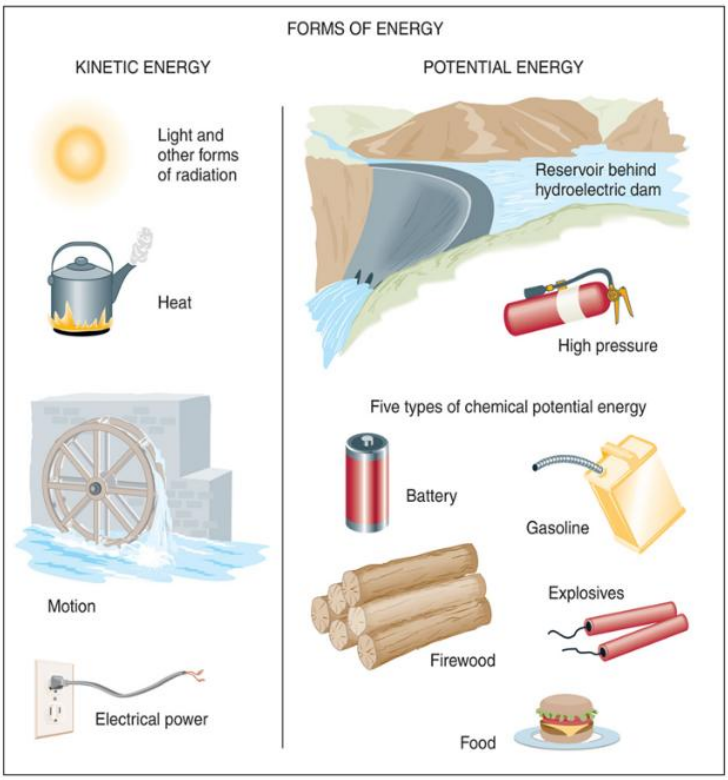
Chapter Two

Solar Radiation and the Seasons

Energy

- **Energy** is defined as the ability to do work
  - **Kinetic energy** – the energy of motion
  - **Potential energy** – energy that can be used

- Energy is conserved!
  (1st law of thermodynamics)



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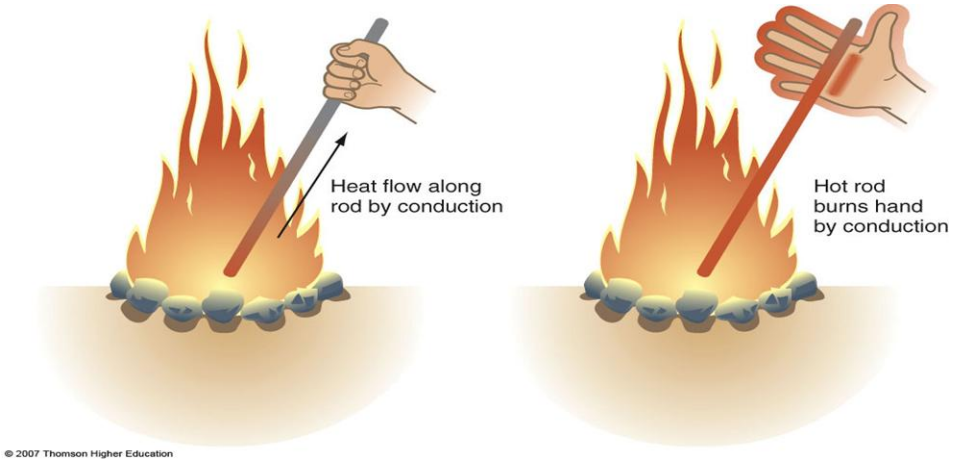
Energy Transfer

Although energy is conserved, it can move through the following mechanisms:

1) **Conduction** – heat transfer by physical contact, from higher to lower temperature



