

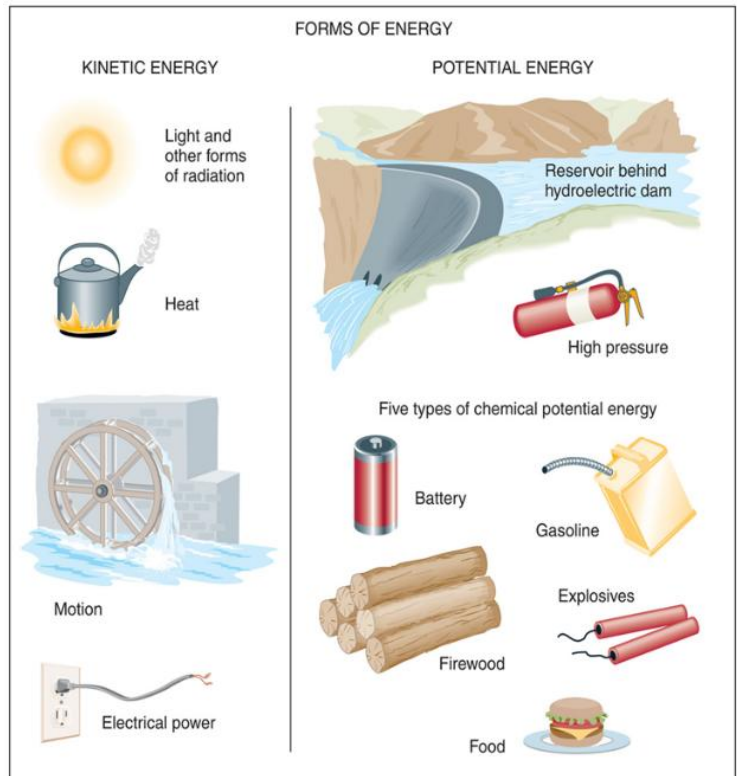
Chapter Two

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)

