6.1 Introduction to Weather

Weather is a term that describes the condition of the atmosphere in terms of temperature, atmospheric pressure, wind, and water. The major energy source for weather events is the Sun. Weather events tend to happen when air masses interact or changes locations. An **air mass** is a large body of air (sometimes covering thousands of square kilometers) with consistent temperature and moisture content throughout. In this section, you will learn how weather happens. You will also learn important terms used for talking about weather.

Weather factors

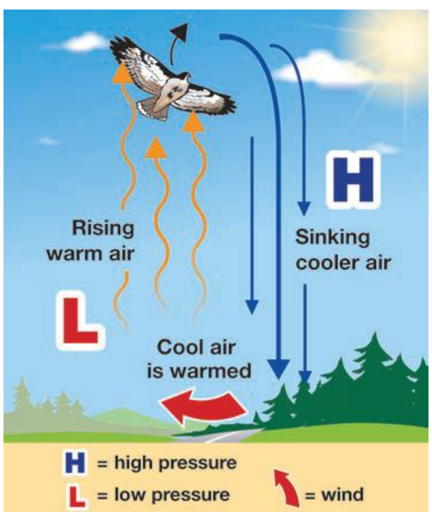
Temperature The temperature of air determines whether it rises or sinks. The Sun warms Earth's surface. As air near the surface is warmed, it expands and becomes less dense. The less-dense air rises. Eventually the warm, less-dense air that rose from the surface cools. The same chain of events that made the air rise now works in reverse and the air sinks back to the ground (Figure 6.1).

Pressure

When warm air rises from Earth's surface, an area of low atmospheric pressure is created. This lower-pressure area draws in air from surrounding higher-pressure areas. Eventually the warm air that rose from the surface cools and becomes denser. This dense, cool air sinks back to the surface causing an area of high atmospheric pressure.

What is wind?

Wind is the horizontal movement of air that occurs as a result of a pressure difference between two air masses. The greater the difference in pressure, the greater the speed of the air flow. Most of these pressure differences are due to unequal heating of the atmosphere.



Convection in the atmosphere

Thermals

A **thermal** is a small, upward flow of warm air. Gliding birds like hawks often ride a thermal as they hunt for food. Pilots of sailplanes (which lack an engine) also ride thermals (Figure 6.2). Thermals usually come and go over a short period of time.

Breezes and specific heat

Convection near coastlines causes *sea breezes* during the day and *land breezes* at night. These breezes occur because water has a higher *specific heat* than land. This means that water warms and cools more slowly than the land.

Sea breezes

During the daytime, the land heats up faster than the ocean. Rising warm air over the land creates a low-pressure area. Eventually the rising air moves out over the sea, cools, and sinks toward the sea surface. The cooling, sinking air mass creates a high-pressure area. Air flows from high- to low-pressure areas. So, during daytime hours, there is a cool sea breeze from sea to land.

Land breezes

During the evening hours, a land breeze occurs because the ground cools rapidly during this time but the ocean remains warm. At night, warm air rises over the sea, creating a low-pressure area. The air sinks over the land creating a high-pressure area. The breeze then flows from land to sea.

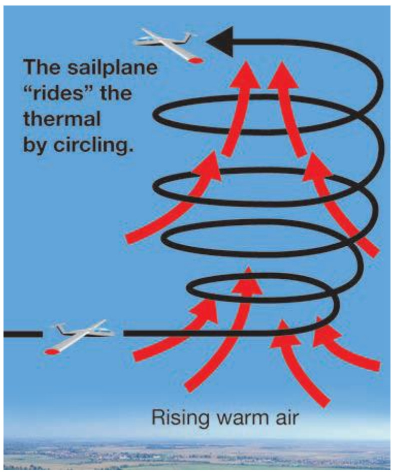
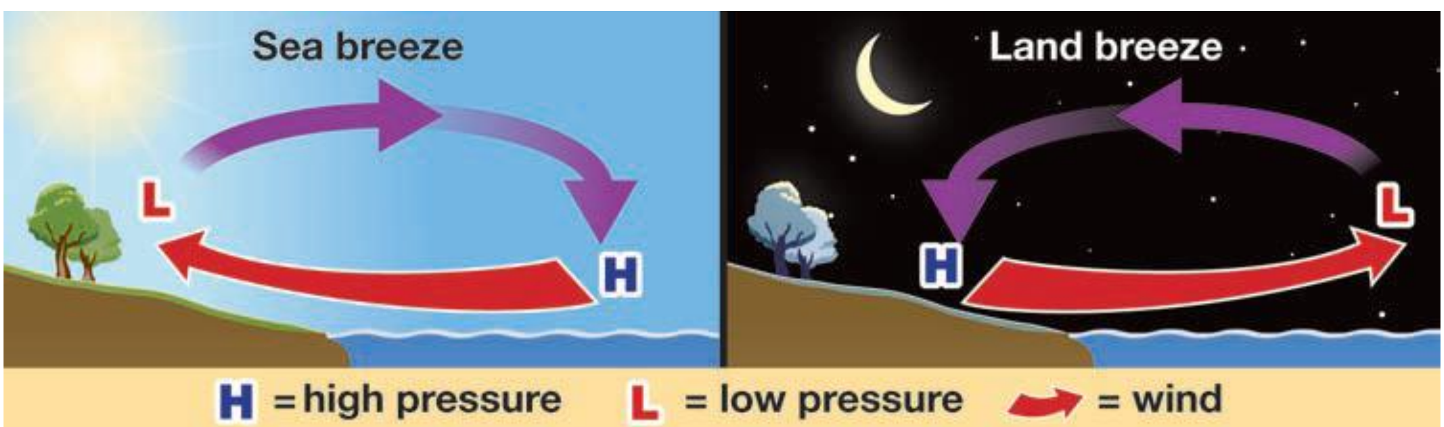


