Section 3

Atmospheric Circulation

California Content Standards

5a Students know how differential heating of Earth results in circulation patterns in the atmosphere and oceans that globally distribute the heat.
5b Students know the relationship between the rotation of Earth and the circular motions of ocean currents and air in pressure centers.
IE.1d Students will formulate explanations using logic and evidence.

Pressure differences in the atmosphere cause the movement of air worldwide. The air near Earth's surface generally flows from the poles toward the equator. The reason for this flow is that air moves from high-pressure regions to low-pressure regions. High-pressure regions form where cold air sinks toward Earth's surface. Low-pressure regions form where warm air rises away from Earth's surface.

OBJECTIVES

- **Explain** the Coriolis effect. 5b
- **Describe** the global patterns of air circulation, and name three global wind belts. 5a
- **Identify** two factors that form local wind patterns. 5a

KEY TERMS

Coriolis effect
trade winds
westerlies
polar easterlies
jet stream

The Coriolis Effect

The circulation of the atmosphere and of the oceans is affected by the rotation of Earth on its axis. Earth's rotation causes its diameter to be greatest through the equator and smallest through the poles. Because each point on Earth makes one complete rotation every day, points near the equator travel farther and faster in a day than points closer to the poles do. When air moves toward the poles, it travels east faster than the land beneath it does. As a result, the air follows a curved path. The tendency of a moving object to follow a curved path rather than a straight path because of the rotation of Earth is called the **Coriolis effect,** which is shown in Figure 1.

Coriolis effect the curving of the path of a moving object from an otherwise straight path due to Earth's rotation

Winds that blow from high-pressure areas to lower-pressure areas curve as a result of the Coriolis effect. The Coriolis effect deflects moving objects along a path that depends on the speed, latitude, and direction of the object. Objects are deflected to the right in the Northern Hemisphere and are deflected to the left in the Southern Hemisphere.

The faster an object travels, the greater the Coriolis effect on that object is. The Coriolis effect also noticeably changes the paths of large masses that travel long distances, such as air or ocean currents. In general, the Coriolis effect is detectable only on objects that move very fast or that travel over long distances.

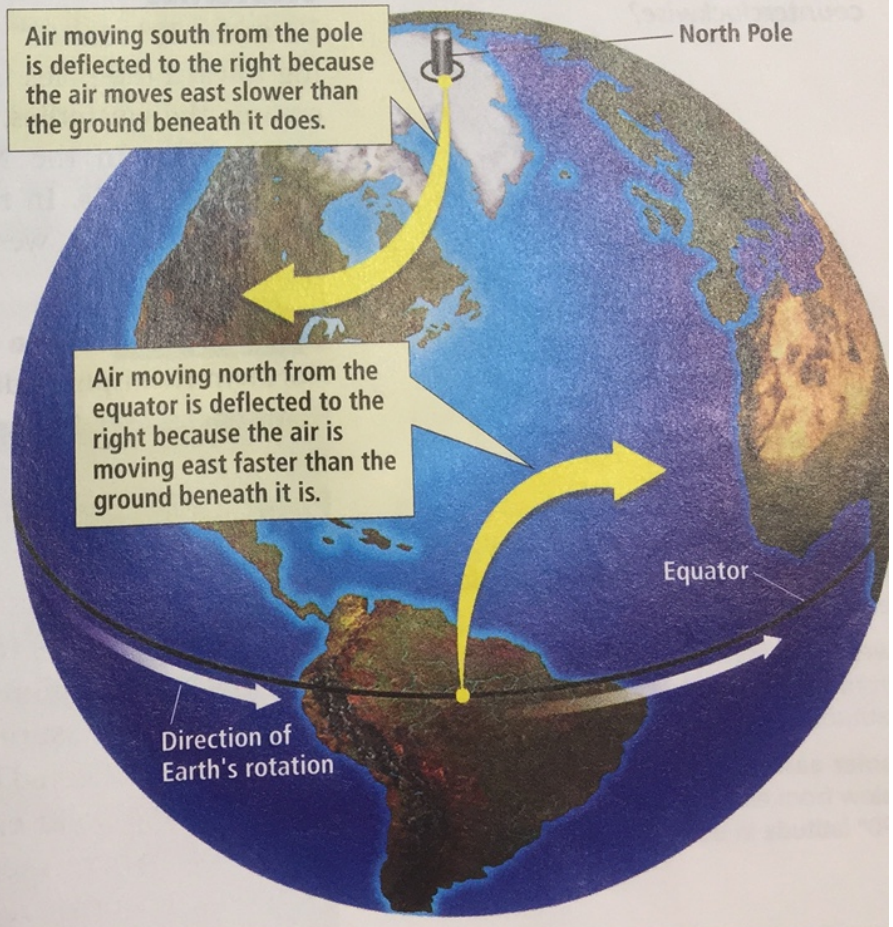


Figure 1 ▶ Because of Earth's rotation, an object that travels north from the equator will curve to the east. This curving is called the Coriolis effect.