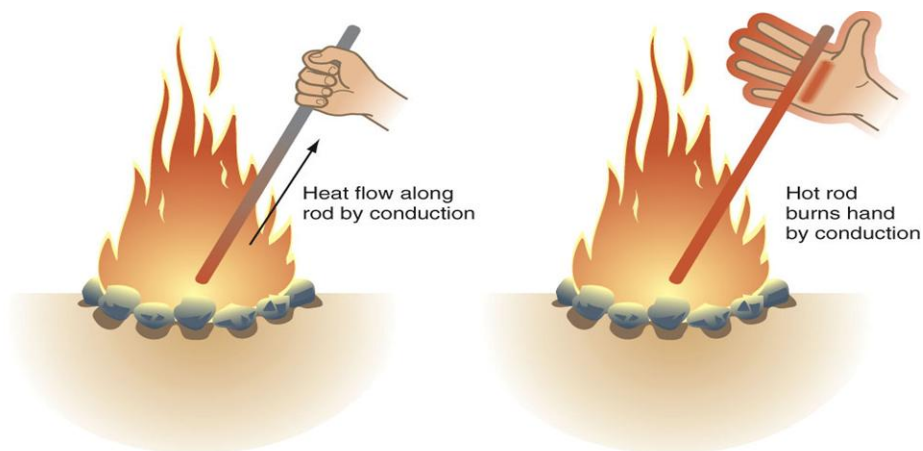


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Energy Transfer

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

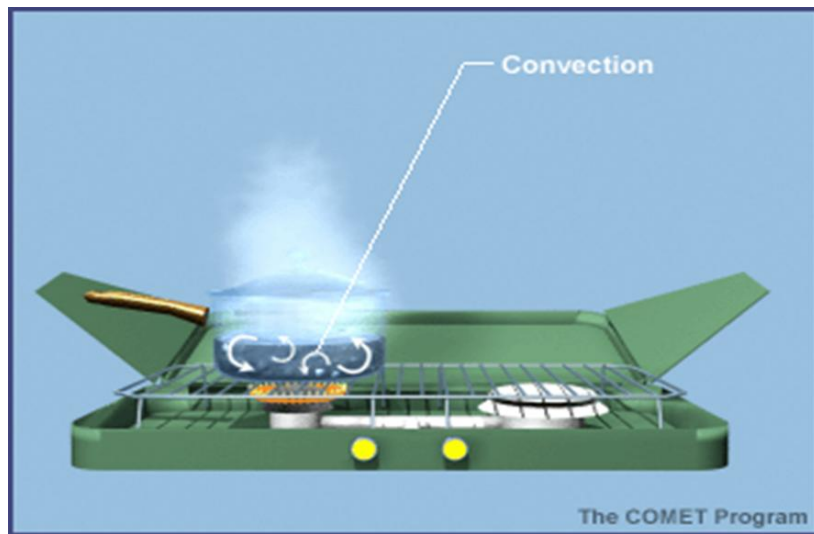
- 1) **Conduction** – heat transfer by physical contact, from higher to lower temperature



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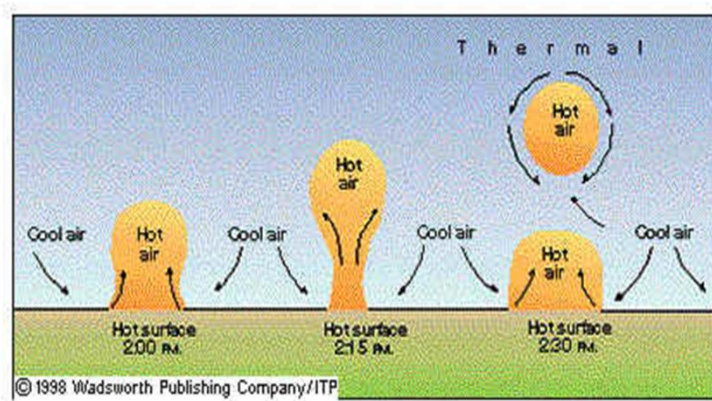
- Occurs at the atmosphere/surface interface
- Partly responsible for daytime heating/nighttime cooling! (The diurnal cycle)

