Section Objectives ■**Describe** the composition of Earth's atmosphere. ■**Explain** how two types of barometers work. ■**Identify** the layers of the atmosphere. ■**Identify** two effects of air pollution.	**The Atmosphere -** Chapter 23 **23.1 - Characteristics of the Atmosphere**
Composition of the Atmosphere	**atmosphere** a mixture of gases that surrounds a planet, such as Earth ■The most abundant <u>elements</u> in air are the gases nitrogen, oxygen, and argon. ■The two most abundant <u>compounds</u> in air are the gases carbon dioxide, CO_2, and water vapor, H_2O. ■In addition to containing gaseous elements and compounds, the atmosphere commonly carries various kinds of tiny solid particles, such as dust and pollen.
Oxygen	■Oxygen makes up about 21% of Earth's atmosphere. ■Land and ocean plants produce large quantities of oxygen in a process called *photosynthesis*. ■Animals, bacteria, and plants remove oxygen from the air as part of their life processes.
Nitrogen	■Nitrogen makes up about 78% of Earth's atmosphere and is maintained through the *nitrogen cycle.* ■Nitrogen is removed from the air mainly by the action of nitrogen-fixing bacteria. ■Decay releases nitrogen back into the atmosphere.
Water Vapor	■As water evaporates from oceans, lakes, streams, and soil, it enters air as the invisible gas *water vapor*. ■Plants and animals give off water vapor during <u>transpiration</u>, one of their processes. But as water vapor enters the atmosphere, it is removed by the processes of condensation and precipitation. ■The percentage of water vapor in the atmosphere varies depending on factors such as time of day, location, and season.
Ozone	**ozone** a gas molecule that is made up of three oxygen atoms ■Ozone in the upper atmosphere forms the *ozone layer*, which absorbs harmful ultraviolet radiation from the sun. ■Without the ozone layer, living organisms would be severely damaged by the sun's ultraviolet rays. ■Unfortunately, a number of human activities damage the ozone layer.
Particulates	■Particulates can be volcanic dust, ash from fires, microscopic organisms, or mineral particles lifted from soil by winds. ■Pollen from plants and particles from meteors that have vaporized are also particulates.

	▪Large, heavy particles remain in the atmosphere only briefly, but tiny particles can remain suspended in the atmosphere for months or years.
Atmospheric Pressure	**atmospheric pressure** the force per unit area that is exerted on a surface by the weight of the atmosphere ▪Gravity holds the gases of the atmosphere near Earth's surface. As a result, the air molecules are compressed together and exert force on Earth's surface. ▪Atmospheric pressure is exerted equally in all directions—up, down, and sideways. ▪Earth's gravity keeps 99% of the total mass of the atmosphere within 32 km of Earth's surface. ▪Because the pull of gravity is not as strong at higher altitudes, the air molecules are farther apart and exert less pressure on each other at higher altitudes. ▪Thus, atmospheric pressure decreases as altitude increases. ▪Atmospheric pressure also changes as a result of differences in temperature and in the amount of water vapor in the air. ▪In general, as temperature increases, atmospheric pressure at sea level decreases.
Measuring Atmospheric Pressure	▪Meteorologists use three units for atmospheric pressure: atmospheres (atm), millimeters or inches of mercury, and millibars (mb). ▪*Standard atmospheric pressure*, or 1 atmosphere, is equal to 760 mm of mercury, or 1000 millibars. The average atmospheric pressure at sea level is 1 atm. ▪Meteorologists measure atmospheric pressure by using an instrument called a *barometer*.
Mercurial Barometers	▪Atmospheric pressure presses on the liquid mercury in the well at the base of the barometer. ▪The height of the mercury inside the tube varies with the atmospheric pressure. ▪The greater the atmospheric pressure is, the higher the mercury rises.
Aneroid Barometer	▪Inside an aneroid barometer is a sealed metal container from which most of the air has been removed to form a partial vacuum. ▪Changes in atmospheric pressure cause the sides of the container to bed inward or bulge out. These changes move a pointer on a scale. ▪An aneroid barometer can also measure altitude above sea level.
Layers of the Atmosphere	▪Earth's atmosphere as a distinctive pattern of temperature changes with increasing altitude. ▪The temperature differences mainly result from how solar energy is absorbed as it moves through the atmosphere. ▪Scientists identify four main layers of the atmosphere based on these differences.
Troposphere	**troposphere** the lowest layer of the atmosphere, in which temperature drops at a constant rate as altitude increases; the part of the atmosphere where weather conditions exist