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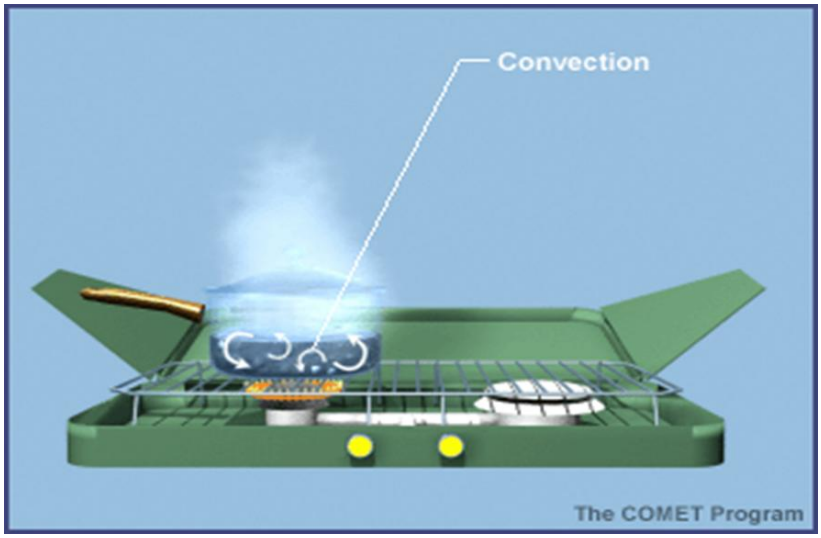
- Occurs at the atmosphere/surface interface

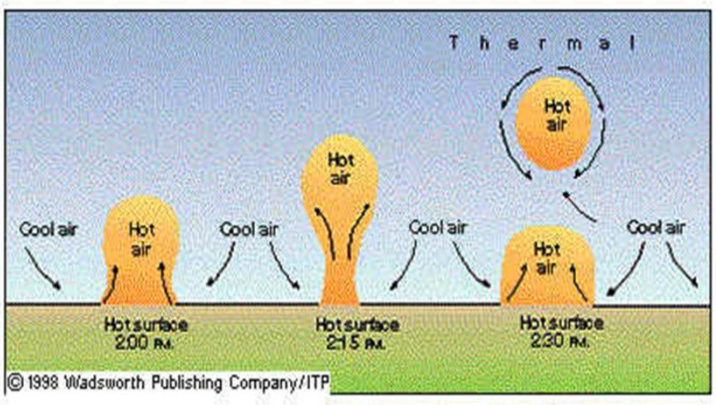
  Partly responsible for daytime heating/nighttime cooling! (The diurnal cycle)

2) **Convection** – heat transfer by movement



Convection in the Atmosphere

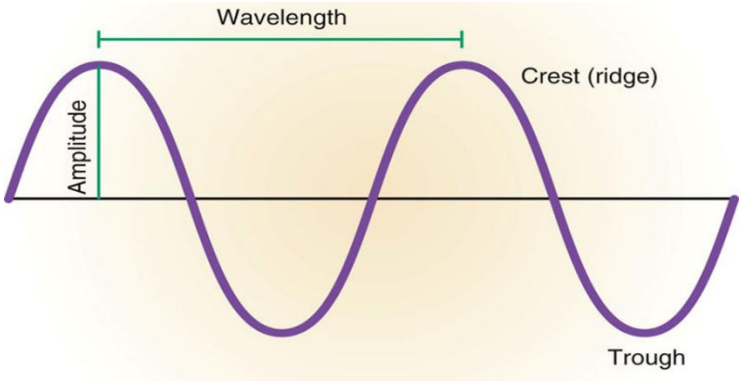
Vertical transport of heat



Horizontal transport of heat = **advection**

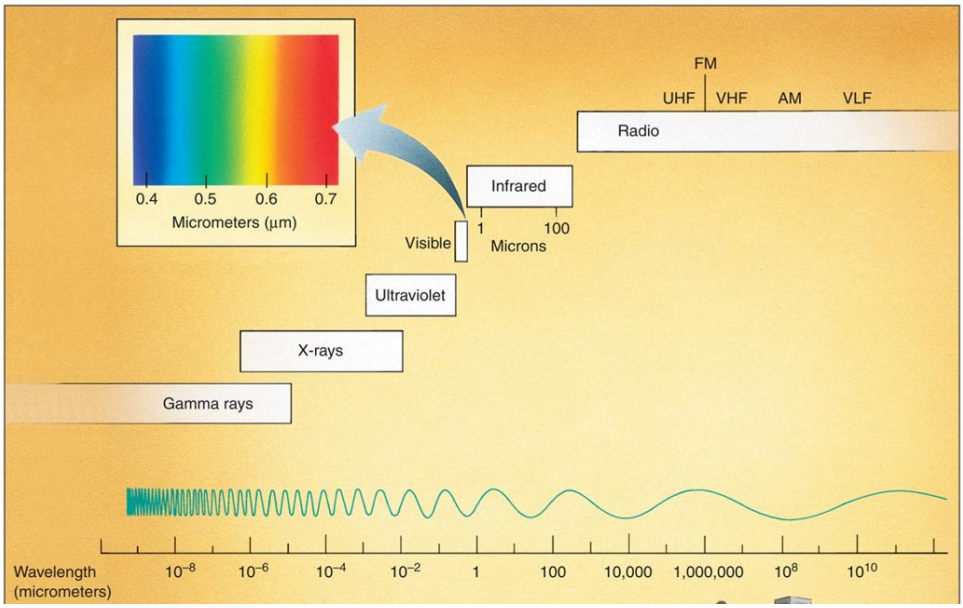
3) **Radiation -** transfer of energy by electromagnetic radiation (no medium required!)

