Chapter 4 Lesson 1: Describing Earth's Atmosphere

Vocabulary

-atmosphere	-troposphere	-ozone layer
-water vapor	-stratosphere	-ionosphere

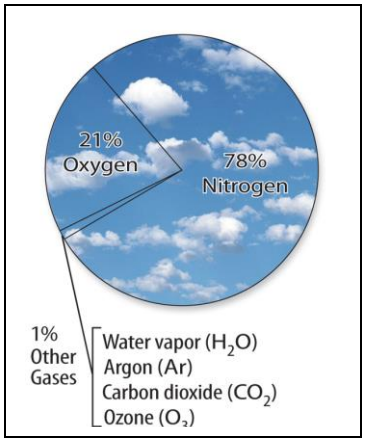
Importance of Earth's Atmosphere

- The **atmosphere** is a thin layer of gases surrounding Earth.
  - Contains the oxygen and water needed for life.
  - Provides insulation and helps keep temperatures on Earth within a range where living organisms can survive.
  - Helps protect living organisms from the Sun's harmful rays.
  - Helps protect Earth's surface from being struck by meteors.

Origins of Earth's Atmosphere

- When Earth formed, it was a ball of molten rock.
- Erupting volcanoes emitting hot gasses from ancient Earth's interior that surrounded the planet to form an atmosphere.
- Ancient Earth's atmosphere was thought to be water vapor with a little carbon dioxide and nitrogen, but not enough oxygen to support life.
- **Water vapor** is water in gaseous form.
- As Earth cooled, the water vapor condensed into liquid, rain fell, and then evaporated from Earth's surface for thousands of years.
- Eventually water began to accumulate on Earth, forming oceans.
- Earth's first organisms could undergo photosynthesis, which changed the atmosphere.
- The organisms removed CO_2 from the atmosphere and released oxygen into it.
- Eventually the levels of CO_2 and oxygen supported the development of other organisms.
- Today, we have more nitrogen in the atmosphere.

Composition of the Atmosphere

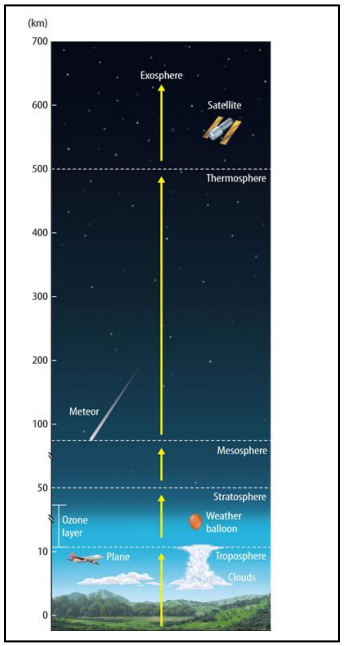


- Today's atmosphere is mostly made up of invisible gases, including nitrogen, oxygen, and carbon dioxide.
- About **78** percent of the atmosphere is nitrogen, and about **21** percent is oxygen.
- The amounts of water vapor, carbon dioxide, and ozone vary.
- Acids in the air are formed when sulfur dioxide and nitrous oxide combine with water vapor.
- Many tiny solid particles, such as pollen, dust, and salt, can enter the atmosphere through natural processes.
- Solid particles of ash from volcanic eruptions and exhaust soot from cars are also present in the atmosphere.
- One way solid particles enter the atmosphere is from volcanic eruptions.
- The most common liquid particles in the atmosphere are water droplets.
- Though microscopic in size, water particles are visible when they form clouds.
- Other atmospheric liquids include acids that result when volcanoes erupt and fossil fuels are burned.

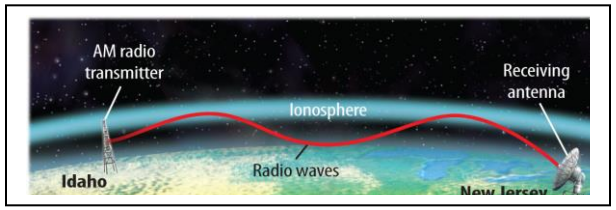
Layers of the Atmosphere

- The atmospheric layer closest to Earth's surface is called the **troposphere**.
  - extends from Earth's surface to altitudes between 8-15 km.
  - The temperature decreases as you move away from Earth.
  - Sunlight passes through the atmosphere, warms Earth's surface, and the warmth is radiated to the troposphere, causing weather.

