Section 2: Solar Energy and the Atmosphere

Preview

Key Ideas

- **Explain** how radiant energy reaches Earth.
- **Describe** how visible light and infrared energy warm Earth.
- **Summarize** the processes of radiation, conduction, and convection.

Radiation

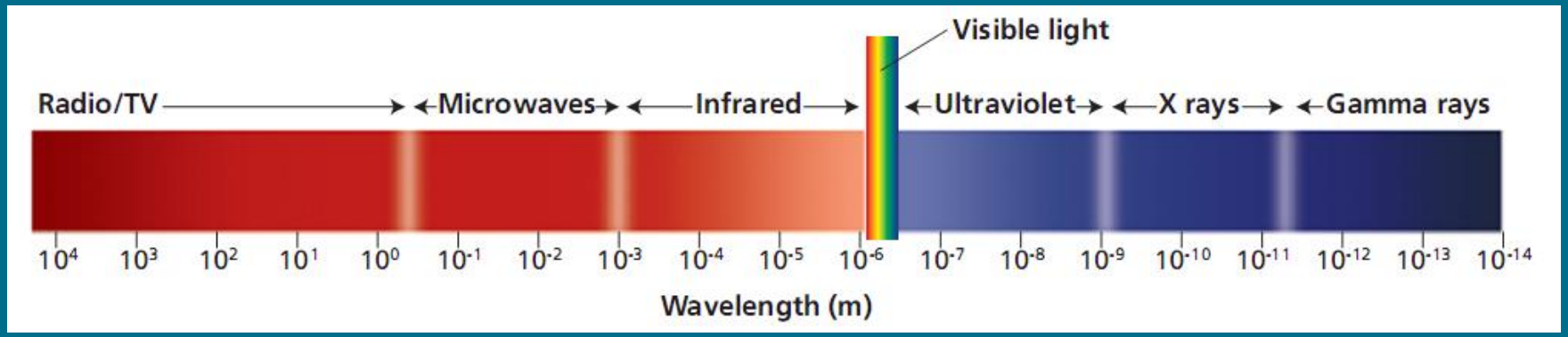
- All of the energy that Earth receives from the sun travels through space between Earth and the sun as radiation.
- *Radiation* includes all forms of energy that travel through space as waves.
- Radiation travels through space in the form of waves at a very high speed—approximately 300,000 km/s.

Radiation, *continued*

- The distance from any point on a wave to the identical point on the next wave, for example from crest to crest, is called the *wavelength* of a wave.
- The various types of radiation differ in the length of their waves.
- **electromagnetic spectrum** all of the frequencies or wavelengths of electromagnetic radiation

Radiation, *continued*

The diagram below shows the the varying waves of the electromagnetic spectrum.



The Atmosphere and Solar Radiation

- As solar radiation passes through Earth's atmosphere, the atmosphere affects the radiation in several ways.
- Most of the solar rays that reach the lower atmosphere, such as visible and infrared waves, have longer wavelengths.
- Most incoming infrared radiation is absorbed by carbon dioxide, water vapor, and other complex molecules in the troposphere.
- As visible light waves pass through the atmosphere, only a small amount of this radiation is absorbed.

The Atmosphere and Solar Radiation, *continued*

Scattering

- Clouds, dust, water droplets, and as 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. This deflection causes the rays to travel out in all directions without changing their wavelength.
- As a result of scattering, sunlight that reaches Earth's surface comes from all directions. The sky appears blue, and the sun appears red at sunset.

The Atmosphere and Solar Radiation, *continued*

Reflection

- 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.
- **albedo** the fraction of solar radiation that is reflected off the surface of an object.

Absorption and Infrared Energy

- Solar radiation that is not reflected is absorbed by rocks, soil, water, and other surface materials. When this happens, the radiation heats the surface materials.
- Gas molecules, such as water vapor and carbon dioxide, in the atmosphere absorb the 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.
- Sometimes, warm air bends light rays to produce an effect called a *mirage.*

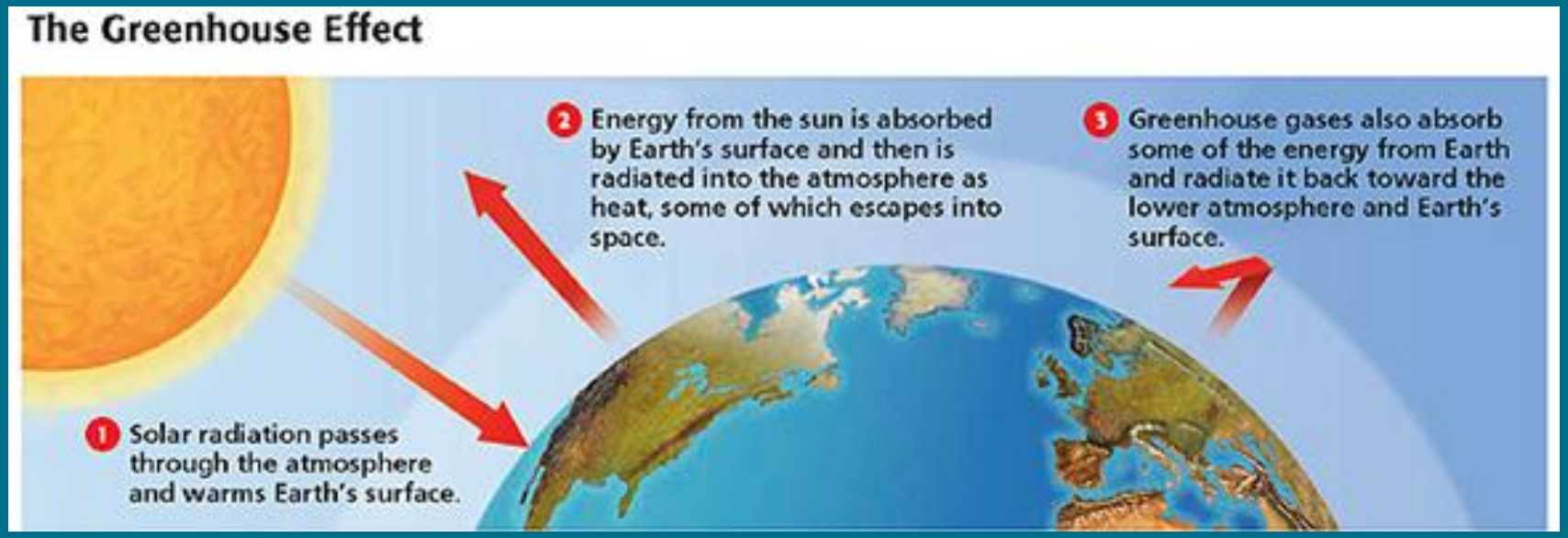
Absorption and Infrared Energy, *continued*

