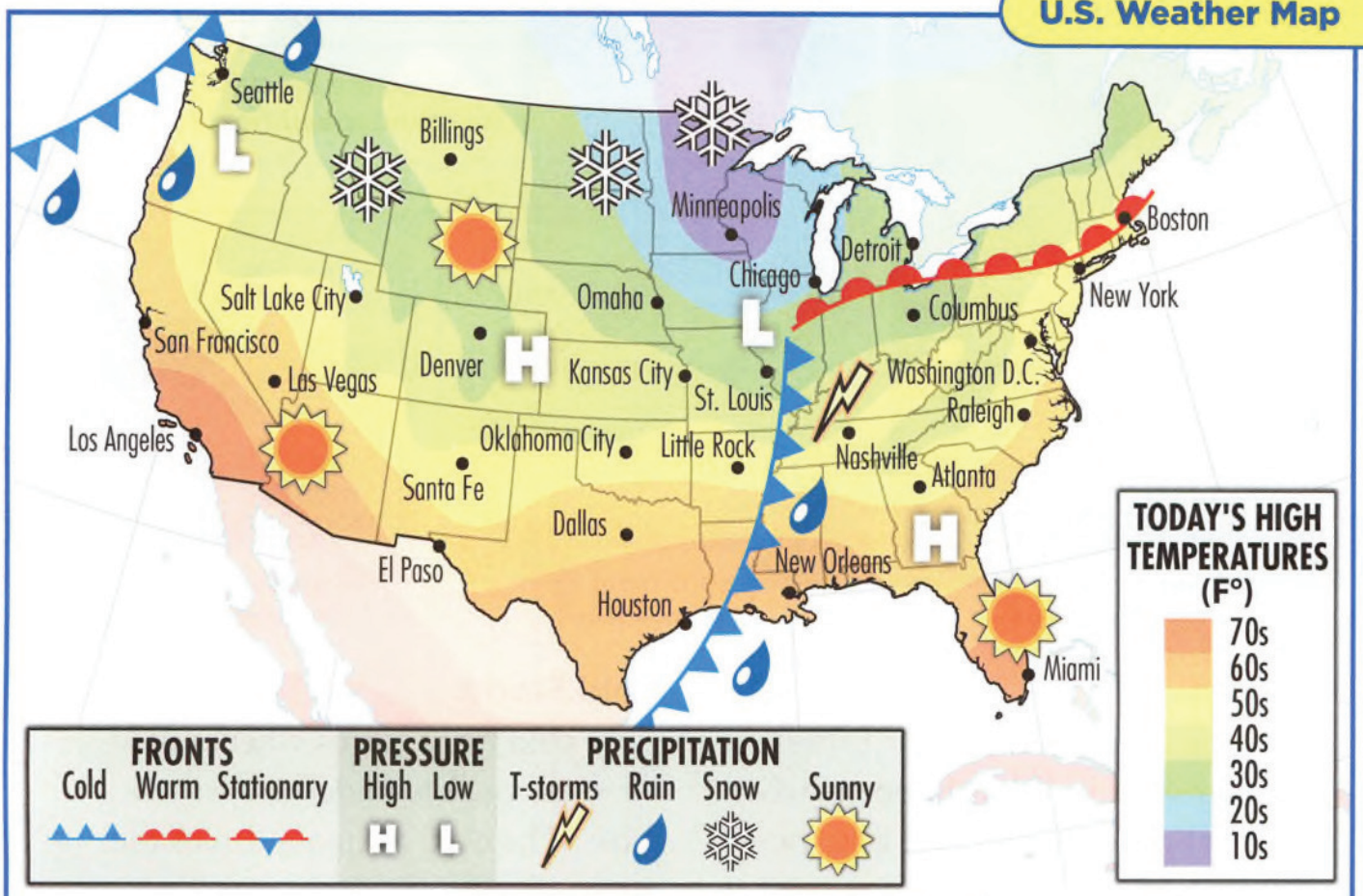
Sometimes rainy weather lasts for days. This can be caused by a stationary front. A **stationary front** is a boundary between air masses that are not moving.

Quick Check

Predict What will happen if a cold air mass pushes into a warm air mass?

Critical Thinking How do warm fronts differ from cold fronts?

U.S. Weather Map



Read a Map

What does this map show about the weather in Nashville?

Clue: Use the legends to find the meanings of the colors and symbols.

What does a weather map show?

Every day, scientists make and share weather maps like the one above. Weather maps show weather conditions at a certain time and place. They tell about air temperature, pressure, precipitation, and winds.

Weather maps might also show the locations of fronts. The fronts appear as a line of triangles or half circles. In the map above, rain and thunderstorms have formed along the two cold fronts.

Forecasting

Maps can help us answer questions. Scientists use weather maps to make forecasts. To **forecast** is to predict weather conditions.

Temperature, air pressure, and the direction of moving fronts give important clues for forecasts. Look at the map again. Do you see the cold front from St. Louis to Houston? The triangles point toward the east. Like most fronts in the United States, this one is moving from west to east. A forecast based on this map might predict a chance of rainy weather for New Orleans.

Scientists use many technologies in forecasting. Satellites in orbit around Earth take pictures of the atmosphere. Computers help scientists analyze weather data and produce better weather maps.

Quick Lab

Weather Forecast

1. Study a weather map from today's newspaper. Compare it to maps from yesterday and the day before, if they are available.
2. **Communicate** Describe today's weather in your region and in surrounding regions.
3. **Predict** Use the weather map to predict tomorrow's weather. Explain your prediction.
4. Study the weather map tomorrow. Compare it to your prediction. How close was your forecast to the actual weather?

Quick Check

Predict How can weather maps be used to predict weather?

Critical Thinking How likely are you to see the same cold front for several days in one place? Why?

