Chapter 9

What Causes Climate? ■ *Section 1 Summary*

Climate is the long-term, average conditions of temperature, precipitation, winds, and clouds in an area. The climate of a region is determined by two main factors: temperature and precipitation.

The same factors that affect climate regions also affect small areas. **Microclimates** are small areas with climate conditions that differ from those around them.

The main factors that influence temperature are latitude, altitude, distance from large bodies of water, and ocean currents. Earth's surface is divided into three temperature zones. The **tropical zone** is the area near the equator, between about 23.5° north latitude and 23.5° south latitude. It has a warm climate because it receives direct sunlight all year. The **polar zones** extend from about 66.5° to 90° north and 66.5° to 90° south latitudes. They have cold climates because the sun strikes the ground at a lower angle. The **temperate zones** are between the tropical and polar zones—from about 23.5° to 66.5° north and 23.5° to 66.5° south latitudes. They have weather that ranges from warm in the summer to cold in the winter. Altitude is an important climate factor because air temperature decreases as altitude increases. Large bodies of water influence temperatures because water heats up and cools down more slowly than land. **Marine climates** have relatively warm winters and cool summers. **Continental climates** occur in inland areas and are often characterized by cold winters and warm or hot summers. Many marine climates are also influenced by ocean currents. **Ocean currents** are streams of water within the oceans that move in regular patterns.

The main factors that affect precipitation are prevailing winds, the presence of mountains, and seasonal winds. A mountain range in the path of prevailing winds influences where precipitation falls. Winds are forced to rise and pass over the mountains. The rising warm air cools, and its water vapor condenses and falls as rain or snow on the **windward** side of the mountains, the side the oncoming wind hits. The land on the **leeward,** or downwind, side of mountains receives little precipitation. Sea and land breezes over a large region that change direction with the seasons are called **monsoons.**

Most places on Earth, outside the tropics, have four seasons. **The seasons are caused by the tilt of Earth's axis as Earth travels around the sun.** The
seasons change as the amount of energy each hemisphere receives from the sun changes. For example, in June the north end of Earth's axis is tilted toward the sun. The Northern Hemisphere receives more energy. It is summer in the Northern Hemisphere and winter in the Southern Hemisphere.

Currents and Climate *Section 2 Summary*

Currents are large streams of moving water that flow through the oceans. Unlike waves, currents carry water great distances. Some currents move water at the surface of the ocean. Other currents move water deep below the surface.

Surface currents, which affect water to a depth of several hundred meters, are driven mainly by winds. Therefore, surface currents follow the major wind patterns of the globe, moving in a circular pattern in the major oceans. The Coriolis effect, which is the effect of Earth's rotation on the direction of winds and currents, is the reason for this circular pattern. The Coriolis effect causes currents to curve to the right in the Northern Hemisphere and to the left in the Southern Hemisphere.

Climate is the pattern of temperature and precipitation typical of an area over a long period of time. Currents affect climate by moving cold and warm water around the globe. **A surface current warms or cools the air above it, influencing the climate of the land near the coast.** The California Current in summer and the Davidson Current in winter help to moderate coastal climates in California.

El Nino and La Nina are short-term changes in the tropical Pacific Ocean caused by changes in ocean surface currents and prevailing winds. El Nino is a warm-water event that causes the surface of the ocean in the eastern Pacific to be unusually warm. It affects weather patterns around the world and is associated with heavy rains, flooding, and mudslides in California. **La Nina** occurs when the waters in the

eastern Pacific are colder than normal.

Deep currents are caused by differences in the density of ocean water. Density, in turn, depends on temperature and salinity. **Salinity** is the total amount of dissolved salts in a water sample. When ice forms near the poles, the salinity of the remaining liquid water increases. This cold, salty water is dense and sinks, flowing along the ocean floor as a deep current. **Deep currents move and mix water around the world. They carry cold water from the poles toward the equator.** They flow much more slowly than surface currents.

Another type of water movement is **upwelling.** This is the upward movement of cold water from the ocean depths to replace warm surface water moved away by winds. **Upwelling brings up tiny ocean organisms, minerals, and other nutrients from the deeper layers of the water.** Without this motion, the surface waters of the open ocean would be very scarce in nutrients. Areas of upwelling usually attract huge schools of fish that feed on these nutrients.

