Name Date Class

Chapter 7: The Atmosphere

■ *Section 1 Summary*

The Air Around You

Weather is the condition of Earth's atmosphere at a particular time and place. Earth's **atmosphere** is the envelope of gases that surrounds the planet.

Earth's atmosphere is made up of nitrogen, oxygen, carbon dioxide, water vapor, and many other gases, as well as particles of liquids and solids.

Plants and animals take oxygen directly from air and use it to release energy from food. A form of oxygen called **ozone** contains three oxygen atoms in each molecule instead of the usual two.

Carbon dioxide is very important because plants need it to survive. The burning of fuels such as gasoline and coal also produces carbon dioxide. **Water vapor** is invisible—it is water in the form of a gas. Water vapor is important in weather. It produces clouds and precipitation.

Earth's atmosphere makes conditions on Earth suitable for living things. The atmosphere contains oxygen and other gases that living things need. The atmosphere also keeps Earth's surface warm and protects Earth from dangerous radiation and meteoroids.

Pollutants are harmful substances in the air, water, or soil. Air pollution can affect the health of humans and other living things. Some air pollution occurs naturally, but many types of pollution are the result of human activity. Although many natural processes add particles to the atmosphere, most air pollution is the result of burning fossil fuels, such as coal, oil, gasoline, and diesel fuels.

The burning of fossil fuels can cause smog and acid rain. The brown haze that develops in sunny cities is called photochemical smog. **Photochemical smog** is formed by the reaction of sunlight to pollutants such as hydrocarbons and nitrogen oxides.

Another result of air pollution is **acid rain,** rain that contains more acid than normal. Acid rain is sometimes strong enough to damage the surfaces of buildings and statues. It also harms lakes and ponds.

In the United States, federal and state governments have passed a number of laws and regulations to reduce air pollution. The Environmental Protection Agency (EPA) monitors the air pollutants in the United States. Air quality in this country has generally improved over the last 30 years. However, the air in many American cities is still polluted. There is an ongoing debate about the costs and benefits of stricter regulations.

■ *Section 2 Summary*

Air Pressure

Air consists of atoms and molecules that have mass. Therefore, air has mass. **Because air has mass, it also has other properties, including density and pressure.** The amount of mass in a given volume of air is its **density.** The force pushing on an area or surface is called **pressure. Air pressure** is the result of the weight of a column of air pushing down on an area. The molecules in air push in all directions. This is why air pressure doesn't crush objects.

A **barometer** is an instrument that is used to measure air pressure. **Two kinds of barometers are mercury barometers and aneroid barometers. A mercury barometer** consists of a glass tube open at the bottom end and partially filled with mercury. The open end of the tube rests in a dish of mercury, and the space above the mercury in the tube contains almost no air. The air pressure pushing down on the surface of the mercury in the dish is equal to the weight of the column of mercury in the tube. At sea level, the mercury column is about 76 centimeters high, on average. An **aneroid barometer** has an airtight metal chamber that is sensitive to changes in air pressure. The thin walls of the chamber flex in and out as air pressure changes, and the movements are recorded on a dial.

In weather reports, air pressure usually is given in inches of mercury. National Weather Service maps indicate air pressure in millibars. One inch of mercury equals 33.87 millibars.

Altitude, or elevation, is the distance above sea level. **Air pressure decreases as altitude increases. As air pressure decreases, so does density.**
Sea-level air has the weight of the whole atmosphere pressing on it, so air pressure is higher at sea level. Air pressure is much lower at the tops of mountains. There, the low density of air can make it hard to breathe because there is less oxygen in each cubic meter of air.

■ *Section 3 Summary*

Layers of the Atmosphere

Scientists divide Earth's atmosphere into four main layers classified according to changes in temperature. These layers are the troposphere, the stratosphere, the mesosphere, and the thermosphere.

You live in the inner, or lowest layer of Earth's atmosphere, the **troposphere. The troposphere is the layer of the atmosphere in which Earth's weather occurs.** The depth of the troposphere varies from 16 kilometers above the equator to less than 9 kilometers above the North and South Poles.

The **stratosphere** extends from the top of the troposphere to about 50 kilometers above Earth's surface. **The stratosphere is the second layer of the atmosphere and contains the ozone layer.** The ozone layer is important because it protects Earth's living things from dangerous ultraviolet radiation from the sun.

Above the stratosphere, a drop in temperature marks the beginning of the next layer, the **mesosphere.** The mesosphere begins 50 kilometers above Earth's surface and ends at an altitude of 80 kilometers. **The mesosphere is the layer of the atmosphere that protects Earth's surface from being hit by most meteoroids.**

The outmost layer of Earth's atmosphere is the thermosphere. The **thermosphere** extends from 80 kilometers above Earth's surface outward into space. It has no definite outer limit, but blends gradually with outer space. The air in the thermosphere is very hot, up to 1,800°C. Despite the high temperature, you would not feel warm in the thermosphere. **Temperature** is the average amount of energy of motion of all the particles of a substance. Because there are so few particles in the thermosphere, an ordinary thermometer cannot accurately measure the temperature there.

The thermosphere is divided into two layers. The lower layer, called the **ionosphere,** begins about 80 kilometers above the surface and extends to about 400 kilometers. Gas molecules here are electrically charged because of the sun's energy. Radio waves bounce back from the ionosphere to Earth's surface. The brilliant light displays called auroras also occur in the ionosphere. The outer layer of the thermosphere is the **exosphere.**

■ *Section 4 Summary*

Energy in Earth's Atmosphere

Nearly all of the energy in Earth's atmosphere comes from the sun. This energy travels to Earth as **electromagnetic waves,** a form of energy that can travel through space. Electromagnetic waves are classified according to wavelength, or distance between waves. The direct transfer of energy by electromagnetic waves is called **radiation.**

Most of the energy from the sun travels to Earth in the form of visible light. However, a full spectrum of electromagnetic energy is present in solar radiation. Visible light is a mixture of all of the colors that you see in a rainbow. The different colors are the result of different wavelengths of visible light. Red and orange light have the longest wavelengths, and blue and violet have the shortest wavelengths.