Strong winds and lightning can make a storm dangerous.

What are the signs of severe weather?

Have you ever heard a loud clap of thunder just before a storm? Thunder is the booming sound made when lightning quickly heats the air around it. Thunder tells you that a storm is nearby.

If you see a tall, swirling mass of air shaped like a funnel, take cover! It could be a tornado. A *tornado* is a rotating column of air that touches the ground during a thunderstorm. Tornadoes can reach speeds of 400 km per hour (250 mph) or more.

A *hurricane* is a very wide storm. A typical one spans about 480 km (300 mi) across. Hurricanes form over warm water in the ocean. They bring very heavy rains and strong winds. If a hurricane moves across land, it can cause severe damage.

Storm Safety

Scientists pay close attention to signs that severe storms are forming. If one appears in their forecast, they alert the government and the public.

Do you know how to stay safe in severe weather? If thunderstorms are predicted, stay away from water and trees. When tornadoes are predicted, head for a sturdy shelter, such as a basement. To avoid a hurricane, you might need to move inland.

In any storm, always listen for directions. Seek out a trusted adult if a severe storm strikes. Be sure to follow warnings on the radio and television.

Quick Check

Predict What might happen if a hurricane strikes the land?

Critical Thinking Why should you stay inside during a storm?

Lesson Review

Visual Summary

When two **air masses** meet, a **front** forms between them. Fronts usually bring a change in the weather.

Scientists use weather maps to make **forecasts** about the weather to come.

It is important to know about **severe storms** so you can stay safe.

Make a FOLDABLES Study Guide

Make a three-tab book. Use it to summarize what you read about tracking the weather.

Think, Talk, and Write

1. **Vocabulary** To _____ is to predict the weather.

2. **Predict** Study today's weather map. Forecast the weather for tomorrow.

My Prediction	What Happens

3. **Critical Thinking** How can a battery-powered radio help you stay safe during a storm?

4. **Test Prep** **A storm usually forms**
   - **A** inside an air mass.
   - **B** along a front.
   - **C** over tall buildings.
   - **D** over a river.

5. **Test Prep** **Which term describes a very tall, gray funnel shape?**
   - **A** hurricane
   - **B** tornado
   - **C** cold front
   - **D** thunderhead

6. **Essential Question** How do fronts and air masses change the weather?

Writing Link

Write a Short Essay
Write an essay about a storm that you experienced. Or ask an adult to tell you about a storm he or she remembers. Include facts about the storm and how it affected people.

Social Studies Link

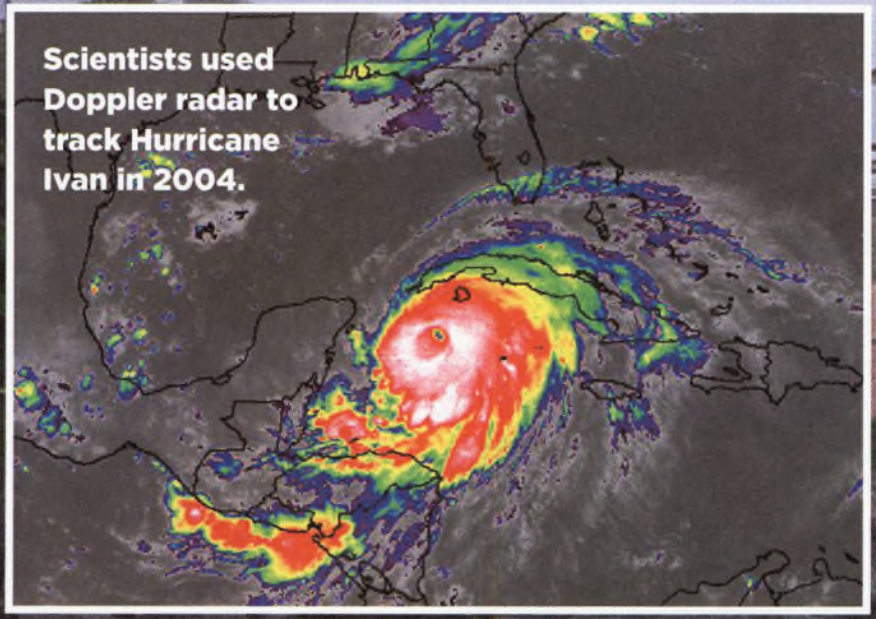
History Report
Research and write a report on a severe weather event in history. If possible, write about an event in your area. Include information about how people solved problems caused by the event.

Hurricane Season

June is the beginning of a busy time for the National Hurricane Center in Miami, Florida. That's when hurricane season begins, and the scientists at the center are ready for action.

Hurricanes develop at sea under particular conditions. These include warm ocean water, low pressure, moist air, and light winds. They usually happen in the Atlantic and northeast Pacific Oceans from June through November. When a hurricane forms, it can bring violent winds, large waves, floods, and lots of damage.

To study a hurricane, scientists gather large amounts of data. Satellites that orbit Earth collect information about cloud patterns. They record temperatures on top of clouds and at the sea surface. Satellites also measure the direction and speed of winds above the ocean. This information helps scientists track the size, path, and intensity of a storm.



Scientists used Doppler radar to track Hurricane Ivan in 2004.