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



Convection in the Atmosphere

Vertical transport of heat

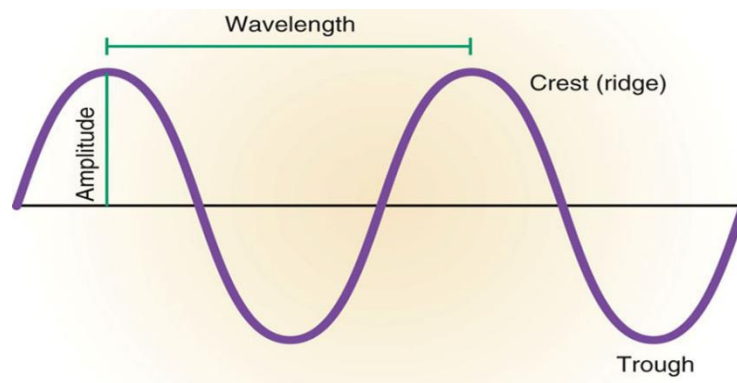


Horizontal transport of heat = **advection**



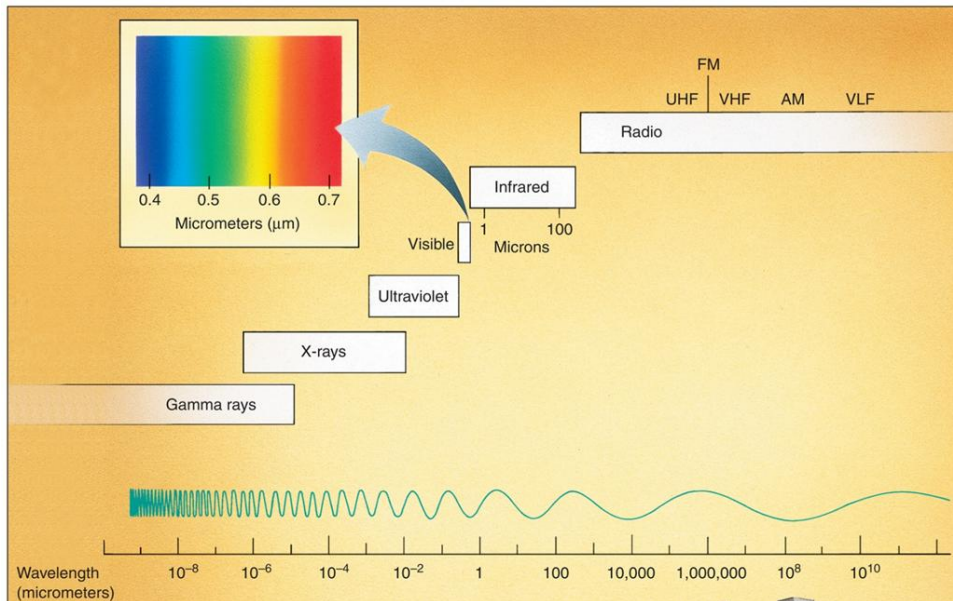
3) **Radiation** - transfer of energy by electromagnetic radiation (no medium required!)

Characteristics of radiation



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

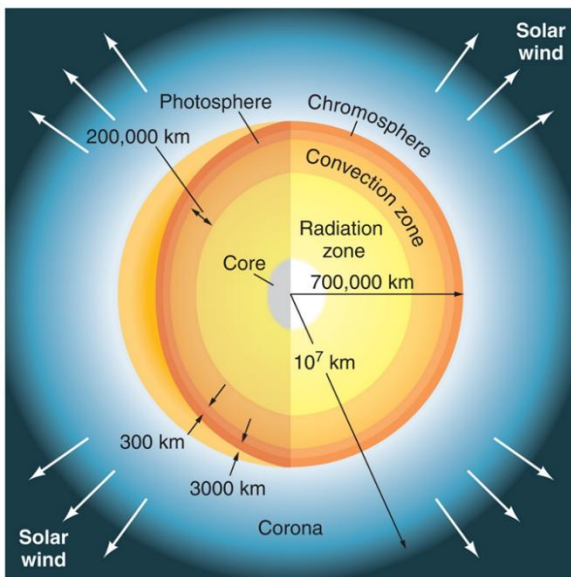
- The wavelength of radiation determines its type



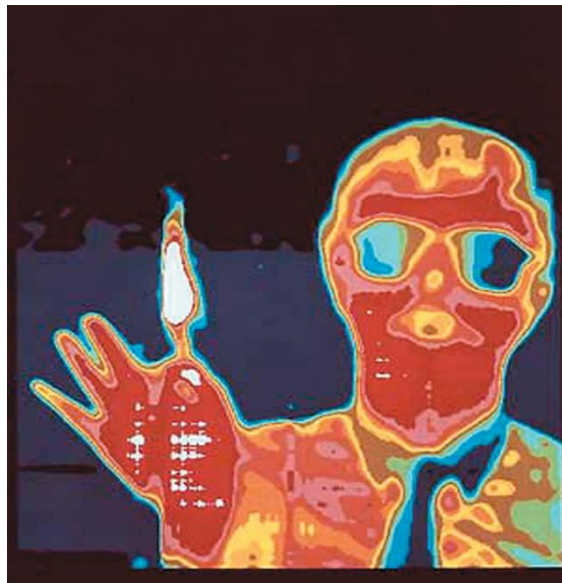
- The amplitude determines the intensity

What emits radiation?

