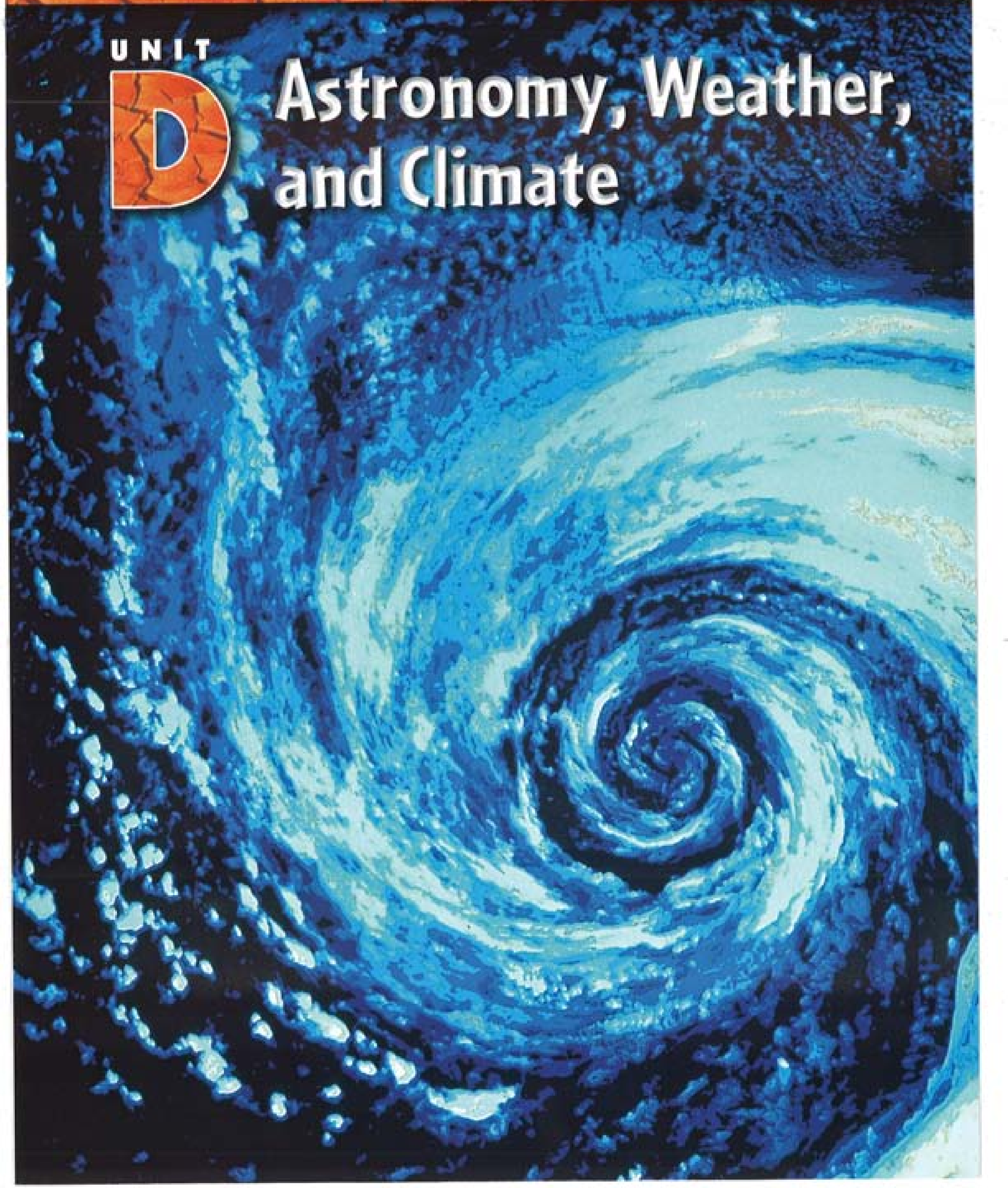
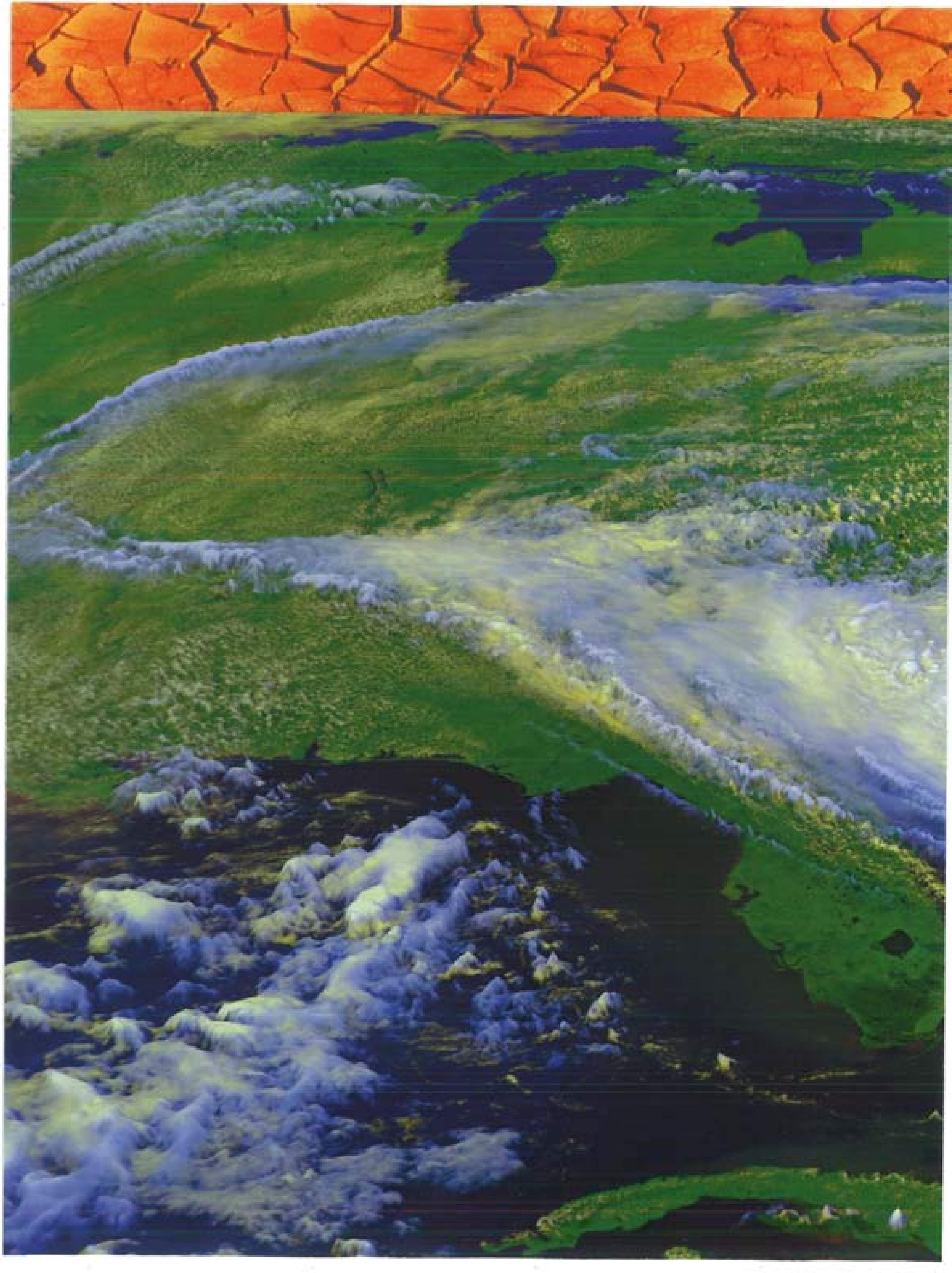
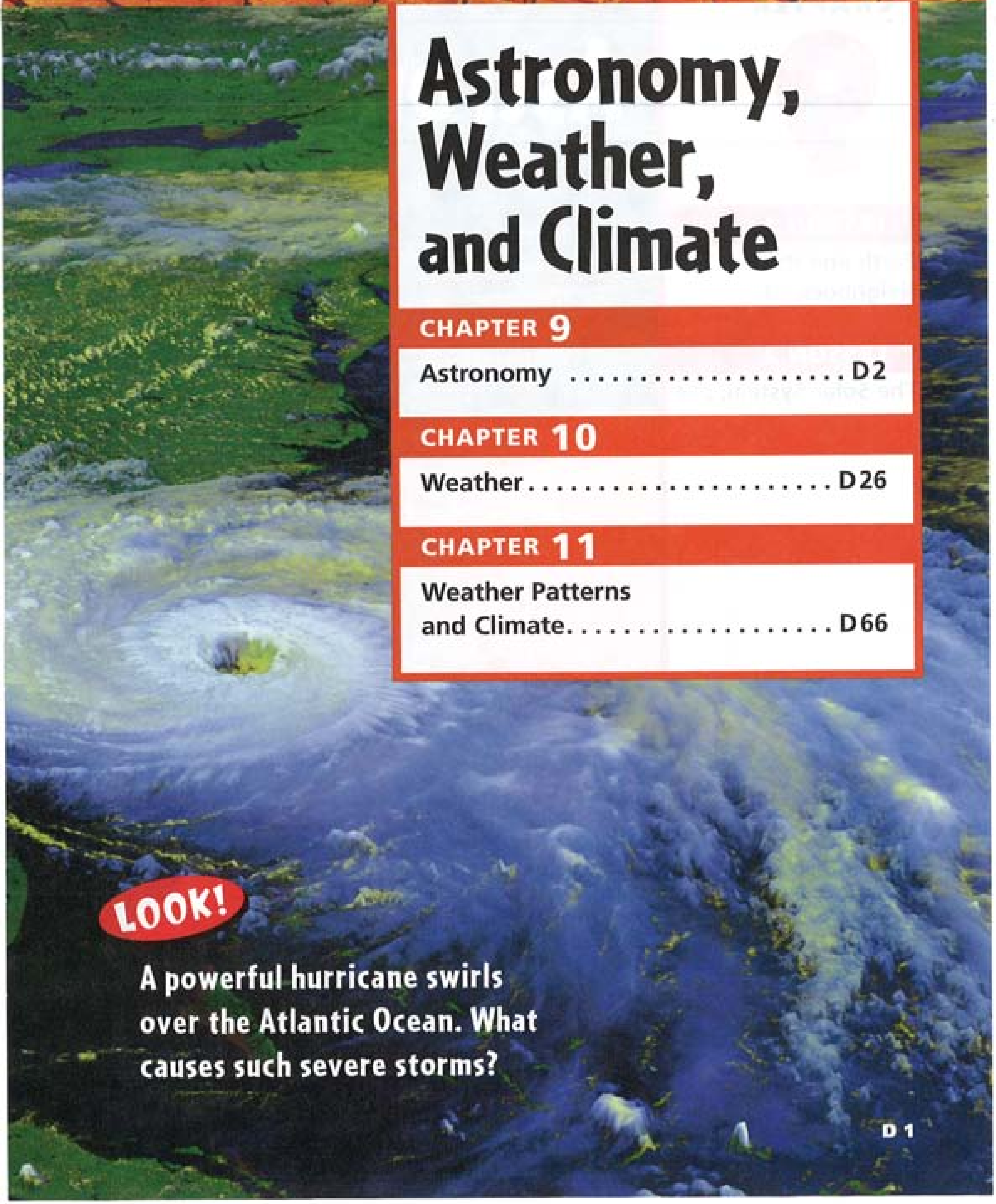
Earth Science

UNIT D Astronomy, Weather, and Climate







Astronomy, Weather, and Climate

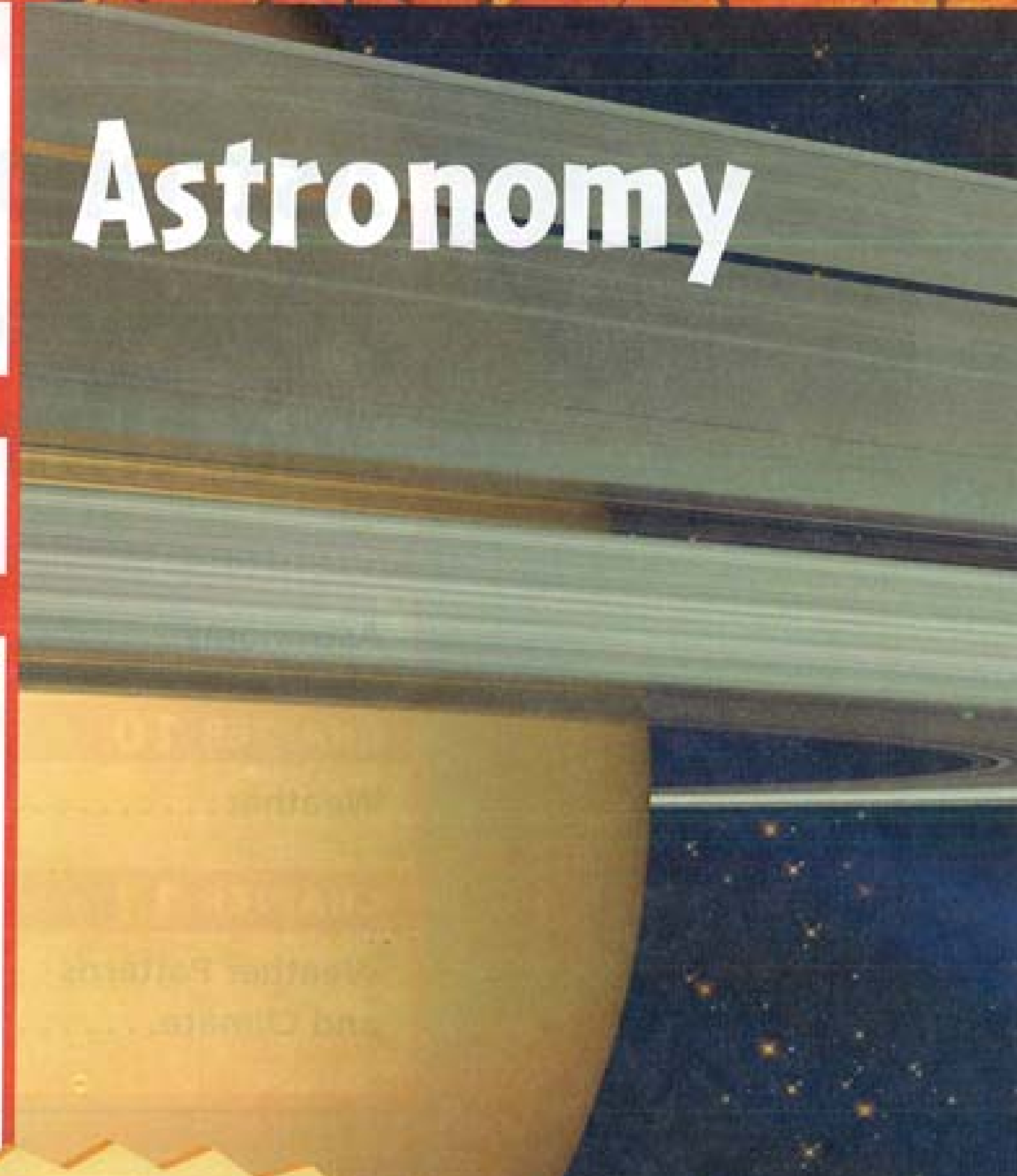
LOOK!

A powerful hurricane swirls over the Atlantic Ocean. What causes such severe storms?

CHAPTER

9

Astronomy



Did You Ever Wonder?

Did you ever see the clear night sky far from city lights? Did it ever seem to you that the stars formed patterns in the sky? Have you watched for one especially bright light that does not twinkle? A light that people call "the evening star"? It is not a star at all. It is the planet Venus. Venus and Earth are only two of many planets in our solar system. What are the other planets like?

INQUIRY SKILL **Make a Model** The Moon orbits Earth each month. Why does the Moon seem to change shape from night to night? Make a hypothesis. Design a model to test your hypothesis.

LESSON 1

Earth and Its Neighbors

Vocabulary

solar system, D6
planet, D6
gravity, D8
inertia, D8
revolve, D10
constellation, D12

Get Ready

Saturn is not standing still in one spot. It is moving around the Sun in an almost circular path. What holds Saturn, and all the other planets, near the Sun? What keeps each planet on its path?

Inquiry Skill

You use variables when you identify and separate things in an experiment that can be changed or controlled.

Explore Activity

How Are Earth and the Sun Held Together?

Materials
- clay
- string
- scissors
- meterstick
- goggles

Procedure

BE CAREFUL! Wear goggles. Twirl the model close to the ground.

1. **Make a Model** Cut a 40-cm length of string. Wrap it around a small, round lump of clay in several directions. Tie the ends to make a tight knot. Measure 60 cm of string, and tie it to the string around the ball.
2. **Observe** Spin the ball of clay slowly—just fast enough to keep the string tight and the ball off the ground. Keep the ball close to the ground. Describe the path of the ball.
3. **Experiment** At one point while spinning, let the string go. What happens? Describe the path of the ball of clay. Repeat until you get a clear picture of what happens.

Drawing Conclusions

1. How did your model represent Earth and the Sun? What represented Earth? Where was the Sun located? How did you represent the force between them?
2. **Infer** Explain what happened when you let the string go. Why do you think this happened?
3. FURTHER INQUIRY **Use Variables** How would your results change if the mass of the clay were doubled? Tripled? How does the mass affect the pull on the string? Make a prediction. Try it.

Read to Learn

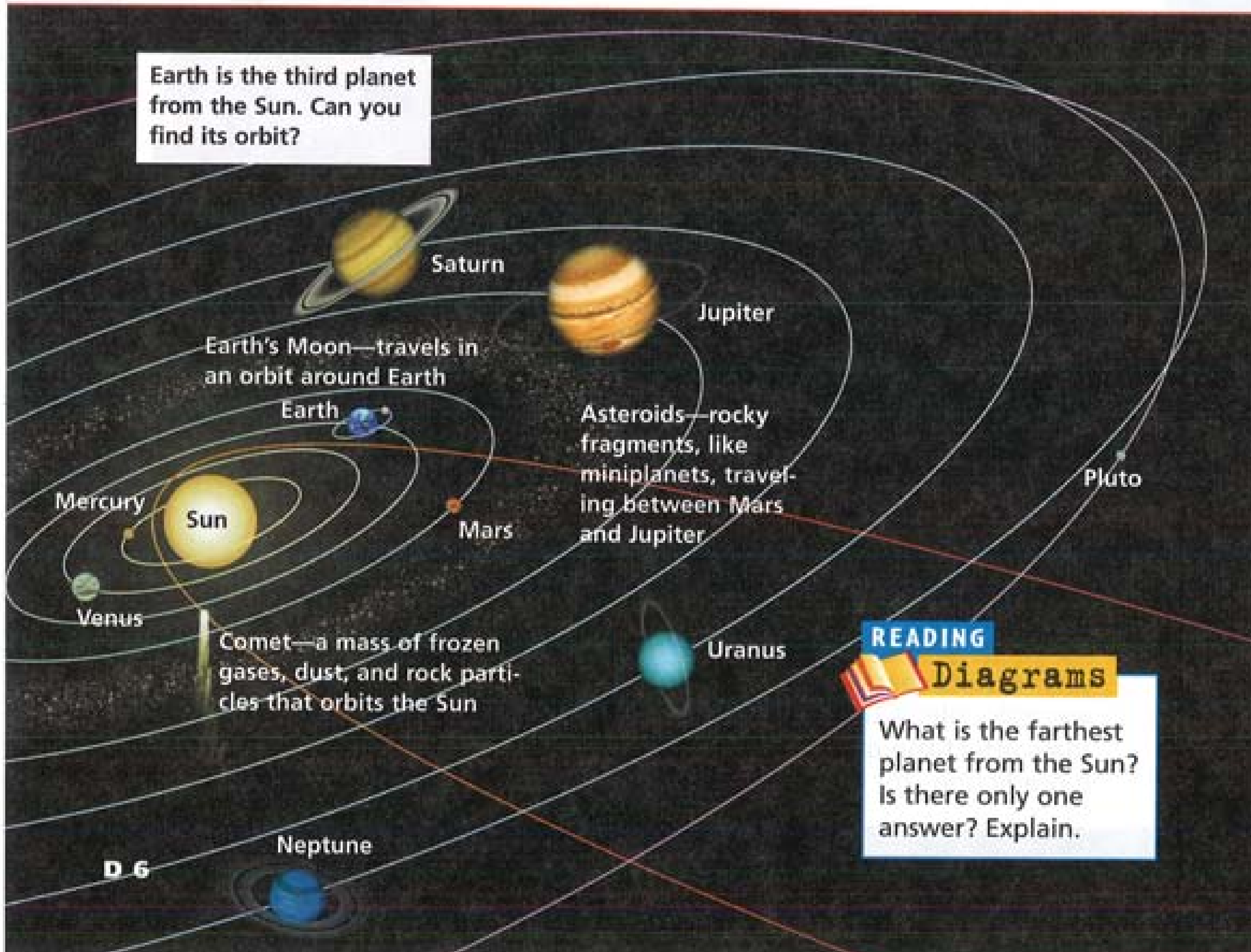
Main Idea **The solar system consists of nine planets, many moons, and many other bodies orbiting the Sun.**

What Is the Solar System?

If you were traveling in a spaceship through space as fast as light, you would be passing stars. Perhaps in time you would approach one star in particular, the star you know as the Sun. If so, you would be approaching your home address, the **solar system**. The solar system is the Sun and the objects that are traveling around it.

Our Sun is an average-size star similar to many other stars in the night sky. It appears so large and bright to us because it is much closer to Earth. The Sun is composed mostly of hydrogen and helium. The formation of helium from hydrogen is what generates light and heat from the Sun.

The objects around the Sun include nine **planets**. Planets are objects that travel around a star in a path. That path is called an *orbit*. The planets are held in orbit around the Sun. The planets do not give off light, as stars do. They reflect light from their star, the Sun.



READING Diagrams

What is the farthest planet from the Sun? Is there only one answer? Explain.

Except for Pluto, the orbit of each planet is almost a circle. Each orbit is slightly oval. What effect does an orbit of this shape have on the distance from a planet to the Sun?

One complete trip of an object in its orbit around the Sun takes one *year*. A year is different from planet to planet. For Earth one year is 365.25 days. The table shows how long a year takes for each planet. The time is given in days as days are timed on Earth.

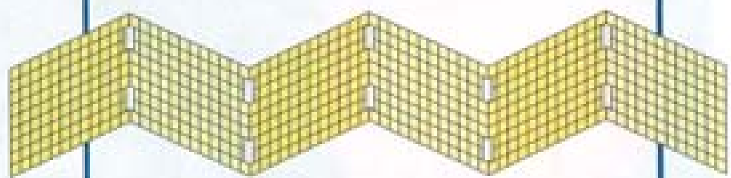
What are the parts of the solar system?

Planet	Average Distance to the Sun (million km)	Year Time for complete orbit around the Sun (in Earth days)
Mercury	57.9	88 days
Venus	108.2	225 days
Earth	149.6	365 days
Mars	227.9	687 days
Jupiter	778.4	4,331 days
Saturn	1,427	10,756 days
Uranus	2,871	30,687 days
Neptune	4,498	60,190 days
Pluto	5,906	90,553 days

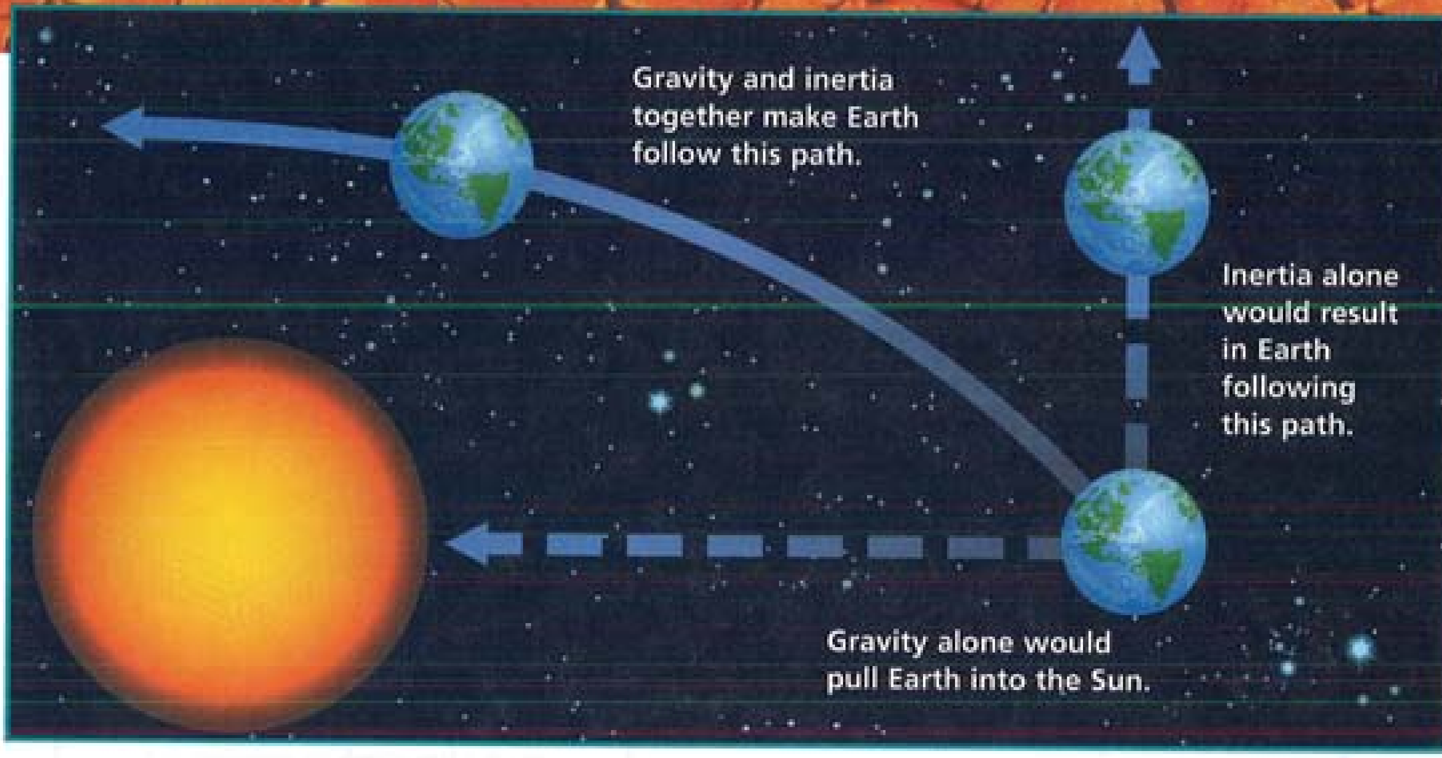
QUICK LAB

Orbit Times

FOLDABLES Make a Folded Graph using graph paper as shown. (See p. R 41.)



1. **Communicate** Use graph paper to draw a bar graph to compare the revolution times for the planets. Tape the ends of the graph paper together to make an accordian graph. The horizontal axis represents time. Decide how much time each square represents. The vertical axis represents the planets. How many pieces of graph paper will you need?
2. **Interpret Data** What relationship can you find between the length of the year (time) and the planet's location in the solar system?
3. How could you change your graph to show the relationship even better? What might your new graph reveal?



What Keeps the Planets in Orbit?

The planets orbit the Sun, but what holds them in their paths? What keeps them from flying off into space?

Gravity

Over 300 years ago, Sir Isaac Newton described an invisible force holding the Sun and a planet together. He called the invisible force **gravity**. He described gravity as a property of all matter. It is a force of attraction, or pull, between any object and any other objects around it.

Gravity depends on two measurements—mass and distance. The more matter, or mass, in an object, the greater the pull in the object's direction. The closer two objects are, the stronger the pull of gravity between them.

The Sun has far more mass than any of the planets, so its gravity is much stronger, too. The Sun's gravity holds all of the objects in the solar system together. Without gravity, everything orbiting the Sun would go flying off into space.

Inertia

Gravity is not the only reason the planets stay in their orbits. Gravity alone would pull the planets into the Sun, because the Sun is so massive. That doesn't happen because the planets are moving. All objects—including the planets—have a property called **inertia** (i·NUR·shuh). Inertia is the tendency of a moving object to keep moving in a straight line.

Without gravity, the planets' inertia would keep them moving in straight lines. Gravity "steers" the planets in their oval paths around the Sun. Together, gravity and inertia keep the planets in their orbits.

READING Sequence of Events
How do gravity and inertia keep a planet in orbit?

What Makes a Day?

The Sun does more than just hold the planets in their orbits in the solar system. It also provides them with light and warmth. The Sun is the reason for day and night. All planets spin, or *rotate*, like huge spinning tops.

READING Tables

Make a list of planets in order from the shortest day to the longest day.

Planet	Day = time for complete spin (in Earth hours or days)
Mercury	59 days
Venus	243 days
Earth	24 hours
Mars	24 hours 37 minutes
Jupiter	9 hours 56 minutes
Saturn	10 hours 40 minutes
Uranus	17 hours 14 minutes
Neptune	16 hours 7 minutes
Pluto	6.39 days

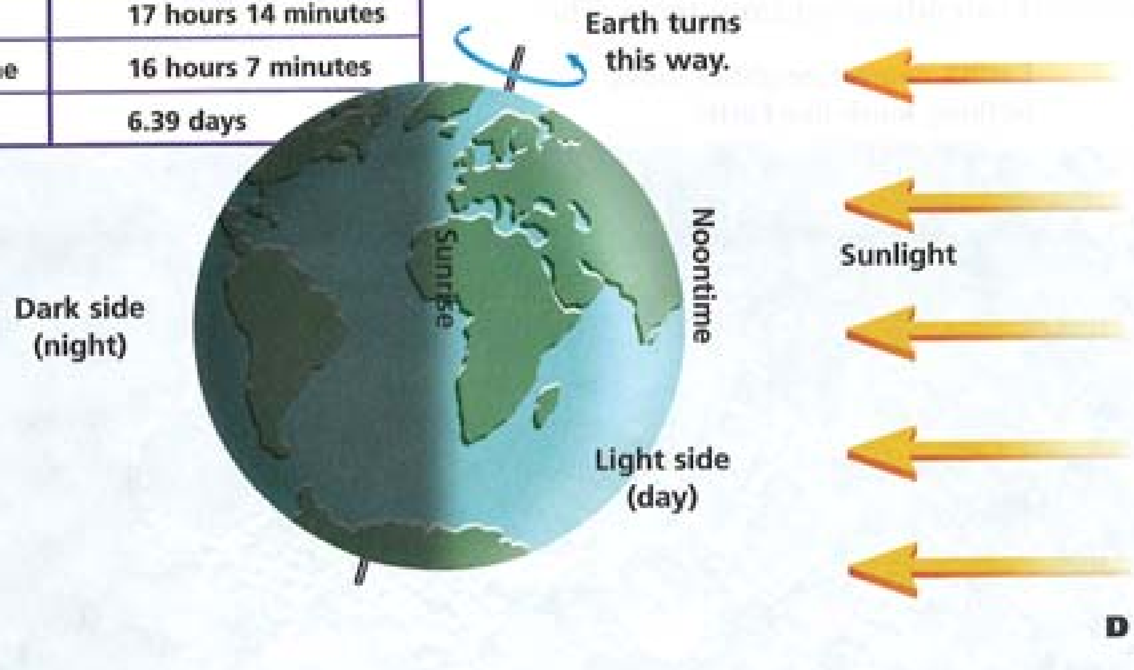
Length of Day

At any point in time, half of a planet is facing the Sun—it has daylight on that half. At the same time, half is facing away from the Sun—that half is in darkness, night.

As a planet rotates, places that are in darkness eventually turn to face the Sun, and those in daylight eventually turn away. Each planet makes one complete spin in its day. Each planet has its own speed of turning. The length of a day (that is, one complete day-night cycle) is different for each planet.

How much light and warmth a planet receives depends on how far it is from the Sun. Light spreads out as it travels outward from the Sun. An area of one square meter on the planet Mercury receives much more energy than an area of one square meter on a farther planet—such as Pluto. That is why Mercury is much hotter than Pluto.

What is a day?



What Is the Moon Like?

The Moon is Earth's nearest neighbor—"only" 384,000 km (240,000 mi) away. However, the Moon is not like Earth. There is no water to drink, no air to breathe. There is no weather, either. Without an atmosphere and oceans to trap and circulate heat, temperatures change greatly during a lunar day. With the Sun overhead, temperatures climb to over 123°C (253 °F). During a lunar night, temperatures can drop to -110°C (-170°F) or lower. At the Moon's shaded south pole, temperatures can drop to -233°C (-387°F).

The Moon has a rocky surface. With a telescope you can see its surface features. These include dark-colored regions called *maria* (MAHR·ee·uh). Maria is Latin for "seas." In the past, people thought these areas were oceans. The maria are really dry, flat land surrounded by mountains and ridges. Much of the Moon's surface is covered with huge dents, called craters. Some craters have trails of rock and dust extending out from them. The trails reflect sunlight and look like rays coming out of the crater.