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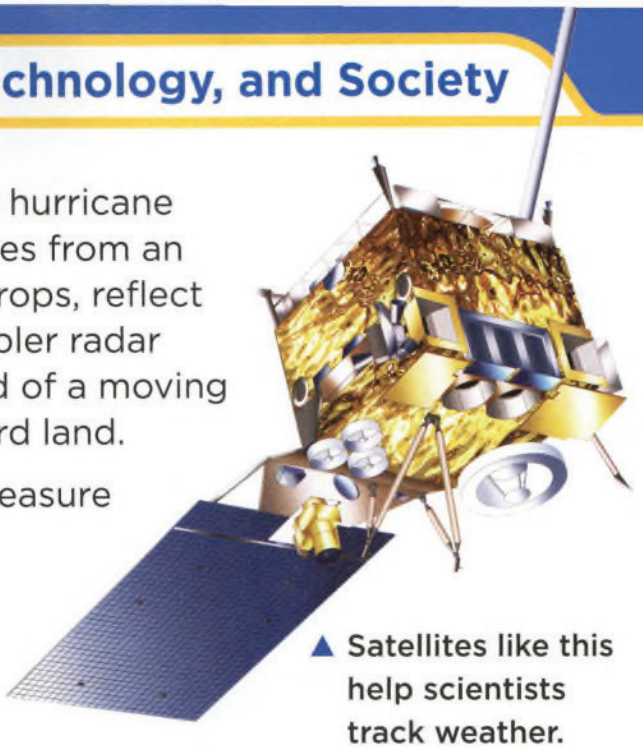
Doppler radar is another tool that hurricane scientists use. It sends out radio waves from an antenna. Objects in the air, like raindrops, reflect the waves back to the antenna. Doppler radar can measure the direction and speed of a moving object, like a hurricane moving toward land.

Buoys spread across the ocean measure conditions like surface wind, waves, temperature, and fog. Planes fly to the center of a hurricane to gather data about wind, pressure, temperature, and humidity.



▲ Satellites like this help scientists track weather.

Scientists enter all of this data into supercomputers to create a model of the hurricane. This model helps them predict the wind speed, size, and direction of the hurricane, and where and when it might hit land. Accurate predictions of a hurricane's path can reduce the loss of life and property.

Fact and Opinion

- Facts tell you about something that has really happened.
- Opinions are what someone thinks about facts or events.

Write About It

Fact and Opinion

1. What technologies help scientists study hurricanes?
2. What do you think would happen during a hurricane in your neighborhood?

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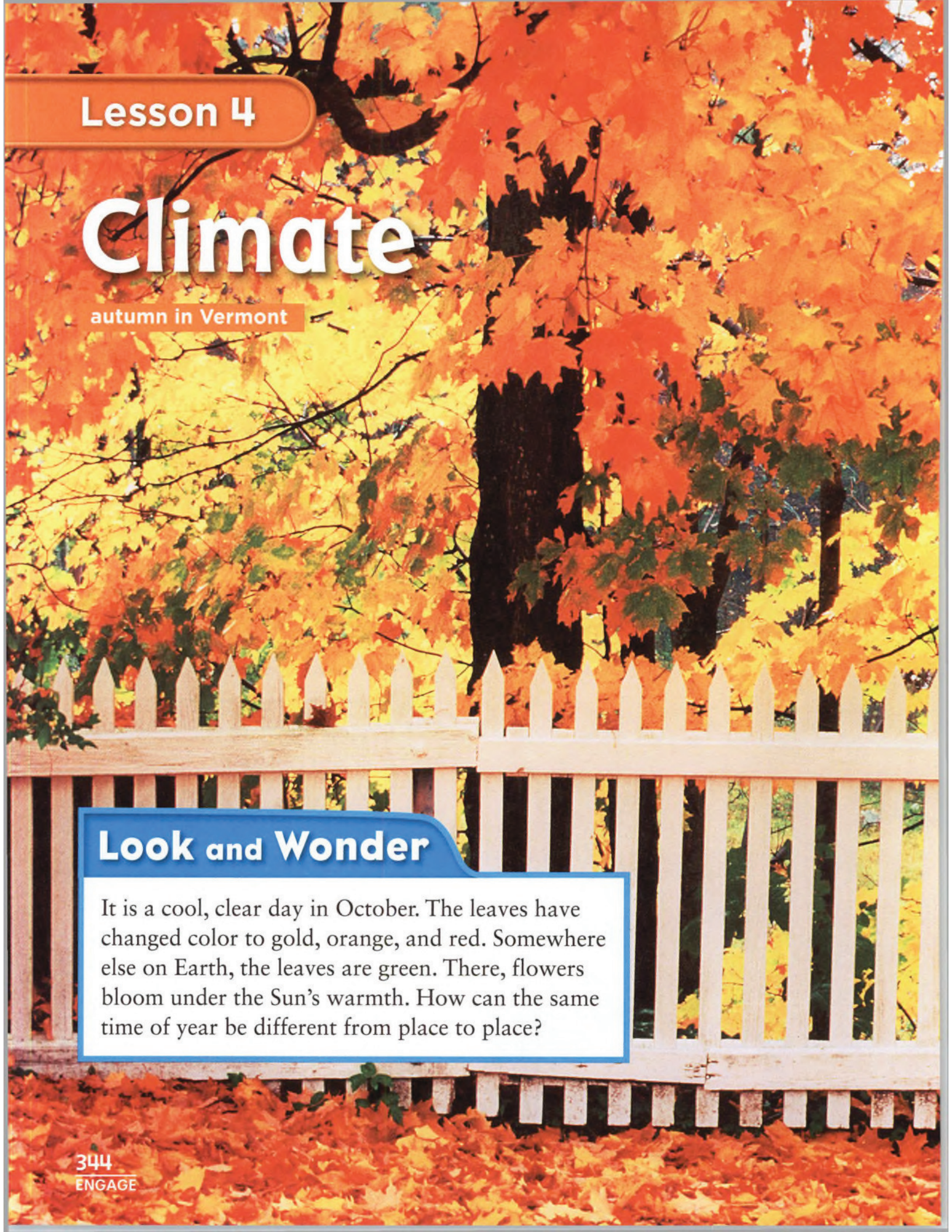
Lesson 4

Climate

autumn in Vermont



Look and Wonder

It is a cool, clear day in October. The leaves have changed color to gold, orange, and red. Somewhere else on Earth, the leaves are green. There, flowers bloom under the Sun's warmth. How can the same time of year be different from place to place?