	■At an average altitude of 12 km, the temperature stops decreasing. This zone is called the *tropopause* and represents the upper boundary of the troposphere.
Stratosphere	**stratosphere** the layer of the atmosphere that lies between the troposphere and the mesosphere and in which temperature increases as altitude increases; contains the ozone layer ■In the upper stratosphere, the temperature increases as altitude increases because air in the stratosphere is heated from above by absorption of solar radiation by ozone.
Mesosphere	**mesosphere** the coldest layer of the atmosphere, between the stratosphere and the thermosphere, in which the temperature decreases as altitude increases ■The upper boundary of the mesosphere, called the *mesopause,* has an average temperature of nearly –90℃, which is the coldest temperature in the atmosphere.
Thermosphere	**thermosphere** the uppermost layer of the atmosphere, in which temperature increase as altitude increases; includes the ionosphere ■The lower region of the thermosphere, at an altitude of 80 to 400 km, is commonly called the *ionosphere*. ■Interactions between solar radiation and the ionosphere cause the phenomena known as *auroras*.
Air Pollution	■Any substance in the air that is harmful to people, animals, plants, or property is an *air pollutant*. ■Main source = burning fossil fuels. ■Acid precipitation (acid rain) forms from gases given off from burning fossil fuels. ■Temperature inversion: when warm air traps cooler, polluted air beneath. ■*Smog* is a general term for air pollution. ■Air pollution can be controlled ONLY by preventing pollutants from being released into the atmosphere.

	23.2 - Solar Energy and the Atmosphere
Radiation	■All of the energy that Earth receives from the sun travels through space between Earth and the sun as radiation. ■*Radiation* includes all forms of energy that travel through space as waves. ■Radiation travels through space in the form of waves at a very high speed—approximately 300,000 km/s. **electromagnetic (EM) spectrum** all of the frequencies or wavelengths of electromagnetic radiation
Scattering	■Clouds, dust, water droplets, and gas molecules in the atmosphere disrupt the paths of radiation from the sun and cause scattering. ■Scattering occurs when particles and gas molecules in the atmosphere reflect and bend solar rays.
Reflection	**albedo** the fraction of solar radiation that is reflected off the surface of an object. ■The amount of energy that is absorbed or reflected depends on characteristics such as color, texture, composition, volume, mass, transparency, state of matter, and specific heat of the material on which the solar radiation falls. ■The intensity and amount of time that a surface material receives radiation also affects how much energy is reflected or absorbed.
Absorption and Infrared Energy	■Solar radiation that is not reflected is absorbed by rocks, soil, water, and other surface materials. ■Gas molecules, such as water vapor and carbon dioxide, in the atmosphere absorb these infrared rays. ■The absorption of thermal energy from the ground heats the lower atmosphere and keeps Earth's surface much warmer than it would be if there were no atmosphere.
The Greenhouse Effect	**greenhouse effect** the warming of the surface and lower atmosphere of Earth that occurs when carbon dioxide, water vapor, and other gases in the air absorb and reradiate radiation ■Earth's atmosphere slows the escape of energy that radiates from Earth's surface.
Variations in Temperature	■Radiation from the sun does not heat Earth equally at all places at all times. ■Earth's surface must absorb energy for a time before enough heat has been absorbed and reradiated from the ground to change the temperature of the atmosphere. ■The temperature of the atmosphere in any region on Earth's surface depends on several factors, including latitude, surface features, and the time of year and day.
Conduction	**conduction** the transfer of energy as heat through a material ■The molecules in a substance move faster as they become heated. ■Collisions between the particles result in the transfer of energy, which warms the substance. ■Thus, conduction heats only the lowest few centimeters of the atmosphere,