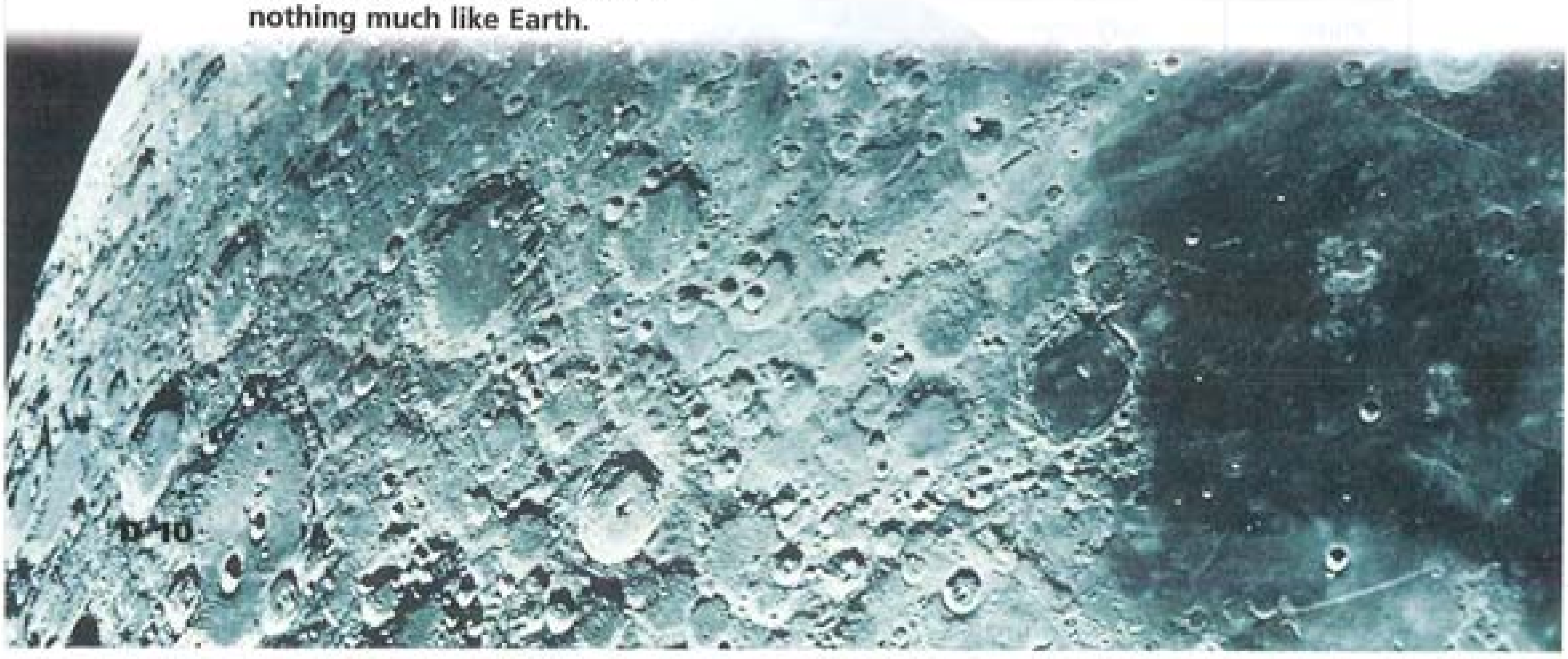
At the same time Earth is **revolving**, or orbiting, around the Sun, the Moon is revolving around Earth. The Moon rotates on its axis once in the time it takes to orbit once around Earth. That means that the same side of the Moon is always facing Earth. However, the Moon seems to change shape, or phase, from day to day.

How Do Moon Phases Happen?

The light of the Moon comes from the Sun's rays striking it. Half of the Moon always faces the Sun, while the other half is in darkness. As the Moon travels around Earth we see different amounts of the lighted half. These are known as the Moon's phases. The phase we see depends on where the Moon is in relation to Earth and the Sun. It takes the Moon 29.5 days to complete all its phases.

How does the Moon differ from Earth?

Earth's nearest neighbor looks nothing much like Earth.



Phases of the Moon

Third Quarter Moon

The Moon is three quarters of the way around Earth. This is sometimes called a half Moon.

Waning Crescent Moon

The left sliver of the Moon is the only part that you can see lighted.

Waning Gibbous Moon

As the Moon continues to move in its orbit, less of the lighted side is visible from Earth.

New Moon

The Moon is between the Sun and Earth.

The Moon is not visible in the sky.

Full Moon

Earth is between the Moon and the Sun.

The entire lighted side of the Moon is visible.

Waxing Crescent Moon

As the Moon moves in its orbit, more of the lighted side becomes visible from Earth.

Waxing Gibbous Moon

The gibbous Moon is almost full.

First Quarter Moon

The Moon is a quarter of the way around Earth. This is sometimes called a half Moon.

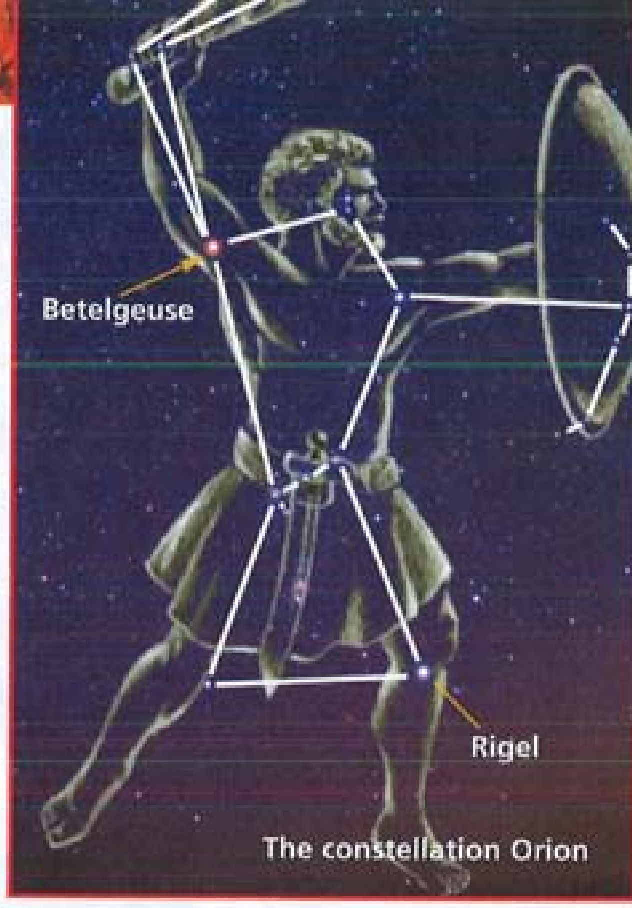
What Are Constellations?

When you look into the night sky, what else can you see besides the Moon? If the sky is dark enough, you can also see the stars. What are stars? A star is a large, hot ball of gas that is held together by gravity and gives off its own light. Stars look like points of light in the night sky. Unlike the Moon, stars are far outside the solar system.

In the past people looked at the stars and saw them arranged in groups that formed patterns in the sky. These patterns are called **constellations**. To these people the patterns looked like pictures of animals or people.

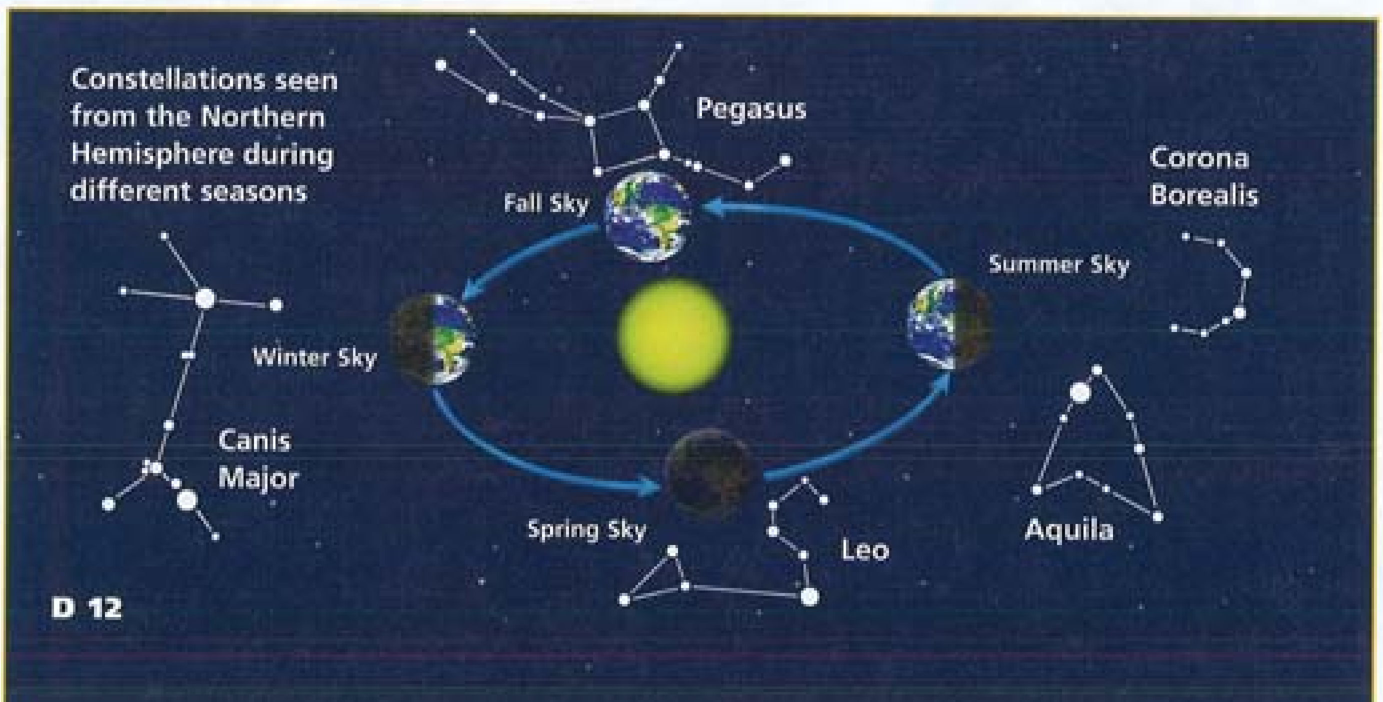
How can you find a star like Rigel in the night sky? The easiest way is by looking for its constellation. Rigel, for example, is a star in the constellation Orion, the hunter.

The pattern of stars in a constellation always looks the same even though the constellations appear to change position during the night and from season to season. As Earth travels in its orbit around the Sun, its night side faces different directions. You see only the constellations that are in that direction. For example, in the Northern Hemisphere, we see the constellation Orion in the winter months.



The constellation Orion

Why do constellations appear to move across the sky?



Lesson Review

L·I·N·K·S

Why It Matters

Earth is teeming with life and movement. The Sun's energy helps produce seasons, day-to-day weather, and climates.

When astronauts first visited the Moon in 1969, they faced a tough problem. How do you survive in such a place? They had to bring all of the things they needed to stay alive all the way from Earth.

Earth is the only member of the solar system that supports life as we know it.

e-Journal Visit our Web site **www.science.mmhschool.com** to do a research project on the solar system.

Think and Write

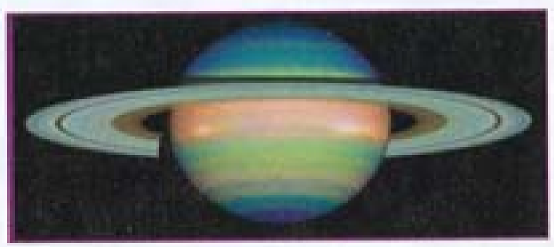
1. How would you state your address in space? Explain your answer.
2. How is gravity important for Earth?
3. What keeps the planets in orbit around the Sun? Explain.
4. Why is the Moon unlivable compared with Earth?
5. **Critical Thinking** Would you weigh the same on the Sun as you do on Earth? Explain your answer.

MATH LINK

Estimate sizes. Stars come in different colors and sizes. Rigel is a blue supergiant with a diameter about 100 times larger than the Sun. Red supergiant Betelgeuse has a diameter about 1,000 times larger than the Sun. About how much larger is Betelgeuse than Rigel?

SOCIAL STUDIES LINK

Research the planets. Learn more about Earth's neighbors. Which planets have moons? Rings? Which planets are most likely to support life? Use the Internet or an encyclopedia.



WRITING LINK

Expository Writing How are telescopes used to magnify distant objects in the sky, such as the Moon and the planets? Use the Internet or an encyclopedia for your research. Write an essay about your findings.

TECHNOLOGY LINK

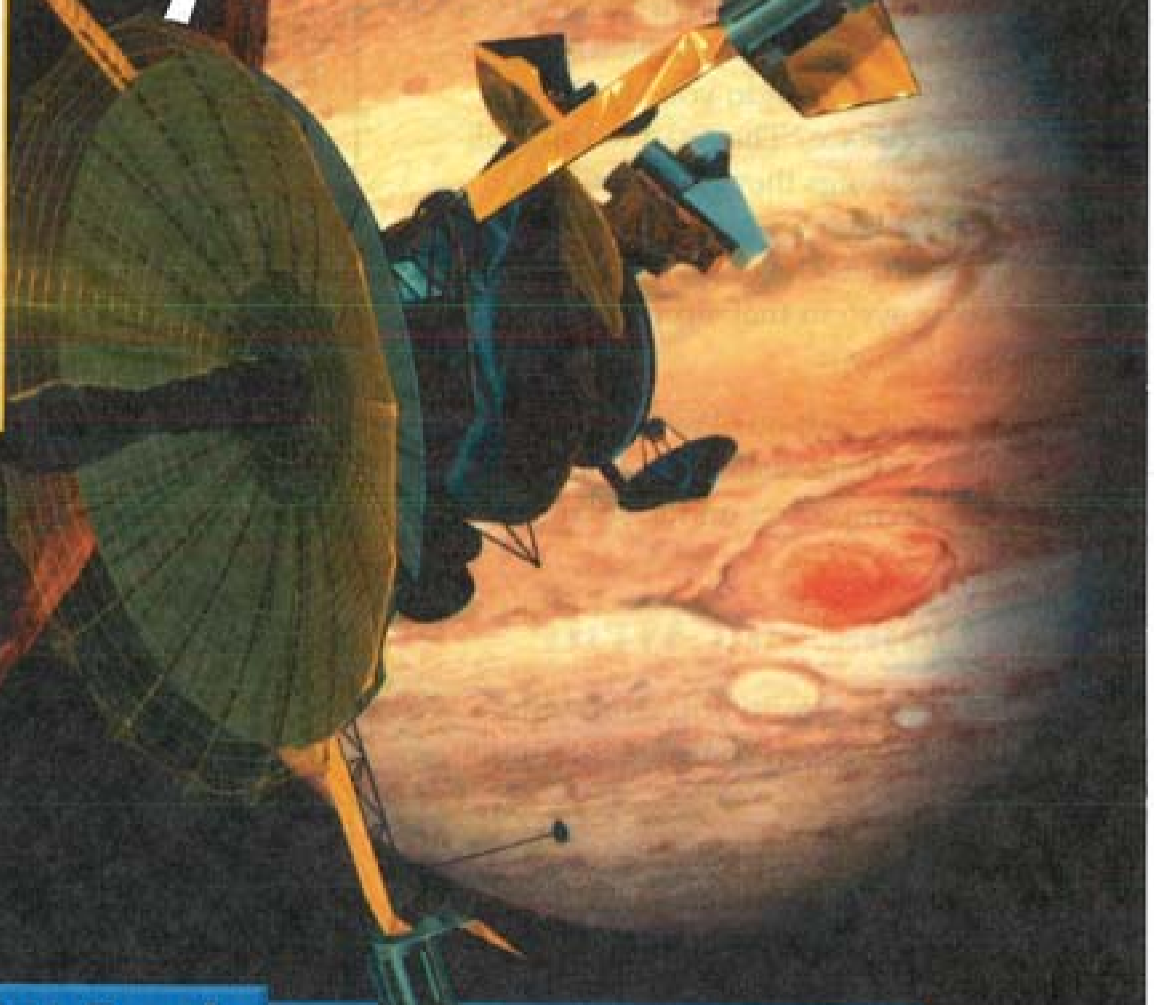
LOG ON Visit **www.science.mmhschool.com** for more links.

LESSON 2

The Solar System

Vocabulary

inner planet, D16
outer planet, D16
asteroid belt, D19
asteroid, D19
meteor, D19
meteorite, D19
comet, D19
galaxy, D20



Get Ready

This is an artist's idea of what a spaceprobe would look like as it passes one of Earth's neighbors. Do you know which planet this is? Even without a telescope you can see several planets during the year. How big is the solar system? How do the distances between planets compare? Construct a model to find out.

Inquiry Skills

You make a model when you make something to represent an object or an event.

Explore Activity

How Do the Distances Between Planets Compare?

Materials

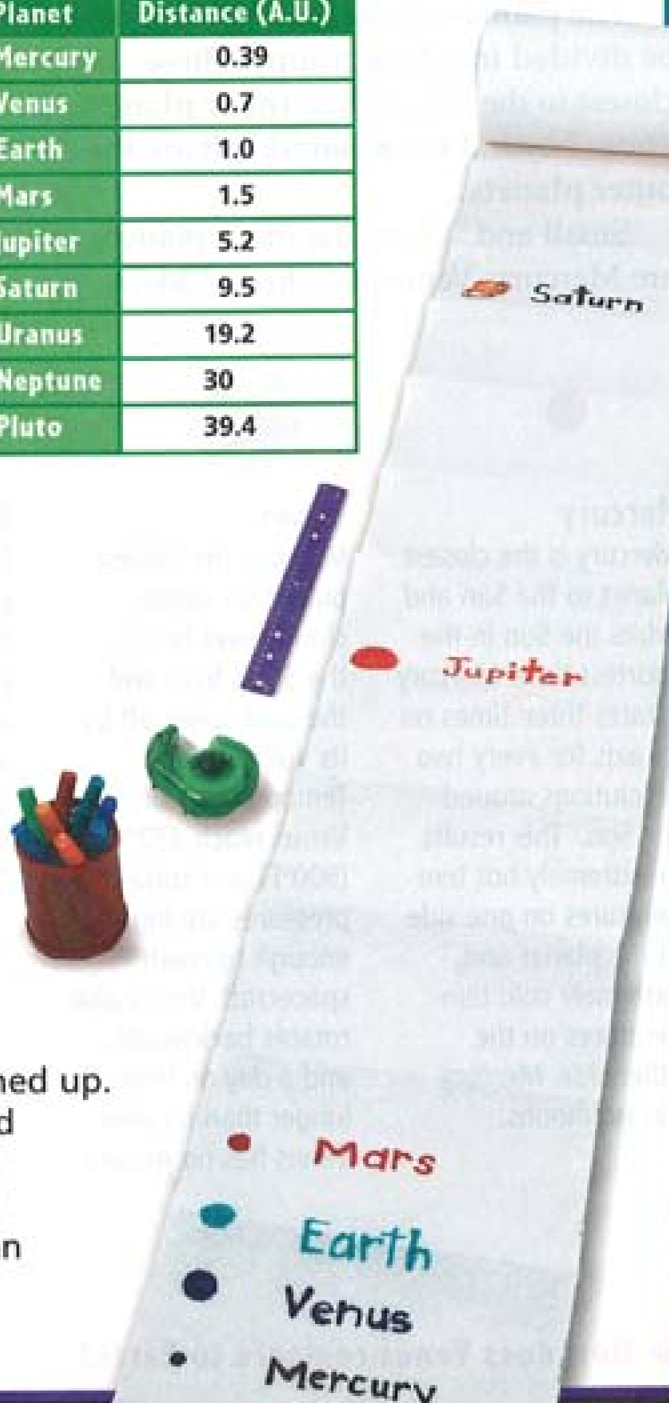
- roll of paper towels
- markers
- tape (optional)
- ruler

Procedure

1 **Use Numbers** Study the chart. Distances are in Astronomical Units (A.U.). One A.U. is the distance from Earth to the Sun. How far from the Sun is Mars? Pluto?

Planet	Distance (A.U.)
Mercury	0.39
Venus	0.7
Earth	1.0
Mars	1.5
Jupiter	5.2
Saturn	9.5
Uranus	19.2
Neptune	30
Pluto	39.4

2 **Make a Model** Let the width of one paper towel be one A.U. Lay out the length of paper towels you need to show the distance from the Sun to Pluto. Measure and mark the location of each planet.



Drawing Conclusions

1 **Interpret Data** Describe how the planets are spaced.

2 **Use Numbers** It takes 8 minutes for light to travel from the Sun to Earth. How long does it take for light to travel to Jupiter? To Pluto?

3 FURTHER INQUIRY **Make a Model** Your model has all the planets lined up. Actually, the planets are scattered in different places in their orbits. How can you change your model to be more accurate? Make a plan and try it.

Read to Learn

Main Idea **Our solar system consists of four inner planets, five outer planets, moons, and other small bodies.**

How Do the Inner Planets Compare?

The planets of our solar system can be divided into two groups. Those closest to the Sun are the **inner planets**. Those beyond the asteroid belt are the **outer planets**.

Small and warm, the inner planets are Mercury, Venus, Earth, and Mars. The inner planets have solid, rocky crusts. They are much denser than the outer planets. The craters on their surfaces are "scars" left by space debris that constantly bombarded them in their early years. Except for Mercury, they are all geologically active. In this group is the only planet known to support life, Earth. All of these planets are formed from the same materials. As a result, studies of Earth have given us a lot of knowledge about the other inner planets. None of the inner planets have rings. They all have atmospheres. They have few, if any, moons.

Mercury

Mercury is the closest planet to the Sun and orbits the Sun in the shortest time. Mercury rotates three times on its axis for every two revolutions around the Sun. This results in extremely hot temperatures on one side of the planet and extremely cold temperatures on the other side. Mercury has no moons.

Venus

Venus is the hottest planet. Its dense cloud cover holds in the Sun's heat and the heat given off by its volcanoes. Temperatures on Venus reach 482°C (900°F) and surface pressures are high enough to crush spacecraft. Venus also rotates backwards, and a day on Venus is longer than its year. Venus has no moons.

Earth

Earth is the water planet. It is our home. It has the right temperatures and resources for life as we know it to exist. Earth has one Moon.

Mars

The largest volcano in our solar system, Olympus Mons, is found on Mars. Mars has a thin atmosphere, but has strong winds and pink dust storms. There may once have been liquid water on Mars' surface. From the surface of Mars, its two moons, Phobos and Deimos, seem to move in opposite directions. Swift Phobos rises in the west and sets in the east usually twice a Martian day.

How does Venus compare to Earth?

Inquiry Skill BUILDER

SKILL Make a Model

Making a Model of the Solar System

In this activity you will make a model to compare the sizes of the planets in the solar system. The table "Comparing a Planet's Radius with Earth's" will tell you how the radius of each "model planet" you make would compare to your model of Earth.

Materials

- construction paper
- white paper
- pencil
- string 25 cm long
- metric ruler
- colored markers or colored pencils
- tape

Procedure

1. **Use Numbers** Look at the table. How much bigger is Jupiter's radius than Earth's radius? How much smaller is Mars' radius than Earth's?
2. **Measure** Let your model Earth's radius be 1 cm. Using this scale, how big would you need to make the radius of Jupiter? How big would you need to make the radius of Mars?

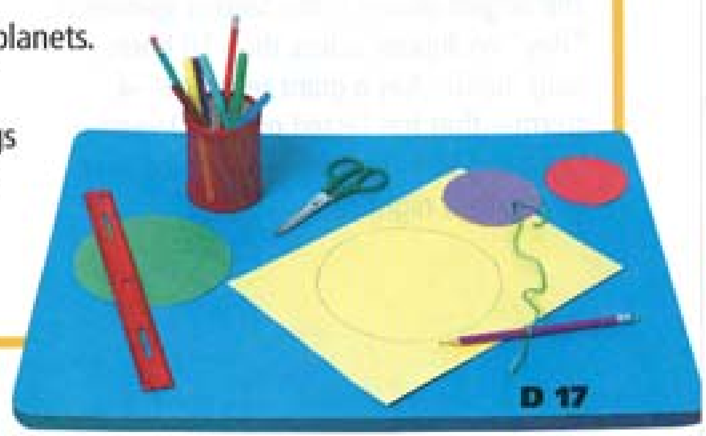
Comparing a Planet's Radius with Earth's

Planet	Radius (in Earth radii)	Planet	Radius (in Earth radii)
Mercury	0.38 x Earth	Jupiter	11.2 x Earth
Venus	0.95 x Earth	Saturn	9.5 x Earth
Earth	1 x Earth	Uranus	4.0 x Earth
Mars	0.53 x Earth	Neptune	3.9 x Earth
		Pluto	0.18 x Earth

3. **Make a Model** Draw a model Earth with a 1cm radius. Cut out your model. Repeat this process for each planet.

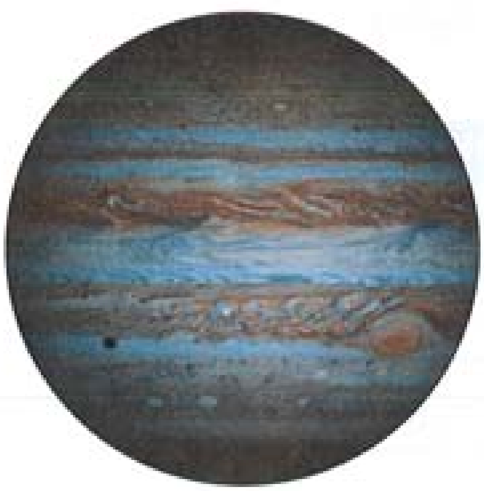
Drawing Conclusions

1. **Compare** Look at the sizes of your model planets. Which planets are almost the same size?
2. **Compare** The radius for Saturn and its rings is over 28.5 times Earth's radius. How much larger is that than Jupiter's radius?



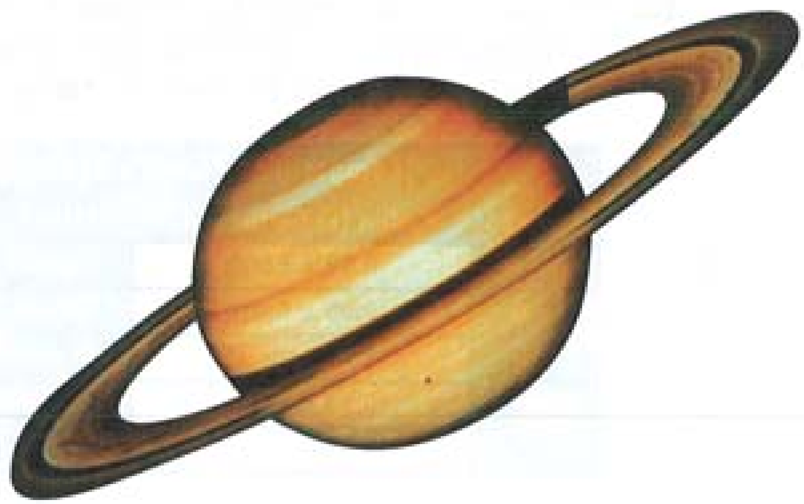
How Do the Outer Planets Compare?

Beyond the asteroid belt lie the outer planets. They are Jupiter, Saturn, Uranus, and Neptune—the gas giants— and tiny, icy Pluto. These planets formed in an area where temperatures were lower. This allowed lighter, less dense materials to clump together and form planets. The cores of the gas giants are dense and rocky. Surrounding the core of each planet are layers of dense liquids. Each gas giant is surrounded by large envelopes of gases. The gas giants also have rings. These range from the breathtaking rings of Saturn to the faint gray rings of Uranus. All of the outer planets have many moons, except for Pluto, which has only one. The period of revolution is much slower among the outer planets. The outer planets take many years to orbit the Sun. However, the gas giants rotate in a period of hours, not days.



Jupiter

The largest planet is the fastest spinner. A "day" on Jupiter is less than 10 hours long. Jupiter has a giant red spot—a storm—that has lasted over 300 years. Lightning bolts and auroras can be seen on Jupiter's night side.



Saturn

Find an ocean big enough and this "Lord of the Rings" would float! Giant Saturn is less dense than water! Saturn has the most visible and beautiful rings of all the planets. Saturn is almost twice as far from the Sun as Jupiter.

Between and Beyond the Planets

Between the orbits of Mars and Jupiter is the **asteroid belt**. Here, many small, rocky objects orbit the Sun. These are the **asteroids**. The largest asteroid, Ceres, is about one-fourth the diameter of Earth's Moon.

Pieces of space rock sometimes fall through Earth's atmosphere. Most of them burn up before they hit the ground. These are the "shooting stars," or **meteors**. Space rocks that reach the ground are called **meteorites**. Meteors can come from asteroids. They can also come from material left behind by **comets** as they orbit the Sun.

Comets are "dirty snowballs"—mixtures of ice, rock, and dust "left over" from the formation of the solar system. Beyond Neptune's orbit, 30 to 100 A.U. from the Sun, is the Kuiper Belt. *Short-period comets*—those that take less than 200 years to orbit the Sun—come from here. Beyond Pluto, about 100,000 A.U. from the Sun, is the Oort cloud. *Long-period comets*—those taking up to 30 million years to orbit the Sun—come from here.

What are comets made of? In January, 2004, the spacecraft *Stardust* flew past Comet Wild 2 and collected material from the comet. It also photographed what may be boulders, high cliffs, and impact craters on the comet's surface

Uranus

Uranus has been called "the planet that was knocked on its side." As a result of its tilt, its poles take turns pointing toward the Sun. Even so, Uranus is hotter at its equator, though scientists don't yet know why. Uranus is about twice as far from the Sun as Saturn. A day on Uranus is $17\frac{1}{4}$ hours long, but it takes 84 Earth-years to orbit the Sun. As springtime comes to Uranus, the planet shows that it has the brightest clouds in the outer solar system.

Neptune

Distant Neptune is almost 4.5 billion km from the Sun. Neptune's year is 165 Earth-years long, but its day is only about 16 hours long. Winds whip around Neptune at almost 1250 miles an hour (2000 km/hr).

Pluto

Tiny Pluto is farthest from the Sun. It is made up of frozen gases with lesser amounts of rocky materials. It is the only planet that has not yet been visited by spacecraft. Little is known about Pluto and its moon, Charon. There has even been some debate among astronomers over whether Pluto should be called a planet.

Are There Other Solar Systems?

Our Sun is only one of billions of stars in our own Milky Way galaxy. The Milky Way is only one of billions of star systems in the universe. Are there other Earth-like planets? Might some form of life exist elsewhere in the universe? Scientists are trying to find out.

So far, astronomers have discovered more than 100 giant planets orbiting other stars. These giant planets are more like Jupiter than like Earth. Does that mean there are no Earth-size planets elsewhere? No. It simply means small, Earth-size planets are much harder to detect.

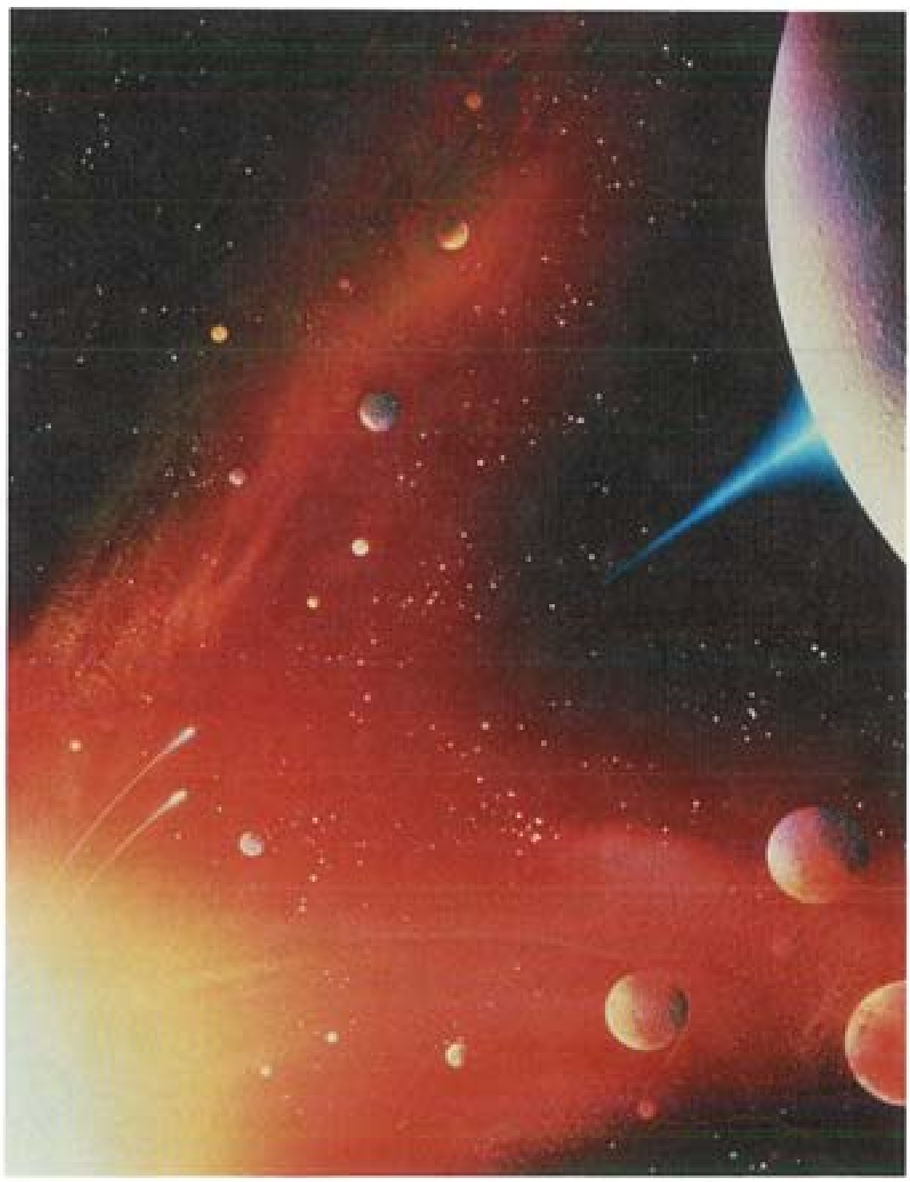
In the next few years, scientists at NASA hope to launch a number of missions to look for planets around other stars. Two missions, in particular, will search for Earth-like planets. The first of those missions is *Kepler*, now scheduled to be launched in 2007. *Kepler* will study 100,000 sun-like stars. It will look for planets orbiting their stars at distances where liquid water could exist.