Explore

Inquiry Activity

What affects weather patterns?

Purpose

Explore the factors that determine the weather patterns in different places.

Materials

- paper
- markers

Procedure

1. Locate the cities of Chicago, Miami, Phoenix, and Seattle on a map.
2. **Predict** The data table shows the yearly temperature and precipitation for these four cities. Predict where each belongs in the table.
3. **Classify** Copy the table. Research the weather patterns of the four cities. Fill in the cities where they belong.
4. Find out the yearly temperature and precipitation for the place where you live. Add this data to your table.

City	Yearly Temperatures	Yearly Precipitation
1	Hot summers mild winters	Very little rain
2	Hot summers warm winters	A lot of rain
3	Hot or warm summers cold winters	Much rain and snow
4	Warm summers mild winters	A lot of rain
5 My Community		

Draw Conclusions

5. Compare the table to your prediction in step 2. How does it compare?
6. **Interpret Data** Which cities are near oceans? How does their data compare to the other cities? Which cities are farthest south? How do they compare to the northern cities?

Explore More

Look at today's weather map. Compare the weather in each of the four cities with your data table. Is today's weather similar to or different from yearly patterns? Can you explain any differences?

Read and Learn

Essential Question

Why do weather patterns change?

Vocabulary

climate, p. 346

current, p. 348

Reading Skill

Fact and Opinion

Fact	Opinion

Technology

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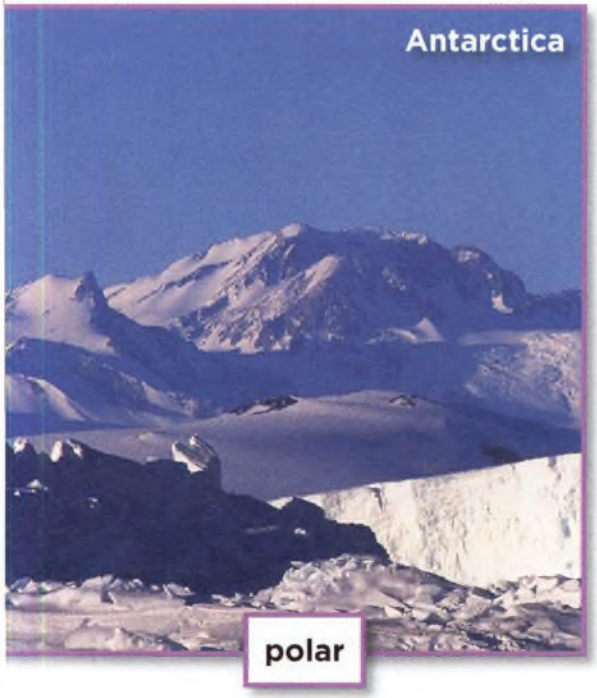
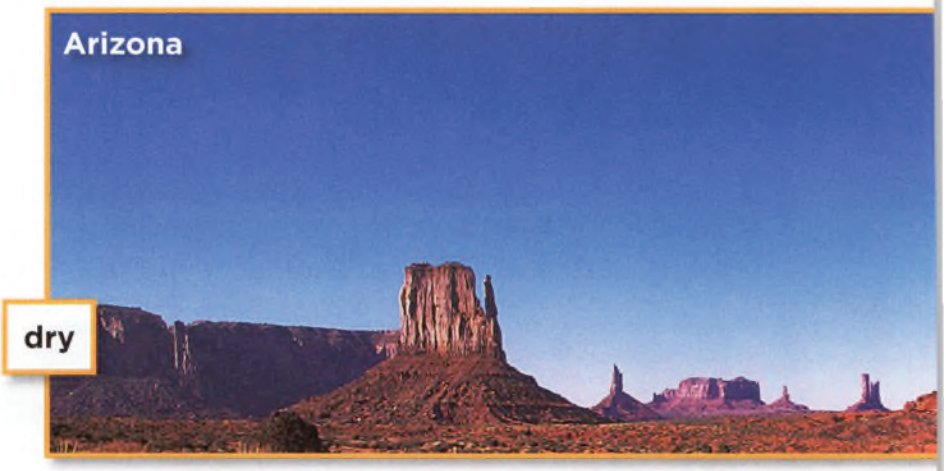
What is climate?

The weather where you live might change from day to day. Yet you can predict what the weather will be like each season. The pattern of seasonal weather that happens year after year is called **climate** (KLI•mut).

Climate is not the same everywhere on Earth. The city of Phoenix is in the southwestern United States. The climate there is warm and dry all year. Snow and rain rarely fall. Seattle is in the northwestern United States. There the climate is cool and wet.

Farmers depend on climate to grow their crops. Some crops grow well in cool climates with steady rain. Other crops need dry climates. Still others need warm, humid climates.





