Solar and Terrestrial Radiation

Energy in the Atmosphere

Ch. 2: Energy in the Atmosphere

- **Heat, Energy, Temperature**
  - → **Definitions**
  - → **Temperature Scales**
- **Heat Transfer**
  - → **Conduction, Convection, Radiation**
- **Electromagnetic Radiation (EMR)**
  - → **Types: Ultraviolet, Visible, Infrared**
  - → **Blackbody Radiation**

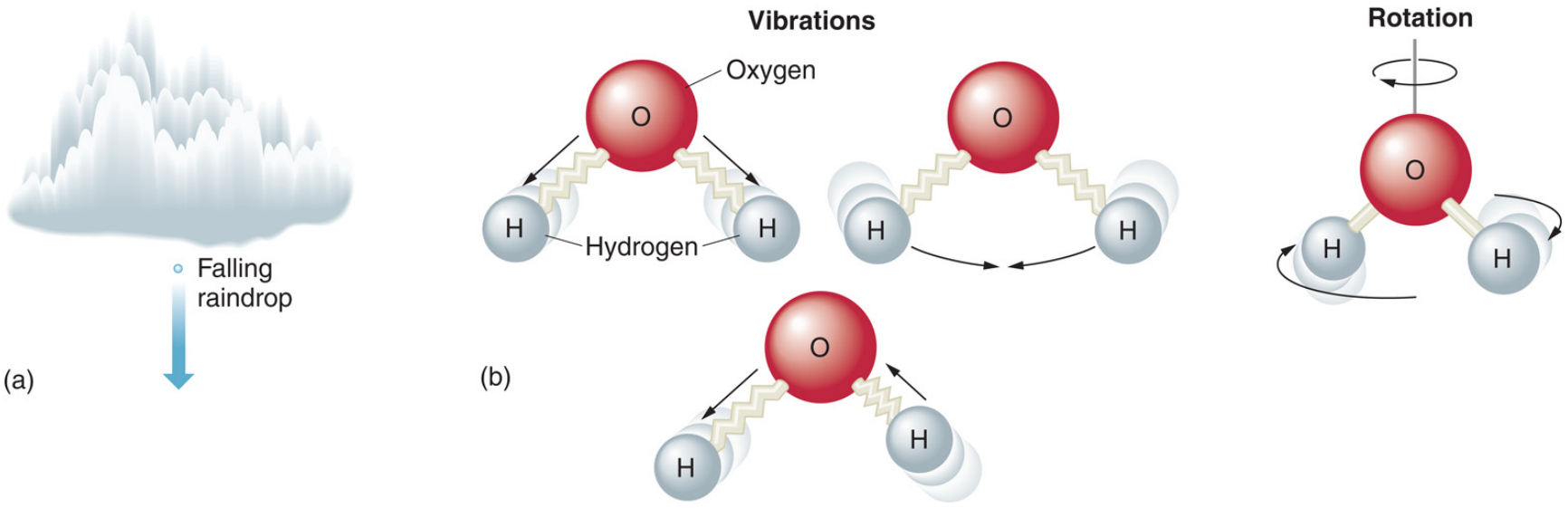
Lecture Topics, cont.

- **Seasons**
  - → **Earth's Axial Tilt**
  - → **Solstices and Equinoxes**
  - → **Solar Angle and Daylight Length**