In 2013, NASA plans to launch the *Terrestrial Planet Finder*—a space telescope that will be able to find small, rocky planets orbiting other stars. The *Terrestrial Planet Finder* would also examine any atmospheres around those planets.

A possible future mission, *Life Finder*, would search such planets for seasonal changes in their atmospheres. It would also search for other changes that might indicate the presence of life.

Why is it harder to search for Earth-like planets than Jupiter-like planets orbiting other stars?

Are there other Earth-like planets elsewhere in the galaxy? Astronomers are trying to find out.



Lesson Review

L·I·N·K·S

Why It Matters

What was the early solar system like? Scientists hope to learn more when *Stardust* returns to Earth with its samples from Comet Wild 2. How likely are there to be Earth-like planets elsewhere in the universe? Scientists may find answers as they study distant solar systems. Might life forms exist on other worlds? Future space missions to Mars and to three of Jupiter's largest moons—which may have oceans below their icy crusts—may give us clues. They may also help us to remember how special our own planet Earth really is.

e-Journal Visit our Web site **www.science.mmhschool.com** to do a research project on space missions.

Think and Write

1. How do the inner planets compare with the outer planets?
2. Name one way Saturn differs from the other gas giants.
3. Name one thing that makes Uranus unusual.
4. **INQUIRY SKILL Make a Model** Model how our solar system might look from another star. (Hint: The Sun's radius is about 100 times Earth's.)
5. **Critical Thinking** Why is it so difficult to design a real-scale model of the solar system?

MATH LINK

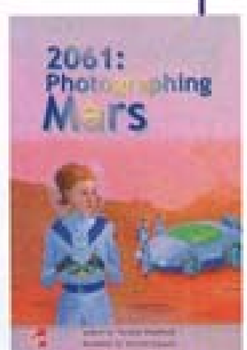
Build a model solar system. The distance from Earth to the Sun (1 A.U.) is about 23,500 times the length of Earth's radius. If you let Earth's radius be one centimeter, about how far away would you have to place your model Pluto from your model Sun?

WRITING LINK

Writing That Compares What do all comets have in common? How do they differ? Compare Comet Hale-Bopp and Halley's Comet. Research both comets. List their similarities and differences in a Venn diagram. Use your Venn diagram to write an essay that compares and contrasts comets.

LITERATURE LINK

Read ***2061: Photographing Mars*** to learn about a teacher's trip to Mars. Try the activities at the end of the book.



TECHNOLOGY LINK

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Amazing Stories

PLANETARY WEATHER

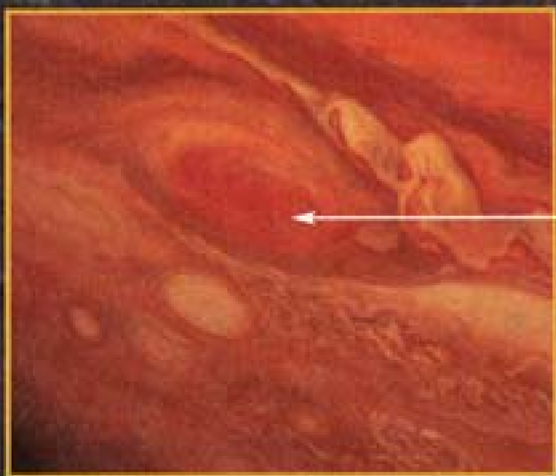
What's the weather like on other planets? Knowing about the atmosphere on other planets tells us more about our entire solar system.

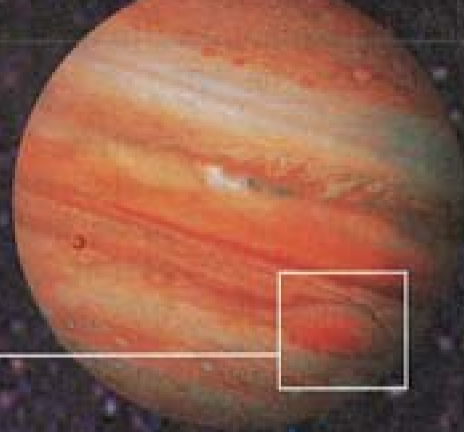
Over the years scientists have learned that Venus's atmosphere is 97 percent carbon dioxide. A greenhouse effect occurs when the layer of carbon dioxide traps the Sun's heat, making Venus's average temperature 460°C (860°F).

Like Earth, Jupiter has storms. The Sun heats our atmosphere which creates conditions that cause storms. But Jupiter receives less of the Sun's heat than Earth. Scientists believe that storms on Jupiter might originate with heat rising from the planet's own hot interior. When it rains on Jupiter it rains liquid helium!

Venus has yellow clouds of sulfuric acid. Precipitation from these clouds is like acid rain on Earth, only worse.

One of Jupiter's storms, the Great Red Spot, is about two times the size of Earth. It began before telescopes were invented.





Saturn has three cloud layers—water clouds, ammonia clouds, and ammonium hydrosulfide clouds. Together they form smog!

There is lightning on Venus, Jupiter, and Saturn. Uranus and Neptune are believed to have lightning as well. The lightning is from electrical discharges. Flashes on Jupiter may be 500 kilometers (310 miles) across.

Pluto has the greatest atmospheric changes of all the planets. That's because its orbit is irregular. When Pluto is at its closest position to the Sun, the heat turns the frozen nitrogen on Pluto into a gas. This gives Pluto an atmosphere and weather to go with it. As Pluto moves farther from the Sun, the gas freezes.

Write ABOUT IT

1. **Why should the atmosphere on Venus be a warning to us on Earth?**
2. **What forms of weather do we share with other planets?**

LOG ON Visit **www.science.mmhschool.com** to learn more about weather on other planets.

Chapter 9 Review

Vocabulary

Fill each blank with the best word or words from the list

comet, D19	**meteor,** D19
constellation, D12	**meteorite,** D19
galaxy, D20	**outer planet,** D16
gravity, D8	**planet,** D6
inner planet, D16	**solar system,** D6

1. The Sun and planets are part of the ______.

2. Earth is a(n) ______that orbits the Sun.

3. The force of ______ keeps planets from flying off into space away from the Sun.

4. A planet between the Sun and the asteroid belt is called a(n)______

5. A planet beyond the asteroid belt is known as a(n) ______.

6. Our Milky Way is a star system known as a(n)______.

7. Stars that seem to form a pattern in the night sky are called a(n) ______.

8. A piece of space rock that burns up in the atmosphere is called a(n)______.

9. A piece of space rock that survives its fall through the atmosphere and lands on the surface is called a(n)______.

10. An object that comes from the Oort cloud is a(n)______.

Test Prep

11. The Moon is unlivable compared with Earth because______.

- **A** there is too much water
- **B** there is too much snow
- **C** there is too much smog
- **D** there is no air to breathe

12. The planet Saturn could ______.

- **F** fit inside Jupiter's Great Red Spot
- **G** fit in the Atlantic Ocean
- **H** float if there were an ocean big enough to hold it
- **J** fit inside the Grand Canyon

13. A year on Mercury is______.

- **A** shorter than a year on Venus
- **B** longer than a year on Jupiter
- **C** the same as a year on Earth
- **D** the same as a year on Mars

14. A day on Venus is ______.

- **F** shorter than a day on Earth
- **G** shorter than a day on Mars
- **H** shorter than a day on Jupiter
- **J** longer than its year

15. Which planets have rings?

A Mars, Jupiter, and Saturn

B Saturn, Pluto, Neptune, and Venus

C Jupiter, Saturn, Neptune, and Venus

D Jupiter, Saturn, Uranus, and Neptune

Concepts and Skills

16. INQUIRY SKILL **Make a Model** Explain how you would model the distances between planets if you were using a football field and put your model Earth on the 2-yard line.

17. **Critical Thinking** Why is it difficult to find Earth-like planets elsewhere in the galaxy?

18. **Reading in Science** Explain the sequence of events that would happen if the force that keeps the planets orbiting the Sun did not exist.

19. **Scientific Methods** Design an experiment to show why Mercury gets much hotter than Pluto.

20. **Decision Making** What would you need to bring along on a space mission to another planet? Explain your choices.

Did You Ever Wonder?

INQUIRY SKILL **Infer** You want to send a spacecraft to visit each of the giant planets. What do you need to consider in planning your mission?

LOG ON Visit www.science.mmhschool.com to boost your test scores.

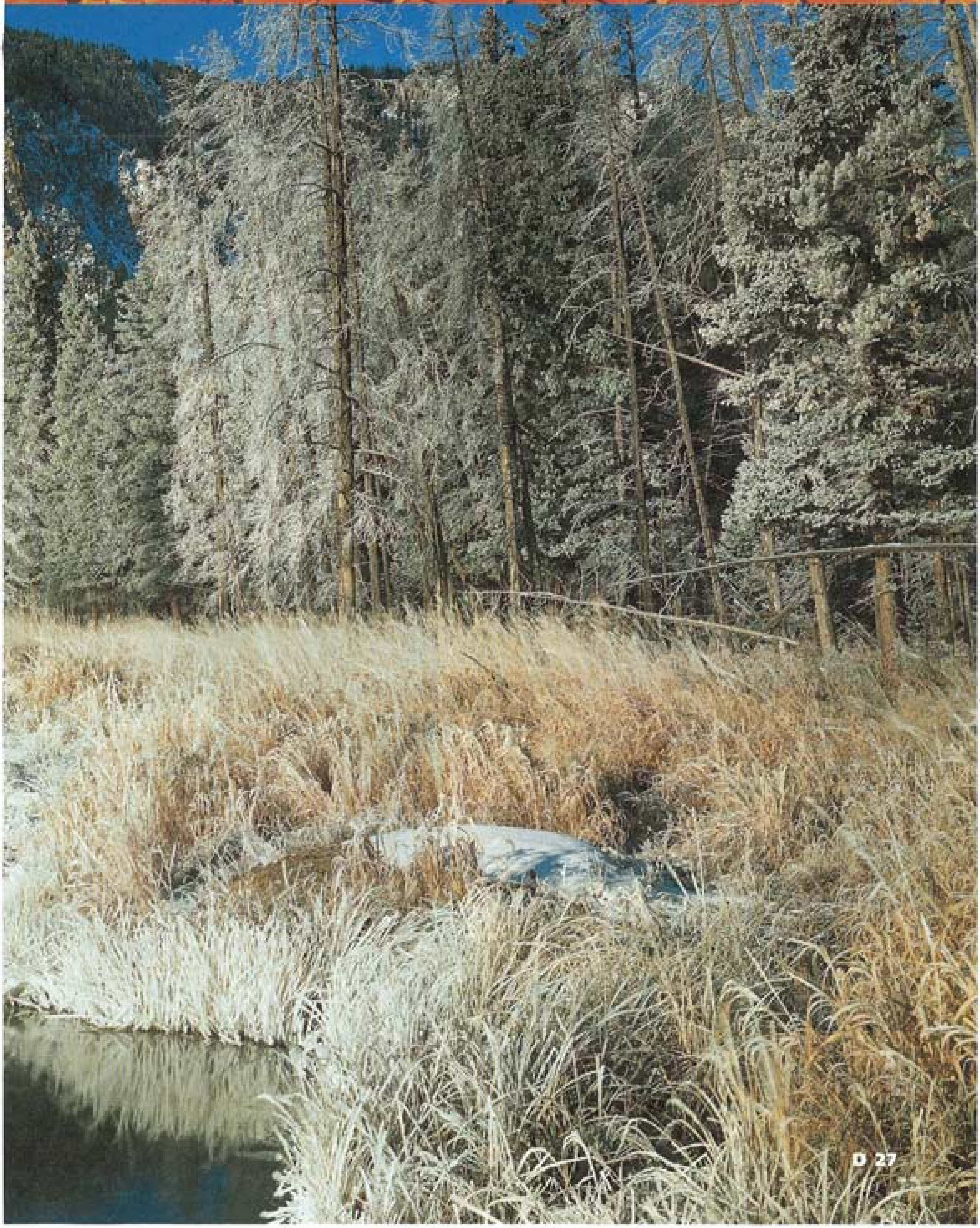
CHAPTER

10 Weather

Did You Ever Wonder?

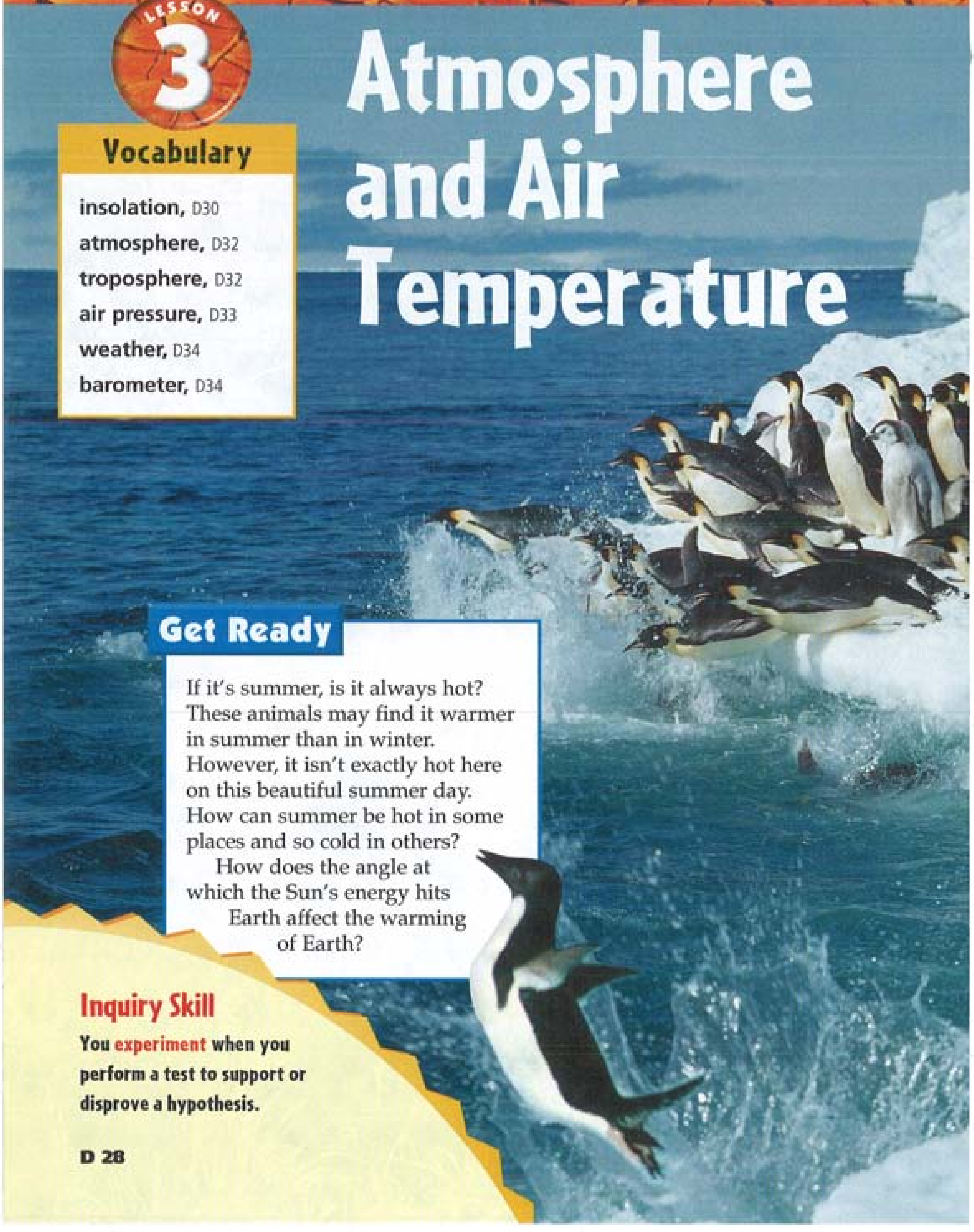
What causes frost to form? Frost forms when it is cold enough for water vapor in the air to change from gas to ice crystals on grass and other objects. In warmer weather dew would form instead of frost.

INQUIRY SKILL **Experiment** **Make frost in your classroom! Layer salt and ice in a metal container. Observe the outside of the container.**



LESSON 3

Atmosphere and Air Temperature



Vocabulary

insolation, D30
atmosphere, D32
troposphere, D32
air pressure, D33
weather, D34
barometer, D34

Get Ready

If it's summer, is it always hot? These animals may find it warmer in summer than in winter. However, it isn't exactly hot here on this beautiful summer day. How can summer be hot in some places and so cold in others?

How does the angle at which the Sun's energy hits Earth affect the warming of Earth?

Inquiry Skill

You experiment when you perform a test to support or disprove a hypothesis.

Explore Activity

Does the Sun's Angle Matter?

Materials

- 3 thermometers
- triangular blocks
- black paper
- white paper
- centimeter ruler
- scissors
- tape
- 150-W clear-bulb lamp
- stopwatch
- foam bowl
- clay

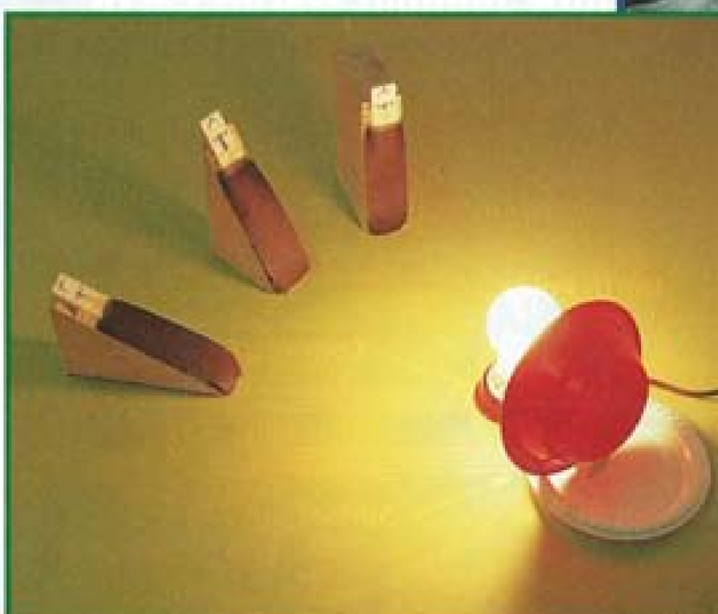
Procedure

BE CAREFUL! Do not look into the lamplight.

1. Place a thermometer onto each of the three blocks, as shown. Cover each with black paper. Put the blocks 20 cm from the light bulb, level with its filament (curly wire).
2. **Observe** Measure the starting temperature at each block. Record the temperatures.
3. **Predict** What will happen when the lamp is turned on? Turn the lamp on. Record the temperature at each block every two minutes for ten minutes.
4. **Communicate** Make a line graph showing the change in temperature at each block over time.
5. **Use Variables** Repeat the activity with white paper.

Drawing Conclusions

1. **Communicate** Which block's surface was warmed most by the lamplight? Which block's surface was warmed the least?
2. **Infer** How does the angle at which light hits a surface affect how much the surface is heated? How does the surface color affect how much it is heated?
3. FURTHER INQUIRY **Experiment** What other factors might affect how much a surface is warmed by sunlight? How would you test your ideas?



Read to Learn

Main Idea **The Sun warms Earth's surface, which transmits heat to the air above it.**

Does the Sun's Angle Matter?

Where do you think you might find warm temperatures all year long? Where would you find very cold weather? That depends a lot on the angle at which sunlight hits a region. Angles make a difference in how much the Sun warms an area. The areas around the equator are hottest. That's because the Sun's path is high overhead at midday. In those areas the Sun's rays hit Earth at their strongest.

The areas around the North and South Poles are coldest. In those areas the Sun is much lower at midday. The Sun's rays hit Earth's surface at a low angle. The strength of the rays is much weaker at this angle.

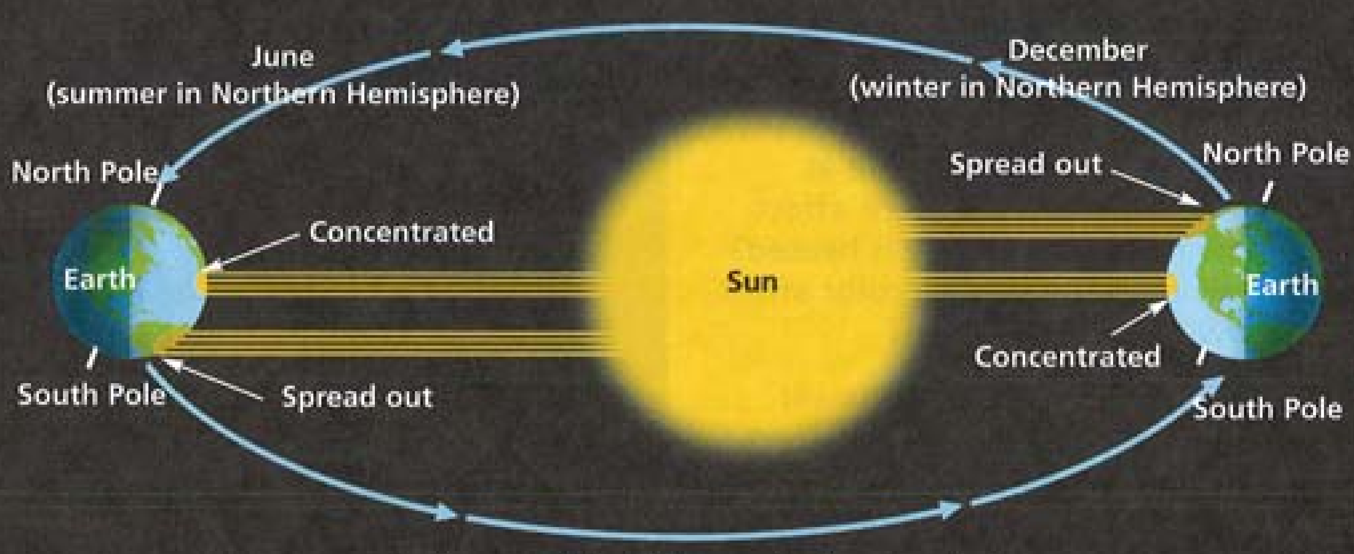
The angle at which sunlight strikes Earth's surface is called the angle of **insolation**. *Insolation* is short for *in*coming *sol*ar radi*ation*. It means the amount of the Sun's energy that reaches Earth at a given place and time.

The diagram shows how sunlight warms Earth in summer and winter. The amount of warming depends on the angle of insolation. The greater the angle, the warmer it gets. The angle of insolation is always smaller near the poles than near the equator. That means while it's freezing cold in one part of the world, it's hot in another.

How do differing angles of insolation cause differences in warming?

How Sunlight Warms Earth

The Sun's rays strike the surface at different angles as Earth travels around the Sun.



Angles count! Earth is actually closer to the Sun when it's winter in the Northern Hemisphere.

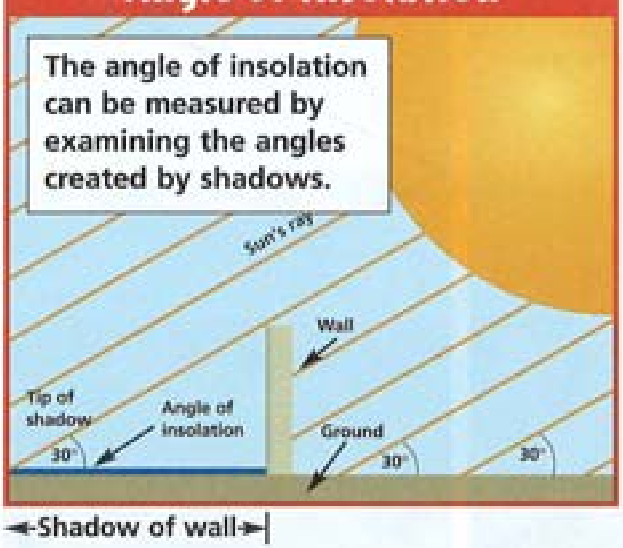
What Affects Insolation?

In the morning the Sun is close to the horizon. What happens as time goes by? At midday the Sun is high up in the sky, as high as it gets during the day. After midday the Sun is lower and lower in the sky.

How does this affect the angle of insolation? How do we measure it? Look at the shadows cast by objects they strike! The lower the angle of the light rays, the longer the shadows. As you can see in the diagram, the angle of insolation is the same as the angle between the ground and the line from the tip of the shadow to the top of the wall.

How does the time of day affect the angle of insolation?

Angle of Insolation



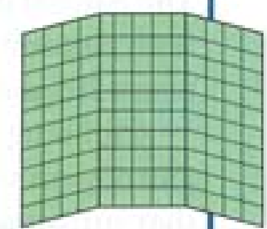
READING Diagrams

What will happen to the angle as the Sun gets higher in the sky? How will this affect the temperature?

QUICK LAB

Investigating Angles

FOLDABLES Make a Trifold Book. (See p. R 42.)



1. Fold a sheet of graph paper lengthwise in three equal parts. Put a small lump of clay in the middle of each part. Stand a toothpick straight up in each lump of clay.
2. Hold a flashlight directly over the first toothpick. Have a partner trace a line around the circle of light and trace the toothpick's shadow.
3. **Use Variables** Repeat step 2 for the other two toothpicks, changing only the angle of the flashlight.
4. **Measure** Count the number of boxes in each circle. Measure the lengths of the toothpick shadows. Record your results.
5. **Infer** Use the Trifold Book to record how the length of the shadow is related to the angle.
6. **Infer** Record how the number of boxes in the circle is related to the angle.

Why Do You Cool Down As You Go Up?

Did you ever climb a high mountain? As you go higher and higher above sea level, air temperatures drop. The natural drop in air temperature with altitude is about 2°C (3.6°F) for every 305 meters (1,000 ft).

Climbing up a mountain is really a journey up into the **atmosphere**, the air that surrounds Earth. The atmosphere reaches from Earth's surface to the edge of space. What if you could travel to the top part of the atmosphere? The diagram of the atmosphere shows what you would find.

You would find that the temperature does not fall steadily with altitude. It changes abruptly several times. These changes mark the boundaries of four main layers. These layers surround Earth like huge shells.

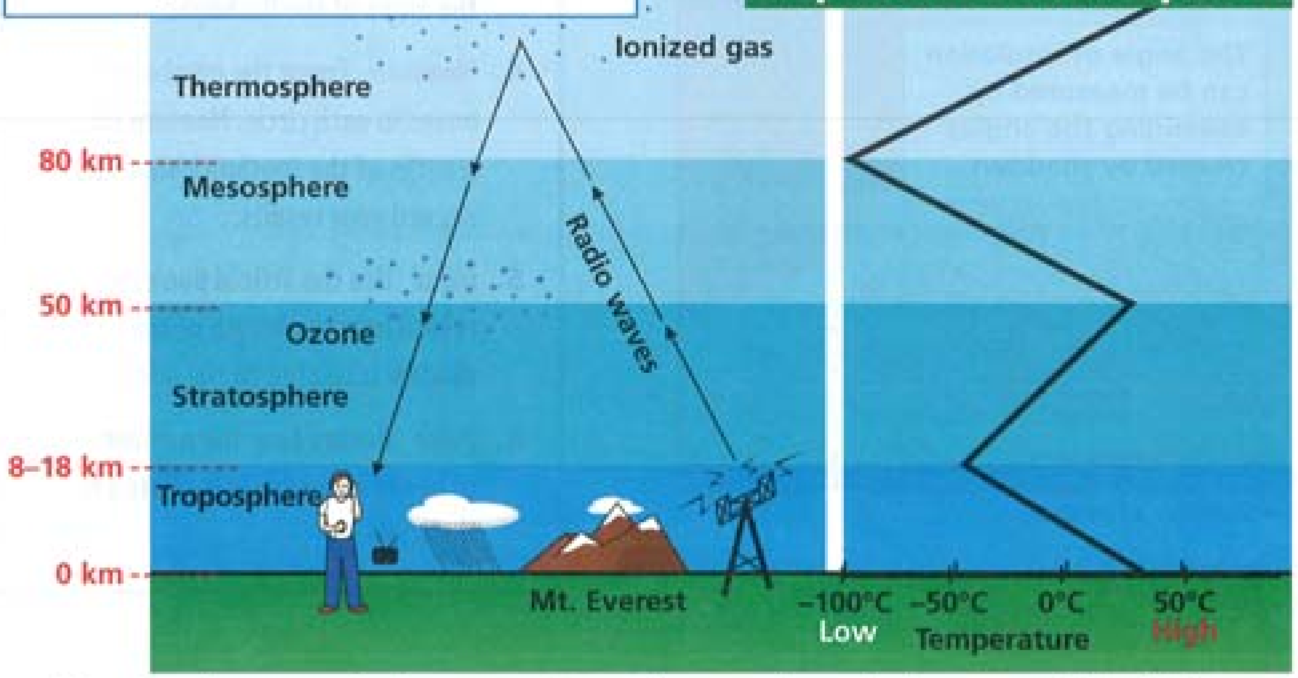
The layer closest to Earth's surface is the **troposphere** (TROP·uh·sfeer). It's the narrowest layer—between 8 and 18 kilometers (5–11 miles) thick—but it contains most of the air in the atmosphere. All life on Earth exists here. In this layer all moisture is found and all clouds, rain, snow, and thunderstorms form. Above this layer the air gradually thins out to the near-emptiness of space, with no exact upper boundary.

READING Diagrams

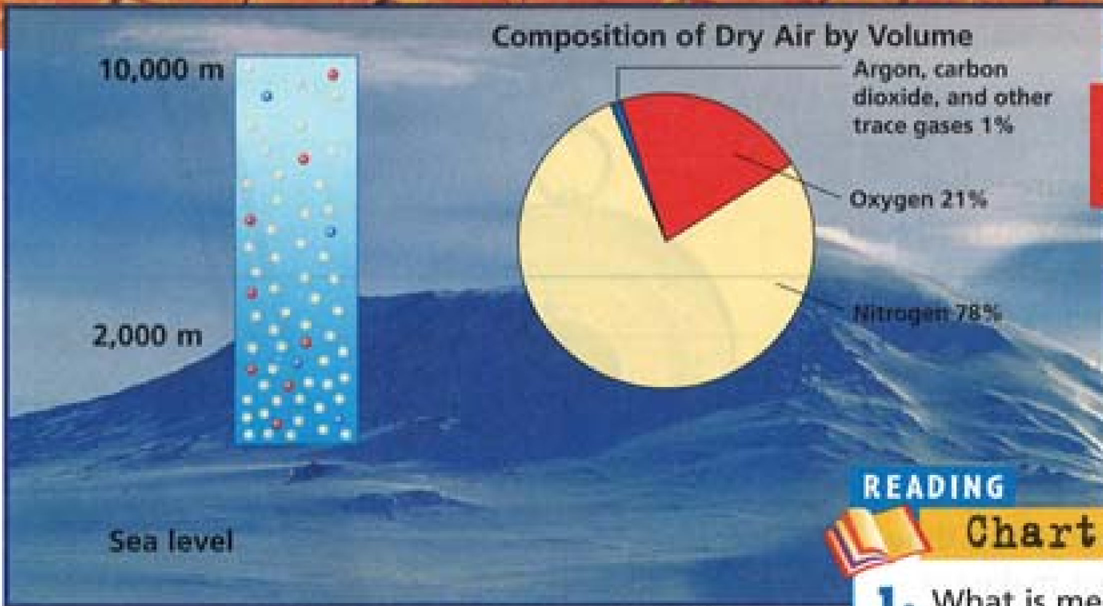
Describe how the temperature changes in each layer of the atmosphere.