Characteristics of radiation



1) **Wavelength** – the distance between wave crests
2) **Amplitude** – the height of the wave
3) **Wave speed** – constant! (speed of light Wave speed – constant! (speed of light - 2.998 x 10^8 m/s)

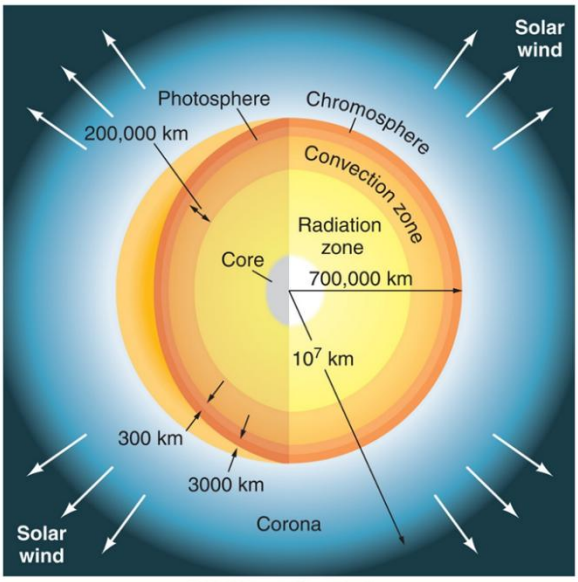
- The wavelength of radiation determines its type



- The amplitude determines the intensity

What emits radiation?

EVERYTHING



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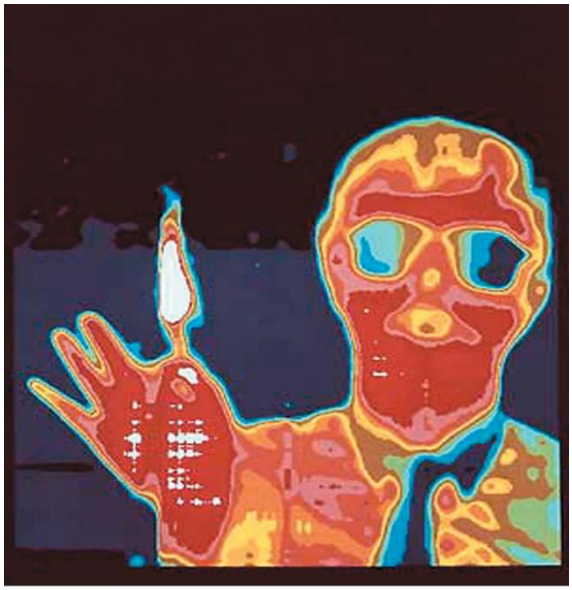

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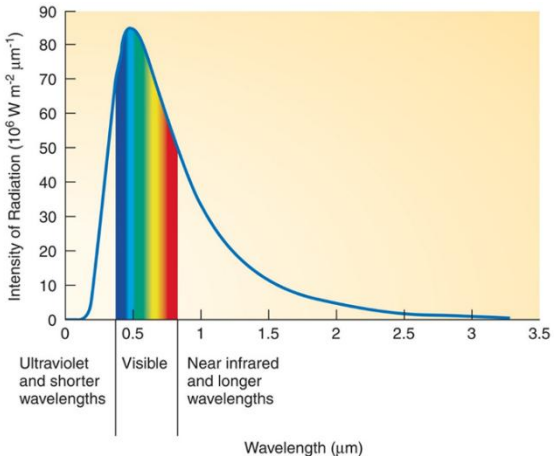
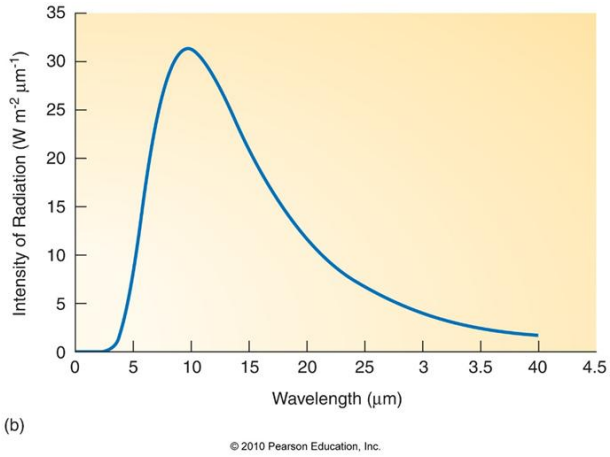
- The types (wavelengths) and intensity (amplitudes) of radiation depend on temperature