Heat and Temperature

- **Kinetic Energy = energy of motion**

  → Higher speed → Higher KE



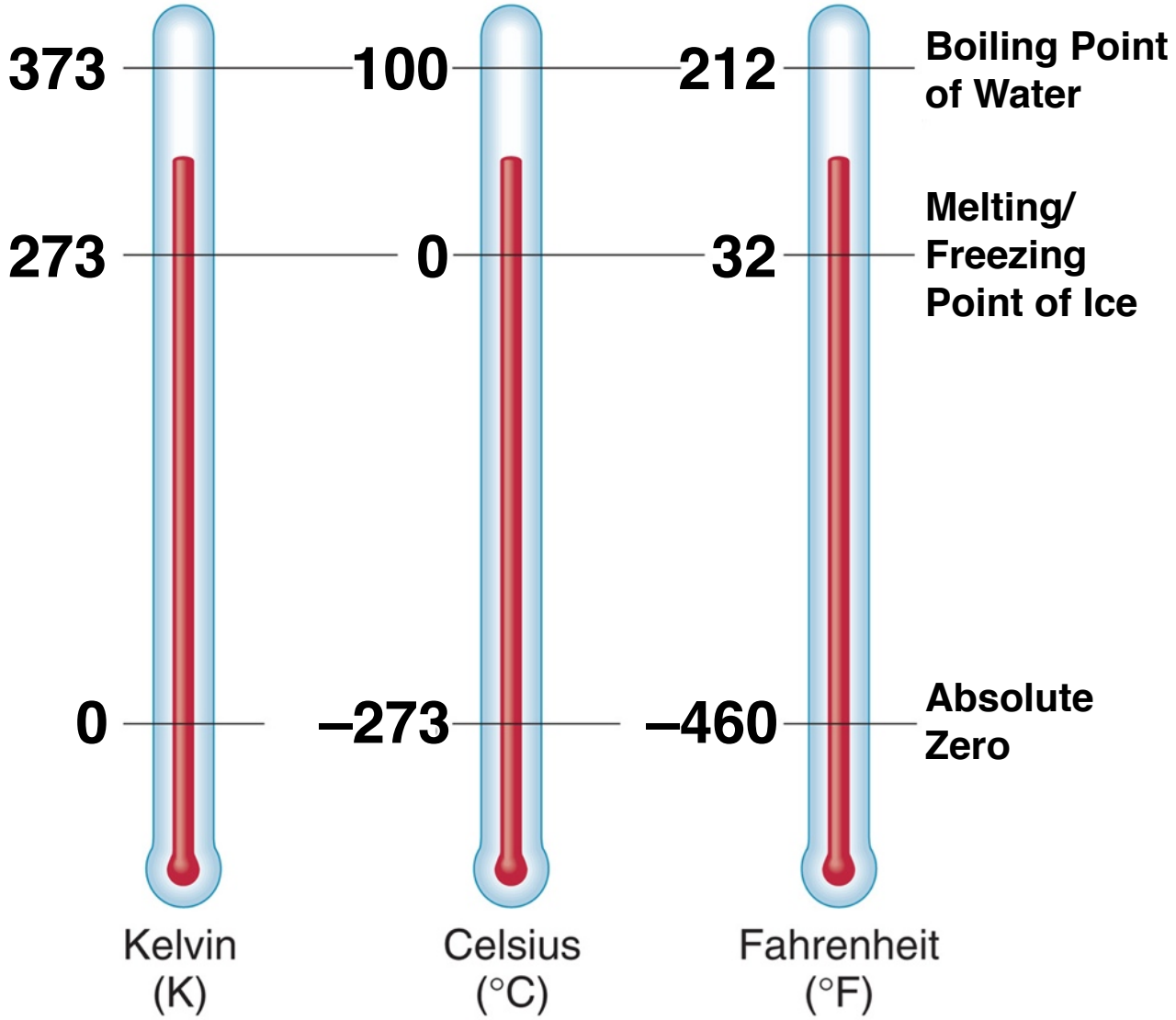
Heat

Cumulative total kinetic energy of all molecules in a substance

Temperature

Proportional to average kinetic energy of individual molecules in a substance

Temperature Scales



Temperature Conversion

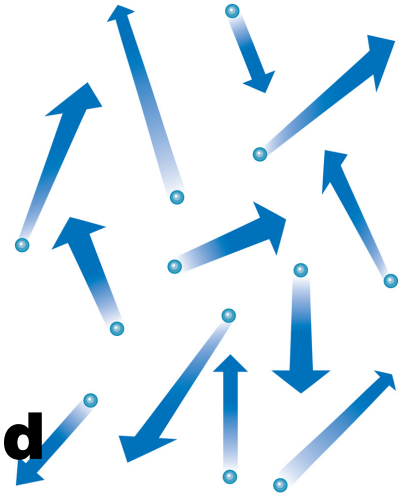
$$K = C + 273$$

$$C = \frac{5}{9}(F - 32)$$

$$F = \frac{9}{5}C + 32$$

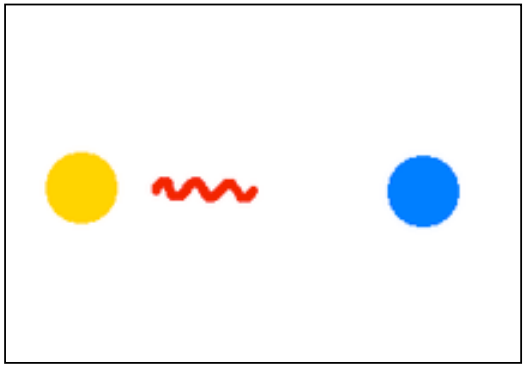
Heat Transfer

- **Heat flows from regions of high heat content to regions of low heat content**
  - → **Usual direction: high temperature regions to low temperature regions**
- **Conduction: heat spread by collisions between molecules**
  - → **Slow!**
  - → **Air is a poor conductor/is a good insulator**