Climate Regions

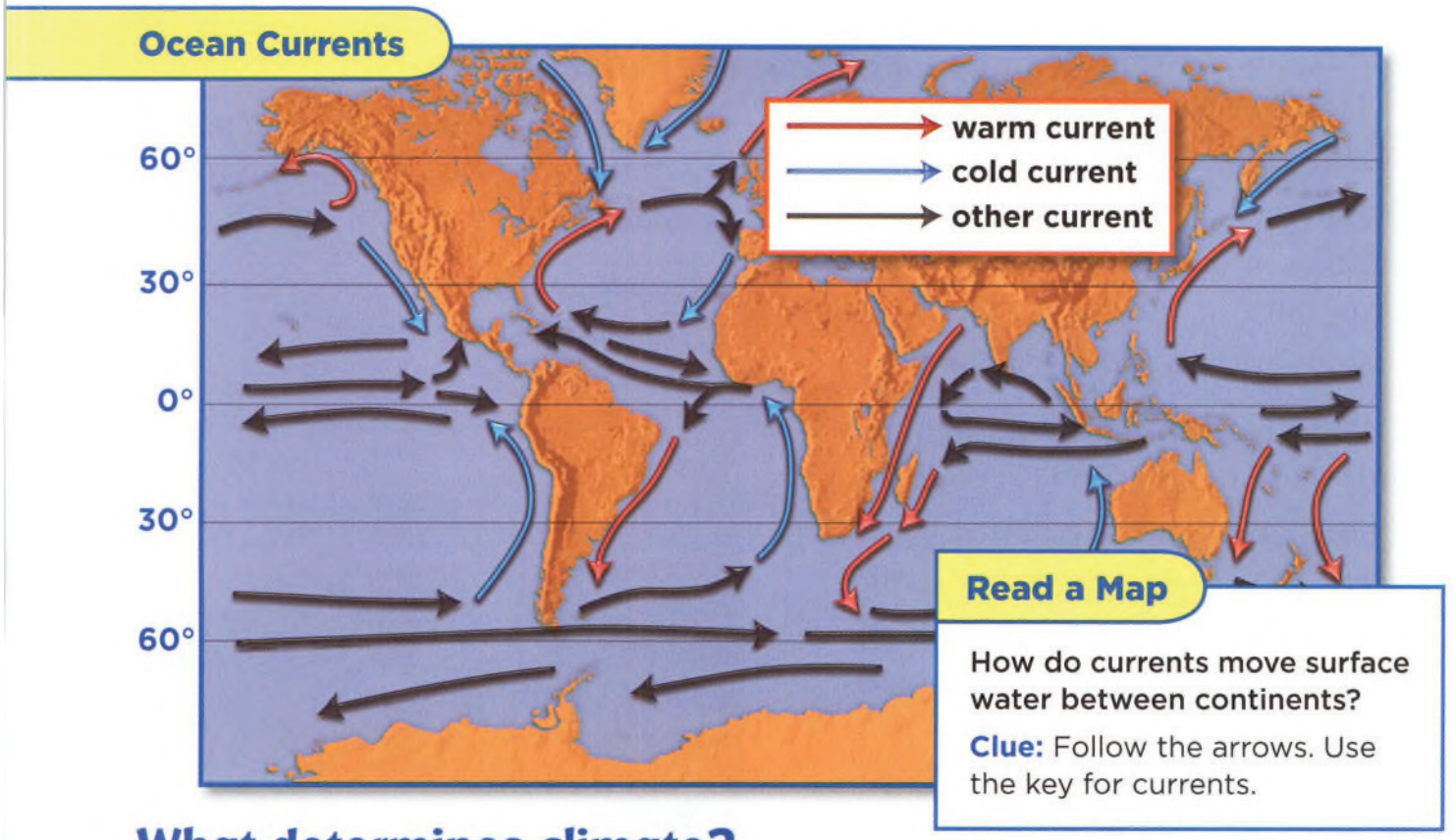
Think of climate as the average weather in a certain place for a long period of time. It has similar patterns of temperature, humidity, precipitation, and wind. We can call such an area a *climate region*.

Polar regions have cold climates with low precipitation. Tropical regions are near the equator. There, the climate is warm, humid, and rainy. *Temperate* regions lie between polar and tropical regions. Temperate climates often have four seasons. Some have just two seasons—a dry one and a rainy one. Still other regions are dry or cool.

Quick Check

Fact and Opinion *Cool climate regions are best.* Is this statement a fact or an opinion? Explain.

Critical Thinking Describe the climate of your region.



What determines climate?

Several things affect a region's climate over time. These include latitude, winds, and ocean currents.

Latitude

The thin lines that run east and west across some maps are lines of latitude. *Latitude* is a measure of how far a place is from the equator. The equator's latitude is set at zero degrees. Latitude increases as you move north or south from there. The highest latitude is at the North and South Poles. Both are 90 degrees.

Climates near the equator are warm and rainy. Between the equator and the poles, the climate is mild or temperate. Near the poles, the climate is cold all year.

Global Winds

Temperature differences between latitudes cause *global winds*. These are winds that move air between the equator and poles. Warm air near the equator rises and moves toward the poles. Cold air near the poles sinks and moves toward the equator.

Ocean Currents

A **current** is a directed flow of a gas or a liquid. Some ocean currents move warm water from the equator to the poles. Others move cold water from the poles toward the equator. There are also currents that move along lines of latitude. Together, these currents form circular patterns in the oceans.

Distance from Water

Do you like to swim at the beach in summer? You might have noticed that the water stays cool even on the hottest days. That is because water heats up more slowly than land does. Water cools more slowly too.

Remember that more than 70 percent of Earth's surface is covered by water. Land and water heat and cool at different rates. These differences affect the air temperature and precipitation nearby.

Climates near lakes and oceans are cloudier and rainier than regions farther inland. Summers are cooler. Winters are warmer. Nearness to water reduces temperature extremes. It also increases moisture in the air.

Quick Lab

Climate in Two Cities

1. Study the data table. It shows climate information for Seattle, WA, and Fargo, ND. Locate these two cities on a map.
2. **Communicate** Describe the climates of the two cities. How do the climates compare?
3. **Infer** What factor best explains the differences between the two climates? Why do you think so?

