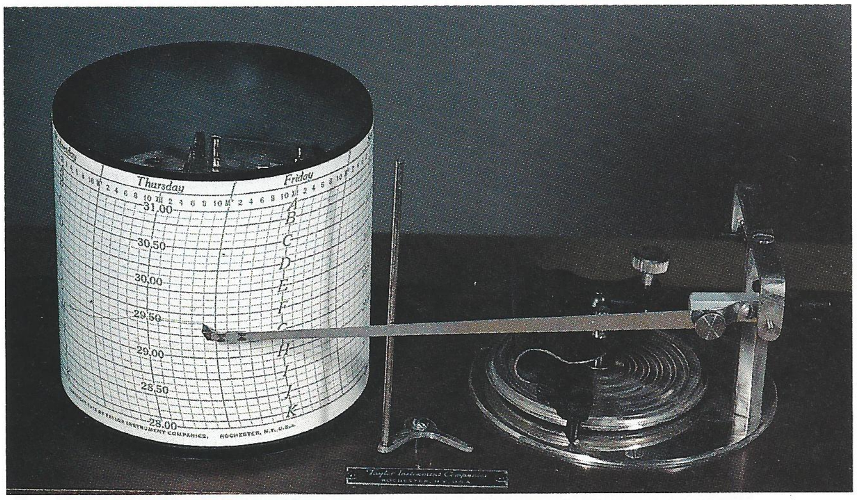

Figure 23–4. Aneroid barometers measure air pressure by the compression and expansion of a sealed metal box. When an aneroid barometer is constructed to keep a continuous record of air pressure, such as the one shown here, it is called a *barograph*.

barometer is called **standard atmospheric pressure** and indicates average atmospheric pressure at sea level. Standard atmospheric pressure, 760 mm or 29.92 inches of mercury, is sometimes referred to as *one atmosphere*.

Official weather maps use another measurement of air pressure, called *millibars* (mb). One millibar is equal to about 0.001 of standard atmospheric pressure.

Aneroid Barometer

The type of barometer most commonly used today does not contain mercury and is called an *aneroid barometer*. The word *aneroid* means "without liquid." Inside an aneroid barometer is a sealed metal container from which the air has been removed. When the atmospheric pressure increases, the sides of the container bend inward. When the pressure decreases, the sides bulge out again. These changes are indicated by a moving pointer on a scale. The movement of the pointer along the scale is controlled by the changing shape of the container. The scale is usually marked to show the pressure either in millimeters or inches of mercury, or in millibars. Aneroid barometers can be constructed to keep a continuous record of atmospheric pressure.

An aneroid barometer can also measure altitude above sea level. When used for this purpose, it is called an *altimeter*. The scale then registers altitude instead of pressure. At high altitudes, the atmosphere is less dense and exerts less pressure. Thus a lowered pressure reading can be interpreted as an increased altitude reading. To accurately measure altitude, an altimeter must be corrected for local weather conditions.

Layers of the Atmosphere

As altitude increases, air pressure decreases rapidly. There are no sharp pressure changes that separate the atmosphere into layers. The atmosphere does, however, show distinct differences in temperature with increasing altitude. The temperature differences mainly result from the way solar energy is absorbed as it moves downward through the atmosphere. Based on temperature differences, scientists identify four layers of the atmosphere.