Randomly moving air molecules

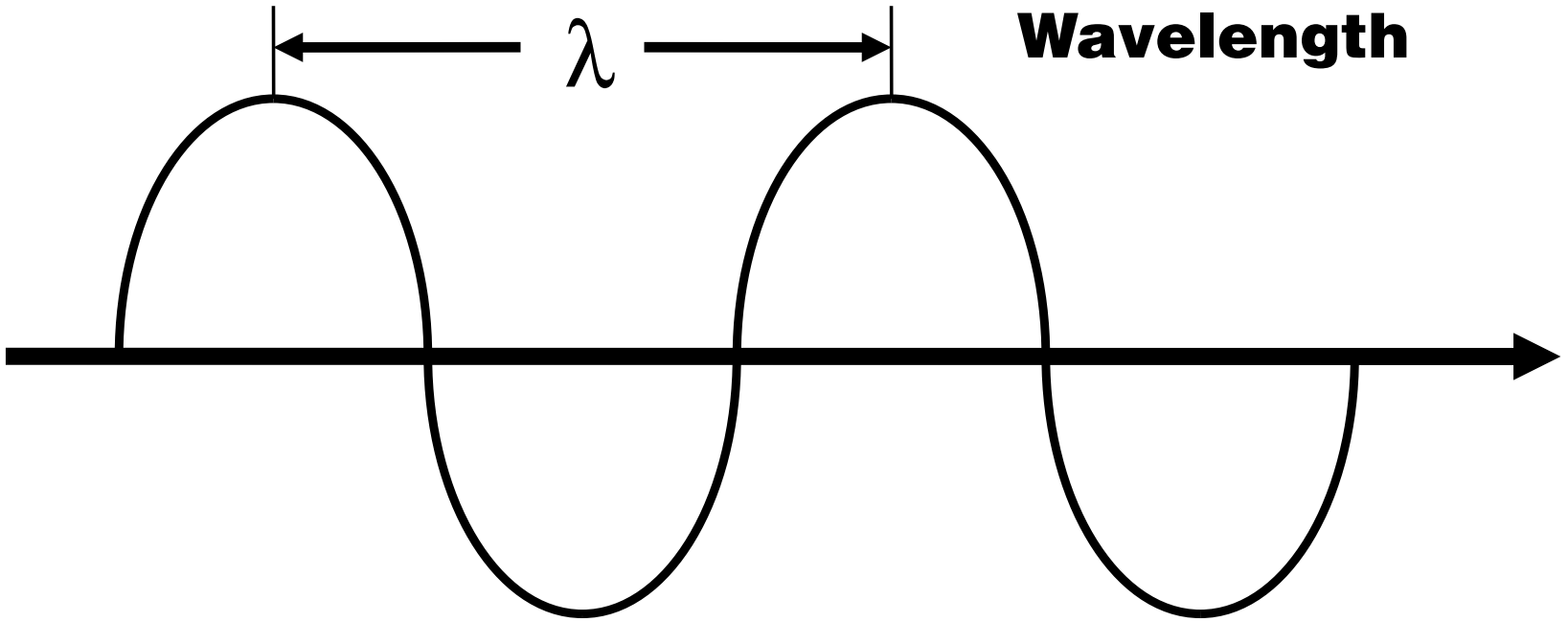
- **Convection: heat transport via bulk movement of air**
  - → **Faster than conduction; as fast as the wind**
  - → **“Convection”: vertical movement**
  - → **“Advection”: horizontal movement**



