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2.2

KEY CONCEPT

The atmosphere has wind patterns.

BEFORE, you learned

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

NOW, you will learn

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

VOCABULARY

weather p. 47
 wind p. 47
 global wind p. 48
 Coriolis effect p. 49
 jet stream p. 52
 monsoon p. 54

EXPLORE Solar Energy

How does Earth's shape affect solar heating?

PROCEDURE

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

MATERIALS

- globe
- flashlight
- ruler



WHAT DO YOU THINK?

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

Uneven heating causes air to move.

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

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

REMINDER

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

CHECK YOUR READING

What is the relationship between air pressure and wind?

VISUALIZATION

CLASSZONE.COM

View an animation of the Coriolis effect.

How Wind Forms

Wind moves from an area of high pressure toward an area of low pressure.



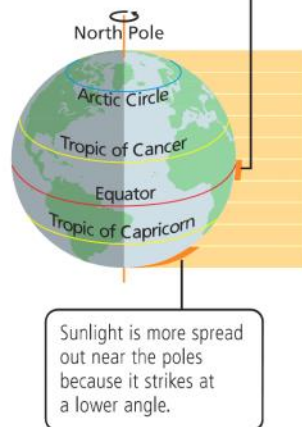
The illustration above shows a common pattern of air circulation caused by uneven heating of Earth's surface:

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

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

CHECK YOUR READING

What factor determines the strength of wind?



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

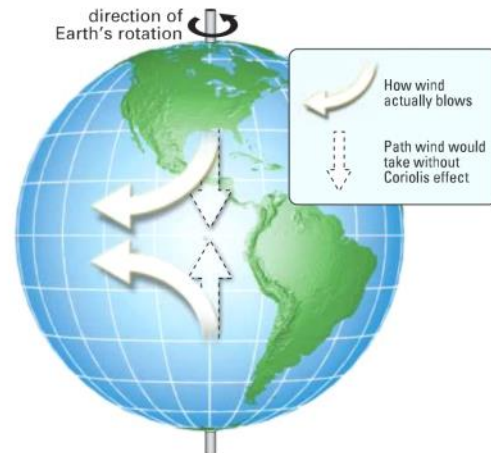
Uneven heating between the equator and the north and south poles causes global winds. Notice in the illustration at left how sunlight strikes Earth's curved surface. Near the equator, concentrated sunlight heats the surface to a high temperature. Warm air rises, producing low pressure.

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

Earth's rotation affects wind direction.

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

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



CHECK YOUR READING

In which direction do winds curve in the Northern Hemisphere?

INVESTIGATE Coriolis Effect

How does Earth's rotation affect wind?

PROCEDURE

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

WHAT DO YOU THINK?

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

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



SKILL FOCUS

Modeling

MATERIALS

- round balloon
- felt-tip pen

TIME

10 minutes





Bands of calm air separate global wind belts.

Earth's rotation and the uneven heating of its surface cause a pattern of wind belts separated by calm regions. Each calm region is a zone of either high pressure or low pressure. The illustration on page 51 shows how each wind belt and the calm regions that border it form a giant loop of moving air. These loops are called circulation cells. The section of a cell that flows along Earth's surface is global wind. Notice that the direction of airflow changes from one circulation cell to the next.

Calm Regions

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

READING TIP

As you read about each region or wind belt, locate it in the diagram on page 51.