- The **stratosphere** is the atmospheric layer directly above the troposphere.
    - extends from 15 km to about 50 km above Earth's surface.
    - The area of the stratosphere with a high concentration of ozone is referred to as the **ozone layer**.
    - The presence of the ozone layer causes the stratospheric temperatures to increase with altitude.

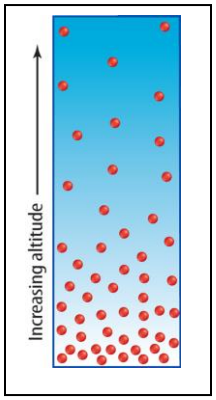


- Ozone has three oxygen atoms and absorbs the Sun's ultraviolet rays more effectively than oxygen.
- Ozone protects Earth from ultraviolet rays that can kill plants, animals, and other organisms and cause skin cancer in humans.
- Combined, the mesosphere and thermosphere are much thicker than the troposphere and the stratosphere, yet only 1 percent of the atmosphere's gas molecules are found in the mesosphere and thermosphere.
    - Most meteors burn up in the mesosphere and thermosphere instead of striking Earth.
    - The **ionosphere** is a region within the mesosphere and thermosphere containing ions.
    - The ionosphere's ions reflect AM radio waves transmitted at ground level.



- **Auroras** occur in the ionosphere when ions from the Sun strike air molecules, causing them to emit vivid colors of light.
- The exosphere is the atmospheric layer farthest from Earth's surface where pressure and density are so low that individual gas molecules rarely strike one another.
- The molecules move at incredibly fast speeds after absorbing the Sun's radiation and can escape the pull of gravity and travel into space.

Air Pressure and Altitude



- Gravity pulls the atmosphere toward Earth, creating air pressure.
- At higher altitudes, the air is less dense and air pressure is lower.
- At lower altitudes, the air is denser and air pressure is higher.

Temperature and Altitude

- Temperature changes in different ways as altitude increases in the different layers of the atmosphere.
- In the troposphere, temperature *decreases* as altitude increases.
- In the stratosphere, temperature **increases** as altitude increases because of the high concentration of ozone.
- In the mesosphere, as altitude increases, temperature again *decreases*.
- In the thermosphere and exosphere, temperatures **increase** as altitude increases.

Chapter 4 Lesson 2: Energy Transfer in the Atmosphere

Vocabulary

-radiation	-convection	-stability
-conduction	-temperature inversion	

Energy from the Sun

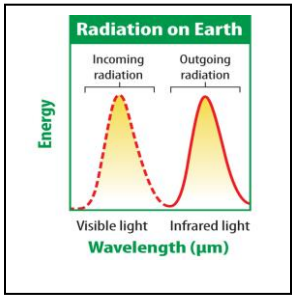
- **Radiation** is the transfer of energy by electromagnetic waves.
- 99% of the radiation from the Sun consists of visible light, ultraviolet light, and infrared radiation.
- The majority of sunlight is visible light that passes through the atmosphere to Earth's surface, where it is converted to heat.
- The wavelengths of ultraviolet (UV) light and infrared radiation (IR) are just beyond the range of visibility to human eyes.
- UV light is harmful to human skin and IR can be sensed as thermal energy or warmth.
- As energy from the Sun is absorbed by Earth, it is radiated back as IR.

Energy on Earth

- As Sun's radiation passes through the atmosphere, some of it is absorbed and some of it is reflected back into space.
- Gases and particles in the atmosphere absorb about 20 percent of incoming solar radiation.
- Oxygen, ozone, and water vapor all absorb incoming ultraviolet radiation.
- Water and carbon dioxide in the troposphere absorb some infrared radiation from the Sun.
- About 30 percent of incoming radiation is reflected into space.
- Bright surfaces, especially clouds, reflect incoming radiation, and some is reflected at Earth's surface.
- Earth's surface only receives and absorbs about 50 percent of incoming solar radiation.