What is the relationship between altitude and temperature?

Layers of the Atmosphere



Most weather occurs in the troposphere. The ozone layer in the stratosphere helps shield us from the Sun's ultraviolet light. *Auroras* (the northern and southern lights) may form in the *ionized* (electrically charged) gas in the thermosphere.



Air in the Atmosphere

Lower altitudes have a larger air column above them, which creates greater air pressure.

READING Charts

1. What is meant by *trace*?
2. Which gas is the most abundant in the atmosphere?

What Happens to the Air Pressure?

As you go higher in altitude, **air pressure** decreases steadily. Air pressure is the force put on a given area by the weight of the air above it. Air is a mixture of gases. It is made up mostly of *molecules* of nitrogen and oxygen. Molecules are the smallest pieces that a substance can be broken into without changing what the substance is.

The molecules have mass. They are attracted to Earth by gravity, so they have weight.

Normal air pressure is greatest at sea level. There the column of air extending above the surface to the top of the atmosphere is tallest. Sea level air pressure is about 1.04 kilograms per square centimeter (14.7 pounds per square inch). As you go higher in altitude, the height of the air column above you becomes shorter. Therefore the weight of that column—or air pressure—becomes less.

In the lower atmosphere, the composition of air varies very little. Up to an altitude of about 100 km (62 mi), air consists of a mixture of gases, water vapor, and dust particles. Nitrogen and oxygen make up 99 percent of the gases in dry air.

Water vapor is a gas. It should not be confused with clouds or fog, which are made of liquid or solid water. The amount of water vapor in air varies from $\frac{1}{10,000}$ of air in dry arctic regions to $\frac{1}{25}$ of air in moist equatorial regions.

The dust in air is made of particles so tiny that 100,000 lined up would only form a row 1 cm (0.4 in.) long. Some of it comes from Earth's surface, from fires and volcanic eruptions, or from tiny crystals of salt.

How does air pressure change with altitude?

What Is Weather?

When you say, "It sure is hot today!" the *it* is the air. You really mean that the air around you is hot. The same is true if you say, "It is windy," or "It is cloudy," or give any other similar description of the **weather**. The weather is simply what the lower atmosphere, or troposphere, is like at any given place and time.

The conditions that make up weather are the characteristics that change. They are air temperature, air pressure, amount of moisture in the air, wind, clouds, and rain or snow.

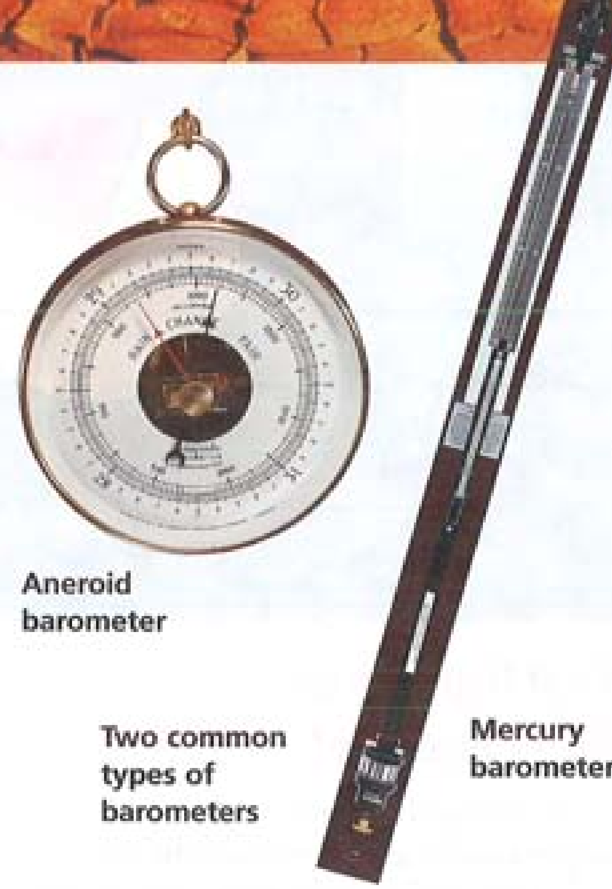
Measuring Temperature

You can measure temperature with a thermometer. Thermometers can use two different temperature scales. The Celsius scale is marked with the letter C. The Fahrenheit scale is shown by the letter *F*.

Measuring Air Pressure

Air pressure is measured with a **barometer** (buh·ROM·i·tuhr). Two common types of barometers are the mercury barometer and the aneroid barometer.

Mercury barometers use a mercury-filled glass tube with one closed end. The open end is submerged in liquid mercury. Air pressure on the mercury pushes it up into the tube. When the weight of the mercury column equals the air pressure, the mercury stops rising.



Two common types of barometers

An *aneroid* (AN·uh·royd) barometer is an accordion-like metal can with most of the air removed. Inside, a spring balances the outside air pressure. When outside air pressure increases, the can squeezes the spring. When air pressure decreases, the spring pushes outward. A needle inside indicates changes in pressure.

You can monitor and record weather conditions for your own weather station. Measure and record air temperature several times a day. Record daily air pressure by using a barometer or by getting air pressure readings from weather reports.

READING Main Idea
What conditions make up weather?

Lesson Review

L·I·N·K·S

Why It Matters

Have you ever heard a day called a "scorcher"? That means a really hot day. On really hot days, your body can lose a lot of moisture. Your body gives off sweat gradually most of the time. On a hot day, your body tends to give off more and more. That's why it's important to have plenty of drinking water handy on a hot day.

On really cold days, many people have other problems—such as frostbite. You have to cover your face, ears, and hands to avoid contact with air at extremely low temperatures.

e-Journal Visit our Web site **www.science.mmhschool.com** to do a research project on the atmosphere.

Think and Write

1. How do temperatures on Earth depend on angles?
2. List factors that affect temperatures of places on Earth.
3. What is air pressure? How does it change in the atmosphere?
4. What is the troposphere? What happens there?
5. **Critical Thinking** Is the weather one or more than just one thing? Defend your answer.

MATH LINK

Solve this problem. The sunniest place on Earth is in the eastern Sahara Desert, where sunlight shines an average of 4,300 hours per year. Calculate the percentage of possible sunlight hours a year this number represents. (Assume 12 hours of daylight per day.)

WRITING LINK

Writing a Poem Write a poem about how the weather affects your life. Use words, such as *splash,* that imitate the sound of the weather.

SOCIAL STUDIES LINK

Research the history of the thermometer. The maximum-and-minimum thermometer was invented in 1780 by English scientist James Six. A column of mercury moves up and down a U-shaped tube. An index moves with it, recording the highest and lowest temperatures. Research the history of the thermometer, and write a report for the class.

TECHNOLOGY LINK

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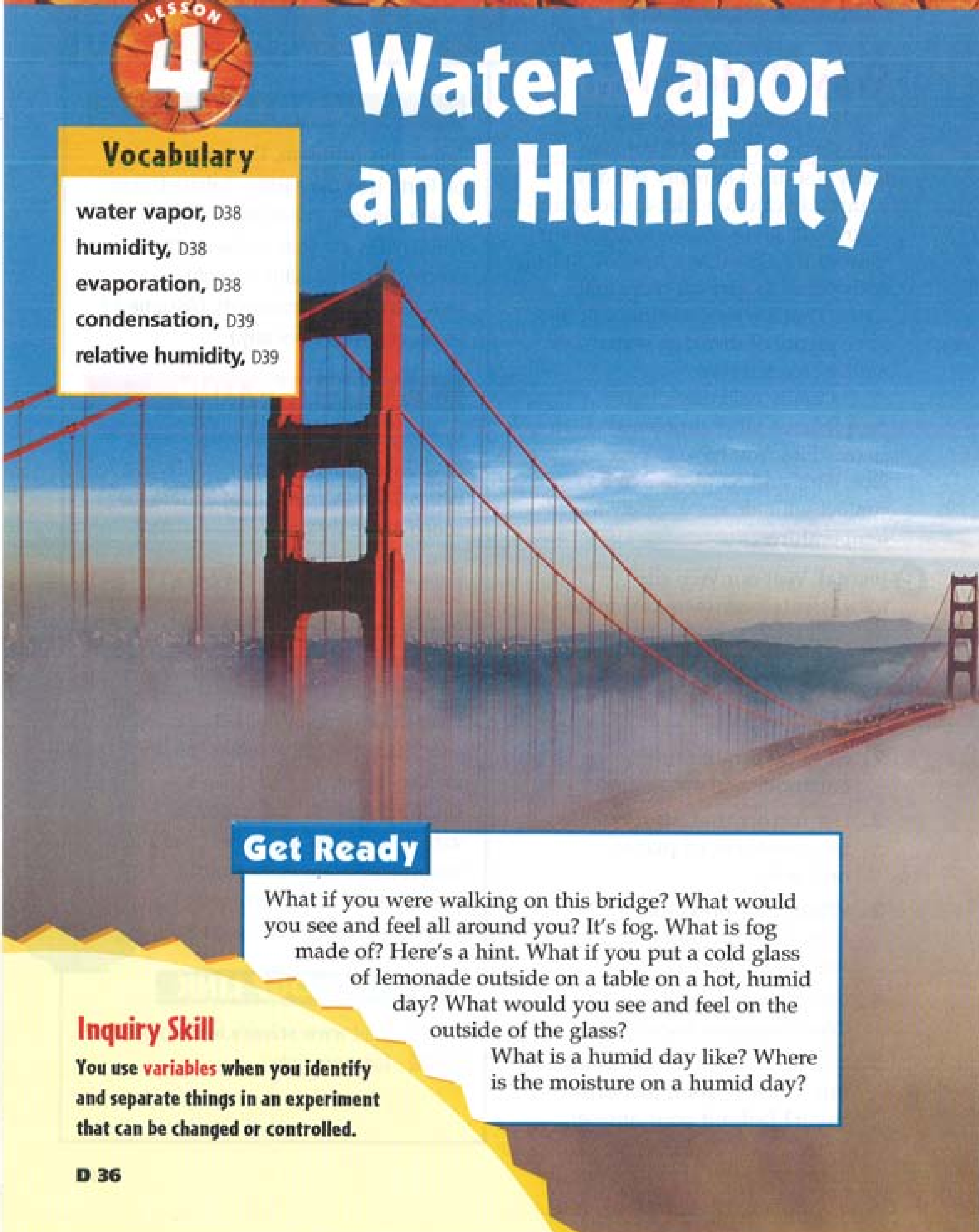
LESSON 4

Water Vapor and Humidity



Vocabulary

water vapor, D38
humidity, D38
evaporation, D38
condensation, D39
relative humidity, D39

Get Ready

What if you were walking on this bridge? What would you see and feel all around you? It's fog. What is fog made of? Here's a hint. What if you put a cold glass of lemonade outside on a table on a hot, humid day? What would you see and feel on the outside of the glass?

What is a humid day like? Where is the moisture on a humid day?

Inquiry Skill

You use variables when you identify and separate things in an experiment that can be changed or controlled.

Explore Activity

Where Does the Puddle Come From?

Materials
- plastic cups
- ice
- paper towels
- food coloring
- thermometer
- goggles

Procedure: Design Your Own

BE CAREFUL! Wear goggles.

1. **Form a Hypothesis** Write down your idea about why a puddle forms around a frosty drink. Where do you think the puddle came from?
2. **Experiment** Describe what you would do to test your idea. How would your test support or reject your idea?
3. **Communicate** Draw a diagram showing how you would use the materials. Keep a record of your observations.

Drawing Conclusions

1. **Communicate** Describe the results of your investigation.
2. **Communicate** What evidence did you gather? Explain what happened.
3. **Infer** How does this evidence support or reject your explanation?
4. **FURTHER INQUIRY** **Use Variables** Do you get the same results on a cool day as on a warm day? Do you get the same results on a humid day as on a dry day? Investigate to test your hypothesis.

Read to Learn

Main Idea **Water on Earth's surface and in the atmosphere changes form and affects the weather.**

Where Does Water Vapor Come From?

Put a frosty glass of lemonade on a table on a hot day. What happens? A puddle forms on the table. Where does the puddle come from? The water level in the glass does not drop as the puddle forms. The water in the puddle isn't lemonade.

The water in the puddle comes from the air around the glass. When the warm air touches the cold glass, the air cools. Droplets of water form, run down the side of the glass, and make a puddle on the table.

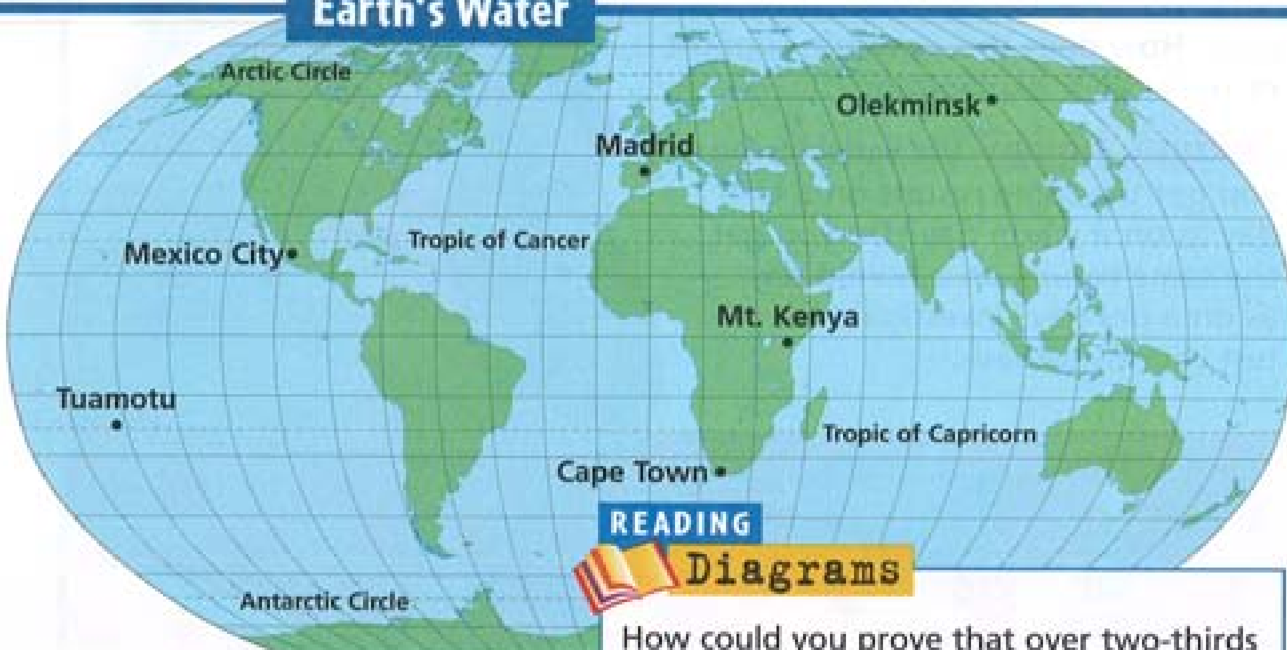
The water in the air is **water vapor**. Water vapor is water in the form of a gas. Water vapor is invisible, colorless, odorless, and tasteless. The amount of water vapor in the air is called **humidity**. Do not confuse humidity with droplets of liquid water you see in rain, fog, or clouds.

How does water vapor get into the air in the first place? More than two-thirds of planet Earth is covered with liquid water—oceans, rivers, and lakes. There is also water in the ground and in plants. To get into the air, this liquid water must be changed into water vapor.

The changing of a liquid into a gas is called **evaporation**. This takes lots of energy. The main energy source for Earth is the Sun. Each day the Sun turns trillions of tons of ocean water into water vapor.

Water molecules absorb the Sun's energy and speed up. "Speedy" water molecules near the surface of the liquid "escape" or evaporate into the atmos-

Earth's Water



READING Diagrams

How could you prove that over two-thirds of the planet is covered with water?

phere as water vapor. Some hit other molecules and return to the liquid. When air is cooled, molecules in the air slow down. The molecules of water vapor in the air also slow down. If they slow enough, water vapor molecules change to molecules of liquid water that collide and stick together to form droplets on cool surfaces. **Condensation** is the changing of a gas into a liquid. You see condensation on shower doors, on cold drink glasses, and as dew on grass in the early morning.

Plants' roots absorb water that has seeped into the ground. Plants transport the liquid water through their roots and stems to their leaves. The leaves then give off water in the process called transpiration. This is the second-largest source of water vapor in the atmosphere.

Two factors determine the amount of humidity in the air. First, there has to be water available to evaporate. Second, the warmer the temperature, the faster the water evaporates. This means that if water is available, warm air will take on more water vapor than cold air.

Relative humidity is a comparison between how much water vapor is in the air and how much the air could hold—at a given temperature.

Relative humidity can affect how a person feels. The higher the relative humidity, the less water can evaporate into the air. The less water, such as sweat, can evaporate from our skin, the warmer and "stickier" we feel.

READING Main Idea

How does water get into the air?

QUICK LAB

Transpiration

FOLDABLES Make a Two-Column Table. (See p. R 41.) Label as shown.

#3 Communicate	
#5 Predict	

1. Place a clear-plastic bag completely over a houseplant. Tie the bag tightly around the base of the stem. Do not put the soil-filled pot in the bag.
2. **Observe** Place the plant in a sunny location. Observe it several times a day. When you are done, remove the plastic bag from the plant.
3. **Communicate** Use the table to describe what you see inside the bag. Explain what happened.
4. **Draw Conclusions** *Transpiration* sounds like *perspiration*—sweating. How might the two processes be alike?
5. **Predict** How would your results vary if you put the plant in the shade?

What Happens When Warm, Moist Air Cools?

How can warm, moist air cool off? In the lower atmosphere, the air gets colder with increasing altitude.

- Air can cool by being pushed upward over mountains by winds.
- Heating the air also causes it to rise. When the Sun heats the ground, air above the ground warms and rises. As it rises, it expands and cools.
- Air can also be pushed upward when cooler air and warmer air meet. When the two meet, they don't mix. The lighter, warm air is pushed up over the heavier, cold air. As a result, the warm air, pushed higher into the atmosphere, cools.

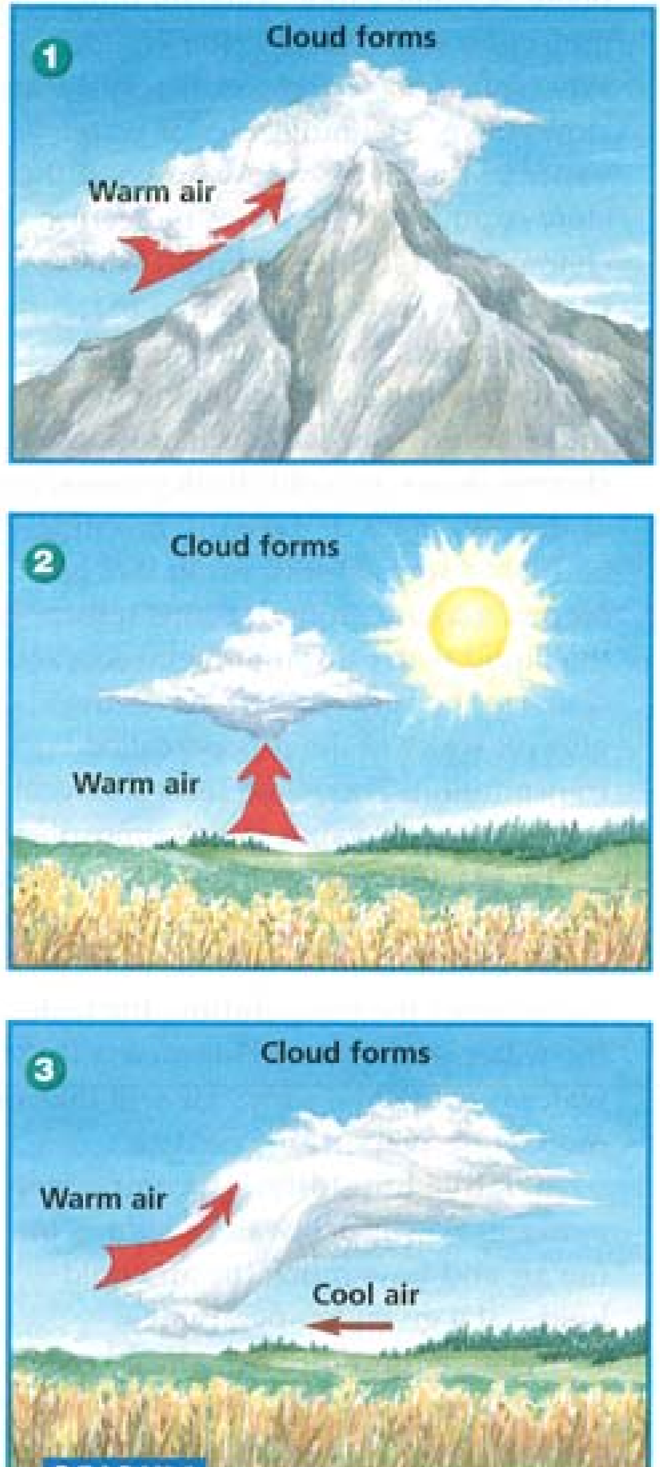
In each case the end result is the same. As the air rises and cools, the water vapor in it condenses into tiny water droplets, forming clouds.

If the temperature is below the freezing point of water, its water vapor will form a cloud of tiny ice crystals.

In order for water vapor to condense, it must have a surface on which the liquid droplet or ice crystal will form. This surface is provided by tiny dust particles in the air. You will learn more about clouds in the next lesson.

How can warm air rise and cool?

How Clouds Form



READING Diagrams

1. What can cause air to rise?
2. What happens to the air temperature as air rises?

Lesson Review

Why It Matters

Have you ever had sweat trickle down your face on a hot day? People sweat every day. Sweating is a way our bodies release wastes. We don't always feel the sweat because we sweat gradually, and it evaporates.

As sweat evaporates, the water droplets absorb heat from the skin's surface, cooling it. In this way your body controls surface temperature.

On very hot days and when you are physically active, you may sweat a lot. The sweat builds up, does not evaporate fast, and collects. On a high-humidity day, you feel even "stickier." On a low-humidity day, the sweat evaporates more quickly.

e-Journal Visit our Web site **www.science.mmhschool.com** to do a research project on humidity.

Think and Write

1. Where does water vapor in the air come from? What process produces it?
2. How is relative humidity different from humidity?
3. What causes water vapor to change into droplets of liquid water?
4. How does water vapor get cooled in the atmosphere?
5. **Critical Thinking** Would you say that the Sun is a cause of clouds? Defend your answer.

L·I·N·K·S

WRITING LINK

Personal Narrative Why are you less comfortable in higher relative humidity? Write about a day in your life when higher relative humidity affected you.

MATH LINK

Find the heat index. Use an almanac to find a heat index prepared by the weather service. This chart tells how warm a person feels at a particular temperature and humidity level. Using the chart, find the heat index for each of the days in the table below. Then use newspaper weather reports for one week last summer. Find the heat index for each of those days.

	Mon	Tues	Wed	Thurs	Fri
High temp.	25°C	35°C	30°C	35°C	25°C
Relative humidity	90%	97%	89%	48%	45%

ART LINK

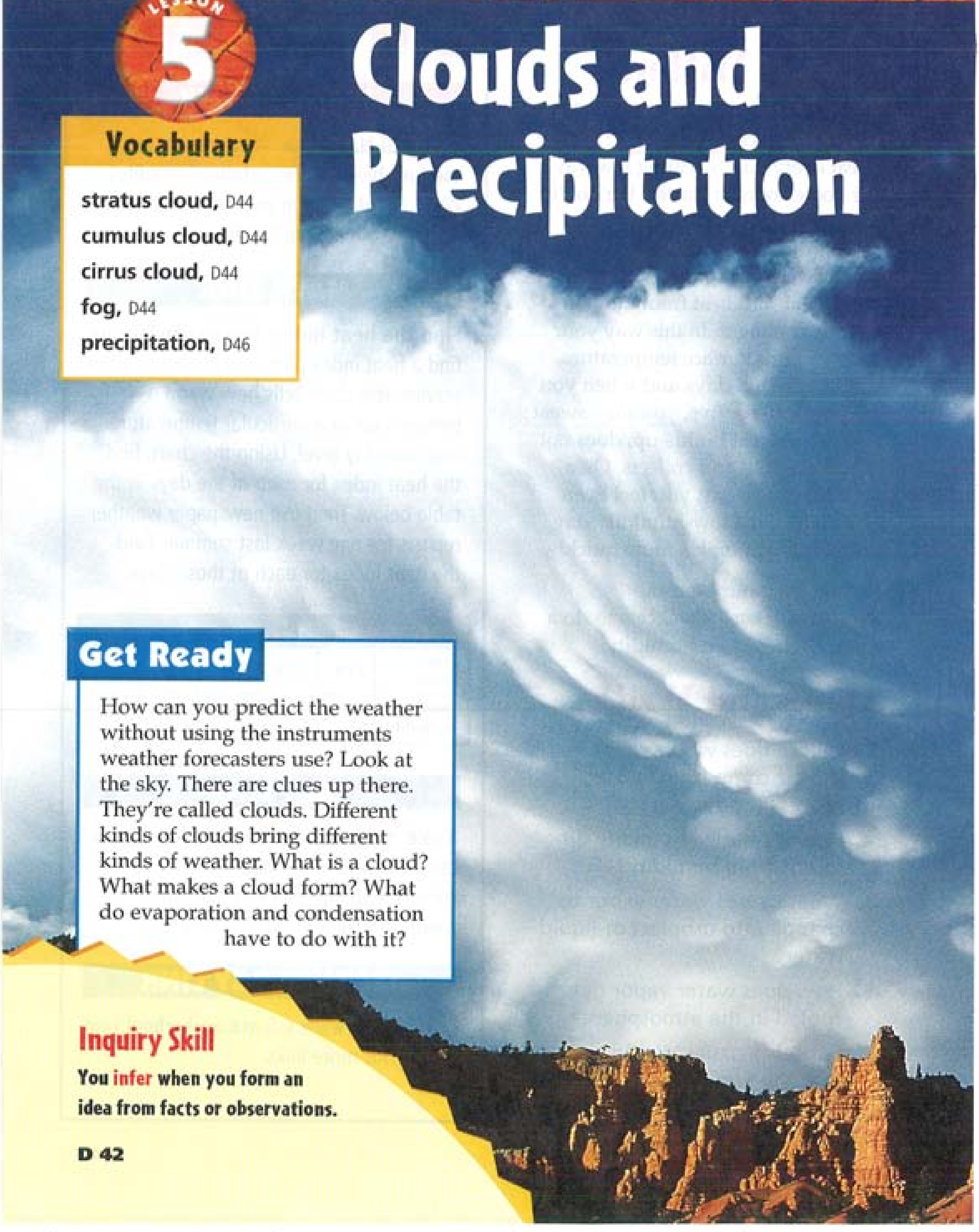
Make a poster. Very hot, humid weather can be dangerous. Make a poster warning about the dangers of very hot, humid weather. Include a list of safety tips.

TECHNOLOGY LINK

LOG ON Visit **www.science.mmhschool.com** for more links.

LESSON 5

Clouds and Precipitation



Vocabulary

stratus cloud, D44
cumulus cloud, D44
cirrus cloud, D44
fog, D44
precipitation, D46

Get Ready

How can you predict the weather without using the instruments weather forecasters use? Look at the sky. There are clues up there. They're called clouds. Different kinds of clouds bring different kinds of weather. What is a cloud? What makes a cloud form? What do evaporation and condensation have to do with it?

Inquiry Skill

You infer when you form an idea from facts or observations.

Explore Activity

How Do Clouds Form?

Materials

- hot tap water
- 2 identical clear containers
- mug
- 3 ice cubes

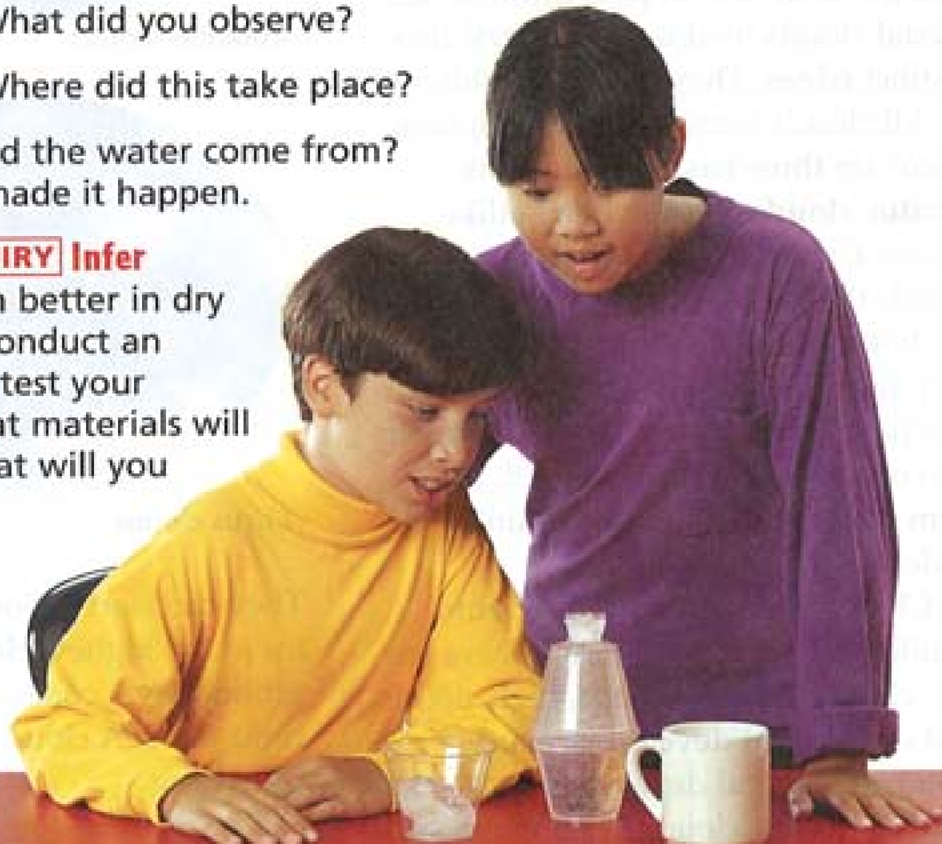
Procedure

BE CAREFUL! Be careful handling the hot water.

1. Chill container 1 by putting it in a refrigerator or on ice for about ten minutes.
2. Fill a mug with hot water.
3. **Make a Model** Fill container 2 with the hot water. Place empty cold container 1 upside down on top of container 2 with the water. Fit the mouths together carefully. Place the ice cubes on top of container 1.
4. **Observe** Record your observations.

Drawing Conclusions

1. **Communicate** What did you observe?
2. **Communicate** Where did this take place?
3. **Infer** Where did the water come from? Explain what made it happen.
4. **FURTHER INQUIRY** **Infer** Do clouds form better in dry or moist air? Conduct an experiment to test your inference. What materials will you need? What will you do?



Read to Learn

Main Idea **Water vapor and ice form clouds that produce precipitation.**

How Do Clouds Form?

What has to happen for a cloud to form? Clouds are made up of tiny water droplets or ice crystals. The air is filled with water vapor. When the air is cooled, the water vapor condenses. That is, the water molecules clump together around dust and other particles in the air. They form droplets of water.

Clouds look different depending on what they are made of. Water-droplet clouds tend to have sharp, well-defined edges. If the cloud is very thick, it may look gray, or even black. That's because sunlight is unable to pass through. Ice-crystal clouds tend to have fuzzy, less distinct edges. They also look whiter.

All clouds form in the troposphere. There are three basic cloud forms. **Stratus clouds** form in blanketlike layers. **Cumulus clouds** are puffy clouds that appear to rise up from a flat bottom. **Cirrus clouds** form at very high altitudes out of ice crystals and have a wispy, featherlike shape. If rain or snow falls from a cloud, the term *nimbo* or *nimbus*—for "rain"—is added to the cloud's name.

Clouds are further grouped into families by height and form. There are low clouds, middle clouds, high clouds, and clouds that develop upward—clouds of vertical development. Cumulonimbus clouds develop upward. These clouds bring thunderstorms.