Sun is HOT (~5600 ^{o}C)
Shortwave radiation



Earth is NOT (~15 oC)
Longwave radiation

- **Blackbody** – an object that absorbs all radiation and emits the maximum amount of radiation at every wavelength (not realistic)
- **Graybody** – an object that emits a fraction (emissivity) of blackbody radiation (more realistic)

Radiation Laws

- **Stefan-Boltzmann Law** – the total amount of blackbody radiation emitted (*I*) is related to temperature:

$$I = \sigma T^4$$

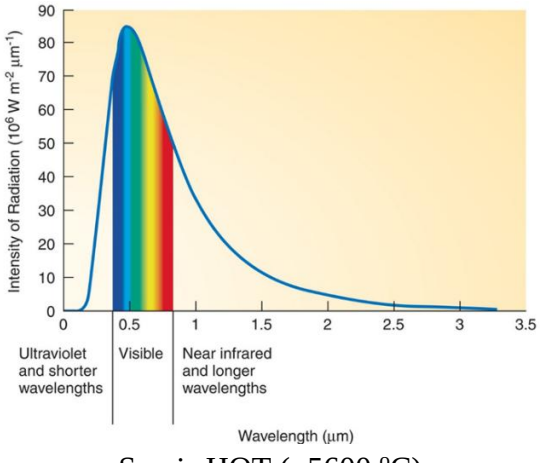
- For a graybody, this becomes:

$$I = \varepsilon \sigma T^4$$

where ε is the emissivity

- **Wien's Law** – the wavelength of maximum blackbody emission is related to temperature:

$$\lambda_{max} = 2900 / T$$



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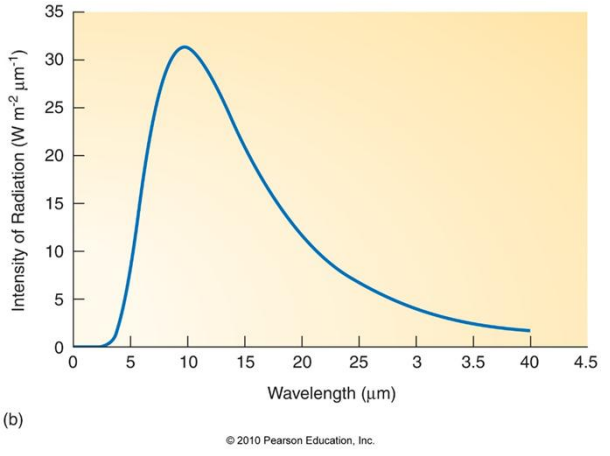
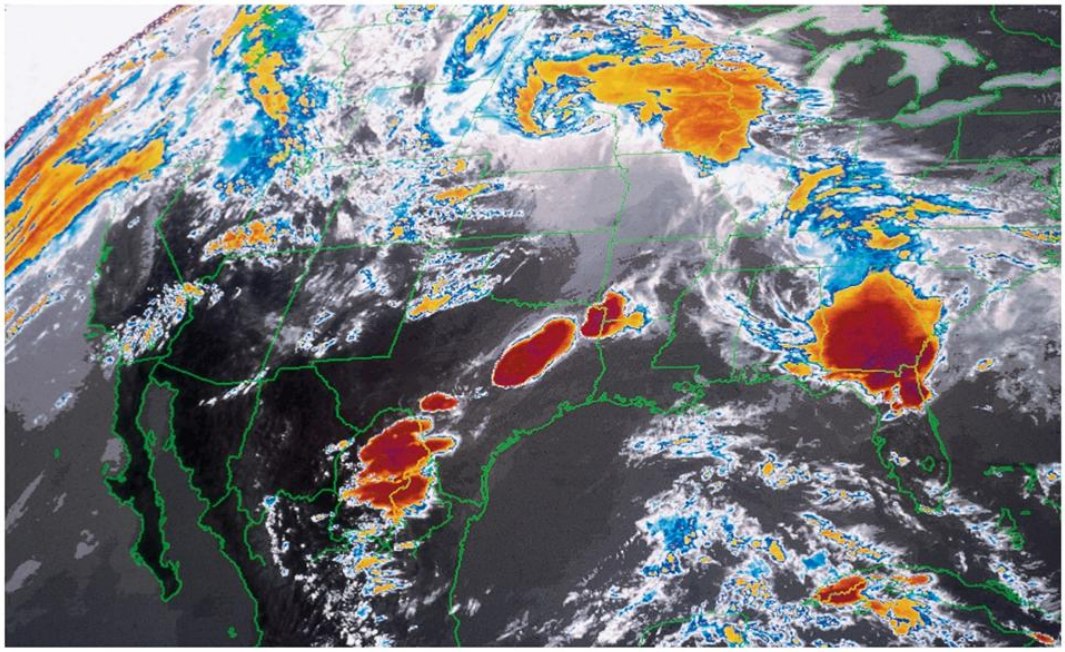