The Greenhouse Effect

- One of the ways in which the gases of the atmosphere absorb and reradiate infrared rays can be compared to the process that keeps a greenhouse warm.
- Earth's atmosphere slows the escape of energy that radiates from Earth's surface.
- **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

Absorption and Infrared Energy, *continued*

The diagram below illustrates the greenhouse effect.



Absorption and Infrared Energy, *continued*

Human Impact on the Greenhouse Effect

- Generally, the amount of solar energy that enters Earth's atmosphere is about equal to the amount that escapes into space.
- However, human activities, in addition to natural causes, are changing this balance and are causing the average temperature of the atmosphere to increase.
- Increases in the amount of carbon dioxide may intensify the greenhouse effect and may cause Earth to become warmer.

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 energy 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.

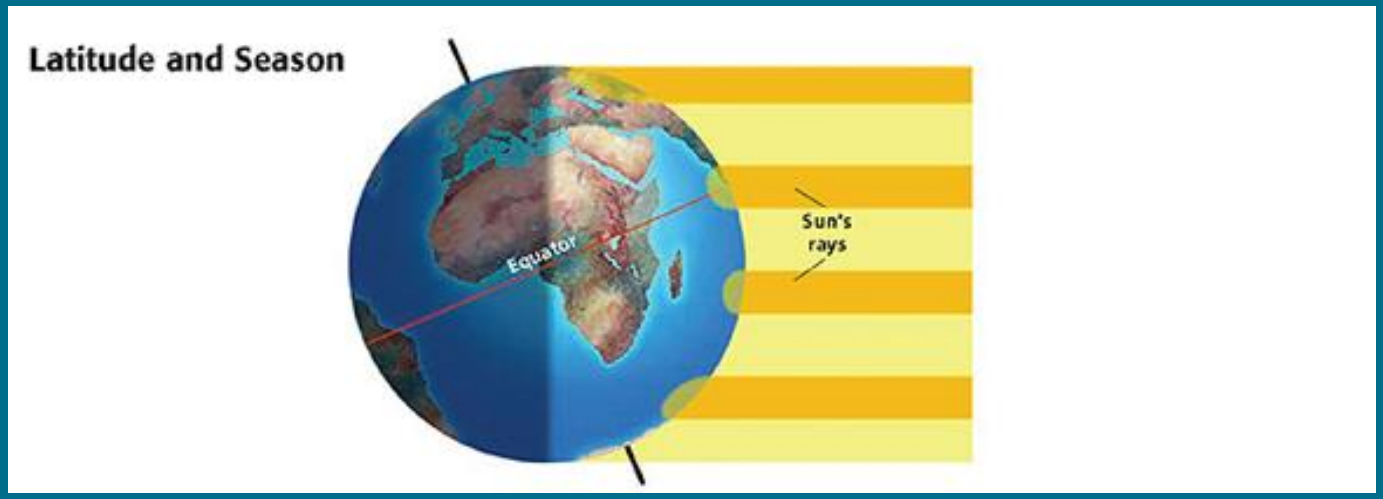
Variations in Temperature, *continued*

Latitude and Season

- Latitude is the primary factor that affects the amount of solar energy that reaches any point on Earth's surface.
- Because Earth is a sphere, the sun's rays do not strike all areas at the same angle. When sunlight hits Earth's surface at an angle smaller than 90°, the energy is spread out over a larger area and is less intense.
- Temperature varies seasonally because of the tilt of Earth's axis. As Earth revolves around the sun once each year, the portion of Earth's surface that receives the most intense sunlight changes.

Variations in Temperature, *continued*

The diagram below shows the relationship between latitude and seasons.



Variations in Temperature, *continued*

Water in the Air and on the Surface

- Because water vapor stores heat, the amount of water in the air affects the temperature of a region.
- Land areas close to large bodies of water generally have more moderate temperatures. Water heats up and cools down slower than land does, so the temperature of water changes less than the temperature of land does.
- The wind patterns in an area also affect temperature.

Reading Check

Why are deserts generally colder at night than other areas are?

Deserts are colder at night than other areas are because the air in deserts contains little water vapor that can absorb heat during the day and release heat slowly at night.

Conduction

- 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.
- **conduction** the transfer of energy as heat through a material
- 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.

Convection, *continued*

- Because warm air is less dense than cool air is, warm air exerts less pressure than the same volume of cooler air does.
- The atmospheric pressure is lower beneath a mass of warm air.
- As dense, cool air moves into a low-pressure region, the less dense, warmer air is pushed upward.
- These pressure differences, which are the result of the unequal heating that causes convection, create winds.