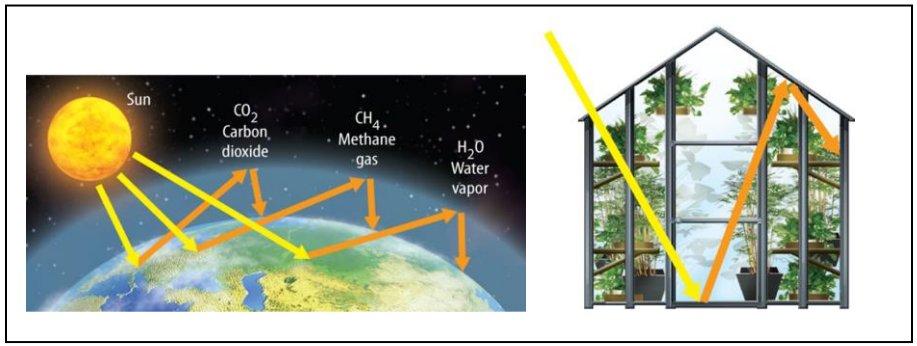
Radiation Balance

- The amount of radiation Earth receives from the Sun is the same as the amount Earth radiates into the atmosphere.
- This radiation balance maintains an overall temperature on Earth.



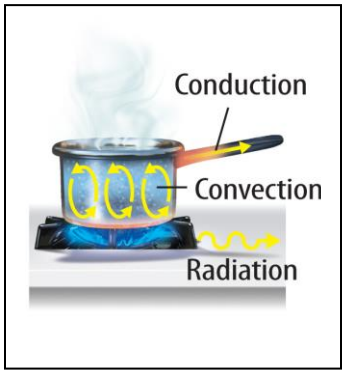
The Greenhouse Effect

- Some of the gases in the atmosphere, called greenhouse gases, act like the glass of a greenhouse, allowing sunlight to pass through but preventing some of Earth's IR energy from escaping.
- When gases in Earth's atmosphere direct radiation back toward Earth's surface, this warms Earth's atmosphere more than normal, creating a heat surplus.
- The gases that trap IR best are water vapor, carbon dioxide, and methane.



Thermal Energy Transfer

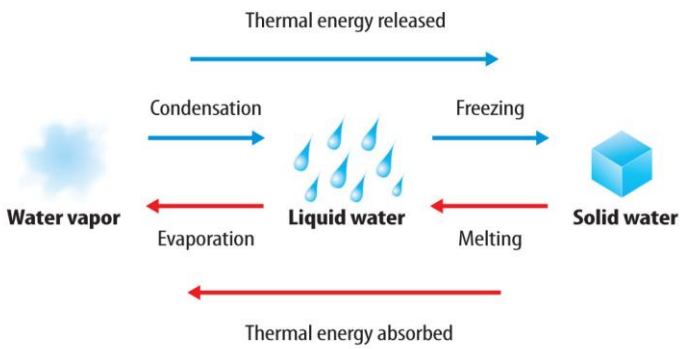
- Conduction occurs when the atmosphere touches Earth.
- **Conduction** is the transfer of thermal energy by collisions between particles of matter.
- Thermal energy always moves from an object with a higher temperature to an object with a lower temperature.
- Energy is transferred through conduction, convection, and radiation.



- The transfer of thermal energy by the movement of matter from one place to another is called **convection**.

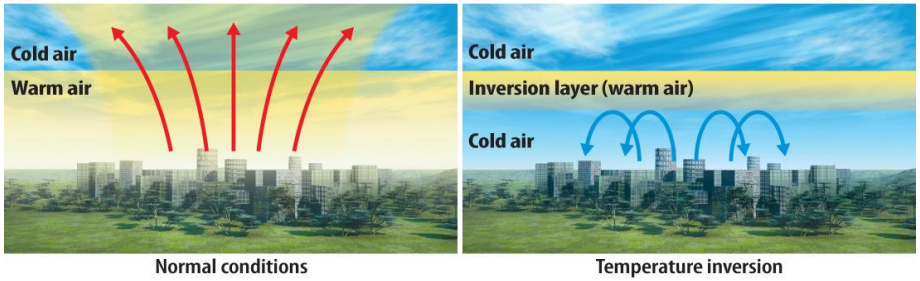
- As molecules of air close to Earth's surface are heated by conduction, they spread apart, becoming less dense.
- Less dense air rises, transferring thermal energy to higher altitudes.
- Latent heat is exchanged when water changes from one phase to another.
- Water is the only substance that can exist as a solid, a liquid, and a gas at the temperature ranges on Earth.
- Latent heat energy is transferred from Earth's surface to the atmosphere.

Water releases or absorbs heat energy during phase changes.