Climate Regions *Section 3 Summary*

Scientists classify climates using a system developed by Wladimir Koppen around 1900. **Scientists classify climates according to two major factors: temperature and precipitation.** The Koppen system identifies broad climate regions. **There are six main climate regions: tropical rainy, dry, temperate marine, temperate continental, polar, and highlands.**

The tropics have two types of rainy climates: tropical wet and tropical wet-and-dry. Tropical wet climates have year-round heat and heavy rainfall. Dense forests grow in tropical wet climates. **Rain forests** have large amounts of rain fall year-round. Tropical wet-and-dry climates have less rainfall and distinct dry and rainy seasons. Tropical grasslands, called **savannas,** are found in tropical wet-and-dry climates.

Dry climates are located in areas where the amount of precipitation is less than the amount of water that could potentially evaporate. Dry climates often lie far from oceans or in the rain shadows of mountains. **Dry climates include arid and semiarid climates.** Arid regions, or **deserts,** get less than 25 centimeters of rain every year. Deserts also have extreme hot and cold temperatures. Semiarid regions, or **steppes,** are usually located on the edges of deserts. A steppe gets enough rainfall for short grasses and low bushes to grow.

Temperate marine climates are humid and have mild winters. **There are three kinds of temperate marine climates: marine west coast, Mediterranean, and humid subtropical.** Marine west coast climates are the coolest temperate marine climates. Humid ocean air brings cool, rainy summers and mild, rainy winters. Mediterranean climates are drier and warmer. In winter, ocean air masses bring cool, rainy weather. Summers are warmer and drier. **Chaparral,** areas with dense shrubs and small trees, are found here. **Humid subtropical** climates are wet and warm, but not as constantly hot as the tropics.

Temperate continental climates are only found on continents in the Northern Hemisphere, and include humid continental and subarctic. Humid continental climates have constantly changing weather. In winter, the weather is bitterly cold with some rain or snow. Summers are hot with high humidity and moderate rainfall. The **subarctic** climates lie north of the humid continental climates. Summers are short and cool. Winters are long and bitterly cold.

The polar climate is the coldest climate region, and includes the ice cap and tundra climates. Ice cap and tundra climates are found only near the poles. Ice caps are covered with ice and snow, and temperatures are always at or below freezing. The **tundra** climate region stretches across northern Alaska, Canada, and Russia. It has short, cool summers followed by bitterly cold winters. Some layers of the tundra soil, called **permafrost,** are always frozen.

Temperature falls as altitude increases, so highland regions are colder than the regions that surround them. Increasing altitude produces climate changes similar to the climate change you would expect with increasing latitude.

Climate Change *Section 4 Summary*

Throughout Earth's history, climates have gradually changed. Over millions of years, warm periods have

alternated with cold periods known as **ice ages,** or glacial episodes. During each ice age, glaciers covered large parts of Earth's surface.

Most past changes in world climates were caused by natural factors. But recently scientists have observed climate changes that could be the result of human activities. For example, over the last 120 years, the average temperature of the troposphere has risen by 0.7°C. This gradual increase in the temperature of Earth's atmosphere is called **global warming.**

Gases in Earth's atmosphere hold in heat from the sun, keeping the atmosphere at a comfortable temperature for living things. The process by which gases in Earth's atmosphere trap energy is called the greenhouse effect. Gases in the atmosphere that trap energy are called **greenhouse gases.** Carbon dioxide, water vapor, and methane are some of the greenhouse gases. **Many scientists have hypothesized that human activities that add greenhouse gases to the atmosphere are warming Earth's atmosphere.**

Many scientists think that an increase in carbon dioxide is a major factor in global warming. Since the late 1800s, the level of carbon dioxide in the atmosphere has increased steadily. This increase could be due to human activities such as the burning of wood, coal, oil, and natural gas. Other scientists think that the warming of Earth is a natural variation in the climate.

The effects of global warming are not known. The possible effects might include increased farming in some areas, destruction of fertile land in other areas, increased hurricane strength, and flooding of low-lying coastal areas due to increased sea levels caused by melting glaciers and polar ice caps.

Another global change in the atmosphere involves the ozone layer. **Chemicals produced by humans have been damaging the ozone layer.**
A large area of reduced ozone, or **ozone hole,** was being created. A major cause of the ozone depletion is a group of compounds called **chlorofluorocarbons,** or CFCs. CFCs can last decades and rise all the way to the stratosphere. In the stratosphere, ultraviolet radiation breaks down the CFC molecules into atoms, including chlorine. The chlorine atoms then break ozone down into oxygen atoms. A decrease in ozone results in an increase in the amount of ultraviolet radiation that reaches Earth. Ultraviolet radiation can cause eye damage and several kinds of skin cancer. In the United States, it will take until 2010 to completely eliminate the use of CFCs.