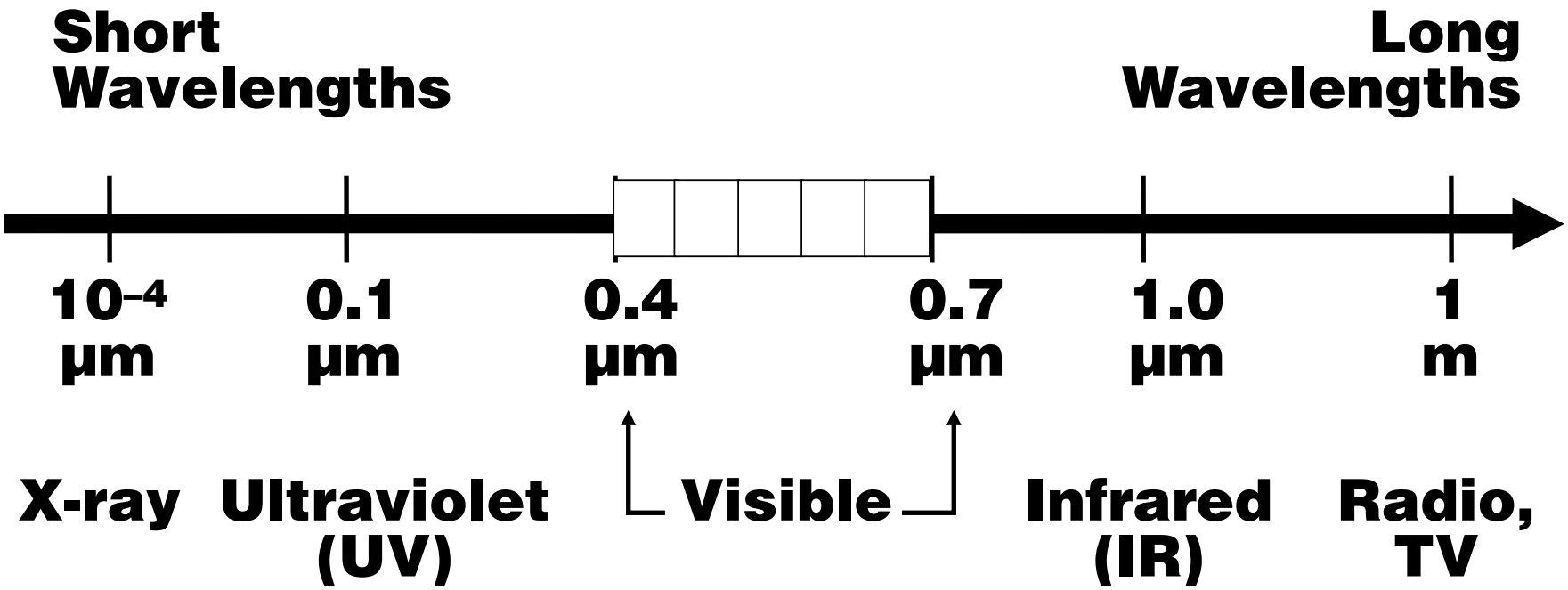
- **Radiation: energy propagating through space in the form of electromagnetic radiation**
  - **→ Moves as fast as speed of light**
  - **→ Can travel through a vacuum**