EVERYTHING

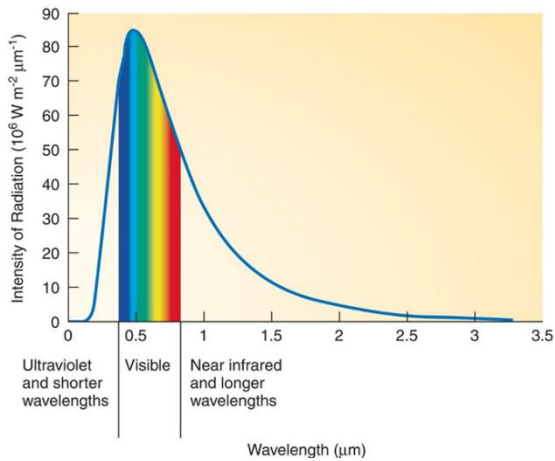


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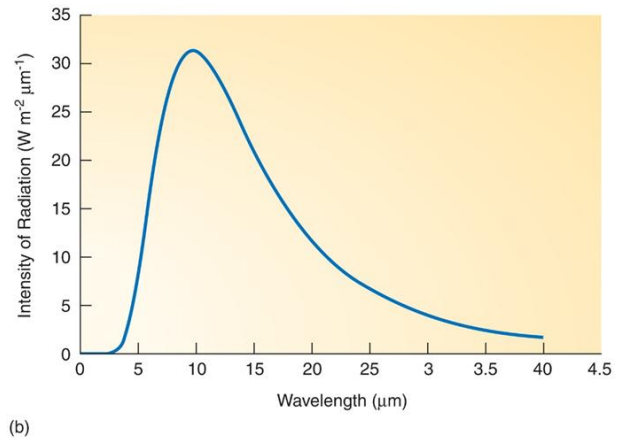


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- The types (wavelengths) and intensity (amplitudes) of radiation depend on temperature



Sun is HOT (~5600 °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:

$$I = \sigma T^4$$

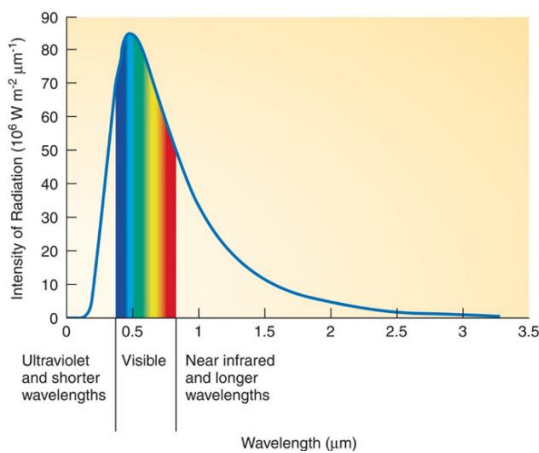
- For a graybody, this becomes:

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

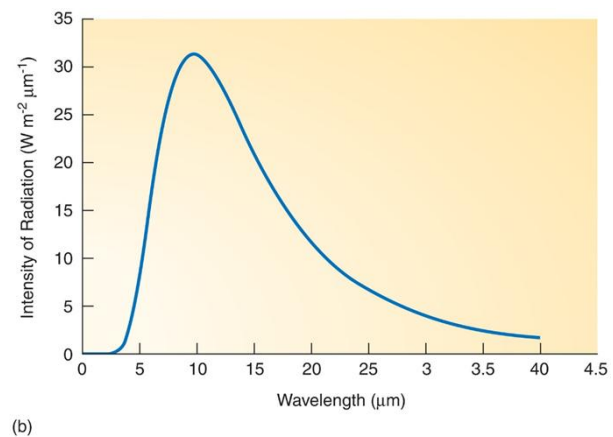
where ε is the emissivity

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

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



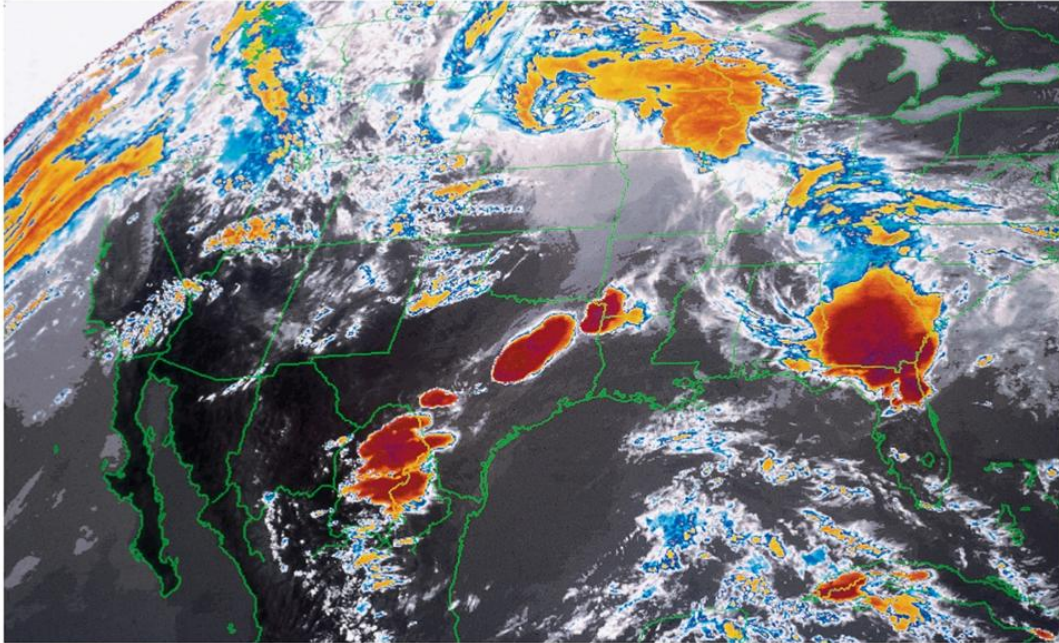
Sun is HOT (~5600 °C)
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Practical use of Radiation Properties

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



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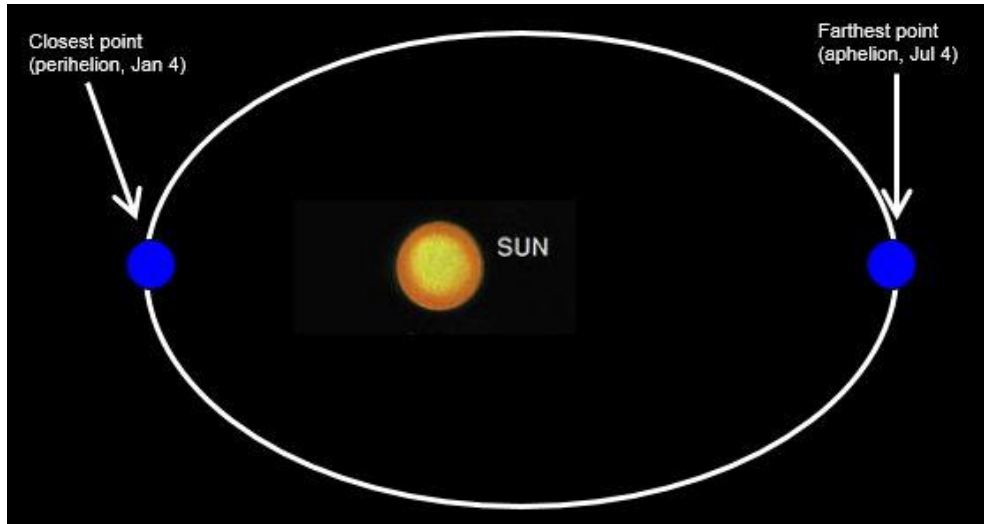
Solar Radiation and the Earth

- The solar constant – the amount of solar radiation hitting the earth at the top of the atmosphere.