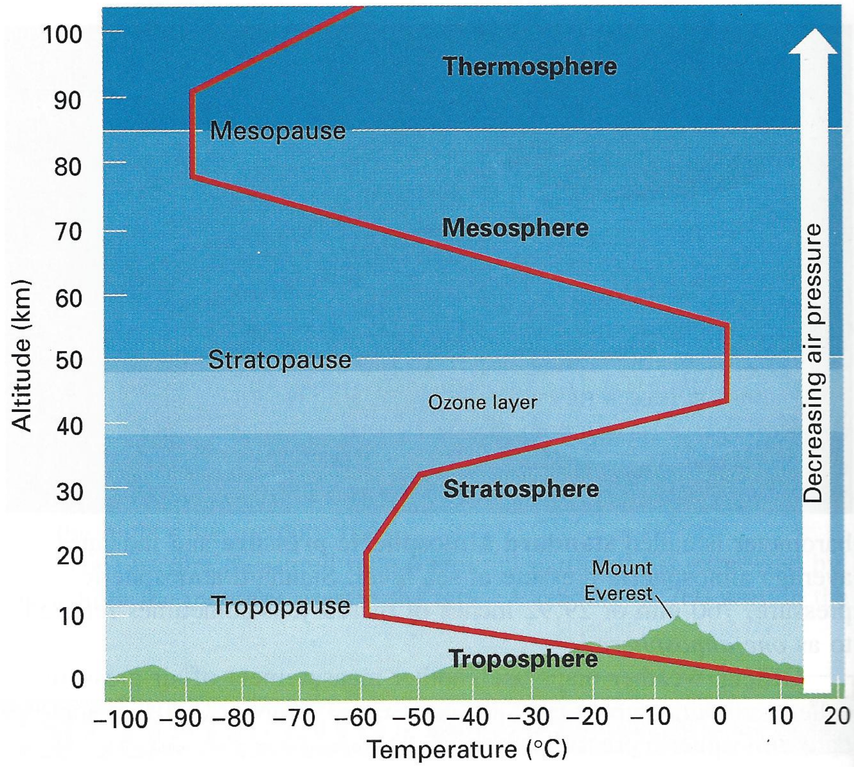

Figure 23–5. The red line indicates the temperature at various altitudes in the atmosphere.

The Troposphere

The atmospheric layer closest to the earth's surface is called the **troposphere.** The word *troposphere* comes from a Greek root meaning "change." The term aptly describes this atmospheric layer in which nearly all weather change occurs. Almost all of the water vapor and carbon dioxide in the atmosphere is found in the troposphere. Temperature within this layer decreases as altitude increases because there is an increase in distance from the warming effect of sunlight absorbed by the earth's surface. The temperature within the troposphere decreases at the average rate of 6.5°C/km. But at an average altitude of 10 km, the temperature stops decreasing. In this zone, called the **tropopause,** the temperature remains nearly constant. The tropopause is the upper boundary of the troposphere. The altitude of this boundary is not constant; it changes with latitude and with the season of the year. For example, at the equator the tropopause is found at an altitude of about 17 km. However, at the poles the altitude of the tropopause varies between 6 km and 8 km.

The Stratosphere

The layer of the atmosphere called the **stratosphere** extends upward from the tropopause to an altitude of 50 km. Almost all of the ozone in the atmosphere is concentrated in the stratosphere. At the base of the stratosphere, the temperature is about –60°C. In the upper stratosphere, the temperature begins to increase as the altitude increases. The air in the stratosphere gets warmer as a result of the direct absorption of solar energy by ozone.

The temperature of the ozone layer rises steadily to an altitude of about 50 km, where the stratosphere reaches its highest temperature. This high-temperature zone, called the **stratopause,** marks the upper boundary of the stratosphere.

The Mesosphere

Above the stratopause and extending to an altitude of about 80 km is the atmospheric layer called the **mesosphere.** In this layer, the temperature decreases as the altitude increases. In fact, the mesosphere is the coldest layer of the atmosphere, dropping to a temperature of −90°C. The upper boundary of the mesosphere, called the **mesopause,** is marked by a return to increasing temperatures.

The Thermosphere

In the atmospheric layer above the mesopause, called the **thermosphere,** the temperature increases steadily with altitude. In the thermosphere, nitrogen and oxygen atoms absorb solar energy. This process explains the high temperatures in the thermosphere. There are not enough data about temperature changes in the thermosphere to determine its upper boundary.

In the very thin air of the thermosphere, a thermometer cannot accurately measure the temperature. A thermometer measures the temperature of the particles, or the energy of the moving molecules, that strike it. Because the air in the thermosphere is so thin, the particles move rapidly but are very far apart. Therefore, they do not strike the thermometer often enough to produce an accurate temperature reading. Special instruments are needed to measure temperature accurately in the thermosphere. These instruments have recorded temperatures of more than 2,000°C in the thermosphere.

The lower region of the thermosphere, at an altitude of 80 km to 550 km, is often called the **ionosphere.** In the ionosphere solar rays absorbed by atmospheric gases cause the atoms of gas molecules to lose electrons and to produce ions and free electrons. The ionosphere gets its name from these ions. The ions and the free electrons are concentrated into four layers. The layers of free electrons can reflect radio waves back to the earth, as shown in Figure 23–6.

Above the ionosphere is the region where the earth's atmosphere blends into the almost-complete vacuum of interplanetary space. This zone of indefinite altitude, called the **exosphere,** extends for thousands of kilometers above the earth.