Circulating Air

- Air is constantly moving and circulating.
- On a hot day, air that is heated becomes less dense, creating a pressure difference.
- Cool, denser air pushes the warm air out of the way and the warm air is replaced by the more dense air.
- The warm air is often pushed upward.
- Warmer, rising air is always accompanied by cooler, sinking air.
- Circulating air affects weather and climate around the world.
- **Stability** describes whether circulating air motions will be strong or weak.
- When air is unstable, circulating motions are strong, and during stable conditions, circulating motions are weak.
- During unstable conditions, ground-level air is much warmer than higher-altitude air.
- As warm air rises rapidly in the atmosphere, it cools to form large, tall clouds.
- Latent heat, released as water vapor, changes from a gas to a liquid, adds to the instability, and produces a thunderstorm.
- A **temperature inversion** occurs in the troposphere when temperature increases as altitude increases.
- During a temperature inversion, a layer of cooler air is trapped by a layer of warmer air above it.



Chapter 4 Lesson 3: Air Currents

Vocabulary

-wind	-polar easterlies	-land breeze
-trade winds	-jet stream	-sea breeze
-westerlies		

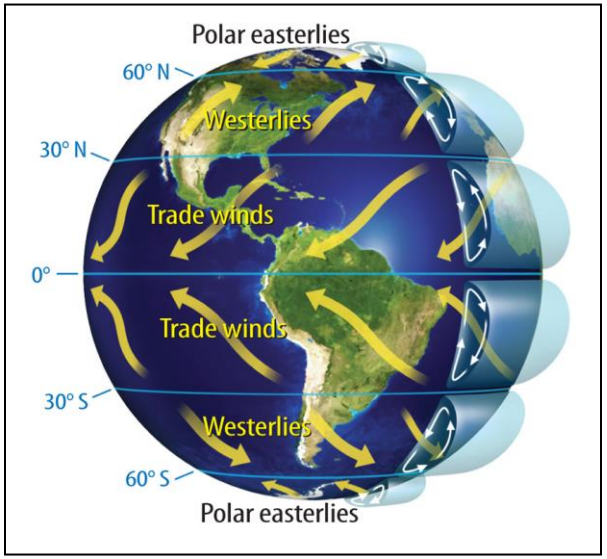
Global Winds

- Wind patterns can be global or local.
- There are great wind belts that circle the globe, and the energy that causes this massive movement of air originates at the Sun.
- Not all areas of Earth receive the same amount of energy from the Sun.

- The differences in pressure between areas with low temperatures and high temperatures create wind.
- **Wind** is the movement of air from areas of high pressure to areas of low pressure.

Global Wind Belts

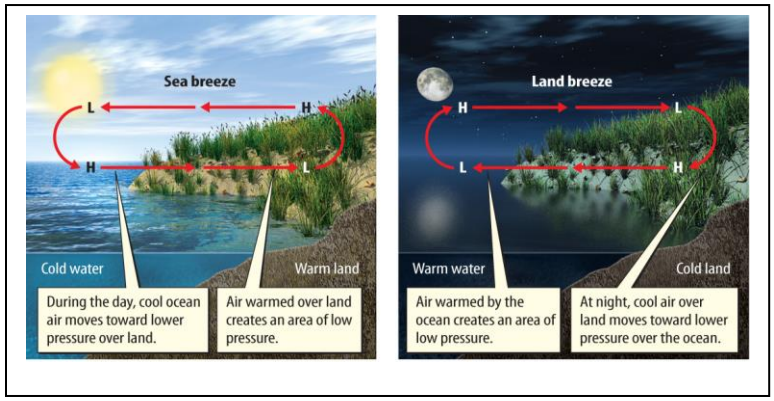
- Three cells in each hemisphere move air through the atmosphere.
- In the first cell, hot air at the equator moves to the top of the troposphere then moves toward the poles until it cools and moves back to Earth's surface near the 30° latitude.
- The second cell, between 30° and 60° latitude, is not a convection cell because its motion is driven by the other two cells.
- The third cell, at the highest latitudes, is also a convection cell. Air from the poles moves toward the equator along Earth's surface, and warmer air is pushed upward by the cooler air near the 60° latitude.