Global Winds

The air that flows from the poles toward the equator does not flow in a single, straight line. Each hemisphere contains three looping patterns of flow called *convection cells*. Each of these convection cells correlates to an area of Earth's surface, called a *wind belt*, that is characterized by winds that flow in one main direction. These winds are called *prevailing winds*. All six wind belts are shown in **Figure 2.**

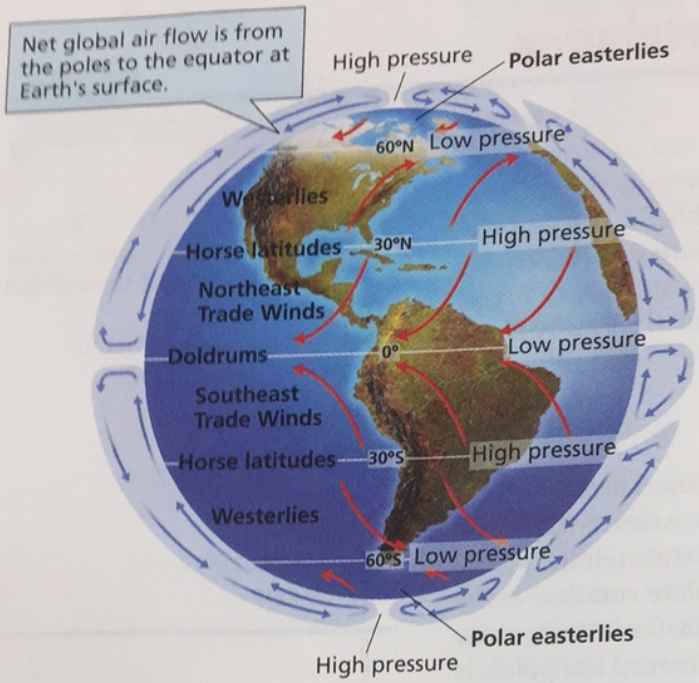


Figure 2 ▶ Each hemisphere has three wind belts. Wind belts are the result of pressure differences at the equator, the subtropics, the subpolar regions, and the poles. Winds in the belts curve because of the Coriolis effect. ***Do winds in the Northern Hemisphere curve clockwise or counterclockwise?***

Trade Winds

In both hemispheres, the winds that flow toward the equator between 30° and 0° latitude are called **trade winds.** Like all winds, the trade winds are named according to the direction from which they flow. In the Northern Hemisphere, the trade winds flow from the northeast and are called the *northeast trade winds*. In the Southern Hemisphere, the trade winds are called the *southeast trade winds*. These wind belts are called *trade winds* because many trading ships sailed on these winds from Europe in the 18th and 19th centuries.

Westerlies

Between 30° and 60° latitude, some of the descending air moving toward the poles is deflected by the Coriolis effect. This flow creates the **westerlies,** which exist in another wind belt in each hemisphere. In the Northern Hemisphere, the westerlies are southwest winds. In the Southern Hemisphere, they are northwest winds. The westerlies blow throughout the contiguous United States.

Reading Check **Name two ways in which the trade winds of the Northern Hemisphere differ from the westerlies of the Northern Hemisphere. (See the Appendix for answers to Reading Checks.)**

trade winds prevailing winds that blow from east to west from 30° latitude to the equator in both hemispheres

westerlies prevailing winds that blow from west to east between 30° and 60° latitude in both hemispheres

polar easterlies prevailing winds that blow from east to west between 60° and 90° latitude in both hemispheres

Polar Easterlies

Toward the poles, or poleward, of the westerlies—at about 60° latitude—is a zone of low pressure. This zone of low pressure separates the westerlies from a third wind belt in each hemisphere. Over the polar regions themselves, descending cold air creates areas of high pressure. Surface winds created by the polar high pressure are deflected by the Coriolis effect and become the **polar easterlies.** The polar easterlies are strongest where they flow off Antarctica. Where the polar easterlies meet warm air from the westerlies, a stormy region known as a *front* forms.

The Doldrums and Horse Latitudes

As **Figure 2** shows, the trade wind systems of the Northern Hemisphere and Southern Hemisphere meet at the equator in a narrow zone called the *doldrums*. In this warm zone, most air movement is upward and surface winds are weak and variable. As the air approaches 30° latitude, it descends and a high-pressure zone forms. These subtropical high-pressure zones are called the *horse latitudes*. Here, too, surface winds are weak and variable.