Stratus clouds

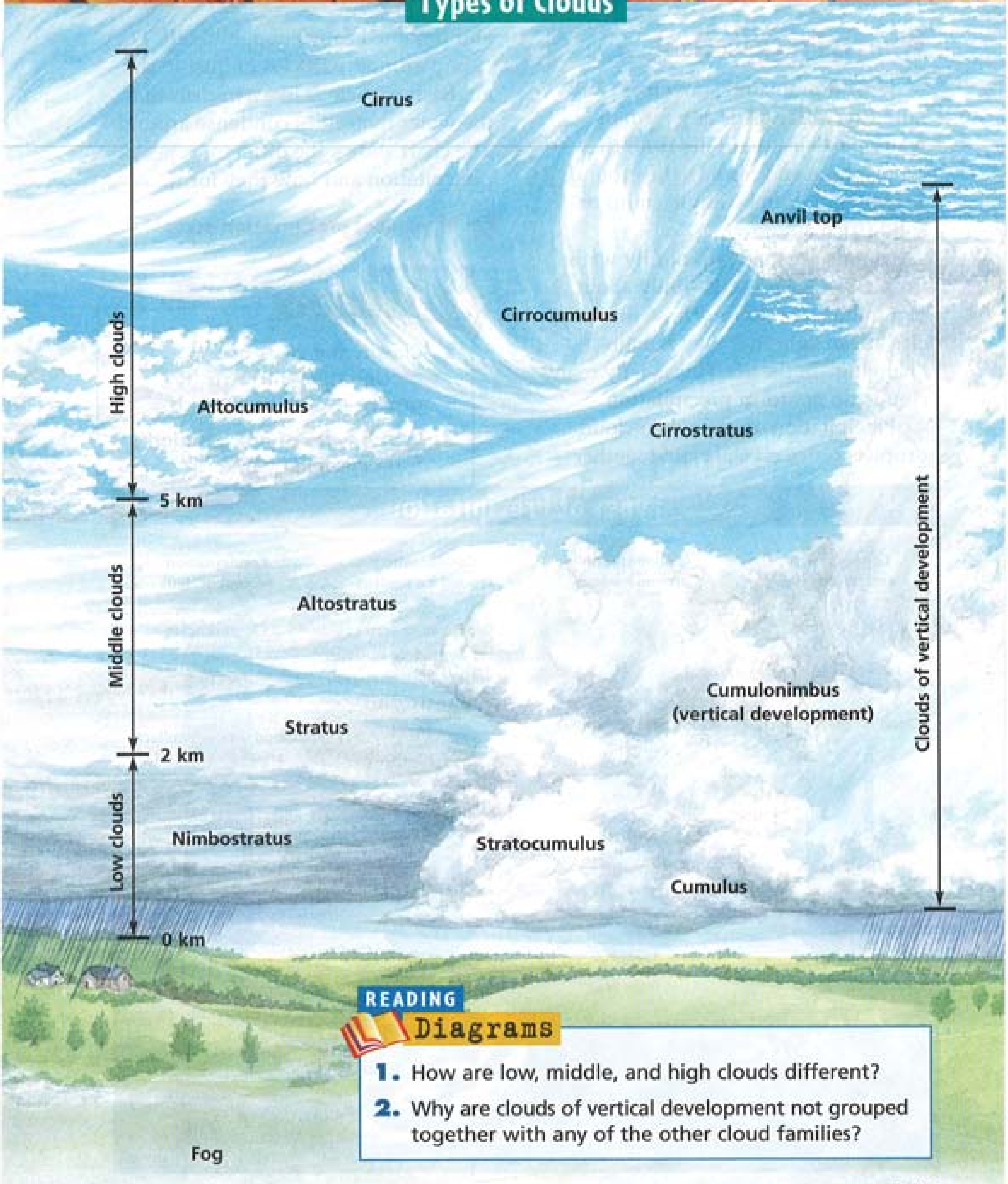
Cumulus clouds

Cirrus clouds

They can start as low clouds and reach up to the highest clouds. If moist air at ground level cools, a cloud can form right there. A cloud at ground level is called **fog**.

What are three basic cloud forms?

Types of Clouds



READING Diagrams

1. How are low, middle, and high clouds different?
2. Why are clouds of vertical development not grouped together with any of the other cloud families?

What Is Precipitation?

How do rain and snow form and fall? **Precipitation** is any form of water particles that falls from the atmosphere and reaches the ground. Precipitation can be liquid (rain) or solid (such as snow).

Clouds are made up of tiny water droplets or ice crystals—only about $\frac{1}{50}$ of a millimeter across. These tiny particles are so light that they remain "hanging" in the air. This is why many clouds do not form precipitation.

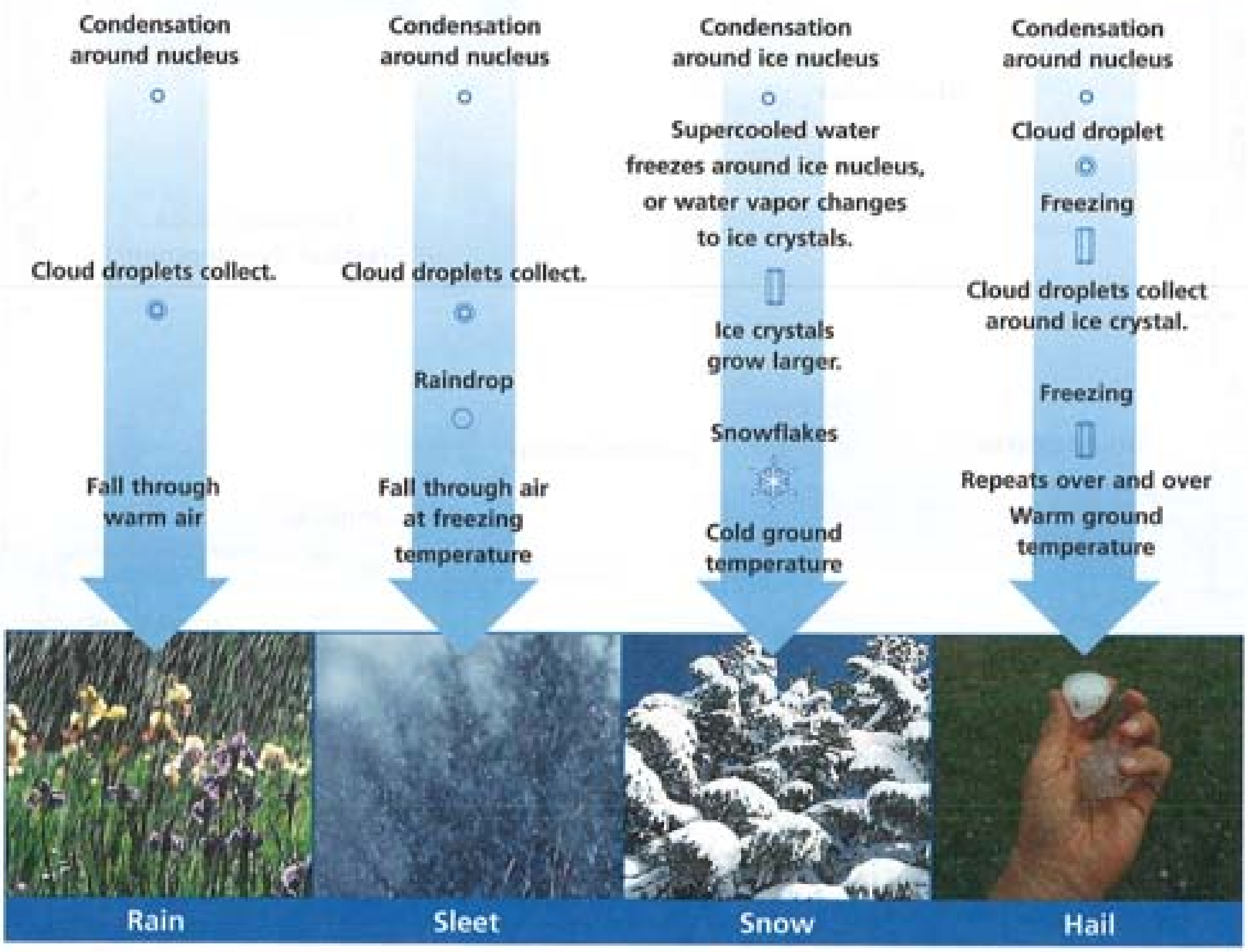
Precipitation occurs when cloud droplets or ice crystals join together and become heavy enough to fall. They clump around particles of dust in the air. Each particle is like a *nucleus* that the water molecules condense around. The chart shows the different types of precipitation and how they form.

When does precipitation occur?

READING Diagrams

1. Classify the types of precipitation into two groups—solids and liquids.
2. Which types of precipitation form in similar ways?

Types of Precipitation



Are Cloud Type and Precipitation Related?

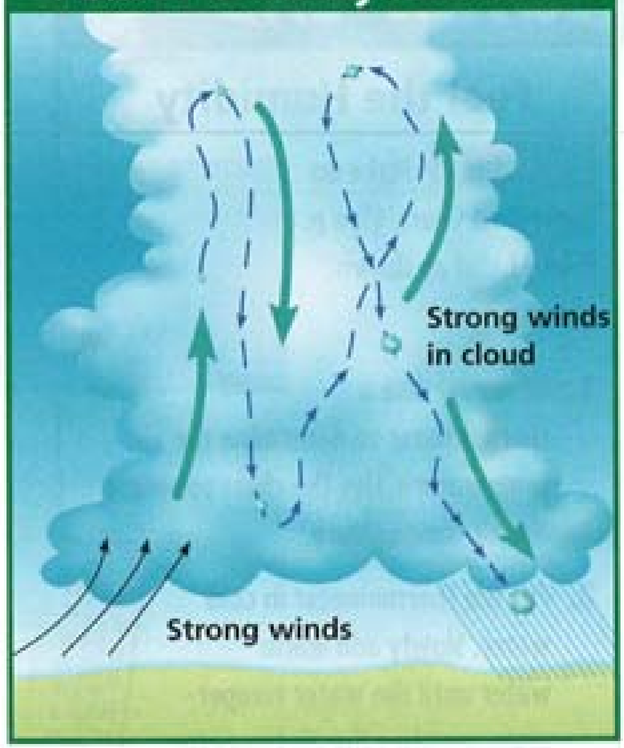
Do certain kinds of clouds give certain kinds of precipitation? Yes.

- In tall clouds there is more chance for droplets to run into one another and combine, making larger raindrops.
- Precipitation from large cumulus clouds is often heavy rain or snow showers that don't last too long.
- Precipitation from stratus clouds is usually long lasting, with smaller drops of rain or snowflakes.
- Clouds with great vertical development hold a lot of water. These clouds are very *turbulent*, or violent. Their tops often reach heights where it is below freezing. They often produce great downpours. They also sometimes produce *hail*. Hail is pellets or lumps of ice.

These clouds have updrafts—strong winds that move up inside. Hail forms when updrafts in these huge clouds hurl ice pellets upward again and again. As the pellets fall, they become coated with water. As they rise, the water freezes into an icy outer shell. This process usually happens over and over, adding more and more layers to the hailstones. The more violent the updrafts, the bigger the hailstones can get before they fall to the ground.

READING **Main Idea**
What kind of cloud can produce hail? Why?

Path of Growing Hailstone



Hailstones form in layers and can sometimes grow very large. Hailstorms can be very dangerous.

QUICK LAB

Feel the Humidity

FOLDABLES Make an Eight-Row Chart. (See p. R 44.) Label as shown.

	Time	Humid Day	Dry Day
1 min.	30 s		
	30 s		
2 min.	30 s		
	30 s		
3 min.	30 s		
	30 s		
	#5 Infer		

1. **Observe** Use a thermometer to determine the air temperature. Use the chart to record the air temperature.

2. Put the thermometer in cold water. Slowly add warm water until the water temperature matches the air temperature.
3. Wrap a 5-cm-square piece of old cotton cloth around the bulb of the thermometer. Gently hold it with a rubber band. Dampen the cloth in the water.
4. **Observe** Gently wave the thermometer in the air. Note the temperatures every 30 seconds for 3 minutes. Record them on your chart.
5. **Infer** What happened to the temperature of the wet cloth? How does the cloth feel? Explain on the bottom of your chart.
6. **Infer** If you try this experiment on a day that is humid and on a day that is dry will you get the same results?

How Do You Record How Cloudy It Is?

As you observe the weather each day, you might wish to record the types of clouds you see in the sky. You can use the charts in this lesson to indicate the cloud family and the types of clouds.

Try to estimate the cloud cover—that is, the amount of the sky covered by clouds. Use the terms *clear, scattered clouds, partly cloudy, mostly cloudy*, or *overcast* to describe cloud cover.

One way to record cloud cover is to make a weather station model. Start by drawing a circle for each day. An empty circle means "clear skies." A fully shaded circle means "completely overcast." Portions of a circle are shaded to show different amounts of cloud cover.

Precipitation is measured with a rain gauge. You can make a simple rain gauge from an empty coffee can. Place it outside, open end up, away from buildings or trees. When the precipitation stops, measure its depth in the can. Keep track of the type of precipitation and how much falls.

What are the terms used to record cloud cover?

○	Clear
●	Overcast
◔	Scattered clouds
◑	Partly cloudy
◕	Mostly cloudy

Symbols are used to show cloud cover on a weather station model.

Lesson Review

Why It Matters

If you ever had a baseball game rained out, you know how rain can ruin your day.

Rain may ruin your plans for a day, and flooding can sometimes cause disasters. However, rain is vital for life on Earth. Rain helps crops grow. Rain helps build the amount of water in wells and water-collecting areas, such as reservoirs. If you ever had a drought in your area, a time when there is little or no precipitation, you know how scarce water can be.

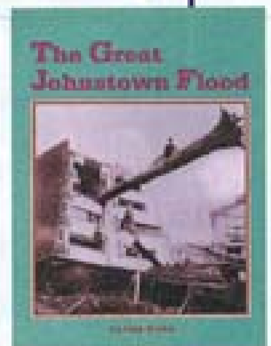
e-Journal Visit our Web site **www.science.mmhschool.com** to do a research project on clouds.

Think and Write

1. How do clouds form?
2. What are some different types of precipitation? Why are there different types?
3. Explain the difference between the way hail forms and the way sleet forms.
4. How can you measure and describe the amount of precipitation and cloud cover on a given day?
5. **Critical Thinking** "Sun showers" are sudden rainfalls on a sunny day. How can a sun shower happen?

L·I·N·K·S

LITERATURE LINK



Read *The Great Johnstown Flood,* the story of the storm that destroyed a town. When you finish reading, think about how you would prepare for a flood. Try the activities at the end of the book.

MATH LINK

Calculate accuracy. Observe clouds in your area each day for a week. Predict weather based on precipitation those clouds are likely to produce. Record how accurate your predictions are. Then, calculate your accuracy in percent.

WRITING LINK

Writing a Story The Inuit have more than 20 different words for snow. Why do you think this is so? Write a "how" or "why" story about why the Inuit have so many words for snow.

TECHNOLOGY LINK

Science Newsroom CD-ROM Choose *On the Vapor Trail* to learn more about how warm, moist air reacts when it cools.

LOG ON Visit **www.science.mmhschool.com** for more links.

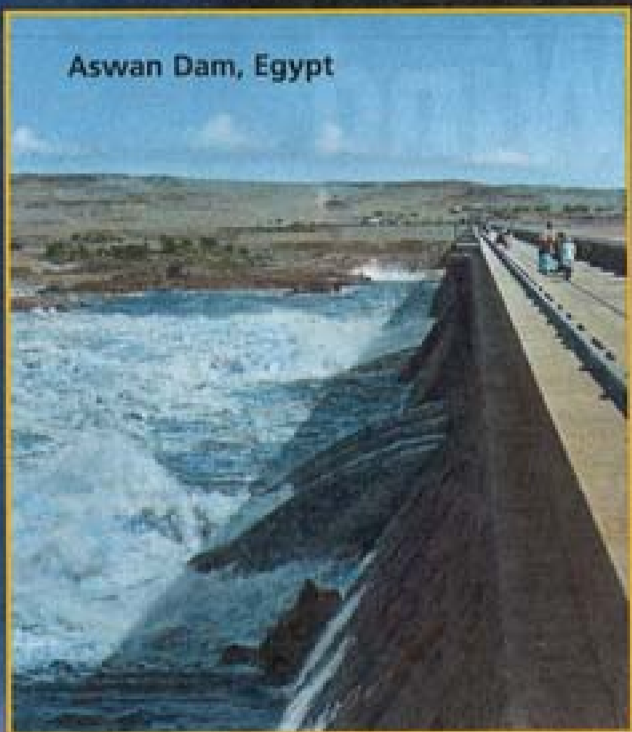
Flood: Good News or Bad?

Can you imagine a flood being good news? It was to many ancient Egyptians living near the Nile River. They looked forward to its annual summer flood. Land that was flooded was better for crops!

No one knew for sure why the flood came. Some people believed that great rains fell near the source of the Nile to start the flood. Much of the water actually comes from rains that fall in the mountains of Ethiopia.

Ethiopia has many mountains over 4,000 meters (13,000 feet) tall. In June the monsoons blow from the South Atlantic over the rain forests of Africa. When the winds reach the mountains of Ethiopia, giant rain clouds let loose their water in great thunderstorms. Rain-filled mountain streams join to form a great river. The river carries the water to the Nile. By July the water reaches Egypt and produces the flood.

and Society


Aswan Dam, Egypt

Today the flood waters are stopped soon after they reach Egypt. A high dam holds back the water to form a great lake. The good news is that buildings on the shore are no longer swept away. Farmers no longer depend on floods to plant one crop each year. Now they have water to plant during summer and winter.

Stopping the flood has changed the environment, and that's bad news. The flood kept the fields fertile; but now farmers must use fertilizer. The Mediterranean Sea was nourished by mud from the Nile. Now fish that were common are gone, and a serious disease is spread by snails thriving in the Nile's slow waters.

What Did I Learn?

1. Where did the Nile flooding start?

- **A** in the Red Sea
- **B** in the Mediterranean Sea
- **C** in the mountains of Ethiopia
- **D** in Saudi Arabia

2. Stopping the Nile flooding

- **F** kept the fields fertile.
- **G** increased the fish population.
- **H** killed off the snails.
- **J** changed the environment.

LOG ON Visit **www.science.mmhschool.com** to learn more about floods.

LESSON 6

Air Pressure and Wind

Vocabulary

wind, D55
convection cell, D55
sea breeze, D56
land breeze, D56
Coriolis effect, D57
isobar, D59

Get Ready

What makes the air move? What causes wind? Winds make these kites fly. Some winds move so fast and powerfully, they can knock down trees or even lift trucks into the air. Some winds can be so gentle, they hardly ruffle your hair. Air moves from one place to another because of differences in air pressure. What causes these differences?

Inquiry Skill

You use variables when you identify and separate things in an experiment that can be changed or controlled.

Explore Activity

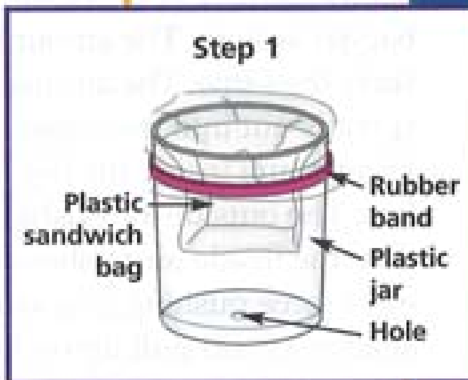
What Can Change Air Pressure?

Materials

- plastic jar with hole in bottom
- plastic sandwich bag
- rubber band
- masking tape

Procedure

1. **Make a Model** Set up a bag-and-jar system as shown. Make sure the masking tape covers the hole in the jar. Have a partner place both hands on the jar and hold it firmly. Reach in and slowly pull up on the bottom of the bag. Describe what happens.
2. **Experiment** Pull the small piece of tape off the hole in the bottom of the jar. Repeat step 1. Push in on the bag. Record your results.
3. **Observe** Place some small bits of paper on the table. Hold the jar close to the table. Point the hole toward the bits of paper. Pull up on the bag, and observe and record what happens.
4. **Experiment** Do just the opposite. Push the bag back into the jar. What happened?



Drawing Conclusions

1. **Observe** What differences did you observe with the hole taped and with the tape removed?
2. **Infer** Explain what happened each time you pushed the bag back into the jar. How does this model show air pressure changes?
3. FURTHER INQUIRY **Use Variables** What happens to the amount of space air takes up if it is warmed? Use the model to test your hypothesis.

Read to Learn

Main Idea **Differences in air pressure on Earth's surface cause wind.**

How Can Air Pressure Change?

Many factors affect the pressure.

Volume

Pulling up on the bag in the diagram below increases the volume inside the bag-jar system. The amount of air inside stays the same. The air inside the jar spreads out into the larger volume. The air pressure inside the bag-jar becomes less. The outside air pushes in harder than the inside air pushes out. That extra force pushing in is what you pull against as you pull up on the bag.

Height Above Earth's Surface

Air pressure depends on the weight of its molecules pressing down on a given area. Molecules are closer together, or more dense, at sea level than high in the atmosphere. Denser air weighs more than an equal volume of less dense air and pushes down harder. That is why air pressure is higher at sea level than high in the atmosphere.

Temperature

Air pressure also depends on temperature. When air is heated, its molecules speed up and spread out into a larger space. The same volume of air weighs less, and the pressure decreases.

Amount of Water Vapor

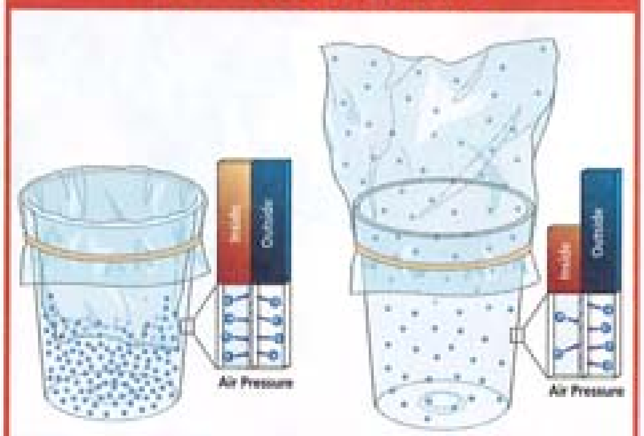
Air is a mixture of nitrogen, oxygen, and other gases. Adding water vapor to air also affects air pressure. Water vapor molecules weigh less than oxygen or nitrogen molecules. Moist air exerts less pressure than dry air.

READING Diagrams

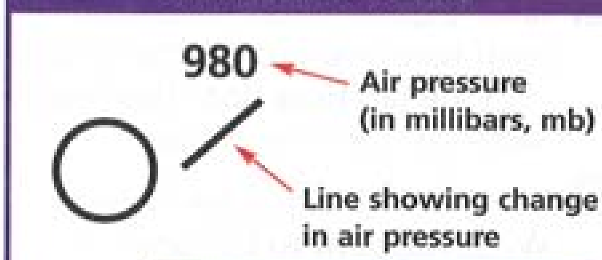
Explain what happens to the air pressure inside the jar as you push down on the bag.

How would an increase in temperature affect air pressure?

Air Pressure Models



Showing Air Pressure on a Station Model



Key:	
/	rising pressure
\	falling pressure
—	pressure is not changing

Why Do Winds Blow?

Think of what happens if you put a blob of soft clay on a table and push down on it, using a flat hand. The clay squishes out from under your fingers, where the pressure is high. It moves to the spaces between your fingers, where the pressure is lower.

Air acts in a similar way. Denser air exerts a higher pressure than less dense air. Like the clay, denser air flows toward less dense air. This flow of air is wind. Air that moves horizontally is called **wind**. Air that rises is an *updraft*. Air that sinks is a *downdraft*.

Convection Cells

How can air become more or less dense? As the Sun's rays hit an area, they transfer energy to the air. The air heats up. Because it is warmer, the heated air is less dense. Then, just like a cork in water, the warm air rises above the surrounding cooler, denser air. On the other hand, if a region of air is cooled, it becomes denser and sinks.

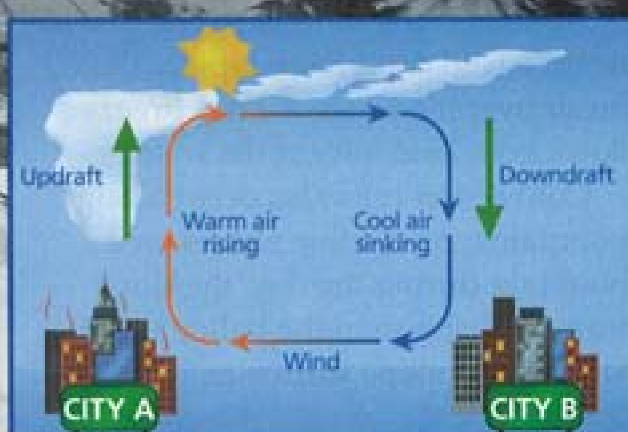
This unequal heating and cooling of the air often makes a pattern of rising air, sinking air, and winds, called a **convection** (kuhn·VEK·shuhn) **cell**. A convection cell is a part of the atmosphere where air moves in a circular pattern because of unequal heating and cooling.

The drawing shows how a convection cell forms. Cities A and B have the same air pressure. Then direct sunlight heats city A. The air above it warms and expands. It becomes less dense and rises, forming an updraft. The air pressure goes down. The unheated air on either side has a higher pressure. This air moves in toward the low-pressure area, making a surface wind.

How are winds produced?

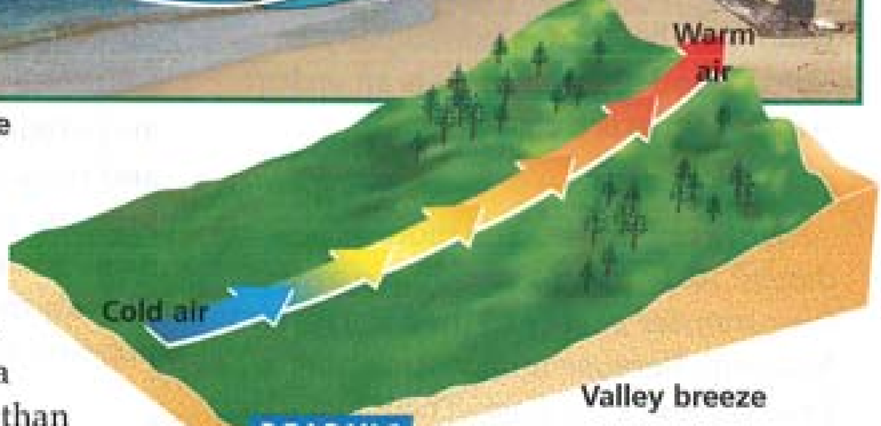
READING Diagrams

Use the diagram to explain what happens to city B during the formation of the convection cell.



Sea breeze

What Are Sea and Land Breezes?



Valley breeze

An example of convection is a breeze that occurs along a coastline. Land warms faster than water. On sunny days air over land warms faster than air next to it over the sea. The warm air expands and rises. Cooler air from over the ocean replaces the rising warm air. A wind blows onto the land. A wind that blows from the sea toward the land is called a **sea breeze**.

At night the reverse happens. The air over the land cools more rapidly than the air over the water. A **land breeze** blows from land toward the water.

Convection cells also occur along mountains. As the Sun shines on a mountain during the day, the slope heats up faster than the valley below. Air over the slope warms and rises. Cooler air over the valley replaces the rising warm air, creating a *valley breeze* that blows up the slope. At night the mountain slope cools rapidly. This causes a *mountain breeze* to blow down the slope.

READING Diagrams

These pictures show what happens during the day. How would you show what happens at night?

How are sea and land breezes produced?

What Is the Coriolis Effect?

Earth's rotation affects winds blowing across its surface. As Earth rotates, every spot on its surface moves with it. However, in the same 24-hour period, places near the poles travel a shorter distance than places near the equator. This means that places near the poles are moving slower!

Now what if you are in an airplane flying in a straight line from the North Pole to Chicago? While you are in the air, Earth is *rotating*, or spinning, underneath you. Earth rotates counterclockwise as seen from the North Pole. As Earth rotates, Chicago is moving west to east. To someone in Chicago, though, the plane's flight path seems to curve to the southwest.

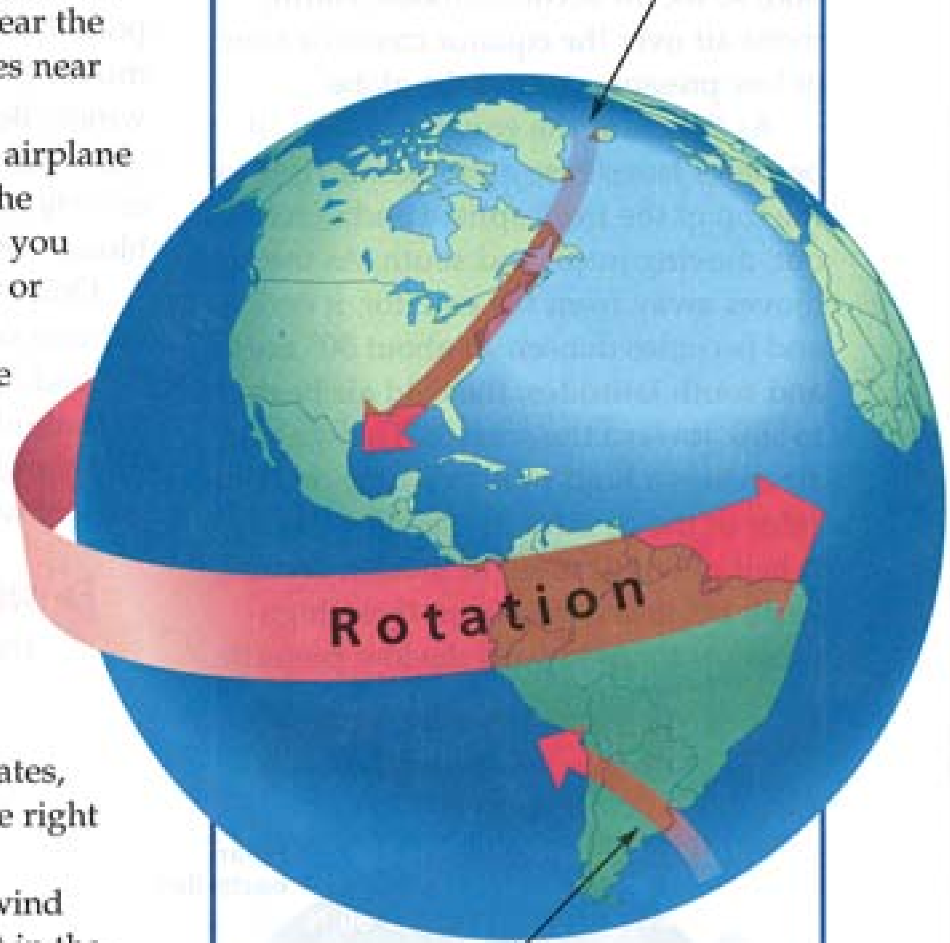
The same thing happens with winds blowing from the North Pole. Because Earth rotates, the winds seem to curve to the right as they head southward.

No matter which way the wind blows, it will curve to the right in the Northern Hemisphere. This curving is known as the **Coriolis effect**. In the Southern Hemisphere, the Coriolis effect causes winds to curve to the left. This is because, as viewed from the South Pole, Earth rotates clockwise. The effect works on other moving objects as well, such as missiles and rockets.

What causes the Coriolis effect?

Coriolis Effect

If you were standing at the North Pole looking south, this arrow would appear to curve to the right.



If you were standing at the South Pole looking north, this arrow would appear to curve to the left.

How Are Global Wind Patterns Produced?

Year round the equator is heated strongly by sunlight. The air becomes very warm. Heat also causes evaporation, so the air becomes moist. Warm, moist air over the equator creates a zone of low pressure around the globe.

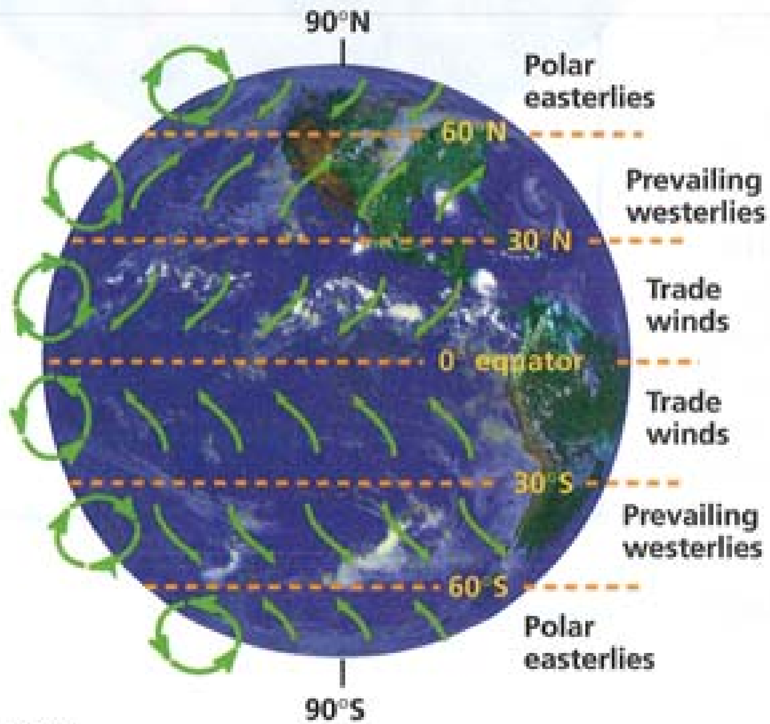
As the air at the equator warms, it becomes less dense and rises. It rises to the top of the troposphere and spreads out, moving north and south. As the air moves away from the equator, it cools and becomes denser. At about 30° north and south latitudes, the cold air begins to sink toward the surface. This sinking air creates a high-pressure zone on both sides of the equator at these latitudes. A belt of winds is set in motion around Earth by air moving from these high-pressure zones toward the low pressure at the equator. These are the *trade winds*. The Coriolis effect curves these winds, as you see in the diagram.