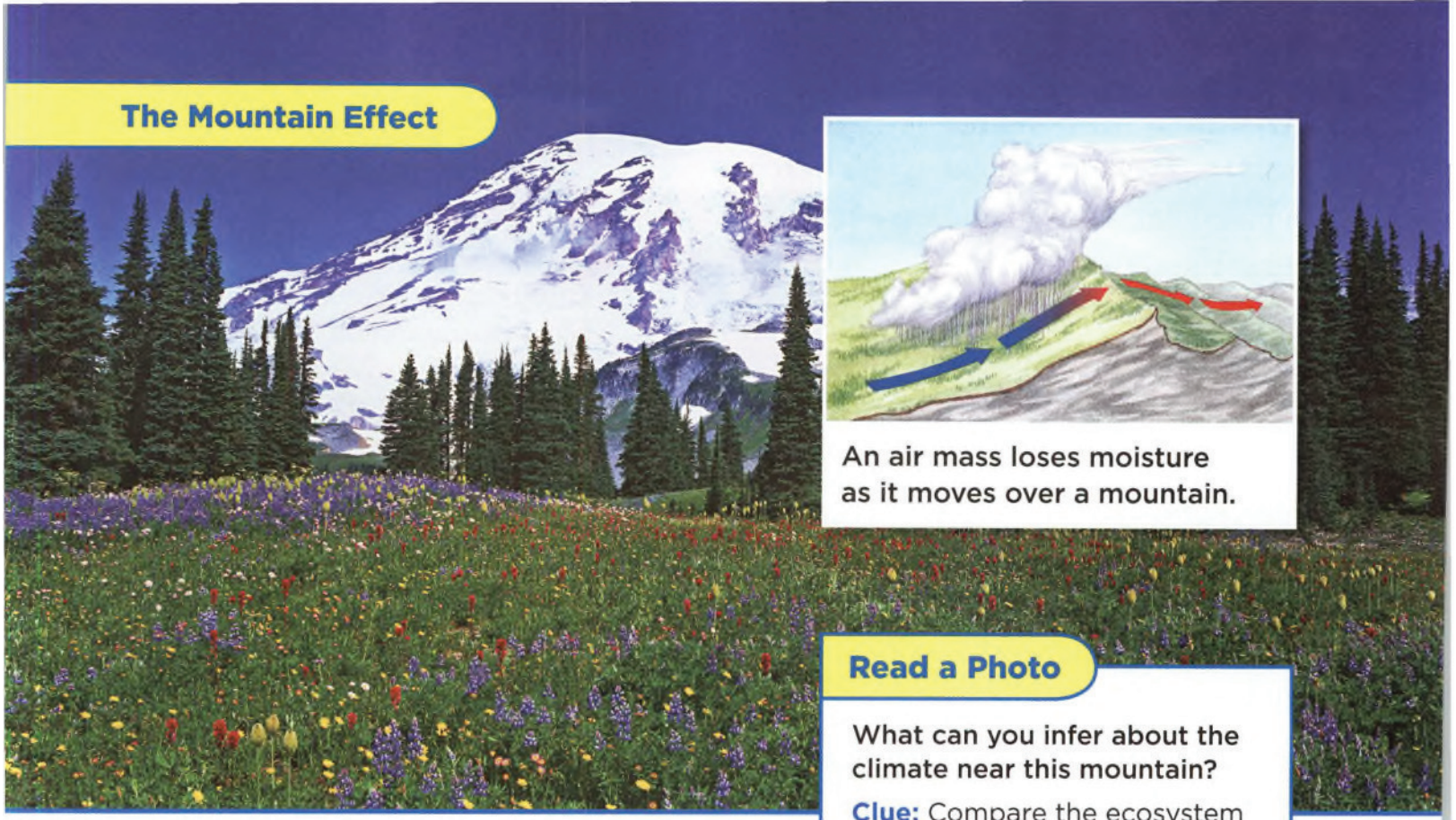
Month	Property	Seattle	Fargo
July	high temperature	75°F	83°F
July	precipitation	19 mm	69 mm
December	high temperature	45°F	20°F
December	precipitation	150 mm	17 mm

Quick Check

Fact and Opinion *The equator has a warm climate.* Is this statement a fact or an opinion? Explain.

Critical Thinking How might sailors in the past have studied ocean currents and global winds?

Indiana is an inland state. Winters there are cold and snowy.



An air mass loses moisture as it moves over a mountain.

Read a Photo

What can you infer about the climate near this mountain?

Clue: Compare the ecosystem at the base of the mountain to its peak.

How do mountains affect climate?

Latitude, water, and winds are not the only factors that affect climate. Mountains also have an effect.

Altitude

Climate at the base of a mountain is always warmer than at its peak. The higher the altitude, the lower the air temperature. *Altitude* is a measure of the height of a place above sea level.

What happens when an air mass meets a mountain? The air rises up the side of the mountain. As the altitude gets higher, the temperature gets cooler. Water vapor in the air condenses into clouds.

Clouds and Precipitation

As a cloud moves up a mountain, its water droplets get heavy. Precipitation falls. By the time the air mass passes over the mountain, the air is dry. For this reason, the climate on one side of a mountain tends to be wet. The climate on the other side is often dry.

Quick Check

Fact and Opinion State one fact and one opinion about mountains and climate.

Critical Thinking How can a mountain "dry out" the air?

Lesson Review

Visual Summary

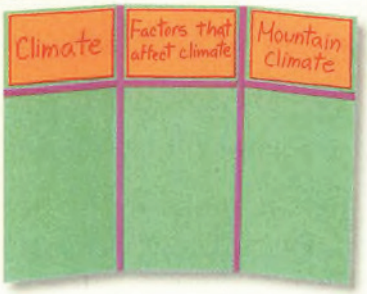
Climate regions have regular patterns of air temperature, humidity, precipitation, and wind.

Factors that affect climate are latitude, global winds, ocean currents, and distance from oceans and lakes.