Earth is NOT (~15 oC)
Longwave radiation

Practical use of Radiation Properties

- Visible satellite imagery doesn't work in the dark
- Infrared (longwave) radiation occurs always – use infrared satellite imagery!



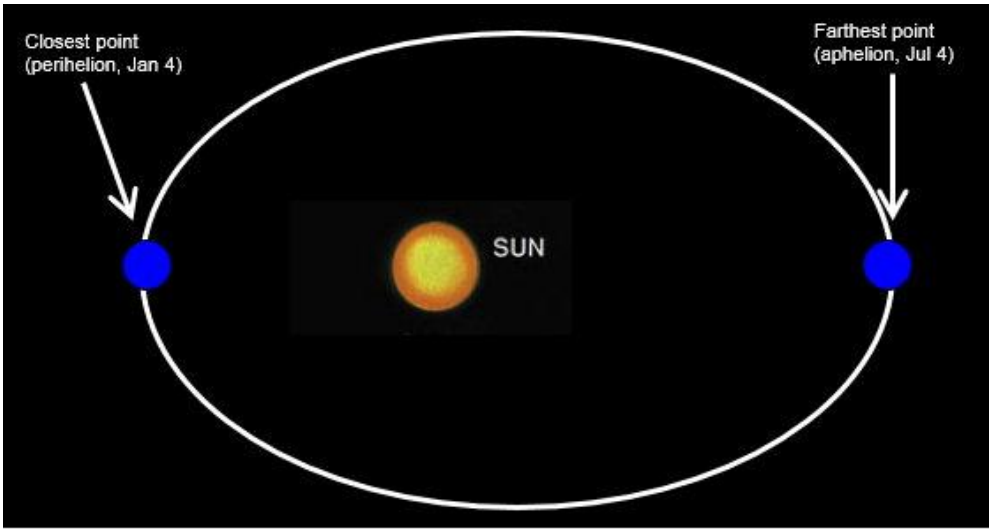
Solar Radiation and the Earth

- The solar constant – the amount of solar radiation hitting the earth

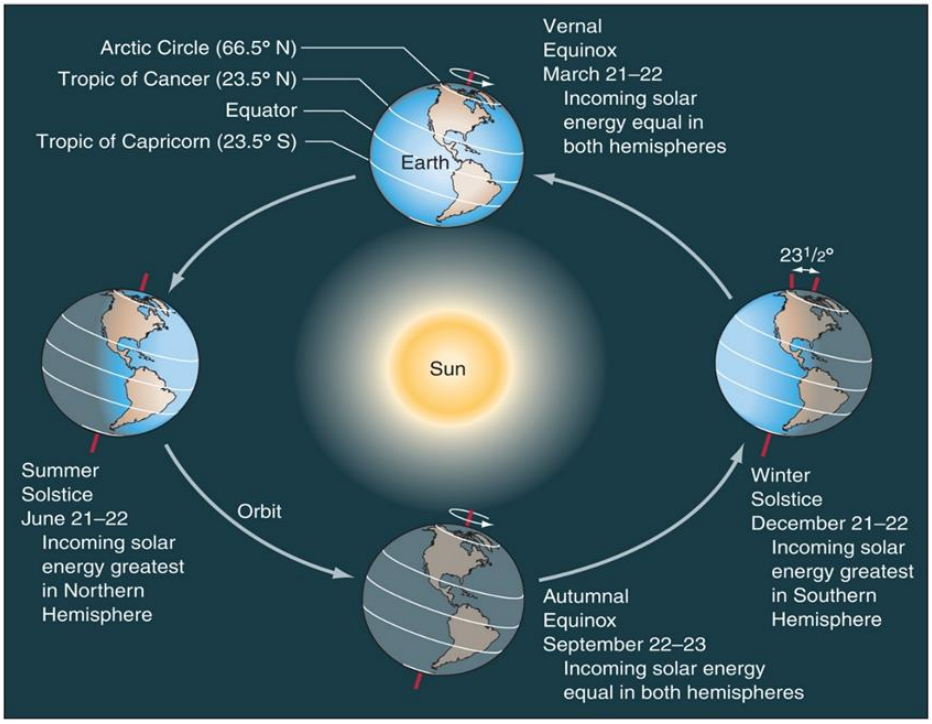
  Earth – 1367 W/m^2

  Mars – 445 W/m^2