The poles get very low-angle sunlight, and the air there is very cold. Cold, dense air can hold very little water vapor. Cold, dry air over the poles has high pressure. Air at the poles moves toward 60° latitude, forming winds. Because of the Coriolis effect, the winds curve. These are the polar *easterly winds. Easterly* means the wind blows "from the east."

Other winds occur between 60° latitude and the poles as well as between 30° and 60° latitudes. Between 30° and 60° latitudes is the zone of *westerly winds.* The continental United States is in the zone of westerly winds.

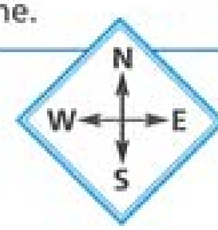
What causes the global trade winds?

Global Wind Zones



READING Diagrams

Make a table listing different global wind zones and a description of the directions in which winds move in each zone.



What Are Isobars?

Why is it important to know about air pressure? Knowing where the air pressure is high or low allows you to predict which way air will move. This is why weather scientists make maps showing air pressure. They start by plotting the air pressure at many different locations on a map. Then they connect all places with the same air pressure with a line. A line on a map connecting places with equal air pressure is called an **isobar**. Isobars make pressure patterns easier to see.

Find the series of circular isobars in the west, surrounding a region of high pressure (H). This pattern is called a *high-pressure system*. Since the center has higher pressure than its surroundings, winds blow outward from the center in a clockwise pattern.

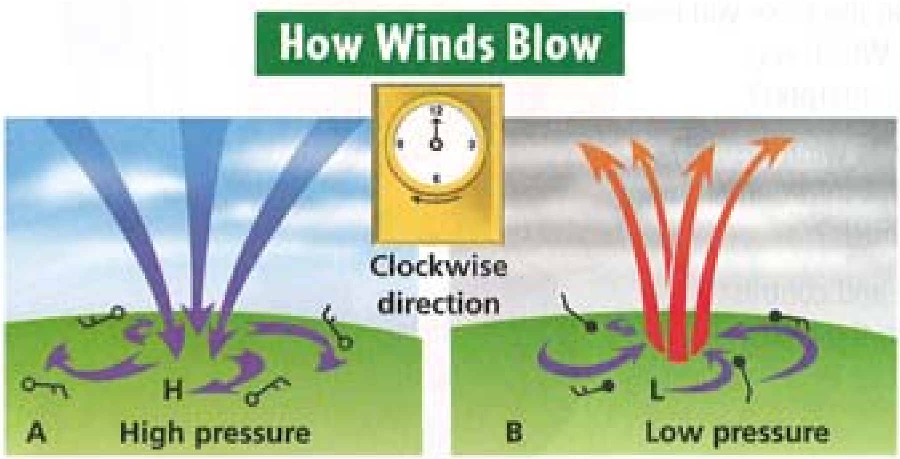
A similar set of isobars in the east marks a *low-pressure system* (L). In a low-pressure system, the central region is surrounded by higher pressure. The winds blow in toward the center in a counterclockwise pattern.

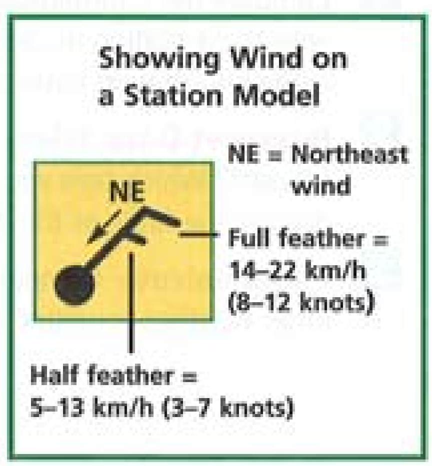
The pressure on each isobar is in millibars (mb).

Isobars also help scientists predict how fast air will move. Big differences in air pressure over short distances cause strong winds. This is shown on a map by drawing closely spaced isobars. Small differences in air pressure cause gentle winds. This is shown by widely spaced isobars.

You show wind on a station model with a straight line touching the circle. The line tells where the wind is blowing from. "Feathers" are used to show speed.

READING **Main Idea**
How do isobars help scientists predict how air will move?



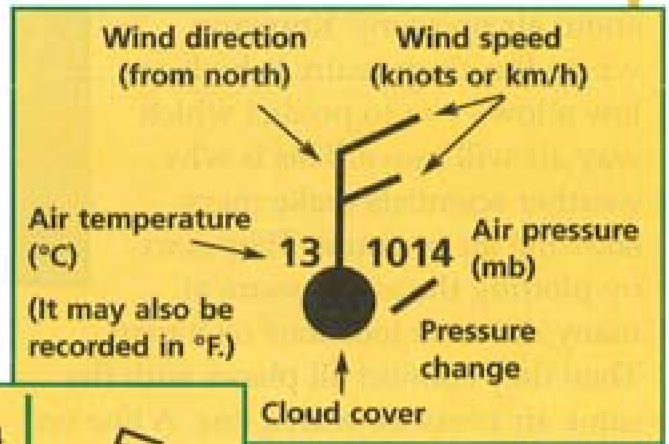


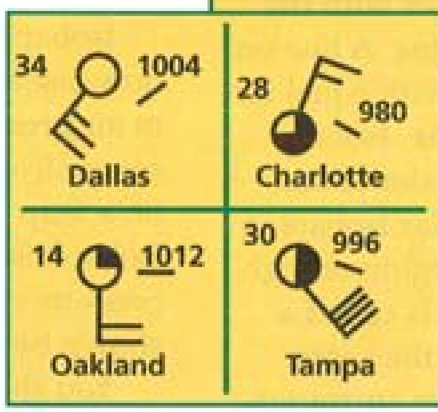
Inquiry Skill BUILDER

SKILL Interpret Data

A Weather Station Model

A weather station model includes temperature, cloud cover, air pressure, pressure tendency, wind speed, and wind direction. The circle is at the location of the station. You will interpret the data, using the information from the weather station models to answer questions and solve problems.





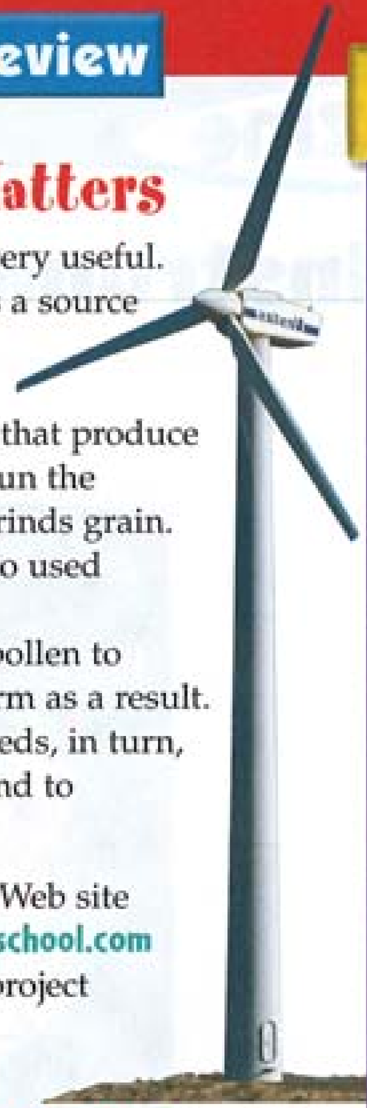
Procedure

1. **Use Numbers** Look carefully at the Dallas weather station model. How fast is the wind blowing? What is the wind direction? Record your answers.
2. **Interpret Data** What other information does this weather station model give you?
3. Look at the other weather station models. Make a table recording weather conditions for each city.

Drawing Conclusions

1. Compare the information in the table you made with these station models. Which way is the information easier to interpret?
2. **Interpret Data** Where was wind fastest? Slowest? Which tells you this information more quickly, the table or the models?
3. **Communicate** Compare and contrast other weather conditions in the cities.

Lesson Review



Why It Matters

Wind can be very useful. It is often used as a source of power. Wind turns windmills, special machines that produce electricity. They run the machinery that grinds grain. Windmills are also used to pump water.

Wind carries pollen to flowers. Seeds form as a result. Many kinds of seeds, in turn, are carried by wind to new places.

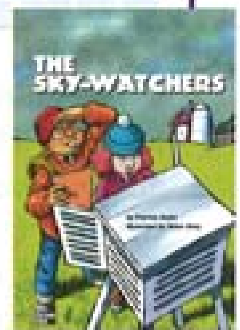
e-Journal Visit our Web site **www.science.mmhschool.com** to do a research project on wind.

Think and Write

1. What makes air pressure change?
2. What causes wind to blow in a particular direction?
3. Why are there zones of winds around the world?
4. **Interpret Data** On a weather map, how can you compare the speed and direction of winds in different locations?
5. **Critical Thinking** How might temperatures near the ocean compare with those inland in winter? In summer? Explain.

L·I·N·K·S

LITERATURE LINK



Read *The Sky-Watchers,* the story of how two students maintained a weather station. When you finish reading, think about how you would build a weather station. Try the activities at the end of the book.

WRITING LINK

Expository Writing Research and write a report on the Beaufort Wind Scale. Include its history. Draw a conclusion about its importance.

MATH LINK

Calculate weather factors. Collect a week's worth of national weather maps from a newspaper. Select a region of the country, such as the Midwest or Southeast. Calculate its average temperature, wind speed, and air pressure.

SOCIAL STUDIES LINK

Write a report. Research the origin of the term "trade winds," and write a report on your findings.

TECHNOLOGY LINK

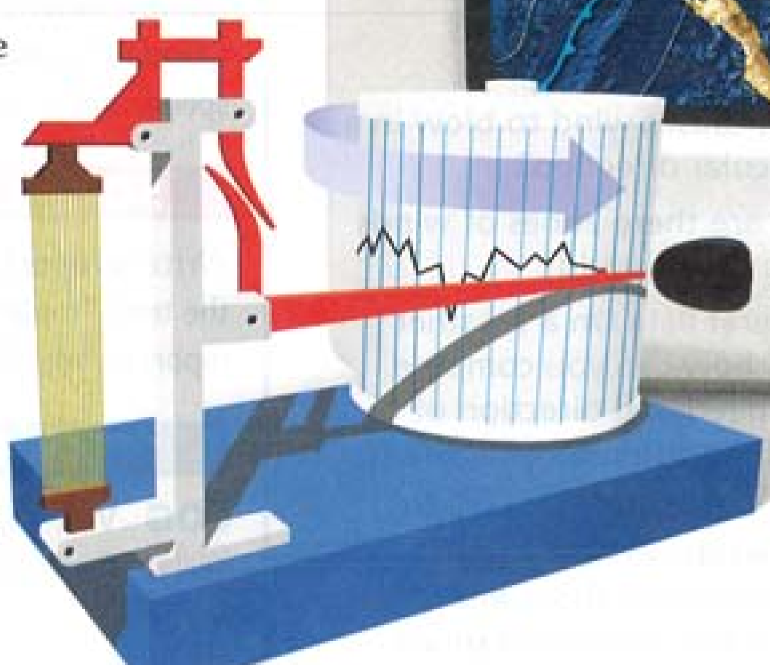
LOG ON Visit **www.science.mmhschool.com** for more links.

Weather: It's Instrumental!

You turn on the TV to catch the weather forecast. The satellite image looks cool, but all you want to know is how warm it is, whether it's windy, and if you're going to get wet on your way to school. Where does that information come from? Not from space, but from a set of instruments at a nearby weather station.

To find the temperature, you need a thermometer. To find how much rain has fallen, you need a rain gauge. Put a straight-sided bucket outside to collect rain water. Later, stick a ruler in the bucket to measure how much rain fell.

Wonder how much moisture is in the air? Your hair is a good indicator! It gets frizzier when it's raining or very humid outside. That's because hair lengthens (and kinks up) when the air is moist. Forecasters use "hair hygrometers" to measure humidity. Hygrometers have pens that are attached to human or horse hairs. As the hair changes length, the pen graphs the change in humidity.



Sally Ride Science

Which way's the wind blowing? A weather vane will tell you. An arrow points in the direction of the wind. The tail of the vane works like a sail to catch the wind. The vane spins until the wind is blowing equally on both sides of the tail. Then the arrow is pointing in the wind direction. If the wind is blowing from the west, the arrow points west. A wind blowing from the west is called a west wind.

How windy is it? The speed of the wind is measured with an anemometer. It uses a set of cups attached to a central pole. As the cups catch the wind, they spin around like a pinwheel. The faster the wind, the faster they spin. Now you can set up a weather station right in your own backyard!

Write About It

1. What weather information do you need before you go outside? What instruments help get that information?
2. What would it take to set up a weather station in your neighborhood or outside your window?

LOG ON Visit **www.science.mmhschool.com** to learn more about measuring weather.

Chapter 10 Review

Vocabulary

Fill each blank with the best word or words from the list.

barometer, D34
cirrus cloud, D44
condensation, D39
Coriolis effect, D57
evaporation, D38
humidity, D38
land breeze, D56
precipitation, D46
sea breeze, D56
stratus cloud, D44

1. Rain, snow, and sleet are kinds of _____.

2. The _____ causes winds to follow a curved path over Earth's surface.

3. A(n) _____ forms in blanketlike layers.

4. Liquid changes directly to a gas by the process called _____.

5. The amount of water vapor in the air is called _____.

6. Wind blowing from the ocean toward the land is called a(n) _____.

7. Wind blowing from the land toward the ocean is called a(n) _____.

8. The process that turns water vapor into raindrops is called _____.

9. A high, wispy cloud made of ice crystals is a(n) _____.

10. A(n) _____ measures air pressure.

Test Prep

11. In a low-presure system _____.

A winds blow out
B winds blow clockwise
C winds blow west
D winds blow inward, counterclockwise

12. Weather takes place in the _____.

F thermosphere
G mesosphere
H troposphere
J stratosphere

13. Water drops that collect on a cold glass of lemonade come from _____.

A the lemonade
B the air
C a puddle
D the glass itself

14. Isobars indicate _____.

F humidity
G temperature
H air pressure
J cloud cover

15. On a hot day, a lake is likely to be ____.

A cooler than nearby land

B hotter than nearby land

C the same temperature as the land

D the cause of the heat

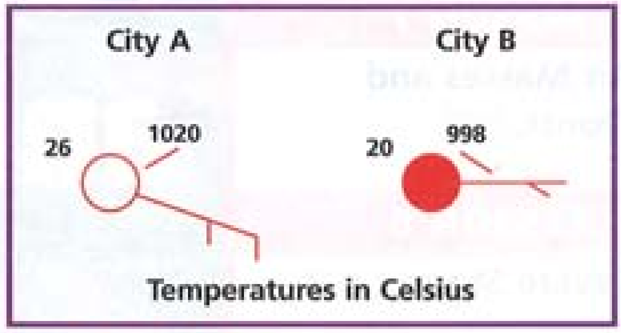
Concepts and Skills

16. **Reading in Science** Write a paragraph explaining why north winds blow to the southwest.

17. **Safety** Why do you need to be careful on hot days when the relative humidity is high? Write a paragraph explaining your answer.

18. **Scientific Methods** How much does humidity change over a day? Write a design for an experiment that would test this.

19. INQUIRY SKILL **Interpret Data** You are given this information on a weather map: What kind of weather is city A having? What kind of weather is city B having? Write a paragraph explaining your answer.



20. **Critical Thinking** What if there were no plants? Do you think Earth would still get as much rain as it does now? Write your ideas. Describe how you might test them.

Did You Ever Wonder?

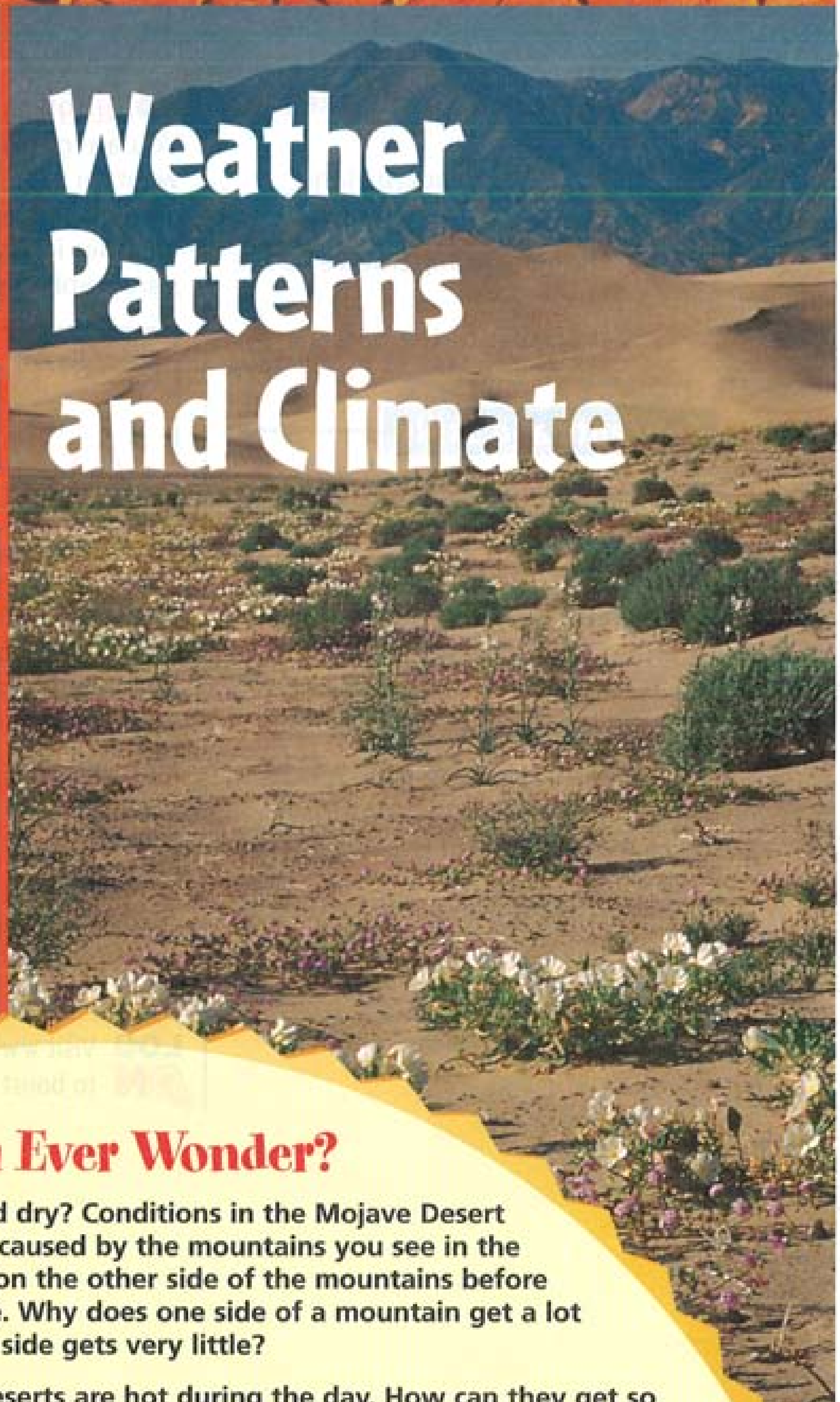
INQUIRY SKILL **Infer** You look up in the sky and see clouds. Why don't those clouds fall to the ground?

LOG ON Visit www.science.mmhschool.com to boost your test scores.

CHAPTER

11

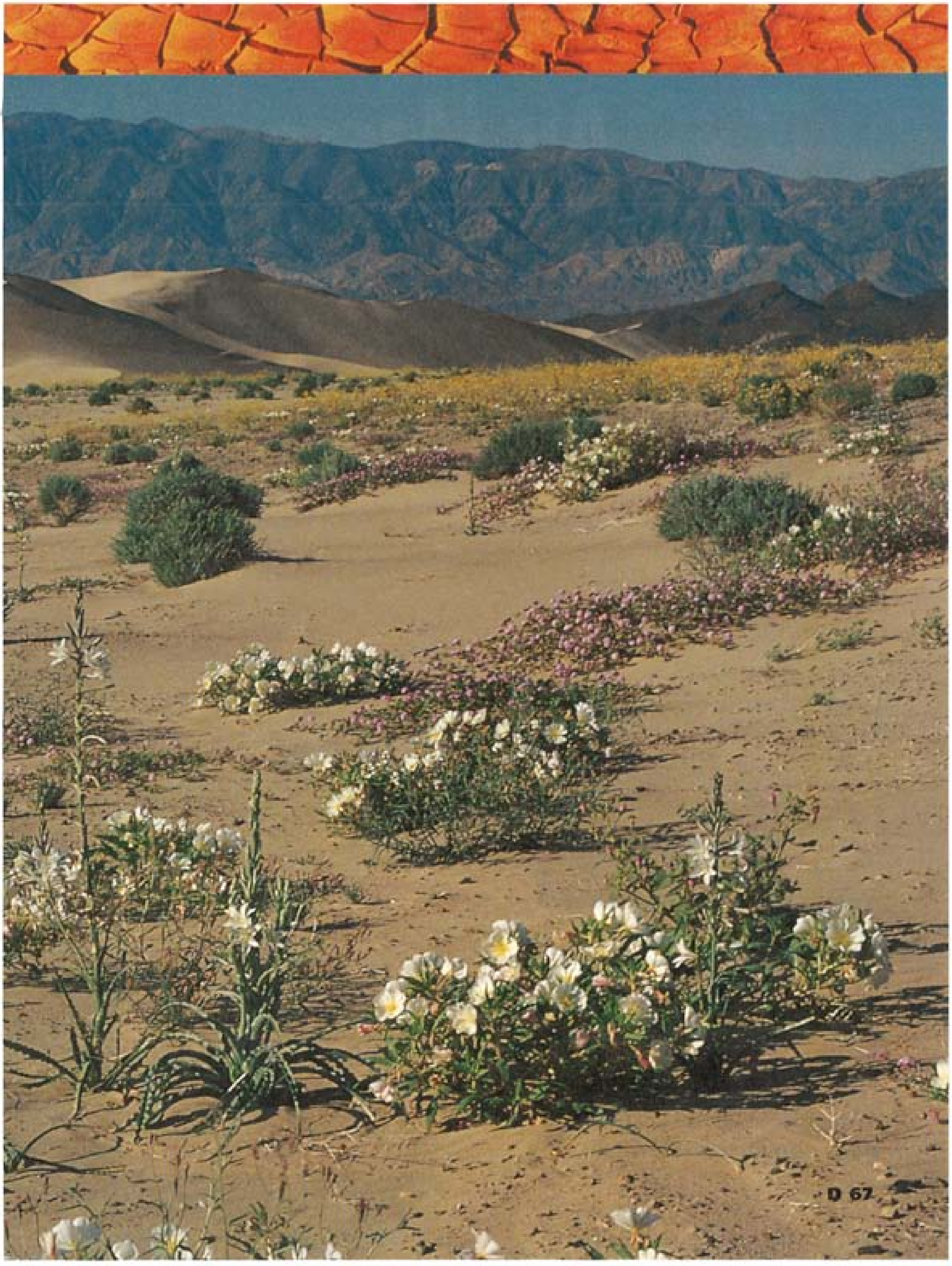
Weather Patterns and Climate



Did You Ever Wonder?

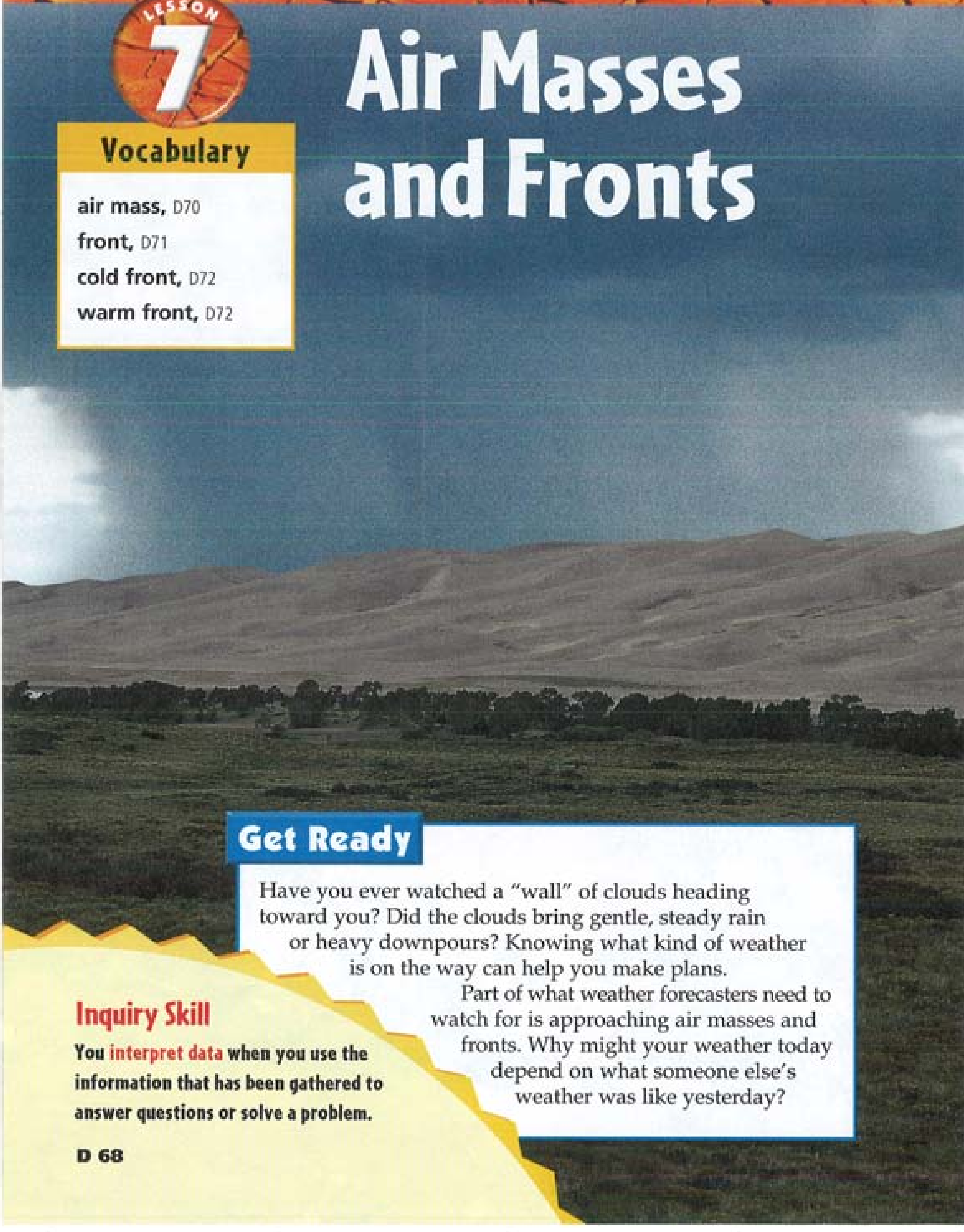
Why is a desert hot and dry? Conditions in the Mojave Desert in California are partly caused by the mountains you see in the background. Rain falls on the other side of the mountains before it can reach the Mojave. Why does one side of a mountain get a lot of rain while the other side gets very little?

INQUIRY SKILL **Infer** **Deserts are hot during the day. How can they get so cool at night?**



LESSON 7

Air Masses and Fronts



Vocabulary

air mass, D70
front, D71
cold front, D72
warm front, D72

Get Ready

Have you ever watched a "wall" of clouds heading toward you? Did the clouds bring gentle, steady rain or heavy downpours? Knowing what kind of weather is on the way can help you make plans.

Part of what weather forecasters need to watch for is approaching air masses and fronts. Why might your weather today depend on what someone else's weather was like yesterday?

Inquiry Skill

You interpret data when you use the information that has been gathered to answer questions or solve a problem.

Explore Activity

How Can You Compare Weather?

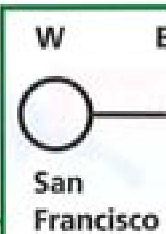
Materials
- station model key
- newspaper weather map (optional)
- pencil
- crayons

Procedure

Communicate Think of the country in large regions—the Northeast, the Southwest, and the coasts. Write a report for the weather in each region based on the map you see here.

Drawing Conclusions

1. **Infer** Which areas are having warm, rainy weather?
2. **Infer** Where is the weather cool and dry?
3. **Predict** How do you think weather in any part of the country may change, based on the data in this map? Give reasons for your answer. How would you check your predictions?
4. **FURTHER INQUIRY** **Interpret Data** What will tomorrow's weather be like? Interpret the information on the weather map in the morning paper. Compare your interpretation to the actual weather during the day.



Lines are drawn to show wind direction, not speed. This is a wind coming from the east, going west—an east wind.

Read to Learn

Main Idea **Weather changes often occur at fronts, where different air masses meet.**

How Do Air Masses Affect Weather?

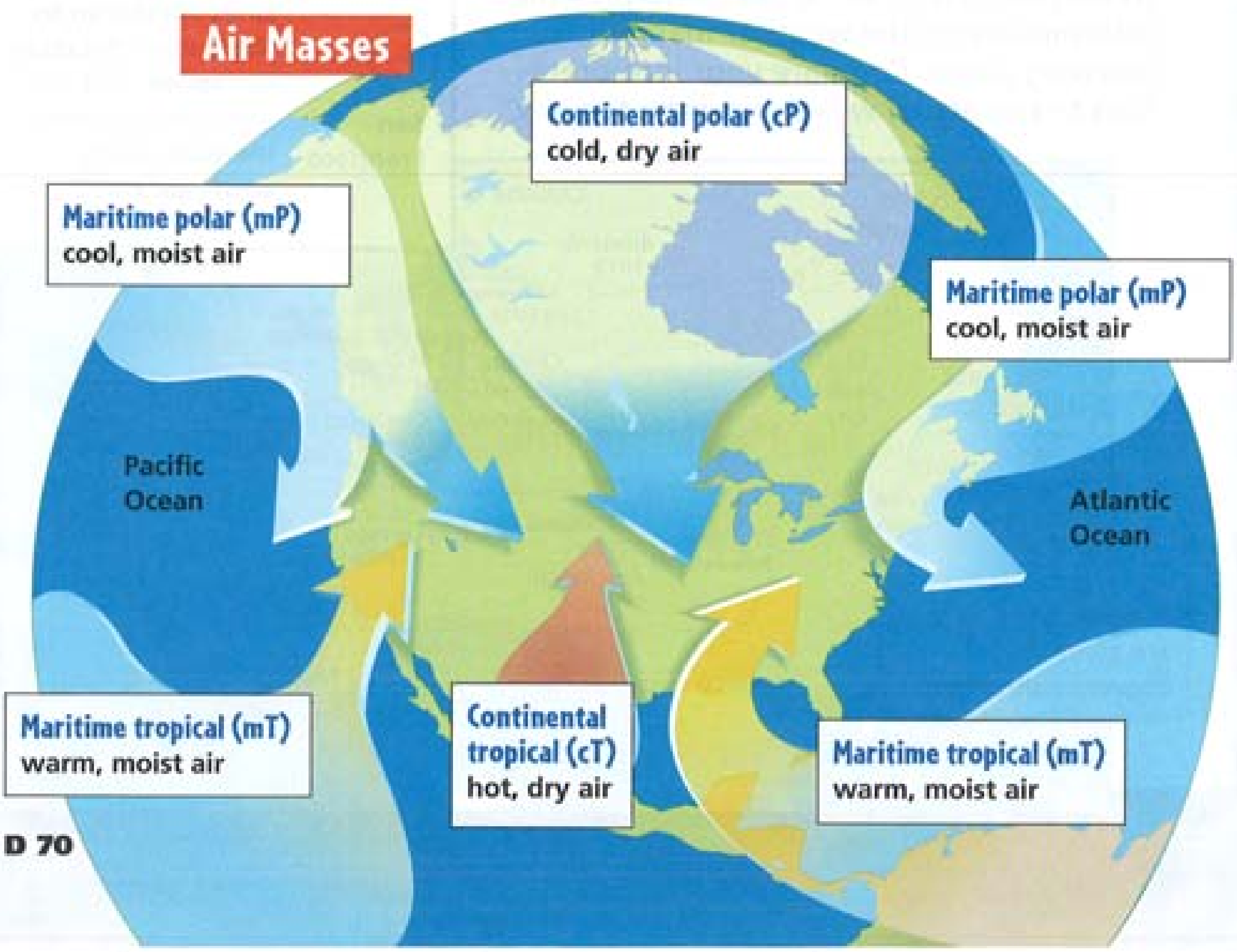
Weather maps show that cities across a large region can share the same weather. They also show how the weather in different areas can differ.