Altitude affects **mountain climates.** The air temperature gets lower as you move up a mountain.

Make a FOLDABLES Study Guide

Make a trifold chart. Use it to summarize what you read about climate.



Think, Talk, and Write

1. **Vocabulary** Ocean _____ move heat from one place to another.

2. **Fact and Opinion** Choose a climate. Why would you enjoy living in this climate? Why would you not enjoy this climate? Include facts from this lesson.

Fact	Opinion

3. **Critical Thinking** How is climate different from weather?

4. **Test Prep** **Latitude is a measure of distance from**

   A an air mass.
   B an ocean current.
   C a mountain.
   D the equator.

5. **Test Prep** **Where is altitude highest?**

   A on a mountaintop
   B at the base of a mountain
   C at sea level
   D in a valley

6. **Essential Question** Why do weather patterns change?

Math Link

Find the Average Temperature
For five years, a weather station recorded high temperatures of 86°F, 89°F, 90°F, 92°F, and 88°F for the same date. What was the average for that date over the five years?

Social Studies Link

Learn about Climate
Choose another country or region. Research and report on its climate. Show how climate affects the people who live there. Find out about the crops they grow.

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Be a Scientist

Materials

paper

scissors

string

heat source

Structured Inquiry

How does warmed air affect the weather?

Form a Hypothesis

Large masses of warm air can affect the climate of a region. You can model how warm air moves. What do you think will happen if you hold a spiral of paper over a heat source? Write your answer in the form "If the air warms, then the paper spiral will..."

Test Your Hypothesis

1. **Be Careful.** Cut a circle of paper to form a spiral.
2. Tie a piece of string to one end of the paper.
3. Have your teacher turn on a heat source, such as a lamp. Carefully hold or hang the spiral about 15 centimeters above the heat source.

4. **Observe** Describe what the spiral does.
5. While holding the spiral above the heat source, turn the heat off. Describe what happens to the spiral.

Draw Conclusions

6. Was your hypothesis correct? How did the paper spiral move when it was heated?
7. **Communicate** What happened to the paper spiral when you turned the heat off? How can you explain this?
8. **Infer** What happens to air over ground that is warmed throughout the day?

Guided Inquiry

Which type of land changes temperature fastest?

Form a Hypothesis

Air is warmed by heat released from the land or water. Of soil, sand, or rock, which type of land holds heat longest? Write your answer in the form of a hypothesis.

Test Your Hypothesis

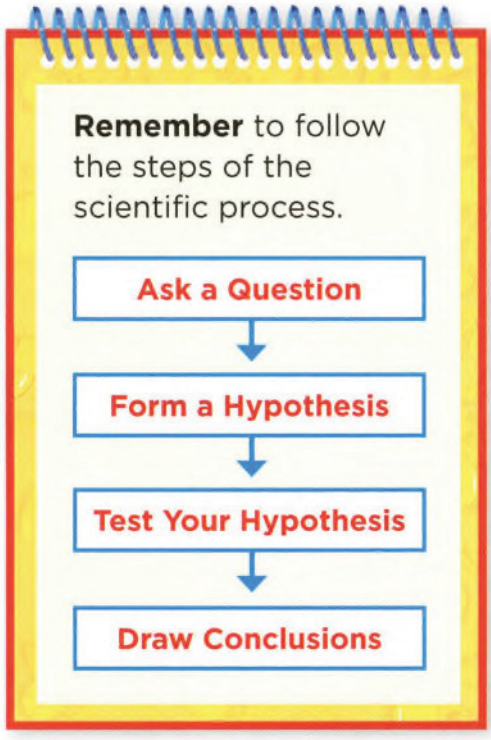
Design an investigation to find out which type of land holds heat longest. Write out the materials you will need and the steps you will follow. Record your results and observations.

Draw Conclusions

Did your results support your hypothesis? Why or why not?

Open Inquiry

What else would you like to learn about air, heat, and climate? Design an investigation to answer your question. Your investigation must be written so that another group can repeat the investigation by following your instructions.



CHAPTER 7 Review

Visual Summary

Lesson 1 Scientists measure the properties of Earth's atmosphere to describe weather.

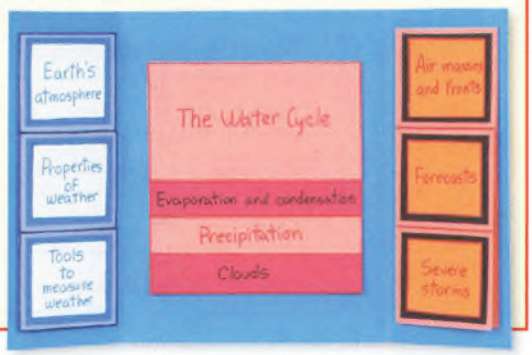
Lesson 2 Water changes state as it moves between Earth's surface and atmosphere.

Lesson 3 We can predict the weather by observing air masses and fronts.

Lesson 4 Climate is the pattern of seasonal weather in a region. Latitude and other factors affect climate.

Make a FOLDABLES® Study Guide

Tape your lesson study guides to a piece of paper as shown. Use your study guide to review what you have learned in this chapter.



Vocabulary

DOK 1

Fill each blank with the best term from the list.

air mass, p. 336
atmosphere, p. 314
climate, p. 346
condensation, p. 325
current, p. 348
evaporation, p. 324
forecast, p. 339
front, p. 337
humidity, p. 316
precipitation, p. 325

1. During the process of _____, a liquid changes slowly into a gas.
2. A large region of air with nearly the same temperature and water vapor throughout is called a(n) _____.
3. The blanket of air surrounding Earth is called the _____.
4. The pattern of seasonal weather in a region over many years is called _____.
5. A measurement of the amount of water vapor in the air is _____.
6. A directed flow of a gas or liquid is called a(n) _____.
7. A boundary between two air masses that have different temperatures is called a(n) _____.
8. A gas changes to a liquid during _____.
9. Water that falls from clouds to Earth is called _____.
10. A(n) _____ is a prediction of weather conditions.