Wind and Pressure Shifts

As the sun's rays shift northward and southward during the changing seasons of the year, the positions of the pressure belts and wind belts shift. Although the area that receives direct sunlight can shift by up to 47° north and south of the equator, the average shift for the pressure belts and wind belts is only about 10° of latitude. However, even this small change causes some areas of Earth's surface to be in different wind belts during different times of the year. In southern Florida, for example, westerlies prevail in the winter, but trade winds dominate in the summer.

Jet Streams

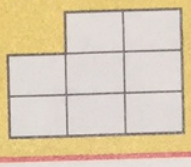
Narrow bands of high-speed winds that blow in the upper troposphere and lower stratosphere are **jet streams.** These winds exist in the Northern Hemisphere and Southern Hemisphere.

One type of jet stream is a polar jet stream. Polar jet streams form as a result of density differences between cold polar air and the warmer air of the middle latitudes. These bands of winds, which are about 100 km wide and 2 to 3 km thick, are located at altitudes of 10 to 15 km. Polar jet streams can reach speeds of 500 km/h and can affect airline routes and the paths of storms.

Another type of jet stream is a subtropical jet stream. In the subtropical regions, very warm equatorial air meets the cooler air of the middle latitudes, and the *subtropical jet streams* form. Unlike the polar jet streams, the subtropical jet streams do not change much in speed or position. A subtropical jet stream is shown in **Figure 3.**

Graphic Organizer **Comparison Table**

Create the **Graphic Organizer** entitled "Comparison Table" described in the Skills Handbook section of the Appendix. Label the columns with "Trade winds," "Westerlies," "Polar easterlies," and "Jet streams." Label the rows with "Latitude" and "Direction.". Then, fill in the table with details about each type of wind.



jet stream a narrow band of strong winds that blow in the upper troposphere

Figure 3 ▶ Clouds in this jet stream are traveling high over Egypt. This remarkable photograph was taken by *Gemini 12* astronauts.

Figure 4 ▶ Sea breezes keep these kites aloft during the afternoon. Overnight, land breezes will blow the flags toward the ocean.

Local Winds

Winds also exist on a scale that is much smaller than a global scale. Movements of air are influenced by local conditions, and local temperature variations commonly cause local winds. Local winds are not part of the global wind belts. Gentle winds that extend over distances of less than 100 km are called *breezes*.

Land and Sea Breezes

Equal areas of land and water may receive the same amount of energy from the sun. However, land surfaces heat up faster than water surfaces do. Therefore, during daylight hours, a sharp temperature difference develops between a body of water and the land along the water's edge. This temperature difference is apparent in the air above the land and water. The warm air above the land rises as the cool air from above the water moves in to replace the warm air. A cool wind moving from water to land, called a *sea breeze*, generally forms in the afternoon, as shown in **Figure 4**. Overnight, the land cools more rapidly than the water does, and the sea breeze is replaced by a *land breeze*. A land breeze flows from the cool land toward the warmer water.

Mountain and Valley Breezes

During the daylight hours in mountainous regions, a gentle valley breeze blows upslope. This *valley breeze* forms when warm air from the valleys moves upslope. At night, the mountains cool more quickly than the valleys do. At that time, cool air descends from the mountain peaks to create a *mountain breeze*. Areas near mountains may experience a warm afternoon that turns to a cold evening soon after sunset. This evening cooling happens because cold air flows down mountain slopes and settles in valleys.

Section 3 Review

1. **Describe** the pattern of air circulation between an area of low pressure and an area of high pressure. 5b
2. **Explain** how the Coriolis effect affects wind flow. 5b
3. **Name and describe** Earth's three global wind belts. 5a
4. **Summarize** the importance of the jet streams. 5a
5. **Identify** two factors that create local wind patterns. 5a

CRITICAL THINKING

6. **Applying Concepts** Determine whether wind moving south from the equator will curve eastward or westward because of the Coriolis effect. 5b, IE.1d
7. **Inferring Relationships** Which has a lower pressure: the air in your lungs as you inhale or the air outside your body? Explain. IE.1d
8. **Applying Ideas** While visiting the Oregon coast, you decide to hike toward the ocean, but you are not sure of the direction. The time is 4:00 P.M. How might the breeze help you find your way? 5a, IE.1d

CONCEPT MAPPING

9. Use the following terms to create a concept map: *wind, sea breeze, global winds, trade winds, westerlies, local winds, polar easterlies, land breeze, mountain breeze,* and *valley breeze*. 5a