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

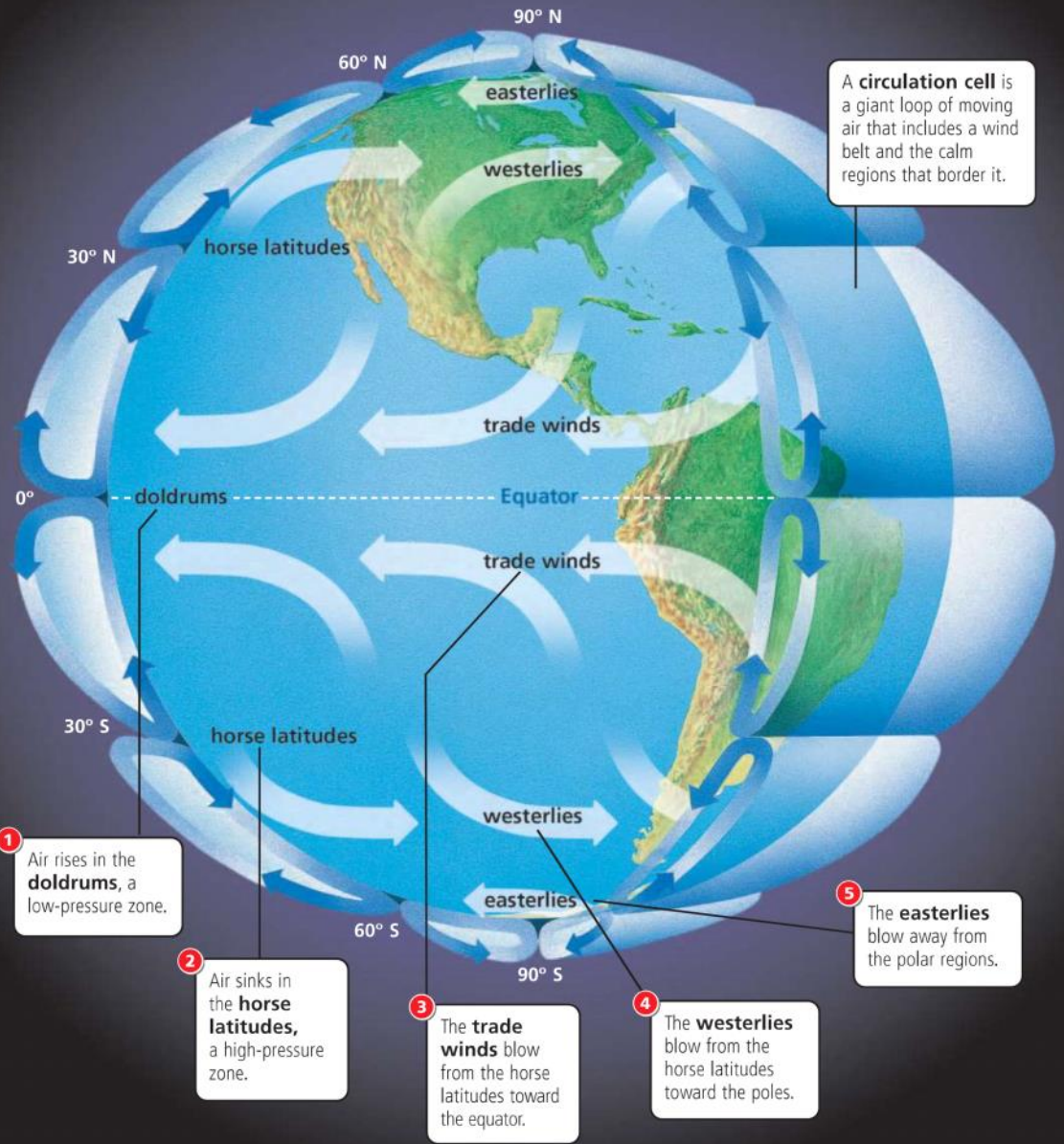
Wind Belts

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

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

Global Winds

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



1 Air rises in the **doldrums**, a low-pressure zone.

2 Air sinks in the **horse latitudes**, a high-pressure zone.

3 The **trade winds** blow from the horse latitudes toward the equator.

4 The **westerlies** blow from the horse latitudes toward the poles.

5 The **easterlies** blow away from the polar regions.

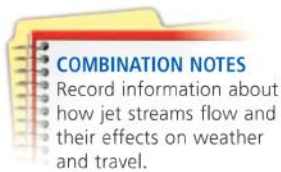
READING VISUALS What are the positions of the calm regions and the wind belts in the circulation cells?

Effects of Wind on Travel

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

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

Jet streams flow near the top of the troposphere.



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



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

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

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

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

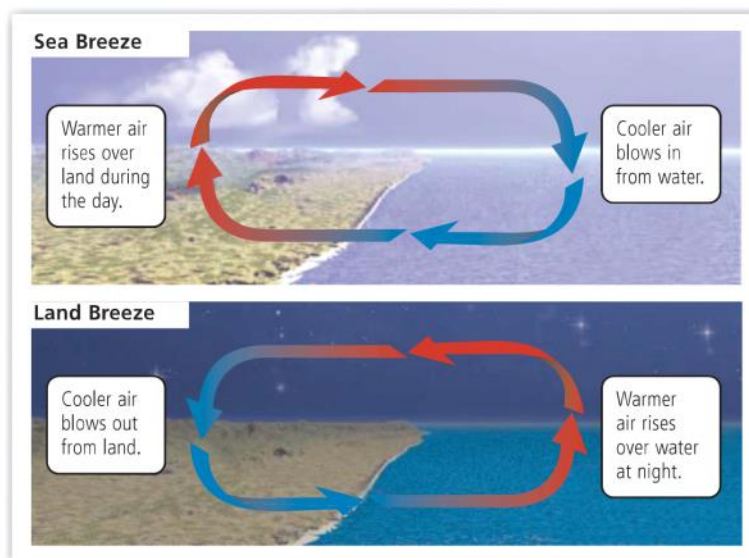
Patterns of heating and cooling cause local winds and monsoons.

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

Local Winds

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

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



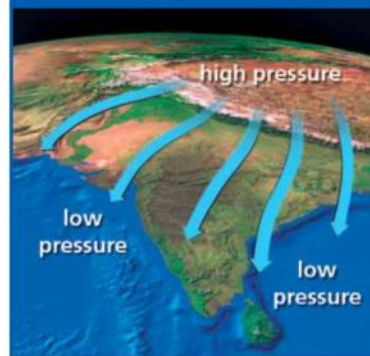
REMINDER

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

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

CHECK YOUR READING

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

Winter Monsoon

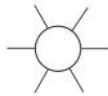
Dry air blows from the high-pressure area over the continent to the low-pressure areas over the ocean.

Summer Monsoon

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

VOCABULARY

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

**Monsoons**

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

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



CHECK YOUR READING How do monsoon winds affect rainfall?

2.2 Review**KEY CONCEPTS**

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

CRITICAL THINKING

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

CHALLENGE

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