LOG ON e-Glossary Words and definitions online at www.macmillanmh.com

Skills and Concepts

DOK 2–3

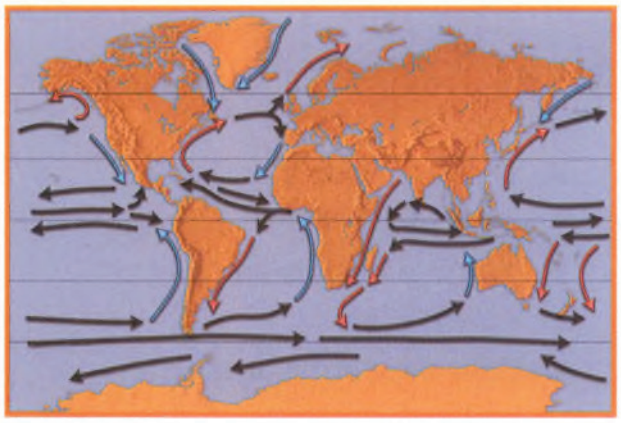
Answer each of the following.

11. **Summarize** Describe the different kinds of fronts.

12. **Make a Model** Construct a simple rain gauge. On an index card, write a short explanation of how it works.

13. **Critical Thinking** A mountain climber goes up a tall peak. At what point in the climb would you expect the air pressure to be the strongest?

14. **Expository Writing** Write a paragraph describing the impact of oceans on climate.



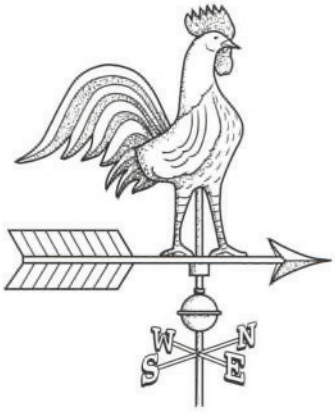
15. **Sequence** What happens to water in a lake during the changing seasons?

16. **Infer** What type of front would you infer from high cirrus clouds?

17. **Critical Thinking** Why can you see your breath outside on a cold winter day but not on a warm summer day?

18. **True or False** *A barometer measures wind speed.* Is this statement true or false? Explain.

19. Look at the picture below. What does this tool measure?



A precipitation **C** wind speed

B wind direction **D** air pressure

The Big Idea

20. What are weather and climate?

Performance Assessment

DOK 3

Weather Words

1. Observe the weather at three different points during the day—morning, afternoon, and evening. Write a description of what you observe at each time of day.

2. Look at a weather report for the same time period. Create a chart comparing your observations to those of weather forecasters.

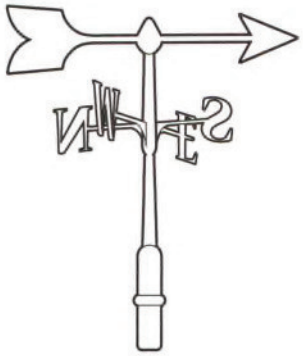
Analyze Your Results

Write a paragraph describing your results. How well did your weather observations compare to reports by weather forecasters? How would you explain any differences?

Test Preparation

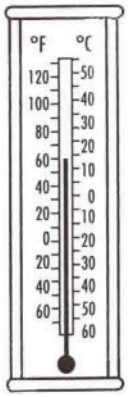
1 Which tool can be used to measure air temperature?

A



B

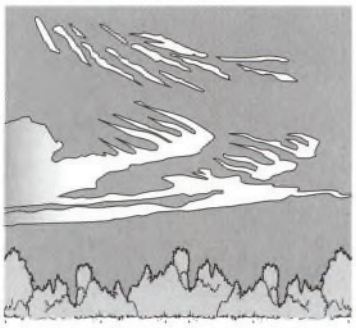
C



D

DOK 1

2 Look at the picture below.



Which type of weather will you most likely find when these clouds are in the sky?

A stormy
B fair
C wet
D snowy

DOK 2

3 **Why does precipitation occur at cold fronts?**

A Warm air cools and water vapor condenses.

B Warm air cools and water evaporates.

C Cold air warms and water vapor forms.

D Cold air warms and water condenses.

DOK 2

4 **If sleet falls, what can you infer?**

A The air below the cloud is freezing.

B A thunderstorm is occurring.

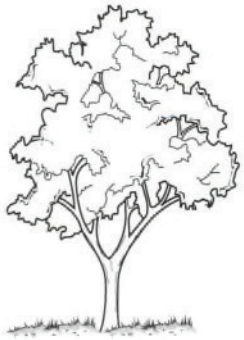
C The ice in a cloud became too heavy and fell.

D Air temperatures are above freezing.

DOK 1

5 Which of these is the source of energy for the water cycle?

A



B

C

D

DOK I

6 What determines whether a storm is a hurricane?

A the amount of precipitation

B the wind direction

C the presence of lightning

D the location where it started

DOK I

7 In which layer of the atmosphere do organisms live?

A thermosphere

B mesosphere

C stratosphere

D troposphere

DOK I

8 Look at the map below.

Which cities most likely have similar climates?

DOK I

Explain why their climates are similar.

DOK 2

Check Your Understanding

Question	Review	Question	Review
1	pp. 316–318	5	pp. 324–327
2	pp. 328–329	6	p. 340
3	pp. 336–337	7	pp. 314–315
4	pp. 324–325, 330	8	pp. 346–350