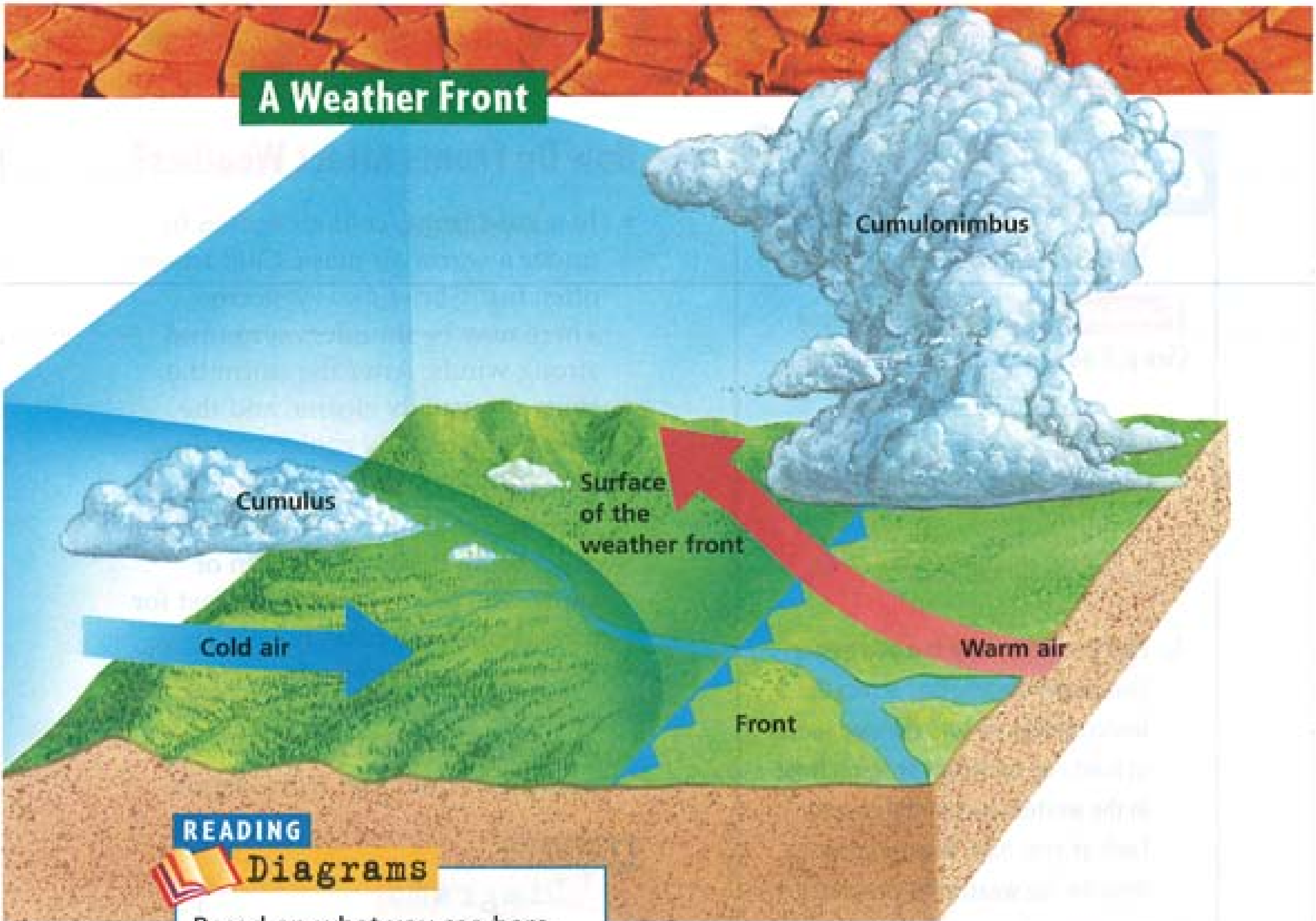
Why are weather conditions in one part of a country different from those in another part? Look back at the map on page D69. Some of the cities are having clear, cool weather. The air throughout this region is cool and dry. Other cities are having warmer, cloudy weather. The air throughout this region is warm and moist. A large region of the atmosphere where the air has similar properties throughout is called an **air mass**.

An air mass gets its properties from the region where it forms. Air over the Gulf of Mexico is above very warm water. The water warms the air, and evaporation from the Gulf adds water vapor. The air becomes warm and moist. Air masses are named for the region they come from.

As air masses move, they bring these conditions with them. What happens if a cool, moist air mass moves over an area that has warm, dry weather? The warm, dry weather will change.

Air Masses





READING Diagrams

Based on what you see here, how would you define front in your own words?

A front forms along the boundary between a warm air mass and a cold air mass.

Once an air mass is formed, it is moved by global winds. In the United States, global winds tend to move air masses from west to east.

Air masses with different conditions can "meet." That is, one runs into another. What happens when air masses with different temperatures meet? They don't mix together. Instead, a narrow boundary forms between them. This boundary is called a **front**. It marks the leading edge, or front, of an air mass that is moving into an area where another air mass is moving out. Weather changes rapidly at fronts. That's because you pass from one kind of air mass into another. Fronts often cause rainy, unsettled weather.

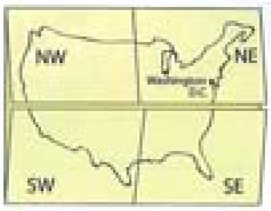
READING **Sequence of Events**

What happens when a cold air mass meets with a warm air mass?

QUICK LAB

Weather Prediction

FOLDABLES Make a Four-Door Book. (See p. R 44.) Label the tabs as shown.



1. Find a weather map in a newspaper that shows the weather across the United States. Be sure the map shows at least one cold front or warm front in the western part of the country. Look at your map. Use the book to describe the weather in your state.
2. Use your book to describe the weather in each region of the country–northwest, southwest, southeast, northeast.
3. **Infer** Weather patterns move from west to east across the United States. How do you think the weather just east of the front will change in the next day or so? Explain under the tabs of your Four-Door Book.

How Do Fronts Affect Weather?

- In a **cold front**, cold air moves in under a warm air mass. Cold fronts often bring brief, heavy storms. There may be thunderstorms and strong winds. After the storm the skies are usually clearer, and the weather is usually cooler and drier.
- In a **warm front**, warm air moves in over a cold air mass. Warm fronts often bring light, steady rain or snow. The precipitation may last for days. Winds are usually light. Warm fronts may also bring fog—stratus clouds that form near the ground. Afterward the weather is usually warmer and more humid.

READING Diagrams

Write a paragraph comparing a warm front with a cold front.

Cold Front

Colder, denser air moves in under a region of warm air.

Warm Front

Warm air moves into a region, rising up and over the colder air mass already there.

What kind of weather does a cold front usually produce?

Lesson Review

L·I·N·K·S

Why It Matters

Weather forecasting is hard. Knowing how the atmosphere is moving lets you predict the weather. The problem is that the atmosphere is huge and complex. A weather forecaster might predict clear weather for tomorrow. However, another air mass might move in. Everything can change.

Computers do high-speed calculations to predict the atmosphere's motion. Predictions are compared with forecasts to account for any differences. Two-day forecasts are calculated every 12 hours. A five-day forecast is calculated daily.

e-Journal Visit our Web site **www.science.mmhschool.com** to do a research project on weather forecasting.

Think and Write

1. What are four different kinds of air masses? How are they different?
2. What kind of weather is produced by a cold front?
3. What kind of weather is produced by a warm front?
4. How can you use weather maps to predict weather?
5. **Critical Thinking** How can you tell the kind of front passing by just observing the weather?

WRITING LINK

Expository Writing Write an interview for the local TV news. Explain how changes in the weather affected the way three people spent their day.

MATH LINK

Graph weather data. Research local newspapers to learn what kinds of fronts have moved through your area and the kind of weather each front brought. Do this for a month. Graph your data. Report what you found.

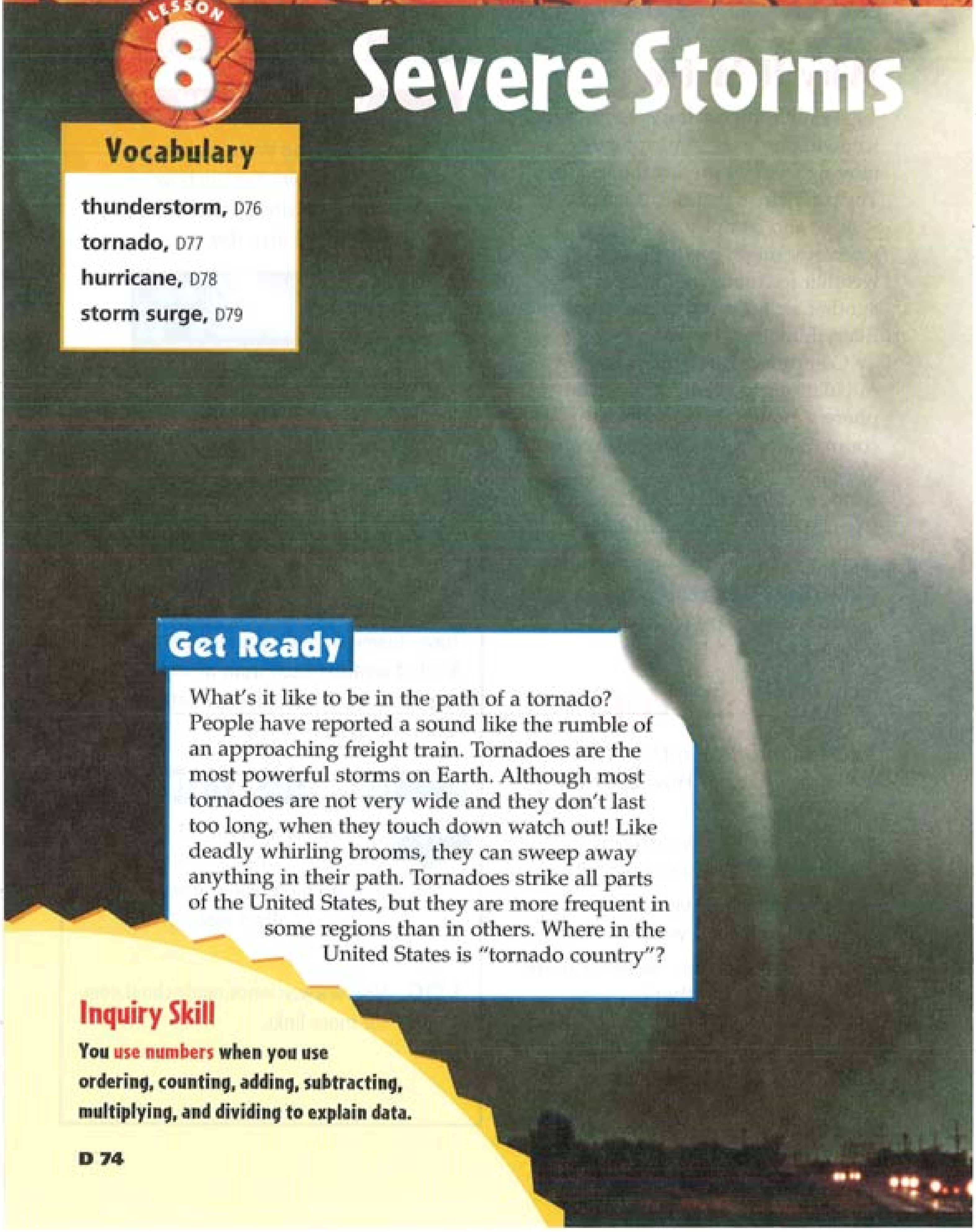
TECHNOLOGY LINK

Science Newsroom CD-ROM Choose *It's Up in the Air* to learn more about how air masses affect weather conditions.

LOG ON Visit **www.science.mmhschool.com** for more links.

LESSON 8

Severe Storms



Vocabulary

thunderstorm, D76
tornado, D77
hurricane, D78
storm surge, D79

Get Ready

What's it like to be in the path of a tornado? People have reported a sound like the rumble of an approaching freight train. Tornadoes are the most powerful storms on Earth. Although most tornadoes are not very wide and they don't last too long, when they touch down watch out! Like deadly whirling brooms, they can sweep away anything in their path. Tornadoes strike all parts of the United States, but they are more frequent in some regions than in others. Where in the United States is "tornado country"?

Inquiry Skill

You use numbers when you use ordering, counting, adding, subtracting, multiplying, and dividing to explain data.

Explore Activity

Where Do Tornadoes Occur?

Procedure

1 **Infer** The table shown here lists how many tornadoes occurred in each state over a 30-year period. It also shows about how many tornadoes occur in each state each year. Look at the data in the table for two minutes. Now write what part of the country you think gets the most tornadoes.

2 Use the red marker to record on the map the number of tornadoes that occurred in each state over the 30-year period. Use the blue marker to record the average number of tornadoes that occurred in a year in each state.

Drawing Conclusions

1 **Use Numbers** Which states had fewer than 10 tornadoes a year? Which states had more than 20 tornadoes a year?

2 **Interpret Data** Which six states had the most tornadoes during the 30-year period?

3 **Interpret Data** Which part of the country had the most tornadoes?

4 **FURTHER INQUIRY** **Communicate** Many people refer to a certain part of the country as "Tornado Alley." Which part of the country do you think that is? Why do you think people call it that? What else might these states have in common? Describe how you would go about finding the answer to that question.

Materials

map of U.S., including Alaska and Hawaii

blue marker

red marker

State	Total	Average per year
AL	668	22
AK	0	0
AZ	106	4
AR	596	20
CA	148	5
CO	781	26
CT	37	1
DE	31	1
FL	1,590	53
GA	615	21
HI	25	1
ID	80	3
IL	798	27
IN	604	20
IA	1,079	36
KS	1,198	40
KY	296	10
LA	831	28
ME	50	2
MD	86	3
MA	89	3
MI	567	19
MN	607	20
MS	775	26
MO	781	26
MT	175	6
NE	1,118	37
NV	41	1
NH	56	2
NJ	78	3
NM	276	9
NY	169	6
NC	435	15
ND	621	21
OH	463	15
OK	1,412	47
OR	34	1
PA	310	10
RI	7	0
SC	307	10
SD	864	29
TN	360	12
TX	4,174	139
UT	58	2
VT	21	1
VA	188	6
WA	45	2
WV	69	2
WI	625	21
WY	356	12

Read to Learn

Main Idea **Thunderstorms, tornadoes, and hurricanes are severe storms that can cause great damage.**

What Are Thunderstorms?

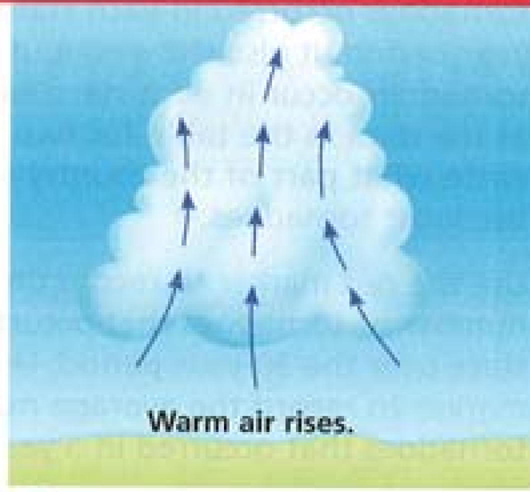
A tornado is a violent kind of storm that forms under special conditions. Often, such storms grow out of a **thunderstorm**, another, more common kind of storm.

Thunderstorms are the most common kind of severe storm. They form in clouds called *thunderheads*, or cumulonimbus clouds. The storms cause huge electric sparks called *lightning*. The lightning heats the air and causes the noise called *thunder*. Thunderstorms usually have heavy rains and strong winds. Some thunderstorms also produce hail. A thunderstorm starts when intense heating causes air to rise very quickly. A cloud forms where there is an upward rush of heated air, an updraft. As more warm, moist air is carried upward, the cloud grows larger. Strong updrafts keep water droplets and ice crystals in the cloud, so they grow in size, too. When the updrafts can't support them anymore, they fall as heavy rain or even hail.

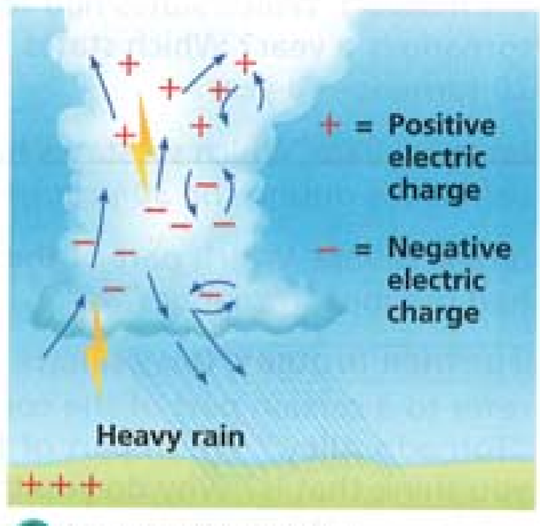
Once the rain falls, it causes downdrafts in the cloud. When the air going up rubs against air going down, static electricity builds up. When enough builds up, there's a huge spark—lightning. Lightning may jump within a cloud, between two clouds, or between a cloud and the ground.

Thunderstorms usually form in warm air just ahead of a cold front. They most often occur in hot humid weather, but can also occur during snow storms, as *thundersnow*.

How a Thunderstorm Forms



1 Strong updrafts form inside the cloud.



2 Electric charges build up inside the cloud.

READING Diagrams

Describe how a thunderstorm forms.

The most violent thunderstorms often spin off even more dangerous storms, called **tornadoes**. A tornado is a violent whirling wind that moves across the ground in a narrow path.

How Tornadoes Happen

Late in the day, when Earth's surface is very warm, convection can get very strong. This can lead to a tornado. A tornado is a sort of runaway convection cell.

When the updraft in a convection cell is really strong, the air rushes in from all sides at high speeds. The air curves into a spin. This lowers the pressure even more. Air rushes in even faster, and the pressure gets even lower, and so on. Like a spinning skater who pulls her arms in close to her sides, the spinning tornado gets faster and faster.

As the tornado gets stronger, a funnel forms that eventually touches the ground. In the center of a tornado, winds can reach speeds of 500 km per hour (about 300 mi per hour) or more. At such high speeds, winds can destroy anything in their path.

The speed of the wind in the tornado is not the speed with which the tornado moves across the ground. It moves across the ground very fast but can change its direction continually.

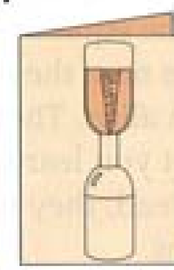
Most tornadoes in the United States occur in the Midwest and the South—especially in the area known as Tornado Alley.

How are tornadoes related to thunderstorms?

QUICK LAB

Tornado in a Bottle

FOLDABLES Make a Half-Book. (See p. R 41.)



1. **Make a Model** Fill a 2-L plastic bottle one-third full of water. Dry the neck of the bottle, and tape over the top with duct tape. Use a pencil to poke a hole in the tape.

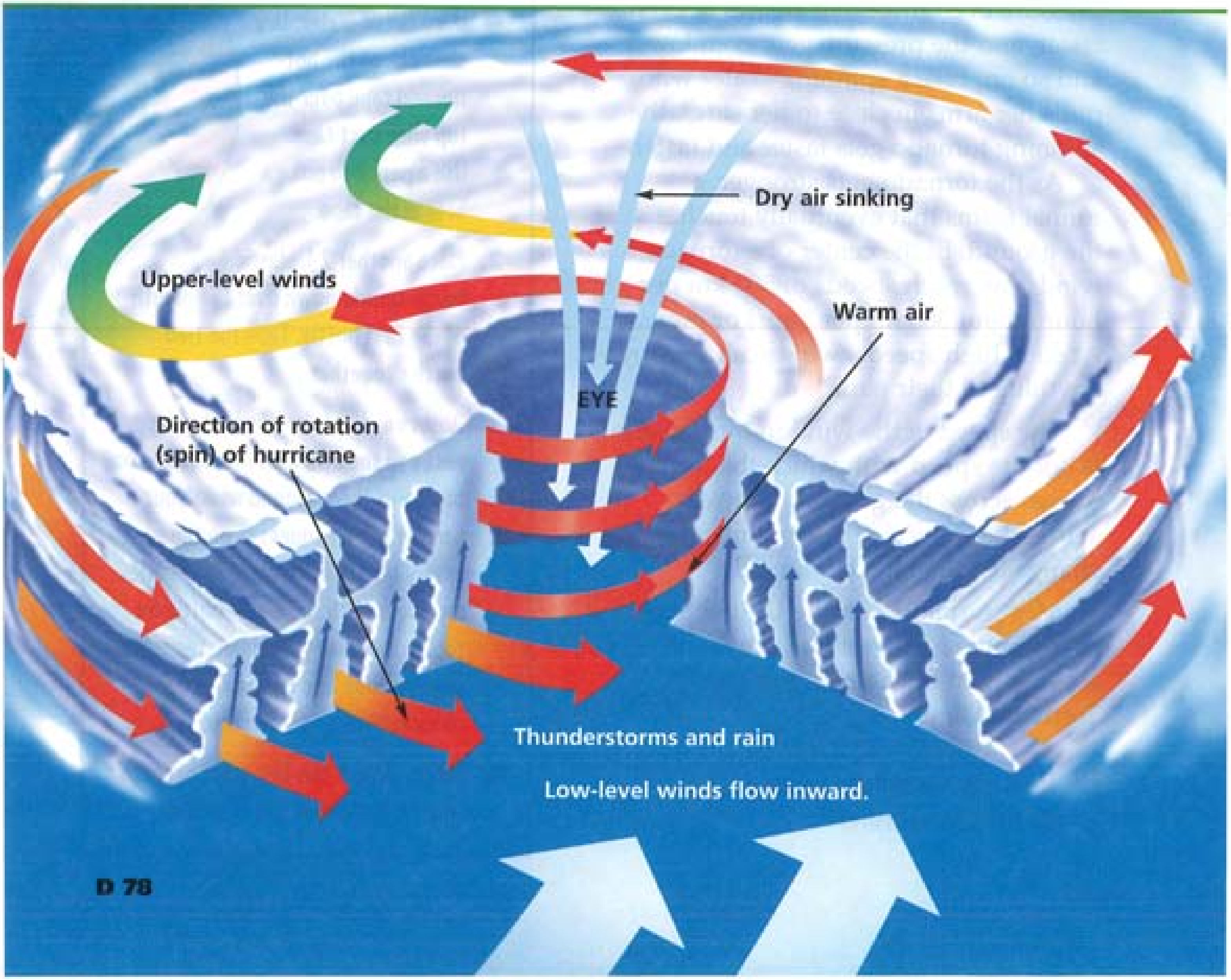
2. Place another 2-L plastic bottle upside down over the mouth of the first bottle. Tape the two bottles together.
3. **Observe** Hold the bottles by the necks so the one with the water is on top. Swirl them around while your partner gently squeezes on the empty bottle. Then place the bottles on a desk with the water bottle on top. Draw what you see on the front of your book and describe your observations under the tab.
4. **Infer** How is this like what happens when a tornado forms? Explain.

How Do Hurricanes Form?

If you live near an ocean or the Gulf Coast, you may have experienced a **hurricane**. Hurricanes are very large, swirling storms with very low pressure at their center. They form over tropical oceans near the equator.

Air masses near the equator tend to be very much alike. They don't form the fronts that you learned about in Lesson 7. Instead, they form lots of thunderstorms.

- Strong heating and lots of evaporation over the ocean can cause a large low-pressure center to form. If this happens, winds begin to blow in toward the low. As this rushing air nears the center, it moves upward and forms a ring of tall thunderstorms.
- The Coriolis effect causes winds to spiral counterclockwise in the Northern Hemisphere. Clusters of thunderstorms are pulled into the spiral. The thunderstorms merge, forming a single large storm.
- As water vapor in the storms condenses, heat is released. The air is



warmed. This decreases the air's density and pressure. Moisture evaporating into the air decreases the air's density and pressure even more. Low air pressure favors more evaporation. This lowers the pressure even more.

- The lower the air pressure, the faster are the winds that blow in toward the center of the storm. When the winds reach speeds of 120 km per hour (about 75 mi per hour) or higher, the storm is a hurricane.
- As the moist air in the storm rises and cools, condensation takes place. The clouds thicken. Heavy rains fall through the high winds. When fully formed, a hurricane has an eye at its center. The eye is an area of light winds and skies that are nearly clear.

Hurricane winds whip up large waves in the ocean. These waves move outward from the storm and pound against a shore for days before the storm arrives. However, it is the **storm surge** that causes the most destruction. Storm surge is a great rise of the sea along a shore. Its main cause is low air pressure.

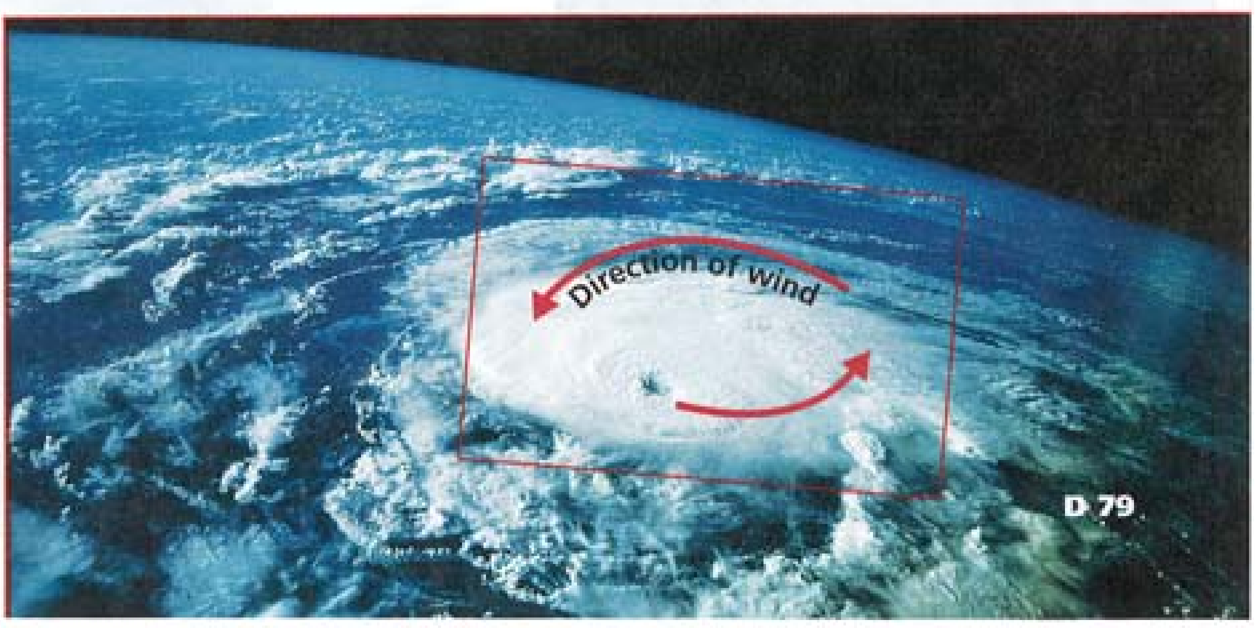
Air pressure normally presses down on the surface of the sea. When the pressure drops in a hurricane, the surface of the sea rises, forming a bulge beneath a hurricane.

When the hurricane moves over a coast, the bulge can cause water levels to suddenly rise several feet, or surge.

Hurricane winds also push water ahead of the storm, forcing water onshore and adding to the storm surge. If the storm surge comes at high tide, it can raise the water level by 7 meters (about 20 feet) or more.

READING **Sequence of Events**

How does lower and lower air pressure lead to the formation of a hurricane?



This satellite photograph shows a hurricane and its eye. Hurricanes can easily grow to more than 700 km (about 400 mi) in diameter. Hurricanes can pick up about 20 billion tons of water a day from the oceans. Much of this water falls as rain over land areas.

How Can Radar Track Storms?

Storms are hard to predict because they form so quickly. Scientists use the best methods possible to try to identify conditions long before a storm occurs. They look for clues, like the movement of fronts and the formation of very low pressure areas. Once these conditions are located, scientists keep a "weather eye" on them to see how they develop.

Special methods are used to find storms as they form. One such method is Doppler radar. The word *radar* stands for *ra*dio *d*etection *a*nd *r*anging. Radar works by sending out radio waves and recording their echo. The change in the radio signal from the original to the echo tells us something about where it reflected.

Doppler radar looks at how the echoes have changed in frequency from the original signals. This information gives clues about the movement of the reflective surface. Doppler radar is a very good tool for scientists to track storms. The radio waves reflect off storm clouds and are picked back up again at the radar stations.

With Doppler radar scientists can tell if rain is moving toward or away from them. Doppler radar can also spot spinning motions of clouds. These motions help warn scientists that tornadoes or hurricanes may be forming. Scientists use Doppler radar to find and track thunderstorms, tornadoes, and hurricanes. Doppler radar helps forecasters predict which way the storms will travel.

How can Doppler radar help in predicting severe storms?

Radar helps forecasters watch how storms form and move.

Lesson Review

Why It Matters

Scientists have used radar systems to track storms since the 1950s. NEXRAD—"NEXt generation of weather RADar"—is a newer form of Doppler radar that is replacing older radar systems. NEXRAD can spot small particles such as blowing dust, very light snow, and even drizzle. NEXRAD is more accurate than conventional radar at predicting floods and flash floods. It can show the exact locations of different fronts. It also shows changes in wind speed and direction. This helps scientists make more accurate weather predictions.

e-Journal Visit our Web site **www.science.mmhschool.com** to do a research project on storms.

Think and Write

1. How does a thunderstorm form?
2. How is a tornado related to a thunderstorm?
3. What causes a hurricane to form? What makes its winds move in a certain direction?
4. Why can hurricanes cause so much damage?
5. **Critical Thinking** Why do you think predicting a severe storm is so difficult?

L·I·N·K·S

WRITING LINK

Explanatory Writing How can you stay safe during an ice storm or a blizzard? Research the ways. Then use the information you find to write a safety manual on how to stay safe during these storms. Include an illustration for each step you list. Be that your safety manual tells people what to do first, next, and last.

ART LINK

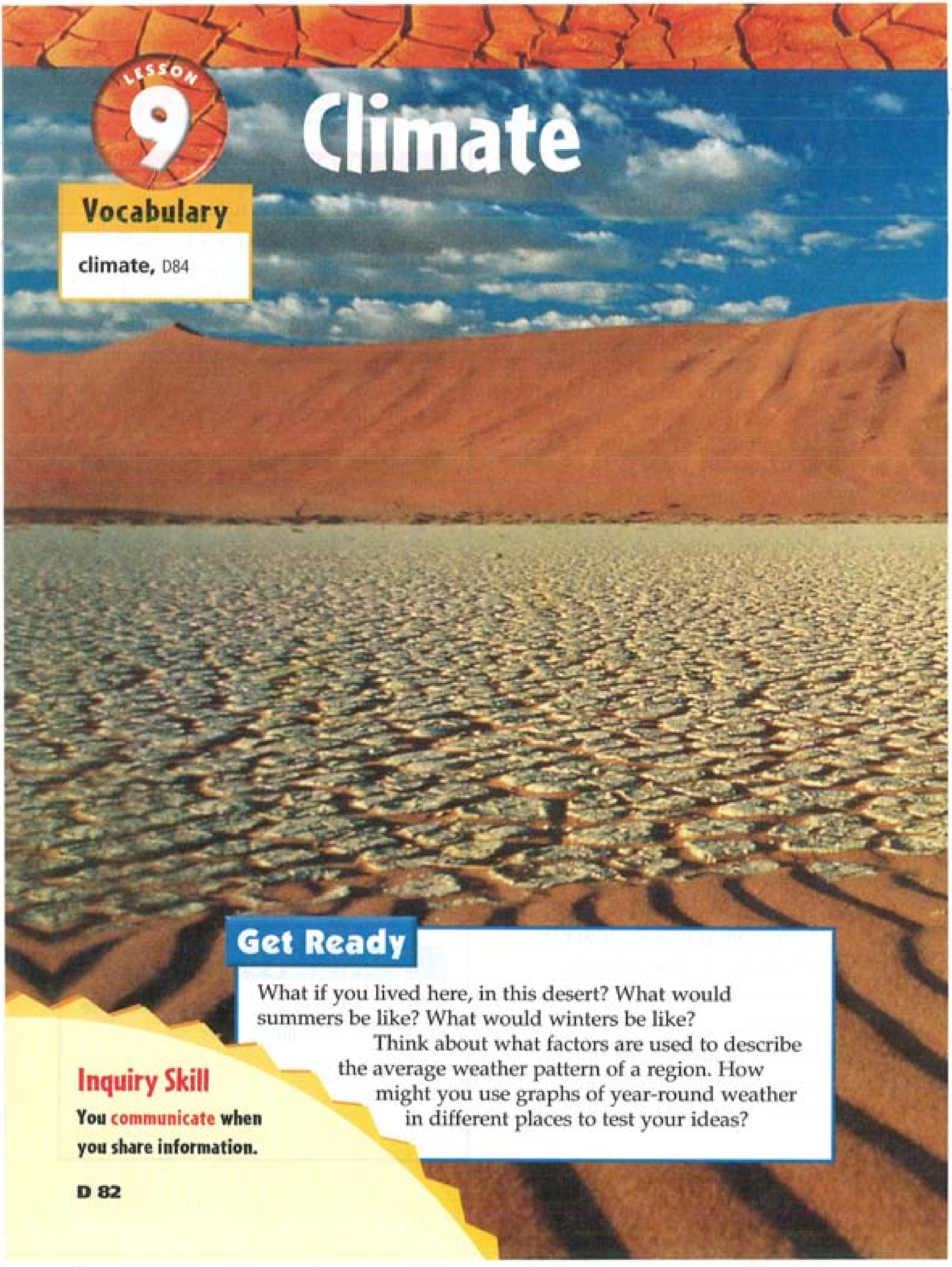
Make a poster. Let others know what to do in a thunderstorm, tornado, or hurricane. Make a poster illustrating important storm safety rules.