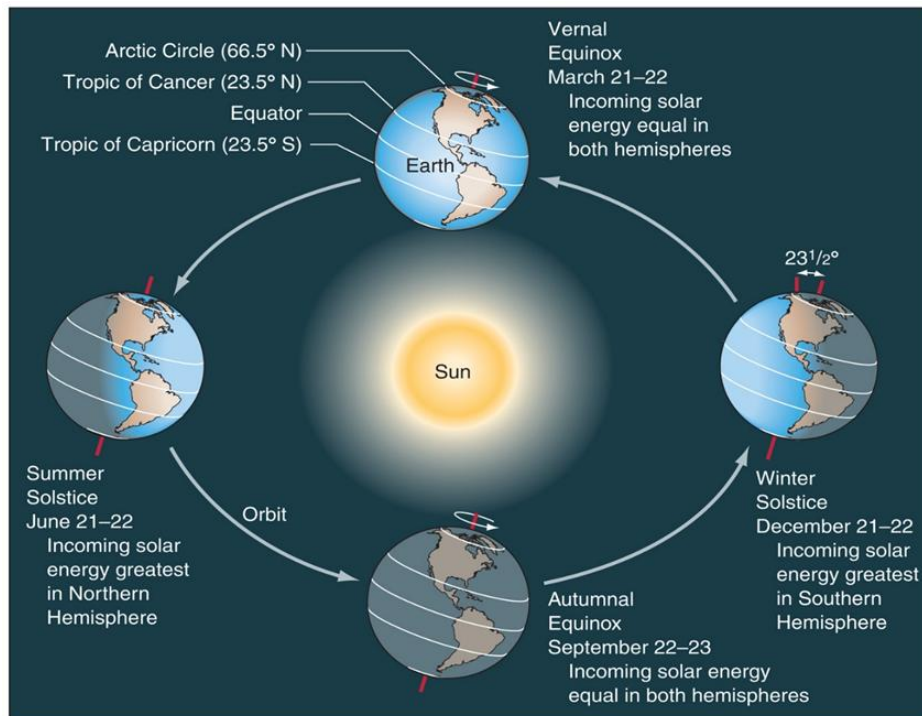
Earth – 1367 W/m^2

Mars – 445 W/m^2

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



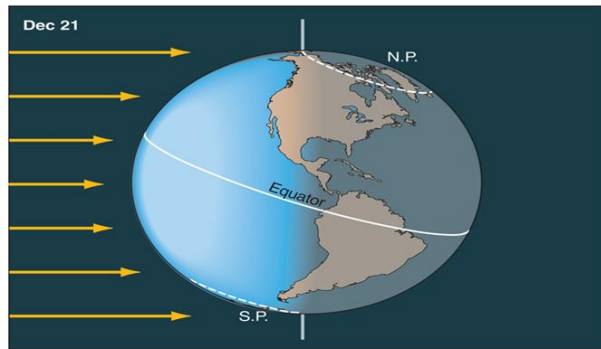
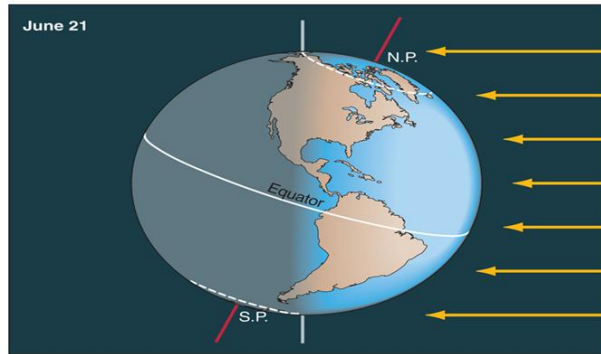
- Earth gets ~7% more radiation in winter (not enough to cause the seasons!) **What does?**
- Earth's tilt is the true cause of the seasons!
Earth's axis is tilted 23.5°