- Earth orbits the sun elliptically (once per 365.25) days

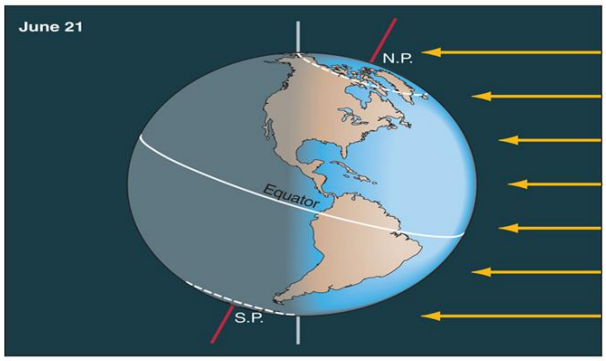


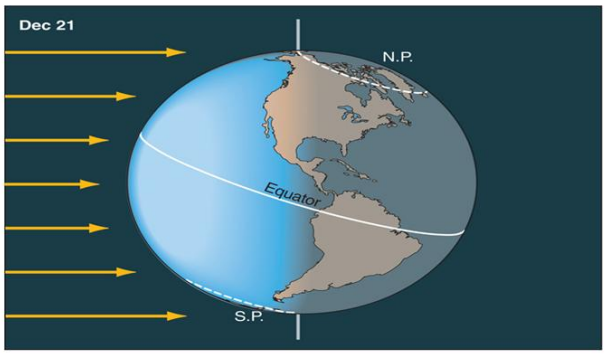
- Earth gets ~7% more radiation in winter (not enough to cause the seasons!) What does?
- Earth's tilt is the true cause of the seasons!
  Earth's axis is tilted 23.5º

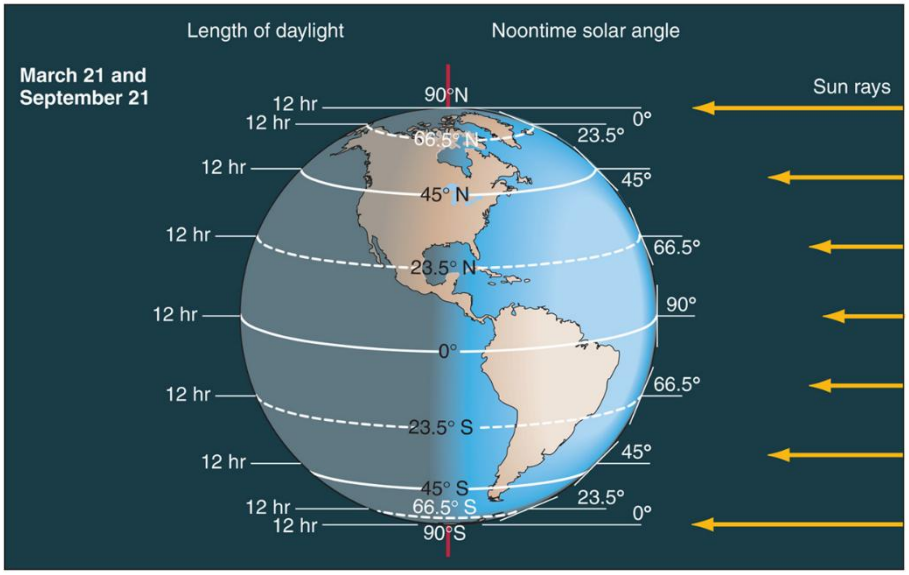


Three factors contribute to the amount of incoming solar radiation **(insolation)**:

1) Period of daylight







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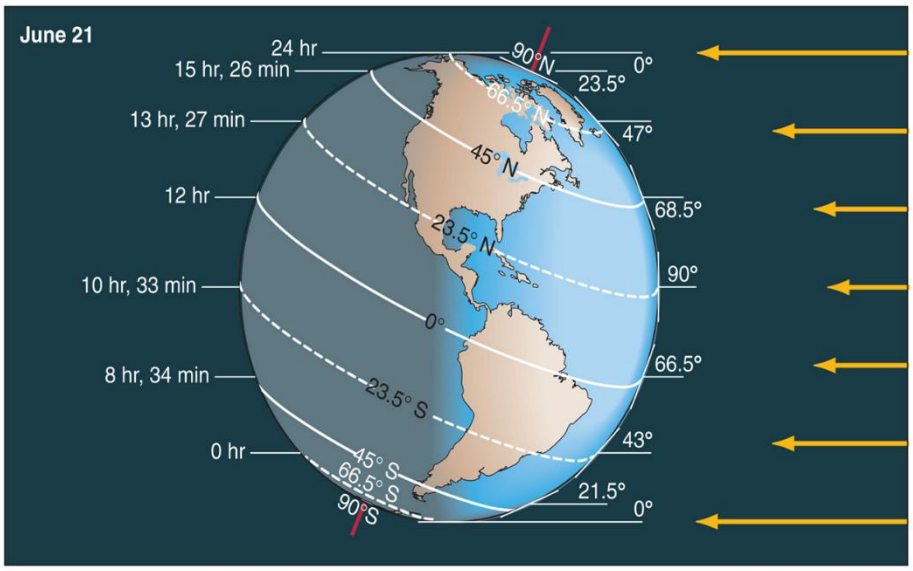
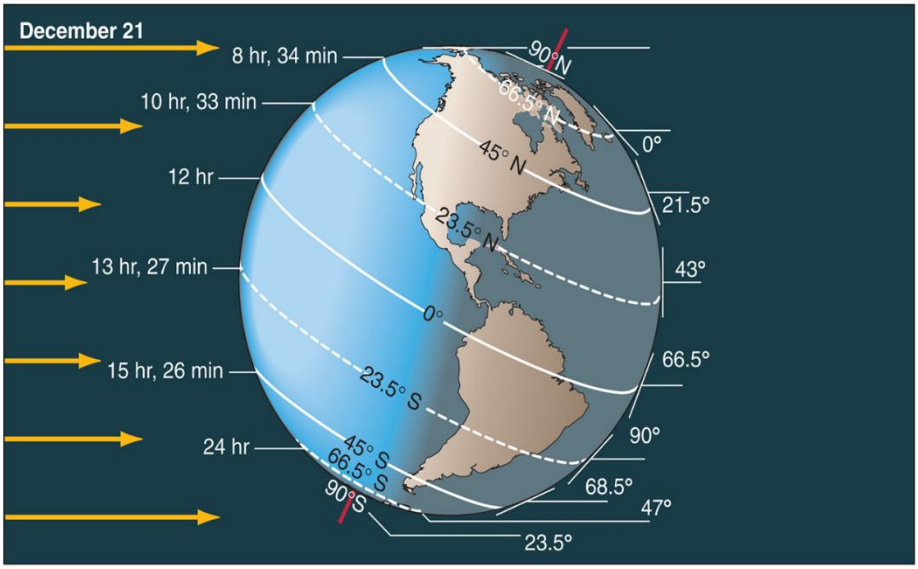
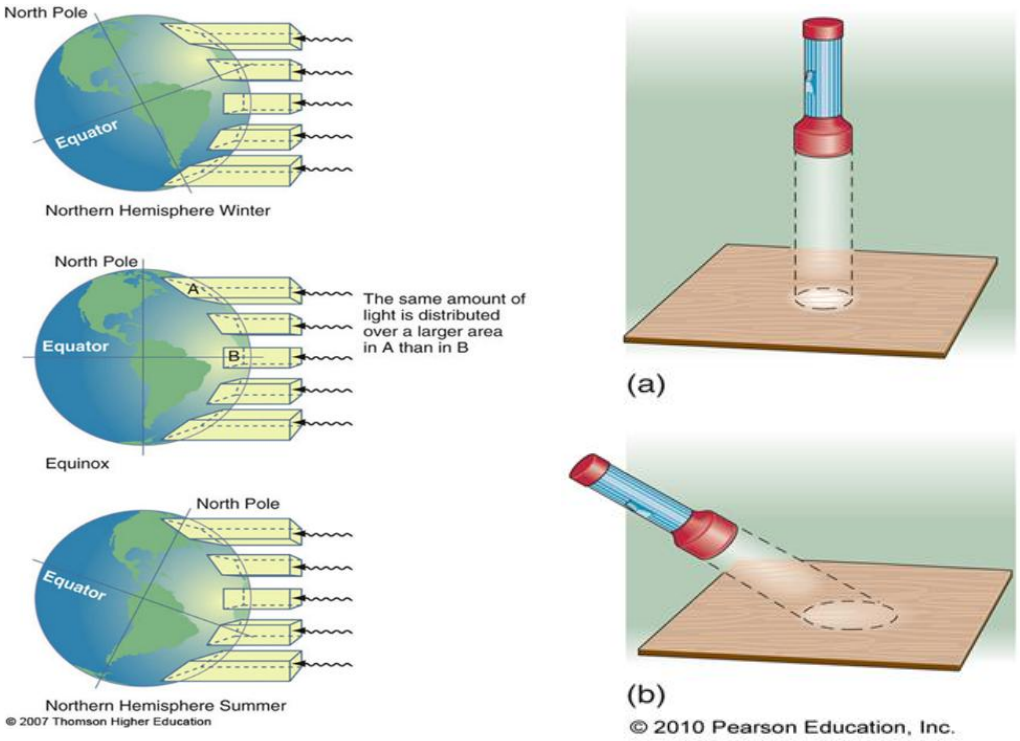