	where air comes into direct contact with the warmed surface of Earth.
Convection	**convection** the movement of matter due to differences in density that are caused by temperature variations; can result in the transfer of energy as heat ■Convection occurs when gases or liquids are heated unevenly. ■The continuous cycle in which cold air sinks and warm air rises warms Earth's atmosphere evenly. ■The atmospheric pressure is lower beneath a mass of warm air. ■Cold air (dense) falls, hot air (less dense) rises ■These pressure differences, which are the result of the unequal heating that causes convection, create winds.

Section 23.3 Objectives ■**Explain** the Coriolis effect. ■**Describe** the global patterns of air circulation, and name three global wind belts. ■**Identify** two factors that form local wind patterns.	**23.3 - Winds**
Coriolis Effect	**Coriolis effect** the curving of the path of a moving object from an otherwise straight path due to Earth's rotation ■The circulation of the atmosphere and of the ocean is affected by the rotation of Earth on its axis. Winds that blow from high pressure areas to lower-pressure areas curve as a result of the Coriolis effect. ■In general, the Coriolis effect is detectable only on objects that move very fast or that travel over long distances.
Global Winds	■Each hemisphere contains <u>three</u> looping patterns of flow called *convection cells.* ■Each convection cell correlates to an area of Earth's surface, called a *wind belt*, that is characterized by winds that flow in one direction. ■These winds are called *prevailing winds.*
Trade Winds	**trade wind** prevailing winds that blow from east to west from 30º latitude to the equator in both hemispheres ■Like all winds, trade winds are named according to the direction from which they flow. ■In the Northern Hemisphere, the trade winds flow <u>from</u> the northeast and are called the *northeast trade winds*. ■In the Southern Hemisphere, they are the *southeast trade winds*.
Westerlies	**westerlies** prevailing winds that blow from west to east between 30º and 60º latitude in both hemispheres ■Between 30º and 60º latitude, some descending air moving toward the poles is deflected by the Coriolis effect. ■In the Northern Hemisphere, the westerlies are the southwest winds. In the Southern Hemisphere, they are the northwest winds.
Polar Easterlies	**polar easterlies** prevailing winds that blow from east to west between 60 and 90 latitude in both hemispheres ■Surface winds created by the polar high pressure are deflected by the Coriolis effect and become the polar easterlies. ■Where the polar easterlies meet warm air from the westerlies, a stormy region known as a *front* forms.
The Doldrums and Horse Latitudes	■The trade winds of the Northern and Southern Hemisphere meet at the equator called the *doldrums*. ■At 30º latitude, air descends and a high-pressure zone forms. These subtropical high-pressure zones are called *horse latitudes*.

	■Both zones have weak & variable surface winds.
Wind and Pressure Shifts	■As the sun's rays shift north and south during the year, pressure and wind belts shift. ■Average shift for the pressure and wind belts is only about 10º of latitude. ■Even this small change causes some areas to be in different wind belts during different times of the year.
Jet Streams	**jet streams** a narrow band of strong westerly winds that blow in the upper troposphere. ■Occur in the Northern and Southern Hemisphere. ■Polar jet streams can reach speeds of 500 km/h and can affect airline routes and the paths of storms. ■Blow in a generally eastward direction
Local Winds	■Movement of air are also 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 a *breeze.*
Land & 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. ■The cool wind moving from water to land is called a *sea breeze*. ■Overnight, the land cools more rapidly than water does, and the sea breeze is replaced by a *land breeze*.
Mountain & Valley Breezes	■A *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.