Figure 6.2: *A thermal is a rising column of warm air. Gliding birds and sailplanes "ride" thermals. In fact, the pilots look for gliding birds to find these invisible air currents.*



The Coriolis effect

Global convection

Convection also occurs on a global scale. Warm, less-dense air at the equator tends to rise and flow toward the poles. Then, cooler, denser air from the poles sinks and flows back toward the equator.

Convection cells

Due to Earth's rotation, rising warm air from the equator doesn't make it all the way to the poles. The combination of global convection and Earth's rotation sets up a series of wind patterns called **convection cells** in each hemisphere. Look at Figure 6.3 and follow the arrows. Do you see where air is rising and sinking?

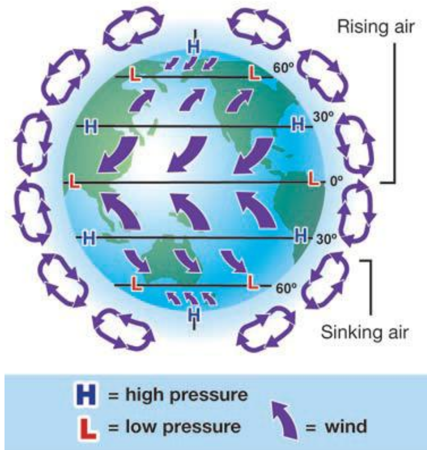


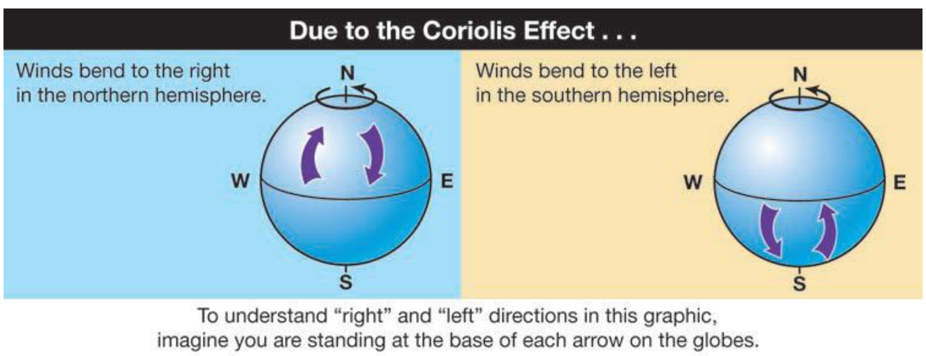
Figure 6.3: *This diagram shows Earth's convection cells and how winds curve due to the Coriolis effect.*

The effects of Earth's rotation

Earth's rotation also changes the direction of airflow. This causes the path of the wind to be curved as it moves between the poles and the equator. In the northern hemisphere, winds bend to the right and move clockwise around a high pressure center (H). In the southern hemisphere, winds bend to the left and move counterclockwise around a high pressure center (H).

The Coriolis effect

This bending of currents of air due to the Earth's rotation is called the **Coriolis effect**. It is named after the French engineermathematician Gaspard Gustave de Coriolis (1792–1843), who first described the phenomenon in 1835.



Global surface wind patterns

Wind and human history

Three important global wind patterns exist in each hemisphere (Figure 6.4). Sailors have used these winds to travel to and explore new lands throughout human history.

Trade winds

The *trade winds* are surface wind currents that move between 30° north or south latitude and the equator. Remember, the air around the equator warms, rises, and flows toward the poles. At about 30° N and 30° S, it cools, sinks, and flows toward the equator again. The Coriolis effect bends the trade winds so that they flow from northeast to southwest in the northern hemisphere and from southeast to northwest in the southern hemisphere.

Prevailing westerlies

The trade winds set up a high-pressure area at about 30° N latitude. Air along the surface between 30° N and 60° N moves northward, from high to low pressure. The air bends to the right due to the Coriolis effect, creating the *prevailing westerlies*. Most of the United States is between 30° N and 60° N, so most of our weather patterns move from southwest to northeast. In the southern hemisphere, the weather patterns between 30° S and 60° S tend to move from the northwest to the southeast.