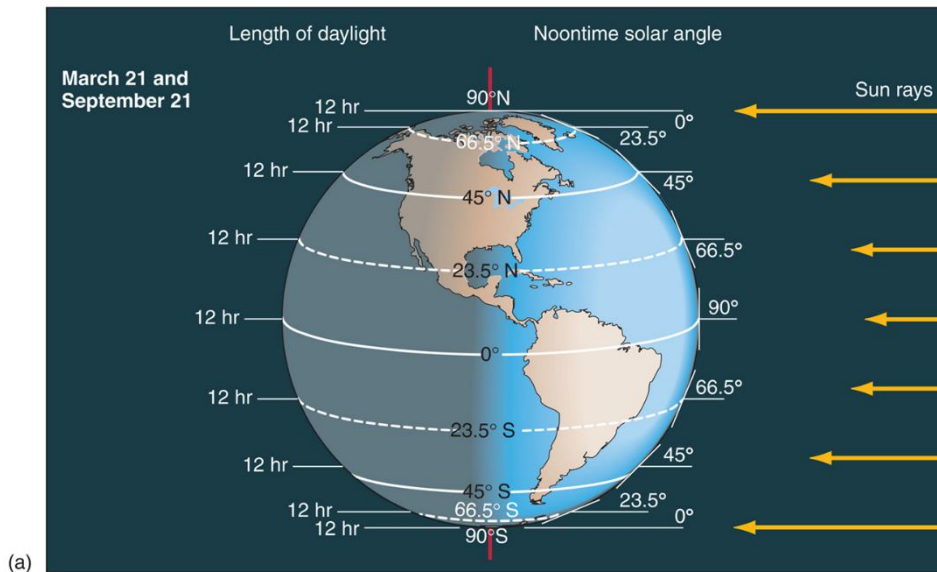
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Three factors contribute to the amount of incoming solar radiation (**insolation**):

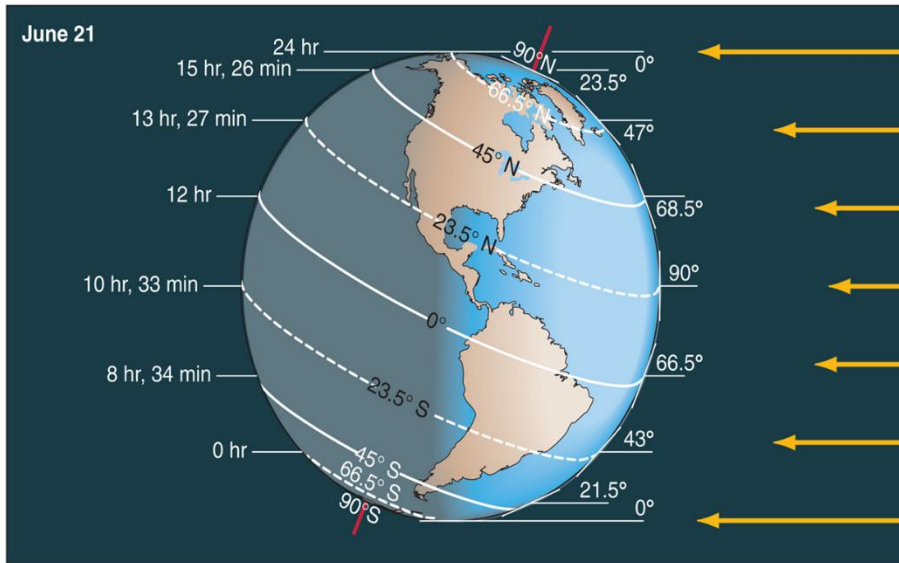
1) Period of daylight



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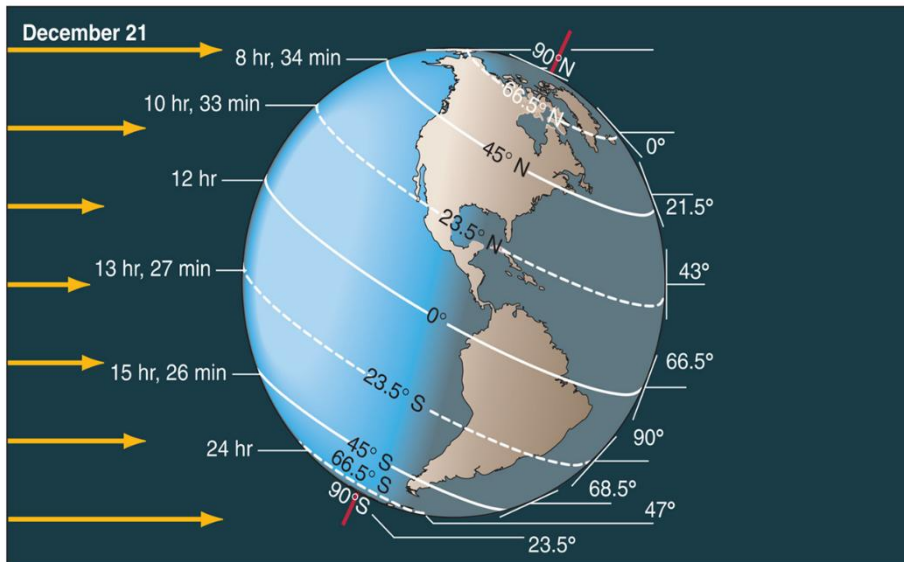