- The three cells exist in both the Northern and Southern Hemispheres.
- Most of the air in this convection cell returns to the equator near Earth's surface.
- The Coriolis effect occurs when the rotation of Earth causes moving air and water to move to the right in the Northern Hemisphere and to the left in the Southern Hemisphere.
- The contrast between high and low pressure and the Coriolis effect creates distinct wind patterns, called prevailing winds.
- The **trade winds** are steady winds that flow from east to west between 30°N latitude and 30°S latitudes.
- The prevailing **westerlies** are steady winds that flow from west to east between latitudes 30°N and 60°N, and 30°S and 60°S.
- The **polar easterlies** are cold winds that blow from the east to the west near the North Pole and the South Pole.
- Located near the top of the troposphere is a narrow band of high winds called the **jet stream**.
- Jet streams influence weather as they move cold air from the poles toward the tropics and warm air from the tropics toward the poles.

Local Winds

- Local winds occur whenever air pressure is different from one location to another.
- A **sea breeze** is wind that blows from the sea to the land due to local temperature and pressure differences.
- A **land breeze** is a wind that blows from the land to the sea due to local temperature and pressure differences.
- Sea breezes and land breezes are created as part of a large reversible convection current.



Chapter 4 Lesson 4: Air Quality

Vocabulary

-air pollution	-photochemical smog
-acid precipitation	-particulate matter

Sources of Air Pollution

- The contamination of air by harmful substances including gases and smoke is called **air pollution**.
- Point-source pollution is pollution that comes from an identifiable source such as large factories.
- An example of natural point-source pollution is an erupting volcano.
- Nonpoint-source pollution is pollution that comes from a wide-spread area, such as a large city.
- Some bacteria found in swamps and marshes are examples of natural sources of nonpoint-source pollution.

Causes and Effects of Air Pollution

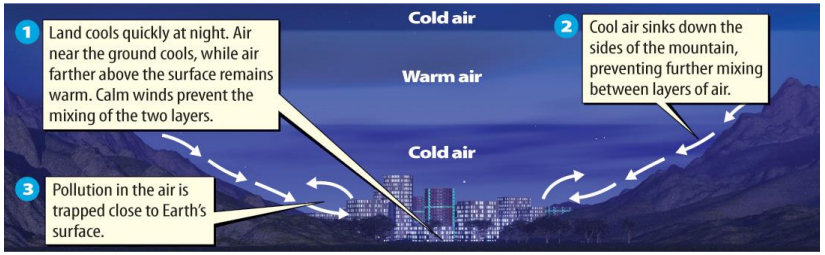
- **Acid precipitation** occurs when sulfur dioxide and nitrogen oxides combine with moisture in the atmosphere and create acids that fall as precipitation.
- Acid precipitation can be in the form of rain, snow, and fog.
- It affects the chemistry of water in lakes and rivers and can harm organisms living in the water.
- Natural sources of sulfur dioxide include volcanoes and marshes.
- The most common sources of sulfur dioxide and nitrogen oxides are automobile exhausts and factory and power plant smoke.
- **Photochemical smog** is air pollution that forms from the interaction between chemicals in the air and sunlight.
- Smog forms when nitrogen dioxide, released in gasoline engine exhaust, reacts with sunlight.
- A series of chemical reactions produces ozone and other compounds that form smog.
- Ground-level ozone is the main component of smog.

Particulate Pollution

- **Particulate matter** is a mixture of dust, acids, and other chemicals that can be hazardous to human health.
- Particulate matter in the atmosphere absorbs and scatters sunlight, which can create haze.

Movement of Air Pollution

- Because air carries pollution with it, some wind patterns cause more pollution problems than others.
- Weak winds or no wind prevents pollution from mixing with the surrounding air, which can create high pollution levels and dangerous conditions.
- At night, cool air sinks down the mountain sides, trapping pollution in the valley below.



Maintaining Healthful Air Quality

- Preserving the quality of Earth's atmosphere requires the cooperation of government officials, scientists, and the public.
- The Clean Air Act gives the U.S. government the power to set air quality standards which protect humans, animals, crops, and buildings from the harmful effects of air pollution.

- Pollution levels are continuously monitored by hundreds of instruments in all major U.S. cities.

Air Quality Trends

- Air quality in U.S. cities has improved over the last several decades.
- Ground-level ozone has not decreased much, however, because as the number of cars on the road increases, air quality standards have not kept up with all pollutant levels.
- Pollution emissions have declined, even though the population is increasing.

- The air inside homes and other buildings can be as much as 50 times more polluted than outdoor air and can impact human health much more than outdoor air quality.
- Indoor air pollution can come from tobacco smoke, cleaning products, pesticides, fireplaces, and radon—an odorless gas given off by some soil and rocks.