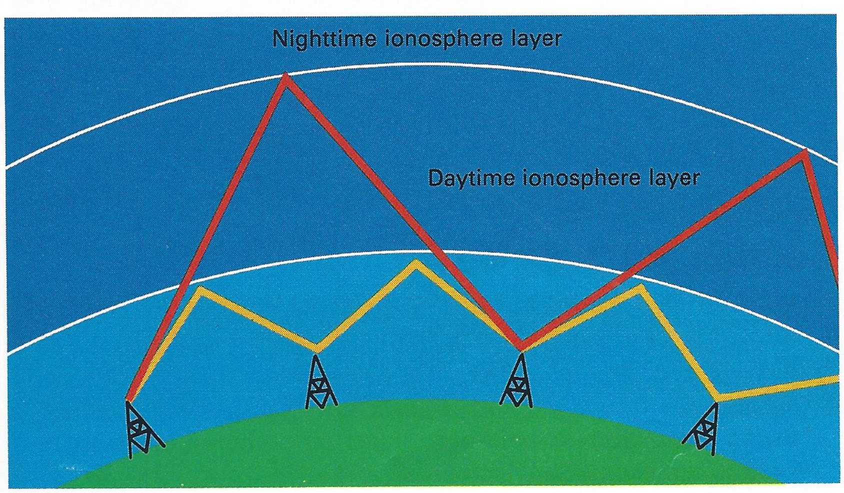

Figure 23–6. Radio waves can be transmitted around the world by reflecting them off of the ionosphere. At night the radio waves can travel farther because the lowest ion layer disappears and the waves are reflected off a higher ion layer.

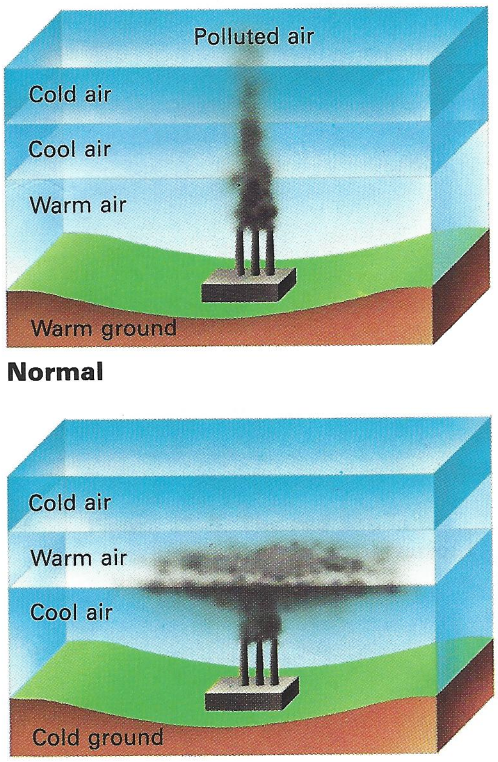

Figure 32–7. Normal conditions are shown at top, and a temperature inversion is shown at bottom. During a temperature inversion, polluted cool air becomes trapped beneath a warm-air layer.

Air Pollution

Any substance in the atmosphere that is harmful to people, animals, plants, or property is an *air pollutant*. Many substances commonly found in air, such as sulfur dioxide, carbon monoxide, lead, and hydrocarbons, are known to be harmful when breathed by humans.

On a few occasions, severe air pollution has caused a large number of deaths. Less dramatic but perhaps more serious are the long-term effects on the health of people, especially children and the elderly, who breathe polluted air. Studies have shown that long-term exposure to pollution decreases one's ability to resist many illnesses.

The main source of air pollution is the burning of fossil fuels. Before automobiles became common, most air pollution resulted from the burning of coal by industry and in homes. Today most air pollution comes from the burning of coal and petroleum fuels. When these fuels burn, the sulfur that is released forms harmful sulfur dioxide gas. The operation of automobile engines produces several harmful substances, such as hydrocarbons, nitrogen oxides, carbon monoxide, and lead.

Acid precipitation is another harmful side effect of the burning of fossil fuels. Gases emitted by the burning of fossil fuels form acids when combined with water in the air. These acids fall to the earth as acid rain, mist, or snow. Over time, acid precipitation poisons fish, ruins soil, and kills crops and trees.

Air pollution can become an even more serious problem as a result of certain weather conditions. A common cause of periodic air pollution is the layering of warm air on top of cool air. Warm air, which is less dense, can trap the polluted cool air beneath it. Meteorologists refer to this condition as a **temperature inversion.** In some areas, topography may make air pollution even worse by keeping the polluted inversion layer from dispersing. Los Angeles, for example, is the site of frequent temperature inversions. Cool Pacific air becomes polluted, is trapped by a warm-air layer above it, and is prevented from moving by mountains that border the city. Under conditions in which air cannot circulate up and away from an area, trapped automobile exhausts produce *smog*. Smog is a general term for air pollution. It was named for a combination of smoke and fog.

Air pollution can be controlled only by preventing pollutants from being released into the atmosphere. International, federal, and local laws have been passed to reduce the amount of air pollutants produced by automobiles and industry.

Section 23.1 Review

1. What are the two most abundant elements in dry air?
2. What does a barometer measure?
3. In which layer of the atmosphere do weather changes occur?
4. Which industrial city—one on the Great Plains or one near the Rocky Mountains—would have fewer air-pollution incidents related to temperature inversions? Why?