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(b)

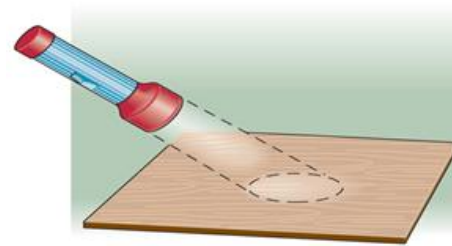
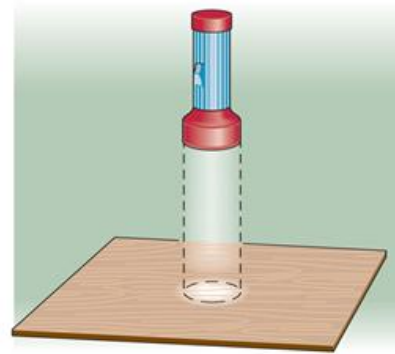
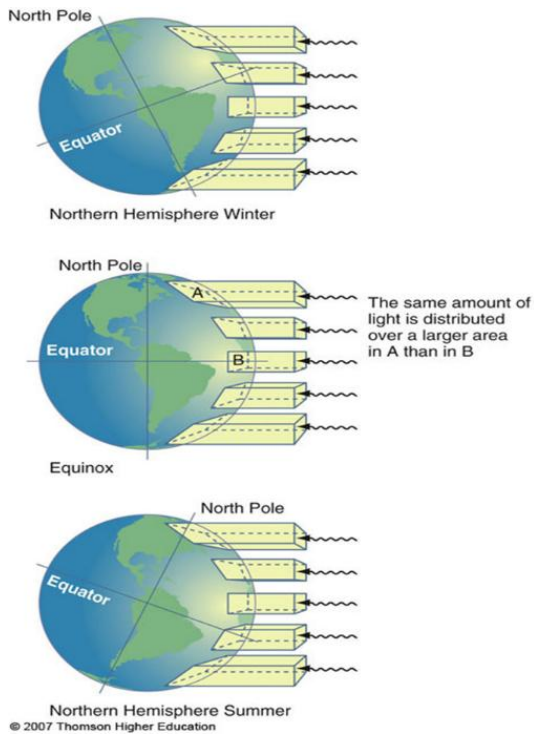
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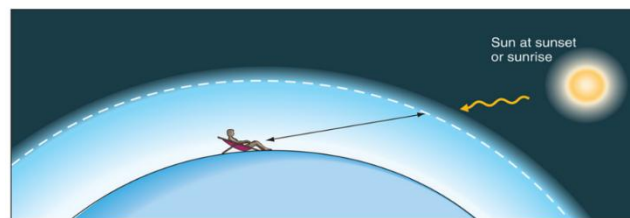
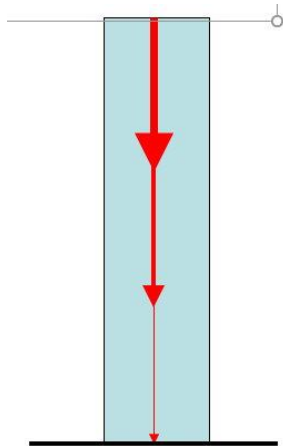
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2) Solar Angle



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3) Beam depletion



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