(b)

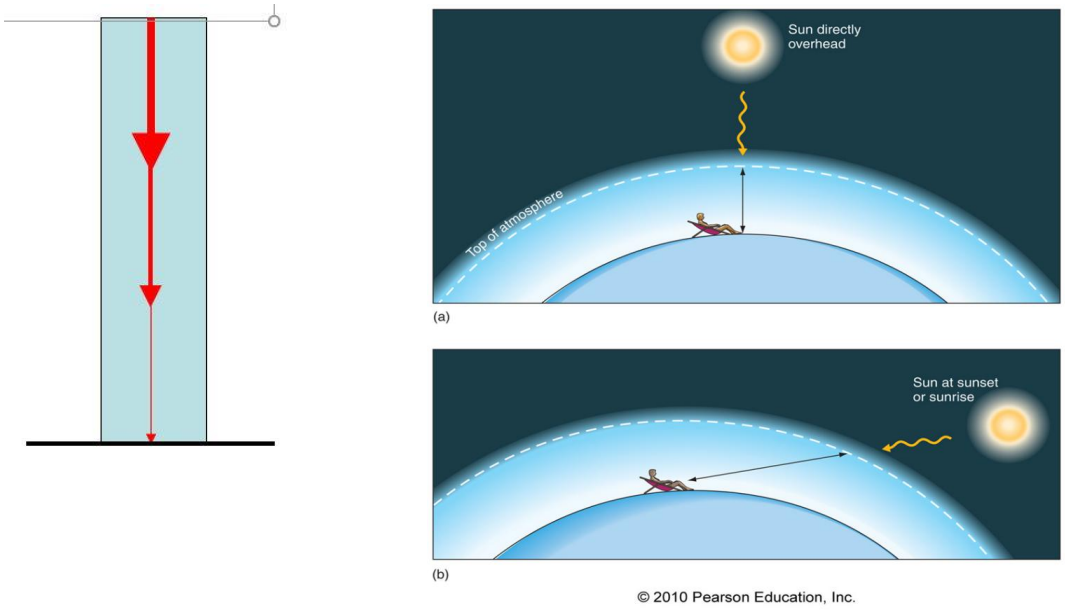


(c)

2) Solar Angle



3) Beam depletion



What's the end result of these 3 mechanisms and the tilt of the earth?

Weather as we know it!

Jet stream… Mid-latitude cyclones…fronts… Thunderstorms…winds