MATH LINK

Find the number of tornadoes. Research how many tornadoes hit your state in the past year. Compare that number with the average number listed for your state in the chart on page D75. Were the number of tornadoes in your state last year higher, lower, or the same as the listed average?

TECHNOLOGY LINK

LOG ON Visit **www.science.mmhschool.com** for more links.



LESSON 9

Climate

Vocabulary

climate, D84

Get Ready

What if you lived here, in this desert? What would summers be like? What would winters be like?

Think about what factors are used to describe the average weather pattern of a region. How might you use graphs of year-round weather in different places to test your ideas?

Inquiry Skill

You communicate when you share information.

Explore Activity

What Do Weather Patterns Tell You?

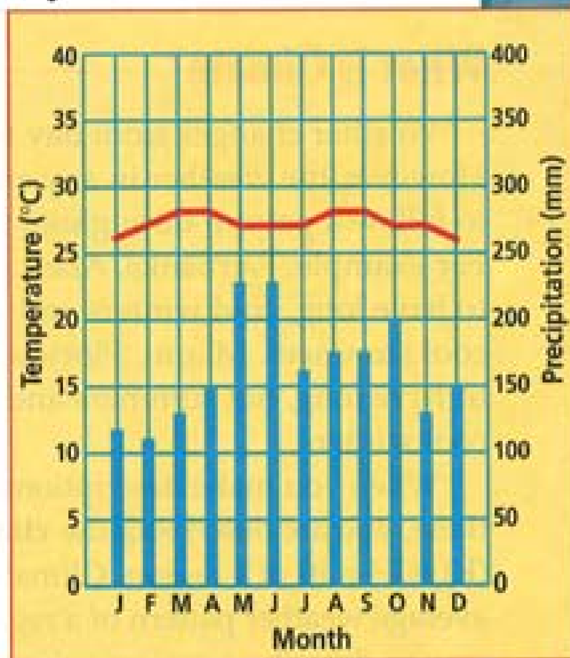
Procedure

1 **Use Numbers** Look at the graph for City 1. The bottom is labeled with the months of the year. The left side is labeled with the temperature in degrees Celsius. Use this scale to read the temperature line. What is City 1's average temperature in July?

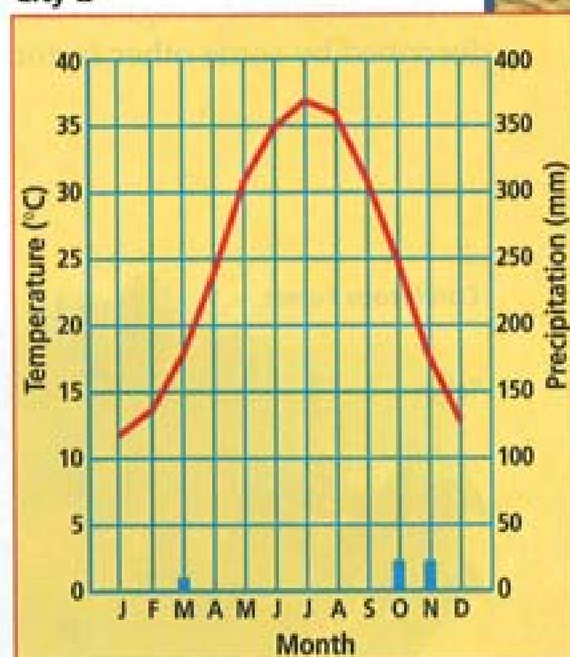
2 **Use Numbers** The right side of the graph shows millimeters (mm) of precipitation. Use this scale to read precipitation bars. What is City 1's average precipitation in July?

3 Repeat steps 1 and 2 for City 2.

City 1



City 2



Temperature (in Celsius)
Precipitation (in millimeters)

Drawing Conclusions

1 **Use Numbers** How does the annual precipitation of the two cities compare?

2 **Interpret Data** When is the average temperature highest for each city? Lowest? When does each city receive the greatest amount of precipitation?

3 **Interpret Data** Describe the average weather pattern for each city. Be sure to include temperature and precipitation, and their relationship to the seasons.

4 FURTHER INQUIRY **Communicate** What would a yearly graph for your community look like? Gather monthly temperature and precipitation data. Construct your graph. Compare it to City 1 and City 2.

Read to Learn

Main Idea **Long-term weather patterns determine climates, which can change over time.**

What Is Climate?

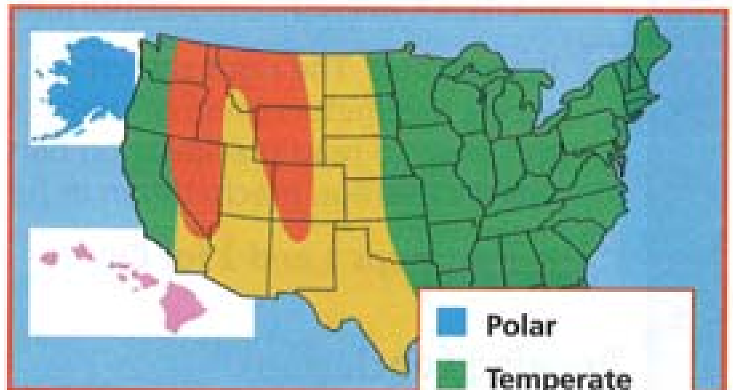
Weather changes from day to day. However, the weather in any area tends to follow a pattern throughout the year. For example, Fairbanks, Alaska, tends to have long, cold winters and short, cool summers. Miami, Florida, tends to have long, hot summers and short, cool winters.

When you make descriptions such as these, you are describing the **climate** (KLIGH·mit) of a region. Climate is the average weather pattern of a region. One way to describe a region's climate is with a temperature-precipitation graph.

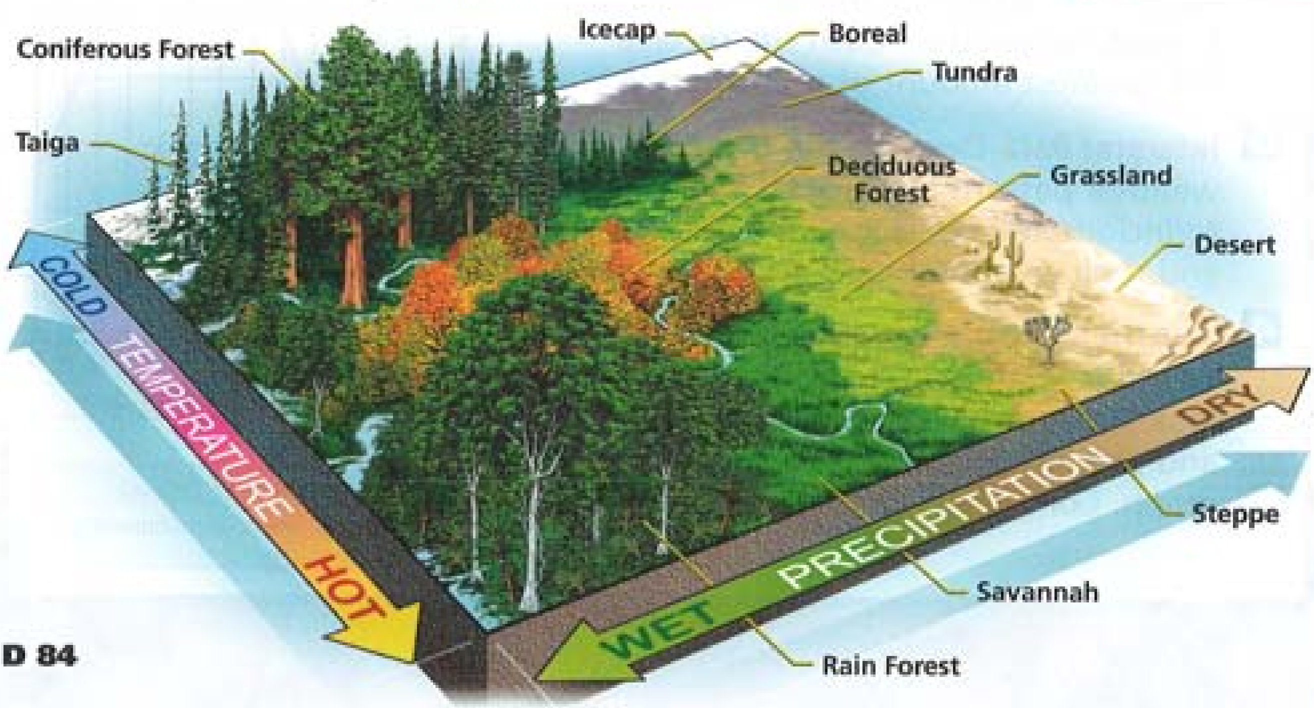
The climate of a region can also be described by some other factors, such as winds, distance from a coast, mountain ranges, and ocean currents. The *climate zones* shown here take all these factors into account.

Another way to describe the climate of a region is by the plants that grow there, such as grasslands or coniferous forests. Each kind of plant requires its own conditions for growth, such as amount of sunlight, precipitation, and temperature.

What factors describe climate?



These are the major climate zones of the United States Which climate zone do you live in?



Inquiry Skill BUILDER

SKILL Measure

Modeling Climates

In this activity you will make a model of the soil conditions in two cities. Use the information in the graphs on page D83. The soil conditions you set up will model—or represent—the climates of the two cities. To do this, you will need to measure the amount of water you use and the amount of time you use the lamp.

Materials

- **stick-on notepaper**
- **marking pencil or pen**
- **2 trays of dry soil**
- **spray bottle of water**
- **lamp**
- **thermometer**

Procedure

1. **Measure** Put 3 cm of dry soil into each tray. Label one tray City 1 and the other tray City 2.
2. **Use Numbers** What do the bars on each graph represent?
3. **Measure** Model the yearly precipitation and temperature like this: Let 5 minutes equal 1 month. One squeeze of water sprayed on the tray equals 10 millimeters of precipitation. Every minute the lamp is on equals 20 degrees of temperature. That means that from 0 to 5 minutes is January. During January the City 2 tray gets no water and the lamp shines on it for $\frac{1}{4}$ minute. The City 1 tray gets 12 squeezes of water and the lamp shines on it for $1\frac{1}{4}$ minutes.
4. **Make a Model** Model the two cities for all 12 months. Record your observations.

Drawing Conclusions

1. **Observe** Examine the soil in the trays. Compare them for the same months. How do they differ?
2. **Communicate** How did measuring help you model climates?

What Affects Climate?

Several things affect temperature and precipitation over a long period of time.

Latitude

One way to describe location is to tell the latitude of a place. Latitude is a measure of how far north or south a place is from the equator. The angle of insolation is different at different latitudes. As a result, the temperatures are different at different latitudes.

- **Tropical Zone** Near the equator temperatures are high all year. Rainfall is plentiful. At about 30° latitude in each hemisphere are deserts, areas of high temperatures and low precipitation.
- **Temperate Zones** In the middle latitudes, summers are warm, and winters are cool or cold. Precipitation may be plentiful.
- **Polar Zones** At high latitudes winters are long and cold. Summers are short and warm. Precipitation all year is low.

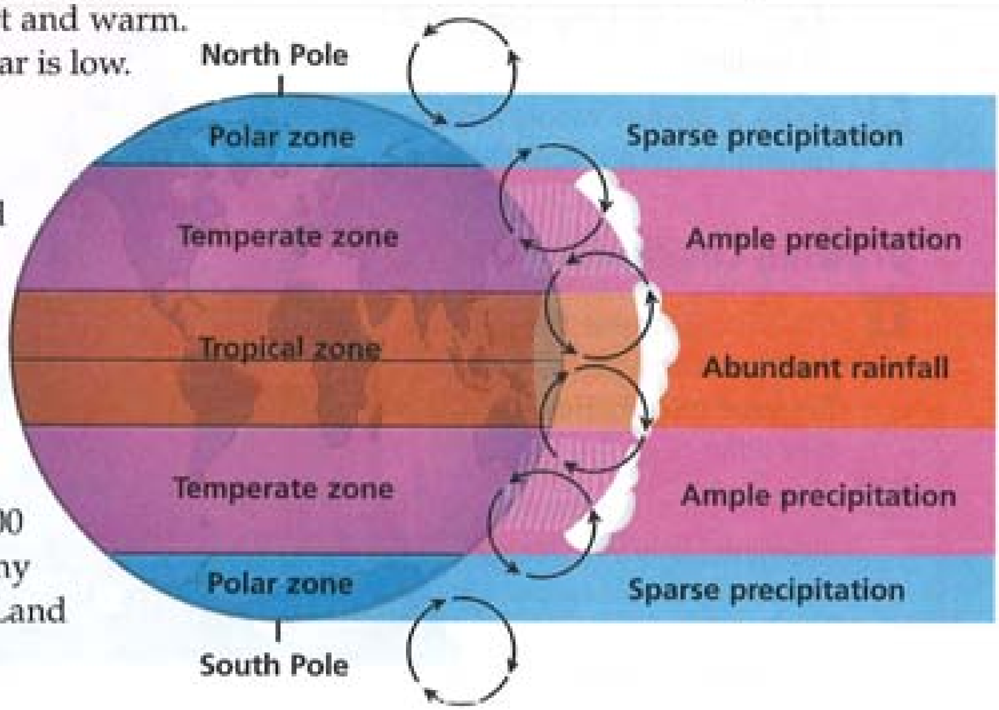
Bodies of Water

A glance at any globe shows that land and water are not evenly distributed. Most of the globe is covered with water. However, some places on a continent can be more than 1,600 km (1,000 mi) from any large body of water. Land and water heat and cool at different rates. Land heats up faster in the sunlight than water does. Land also cools off faster than water. As a result, air temperatures over land are warmer in summer and cooler in winter than they are over oceans at the same latitude.

Winds and Ocean Currents

In Lesson 6 you learned that wind patterns circle the globe. These patterns are not the day-to-day winds. Instead they are winds that blow continually above Earth's surface.

- **Wind Patterns** For example, just above and below the equator, the trade winds blow continually. In the middle latitudes are the westerlies. In the polar areas are the easterlies. Westerlies blow across the continental United States from west (the Pacific) to east (the Atlantic). They bring warm, moist air to the west coast. They push air masses and fronts across the country.

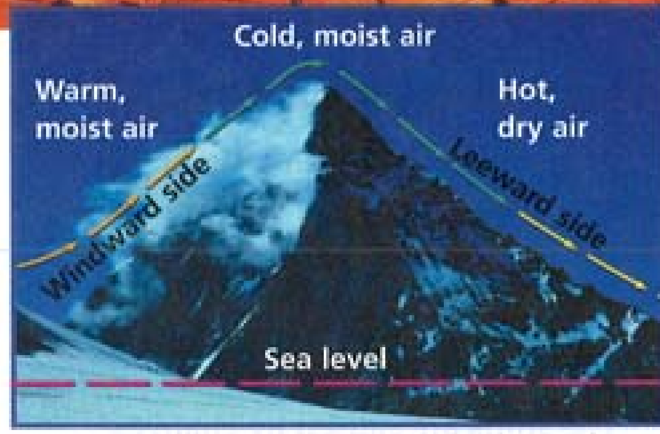


- **Currents** These winds also move water across the surface of the ocean. As ocean water moves, it moves warm or cool air with it. A warm current, the Gulf Stream, flows up along the east coast. The California Current, a cool current, moves down along the west coast.

Altitude

Altitude is a measure of how high above sea level a place is. The higher a place is above sea level, the cooler its climate is.

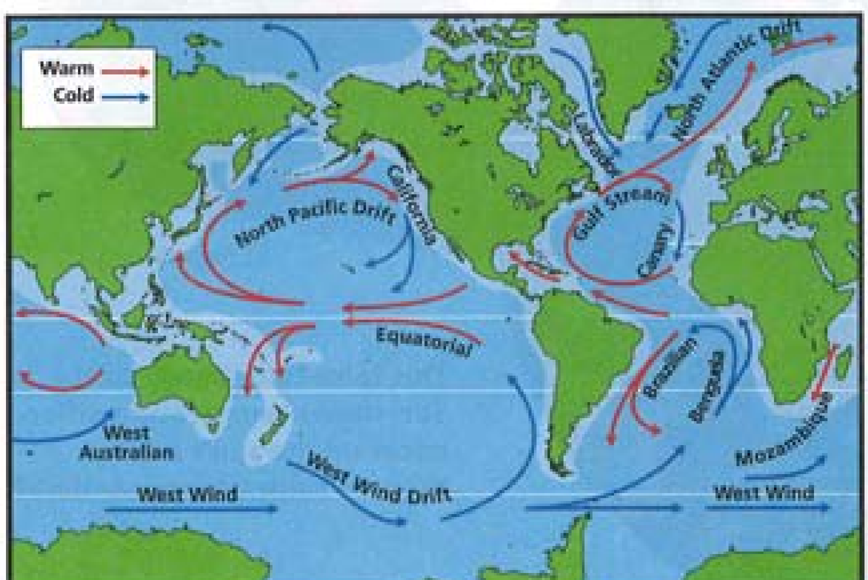
- **Mountains** Along the base of a high mountain, you may find tropical plants growing. Halfway up you might find pine forests. At the mountain peaks, you will find permanent ice and snow. Mountain ranges affect climate, too. The Alps protect the Mediterranean coast from cold polar air. The Himalayas protect the lowlands of India from cold Siberian air. Mountain ranges also affect rain patterns. Often one side of the mountain gets lots of rain while the other side gets very little.



Air passing over a mountain cools. Rain clouds may form and drop their moisture on that side of the mountain. Air reaching the other side is often dry.

- **Rain Shadow** Global wind patterns can force air up along the side of a mountain. For example, warm, moist air from the Pacific Ocean is blown up the side of the Sierra Nevada and the Cascades. As the air moves up, there is precipitation on the windward side. Having lost the moisture, dry air descends down the leeward side of the mountain. This side is said to be in a *rain shadow*.

How does latitude affect climate?



Ocean currents move surface water in huge circular patterns. As ocean currents flow past land areas, they affect the land's climate.

What Causes Climate Change?

There is much evidence that over long periods of time, Earth goes through warming and cooling trends. Warming and cooling are signs that Earth's radiative (energy) balance has shifted. What causes such shifts?

The shifts are caused by changes in sunlight. They are also caused by changes in the movements of air, water, landmasses, and Earth itself.

The Sun's Output

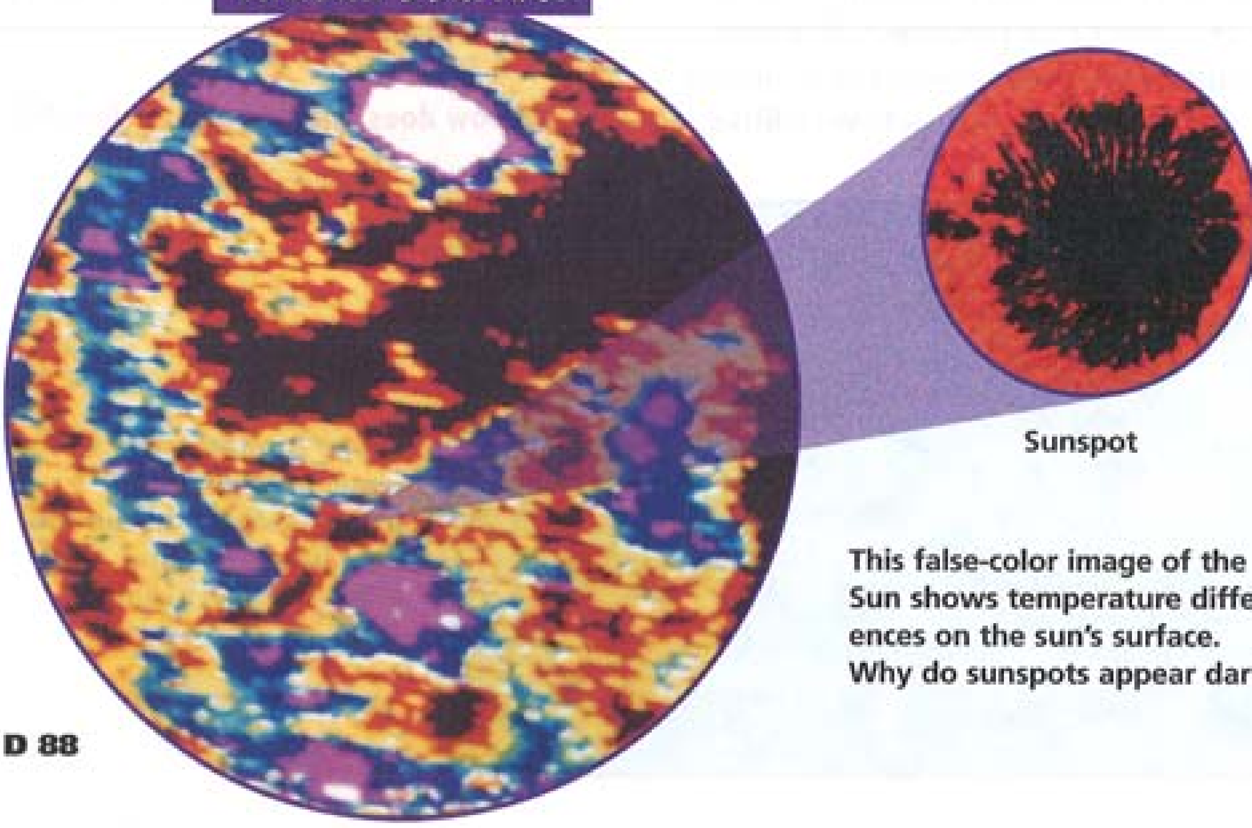
The amount of energy the Sun sends out changes. One clue to how the Sun's output may be changing comes from sunspots. Sunspots are dark areas that appear on the surface of the Sun. They appear dark because they are cooler than the surrounding regions. They appear to be "storms" on the Sun.

Sunspots have been observed for centuries. However, they are not permanent. They appear and disappear over several days or several months.

At times there are many large sunspots. Such a high count is called a *sunspot maximum*. The last sunspot maximum was in 2001.

A sunspot maximum appears to happen about every 11 years. Scientists also record changes in Earth's temperatures about the same times. Around the time of a sunspot maximum, Earth's average temperature has gone up. The pattern is not exact or complete. However, it has led some scientists to suggest that droughts, rainfall, and very cold winters might be related to times when sunspots are very numerous or very few.

The Sun's Surface



This false-color image of the Sun shows temperature differences on the sun's surface. Why do sunspots appear dark?

Currents and Landmasses

How do the oceans help move Earth's heat around? Ocean currents act like huge conveyor belts, carrying heat from the equator to the poles. Changes in the speed and direction of these currents could explain sudden and long-term climate changes.

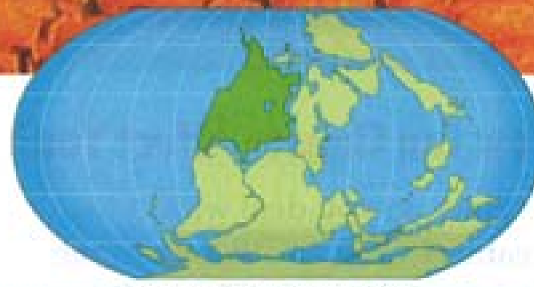
The continents have changed their positions over time. In fact, the continents are still moving very gradually. Their climates are likely to change with their locations.

Volcanoes

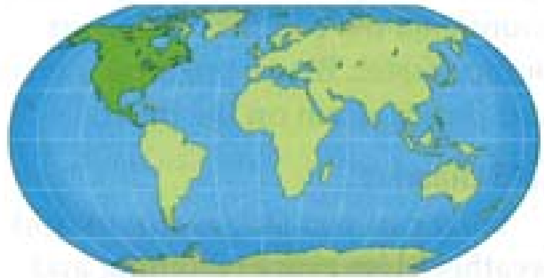
When volcanoes erupt, they send dust and gases into the atmosphere. Atmospheric dust can block sunlight, causing cooling. In the past eruptions were more frequent. The dust from all of those eruptions may have caused enough cooling to trigger ice ages. Volcanic eruptions are not as common today as they were in the past. While eruptions still cause cooling, they probably don't affect long-term climate as much as in the past.

READING Sequence of Events

How might frequent volcanic eruptions change the climate?



300 Million Years Ago



Present

Do you think the ocean currents were the same 300 million years ago as they are today? Changes in ocean currents would profoundly affect climates.

Some of Today's Ocean Currents

How Can Climate Affect You?

How do you deal with cold weather? Cold weather cools the surface of the body. The body responds by circulating warm blood faster to counteract the cooling. The heart pumps faster. Blood pressure increases and puts a strain on the heart.

Cold Climates

How can you stay warm in cold weather? Use proper clothing and shelter. Clothing traps body heat to warm the air close to your body. Cold-weather clothes are often made with materials that trap air between loose fibers. Dressing in layers helps. Your body heats trapped air, and soon a thin, warm layer of air surrounds you.

How to Dress in Hot Weather
Wear light-colored, loose clothing that protects you from the Sun and lets your skin breathe.
Wear a sun hat.
Use sunscreen.

Hot Climates

In hot, dry climates, the main health problem is water loss. Heating the body triggers sweating. When sweat evaporates, it cools the skin. However, if you don't drink enough water, your body eventually stops sweating. No sweat, no cooling. Body temperature rises. This can cause *hyperthermia* (overheating), which can be fatal.

Clothing can help you deal with the heat. Light-colored fabric protects the skin and reflects a lot of the sunlight. Loose clothing lets air circulate so sweat can evaporate and cool the body.

How to Dress in Cold Weather
Protect nose and ears on blustery, cold days.
Keep hands, head, and feet warm.
Dress in layers to trap body heat.

What is the main health problem in hot, dry climates?

Lesson Review

Why It Matters

Since 1900, Earth's average temperature has increased by about 0.5°C (1°F). Most of the warming has come in two periods—from 1920 to 1940 and since the mid-1970s. A drought during the 1920s–1940s led to the Dust Bowl days. Millions of acres of United States farmland dried out. Crops failed. Farmers went broke trying to pay their bills. Many families lost their homes and farms.

Today the warming trend continues.

e-Journal Visit our Web site **www.science.mmhschool.com** to do a research project on global warming.

Think and Write

1. What is climate? What are the main factors that are used to describe the climate of an area?
2. What is a rain shadow?
3. Why are climates different at different places on Earth?
4. **Measure** What variables do you have to measure to describe the average weather pattern, or climate, of a region?
5. **Critical Thinking** Do you think people can live in all climates? Explain your answer.

L·I·N·K·S

WRITING LINK

Persuasive Writing "Greenhouse gases" in the atmosphere let in sunlight, but trap heat. Research what these gases are and how they affect Earth's climate. Write a letter to a politician. Convince this person to pass a law preventing people from placing these gases into the atmosphere.

SOCIAL STUDIES LINK

Report on changing climates. The illustration shows a winter fair on the Thames River in England during the Little Ice Age. Research how Earth's climate changed since farming began. Write a report.

MATH LINK

Make a pie graph. Find out what proportions of greenhouse gases exist in the atmosphere. Make a pie graph.

TECHNOLOGY LINK

LOG ON Visit **www.science.mmhschool.com** for more links.

Chapter 11 Review

Vocabulary

Fill each blank with the best word or words from the list.

air mass, D70
climate, D84
cold front, D72
front, D71
hurricane, D78
lightning, D76
storm surge, D79
thunderstorm, D76
tornado, D77
warm front, D72

1. A boundary between air masses of different temperatures is called a(n) ______.

2. A storm often created in thunderstorms is a(n) ______.

3. A(n) ______ may bring fog.

4. A storm that produces lightning is a(n) ______.

5. A great rise of sea level at a shore due to a hurricane is a(n) ______.

6. Thunderstorms cause large electric sparks called ______.

7. A large region of the atmosphere in which the air has similar properties is a(n) ______.

8. A dangerous storm that forms over warm ocean waters is a(n) ______.

9. A(n) ______ forms when cold air moves in under a warm air mass.

10. The average weather pattern of a region is its ______.

Test Prep

11. Thunderheads are also known as ______.

A cumulus clouds
B cumulonimbus clouds
C stratus clouds
D cirrus clouds

12. Winds curve to the right in the northern hemisphere because of the ______.

F Coriolis Effect
G relative humidity
H Sun
J Moon

13. A ______ usually brings cooler, drier air.

A warm front
B humid day
C storm surge
D cold front

14. The side of a mountain that usually does not get rain is _____.

- **F** in a rain shadow
- **G** facing the Pacific coast
- **H** on the windward side
- **J** facing the wind

15. A hurricane can cause sea level to rise because the air pressure under the hurricane _____.

- **A** is higher than normal
- **B** is lower than normal
- **C** is the same as usual
- **D** does not affect why a hurricane makes the sea level rise

Concepts and Skills

16. Reading in Science Write a paragraph explaining how a thunderstorm forms.

17. Scientific Methods Design a research project to determine whether sunspot activity affects Earth's climate.

18. Product Ads What products are advertised to protect you from the weather in the winter? In the summer? What is each product supposed to do? Are the products as good as the ads say? Write a paragraph explaining your answer.

19. INQUIRY SKILL **Measure** What if your area were to get twice as much rain as usual for the next ten years? Write a paragraph explaining how you would make a model of your climate as it is now. How would you adjust it to study the effect of extra rainfall?

20. Critical Thinking Do you think that Earth is getting warmer? Write a paragraph explaining your hypothesis. Describe what you might do to test your ideas.

Did You Ever Wonder?

INQUIRY SKILL **Form a hypothesis** Are cities warmer than their surrounding areas? How can you test this?

LOG ON Visit **www.science.mmhschool.com** to boost your test scores.

Meet a Scientist

Tim Samaras

TORNADO CHASER

Tornadoes are nature's most powerful storms. They can produce winds that blow at speeds of 300 miles an hour. Tornadoes can destroy homes and kill people. Sometimes people don't have enough warning that a tornado is headed their way. That's where tornado chasers come in. They work to give scientists information to develop warning systems.

Tim Samaras looks for a storm that he thinks will spin off a tornado. Once he spots a tornado, Samaras does the opposite of what most people do. He drives his minivan *toward* the storm to study it.

Inside his minivan are instruments to record weather and wind data. There is also a powerful computer with mapping software to track the storm.

Samaras has also created a tough instrument, or probe. It takes readings from *inside* a tornado. Getting a probe inside a tornado is tricky. Tornadoes don't follow straight paths, so it's hard to guess where they will head next.

In May 2002, near Dodge City, Kansas, Samaras placed a probe in a spot where he hoped a twister would hit. Later, Samaras recovered the probe. It had been inside the twister! The probe had recorded barometric pressure, wind speed, and temperature.

Thanks to the work of storm chasers, scientists are learning why some storms produce tornadoes. They also can be more certain of where a tornado will form. With this information, they are improving storm prediction and saving lives.

Tim Samaras in the field

TOP 5 Worst Years for Tornadoes

The United States has more tornadoes than any other country—about 1,000 a year. Each year, about 38 tornadoes get rated very strong to violent on a scale of wind speed.

1. 1975: 116 strong tornadoes
2. 1965: 75 strong tornadoes
3. 1957: 64 strong tornadoes
4. 1973 and 1976: 59 strong tornadoes
5. 1971: 56 strong tornadoes

Write About It

1. Why is it hard to place a probe in the path of a tornado?
2. Why is the work of storm chasers important?

LOG ON Visit www.science.mmhschool.com to learn more about storm chasers and tornadoes.

Football-Field Solar System

Your goal is to make a model of the solar system.

What to Do

Use the data tables from the Explore activity on page D15 and from the Inquiry Skill Builder on page D17.

Explain how you would make a model solar system on a 100-yard football field, if you placed your model Sun at one end and your model Earth two yards away. Include approximate positions for the asteroid belt, the Kuiper Belt, and the Oort Cloud.

Analyze Your Results

1. Where would Jupiter be placed? Where would Pluto be placed?
2. Approximately where would you place the asteroid belt? Where would you place the Kuiper Belt? The Oort cloud?
3. What else would you have to do if you wanted to make a true scale model of the solar system?

Climate on a Chart

Your goal is to make a climate chart of your local area.

What to Do

A climate chart shows average values for temperature (°C) and precipitation (mm). Use local data to make a climate chart for your area.

Analyze Your Results

1. What is the rainiest month where you live? The least rainy month?
2. What is the hottest month where you live? The coldest?
3. Describe your local climate in words based on your climate chart.