Polar easterlies

Polar easterlies form when the air over the poles cools and sinks creating a high-pressure area. Like the other global winds, this polar wind is bent by the Coriolis effect. The air flows from northeast to southwest in the northern hemisphere, and from southeast to northwest in the southern hemisphere.

The polar front

At about 60 degrees latitude, the polar easterlies meet the prevailing westerlies, at a boundary called the *polar front*. Here, the dense polar air forces the warmer westerly air upward. Some warmer air flows toward the poles, and some flows back toward the 30 degree latitude line.

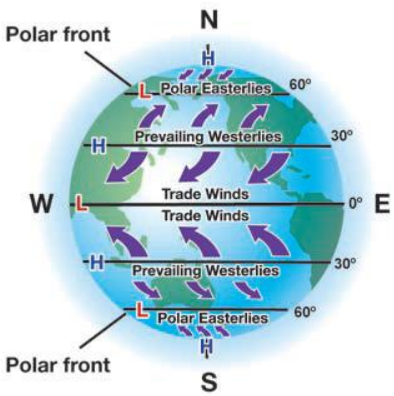


Figure 6.4: *Global surface wind patterns.*

Air and water vapor

Water vapor

You have just learned how air temperature and atmospheric pressure influence weather. Now let's look at a third factor: water vapor in the air. Water vapor is the result of liquid water *evaporating*. Liquid water from oceans, rivers, and even puddles changes to water vapor and mixes with the air (Figure 6.5).

How much water vapor can air hold?

An air mass can be compared to a sponge. Warm air is like a big sponge that can contain a lot of water vapor. Cold air is like a small sponge that can contain less water vapor. Air that contains the maximum amount of water is *saturated*. Like a soggy sponge, saturated air can't hold more water vapor. When more water vapor is added, it condenses and forms droplets.

Relative humidity

Relative humidity is a measure of how much water vapor an air mass contains relative to the total amount of water vapor it could contain at a certain temperature. Let's say we have two air masses with the same number of air molecules. The warm air mass has a greater volume because the molecules are more spaced out. Both air masses contain 50% of the total amount of water vapor they could contain. The graphic below shows that the warm air mass has a greater capacity to hold more water vapor than the cool air mass. It feels more humid on a warm day than on a cool day because warm air can hold so much more water.

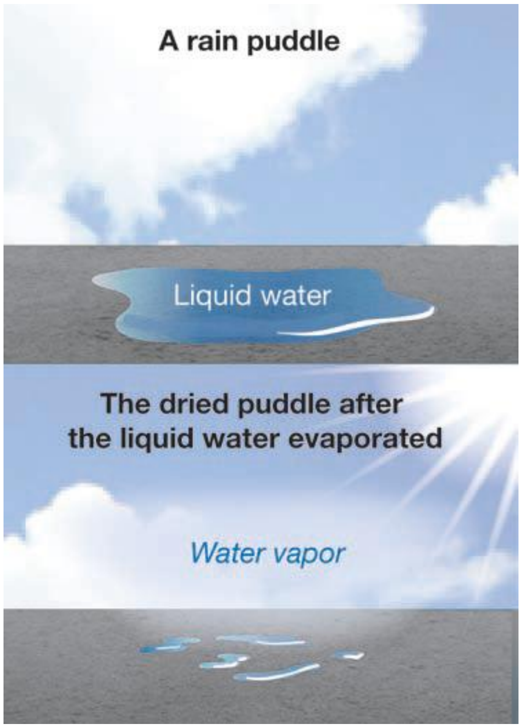


Figure 6.5: *When a puddle dries, the water can becomes water vapor in the atmosphere. However, water in a puddle can also seep into the ground.*

VOCABULARY

weather - the condition of the atmosphere as it is affected by temperature, atmospheric pressure, wind, and water.
air mass - a large body of air with consistent temperature and moisture content throughout.
wind - the horizontal movement of air that occurs as a result of pressure differences between two air masses.
thermal - a small, upward flow of warm air.
convection cells - large wind patterns in Earth's atmosphere caused by convection.
Coriolis effect - the bending of currents of air or water due to Earth's rotation.

6.1 Section Review

1. Define wind. Draw a diagram that illustrates how wind is created.

2. How does convection help birds and sailplanes to fly?

3. Why is the path of the wind curved as it moves from poles to the equator?

4. Why are there three different wind patterns in each hemisphere? What are the names of these wind patterns?

5. Which wind pattern most affects the United States?

6. Which holds more water vapor, a warm or a cold air mass?

7. When the air is filled to capacity with water vapor, it is said to be ___________.

8. What does it mean for an air mass to have 70% relative humidity?

9. An air mass cools to the point where it becomes saturated. What might happen next?

10. A cool (10 °C) air mass warms to 30 °C.
a. Does the volume of the air mass decrease or increase when the temperature goes up?

b. If the amount of water vapor in the air mass stays the same, does the relative humidity increase or decrease when the temperature goes up?