Infrared radiation is a form of energy with wavelengths that are longer than those of red light. Infrared radiation is not visible, but can be felt as heat. **Ultraviolet radiation** is a form of energy with wavelengths that are shorter than those of violet light. Ultraviolet radiation can cause sunburns, skin cancer, and eye damage.

Some sunlight is absorbed or reflected by the atmosphere before it can reach the surface. The rest passes through the atmosphere to the surface.
Dust particles and gases in the atmosphere reflect light from the sun in all directions. This is called **scattering.** Scattered light looks bluer than ordinary sunlight, which is why the daytime sky looks blue. During sunrise and sunset, when sunlight passes through a greater thickness of atmosphere, scattering removes more blue light and causes the sun to look red.

When Earth's surface is heated, it radiates most of the energy back into the atmosphere as infrared radiation. Much of this longer-wavelength radiation cannot travel all the way through the atmosphere back into space. Instead, much of it is absorbed by water vapor, carbon dioxide, and other gases in the air. The process by which gases hold heat in the air is called the **greenhouse effect.** The greenhouse effect is a natural process that keeps Earth's atmosphere at a temperature that is comfortable for most living things. However, emissions from human activities may be altering this process.

■ *Section 5 Summary*

Heat Transfer in the Atmosphere

All substances are made up of small particles, which can be atoms or molecules, that are constantly moving. The faster the molecules are moving, the more energy they have. The total energy of motion in the particles of a substance is called **thermal energy.** Temperature is the average amount of energy of motion in each particle of a substance. It is a measure of how hot or cold a substance is. Temperature is one of the most important factors affecting the weather.

Air temperature is usually measured with a thermometer. A thermometer is a thin glass tube with a bulb on one end that contains a liquid, usually colored alcohol. Thermometers work because liquids expand when they are heated and contract when they are cooled.

Temperature is measured in units called degrees. On the Celsius scale, the freezing point of pure water is 0°C and the boiling point of pure water is 100°C. On the Fahrenheit scale, the freezing point of water is 32°F and the boiling point is 212°F.

Heat is the transfer of thermal energy from a hotter object to a cooler one. **Heat is transferred in three ways within the atmosphere: radiation, conduction, and convection.** Radiation is the direct transfer of energy by electromagnetic waves. The direct transfer of heat from one substance to another substance that it is touching is called **conduction.** Conduction works well in some solids, but not as well in fluids (liquids and gases): In fluids, molecules can move from place to place and take their heat with them. The transfer of heat by the movement of a fluid is called **convection.**

Radiation, conduction, and convection work together to heat the troposphere. Air near Earth's surface is warmed by conduction of heat from the surface to the air. **Within the troposphere, heat is transferred mostly by convection.** When the air near the ground is heated, the molecules have more energy and move faster. The molecules bump into one another and move farther apart, and the air becomes less dense. Cooler, denser air sinks, forcing the warmer, less dense air to rise. The upward movement of warm air and the downward movement of cool air form **convection currents.** Convection currents move heat though out the troposphere.

■ *Section 6 Summary*

Winds

A **wind** is the horizontal movement of air from an area of high pressure to an area of lower pressure. **Winds are caused by differences in air pressure.** Most differences in air pressure are caused by unequal heating of the atmosphere. Convection currents form when Earth's surface is heated by the sun. Cool, dense air with higher air pressure flows underneath warm, less dense air, forcing the warm air to rise.

Winds are described by their direction and speed. Wind direction is determined with a wind vane. The name of a wind tells you the direction the wind is coming from. Wind speed is

measured with an **anemometer.**

Wind blowing over your skin removes body heat. The increased cooling that a wind can cause is called the **wind-chill factor.**

Local winds are winds that blow over short distances. **Local winds are caused by the unequal heating of Earth's surface within a small area.** Local winds form only when large-scale winds are weak.

A **sea breeze** is a local wind that blows from an ocean or a lake. The sun heats land faster than it heats water, so during the day the air over land becomes warmer than the air over water. The cool air blows inland from the water and moves underneath the warm air. At night, land cools more quickly than water, so air over land becomes cooler than air over water. The cool air blows toward the water from the land and moves underneath the warm air. The flow of air from land to a body of water is called a **land breeze.**

Winds that blow steadily from specific directions over long distances are called **global winds. Like local winds, global winds are created by the unequal heating of Earth's surface. But unlike local winds, global winds occur over a large area.** Because Earth is rotating, global winds do not follow a straight path. The way Earth's rotation makes winds curve is called the **Coriolis effect.** In the Northern Hemisphere, global winds curve to the right. In the Southern Hemisphere, global winds curve to the left.

The Coriolis effect and other factors combine to produce a pattern of calm areas and wind belts around Earth. **The major global wind belts are the trade winds, the polar easterlies, and the prevailing westerlies.** The
calm areas are called the doldrums and horse latitudes. **Latitude** is distance from the equator, measured in degrees. The trade winds blow between the equator and 30° north and south latitude, the prevailing westerlies between 30° and 60° north and south latitude, and the polar easterlies between 60° north and south latitude and the poles.

About 10 kilometers above Earth's surface are bands of high-speed winds called **jet streams.** These generally blow from west to east.