Electromagnetic Radiation

Radiation energy propagates as a wave, in energy packets called photons

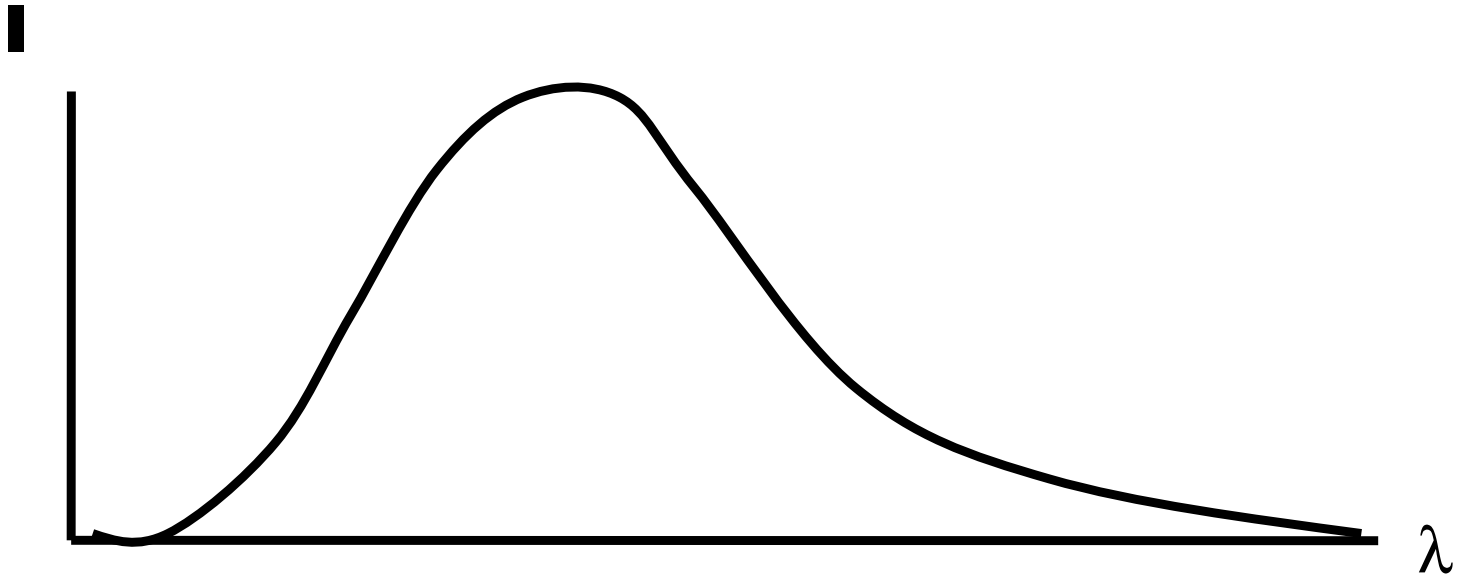


Types of EMR


Short Wavelengths
Long Wavelengths
10–4 µm
0.1 µm
0.4 µm
0.7 µm
1.0 µm
1 m
X-ray
Ultraviolet (UV)
Visible
Infrared (IR)
Radio, TV

Blackbody Radiation

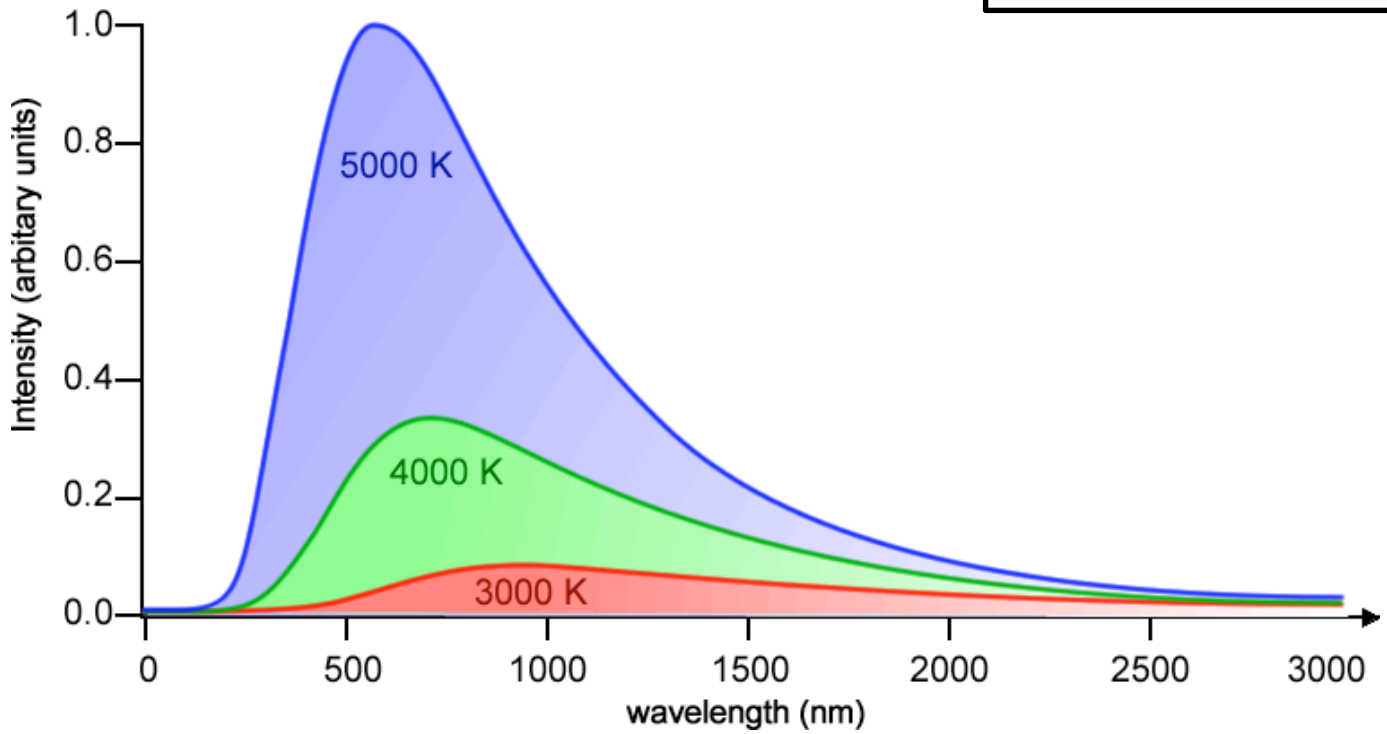
- **Blackbody: an object that absorbs all wavelengths of EMR**
  - **→ And emits all wavelengths of EMR (Kirchoff's Law)**



Stefan-Boltzmann Law

- **Radiation power flux emitted by a blackbody is directly proportional to its temperature**

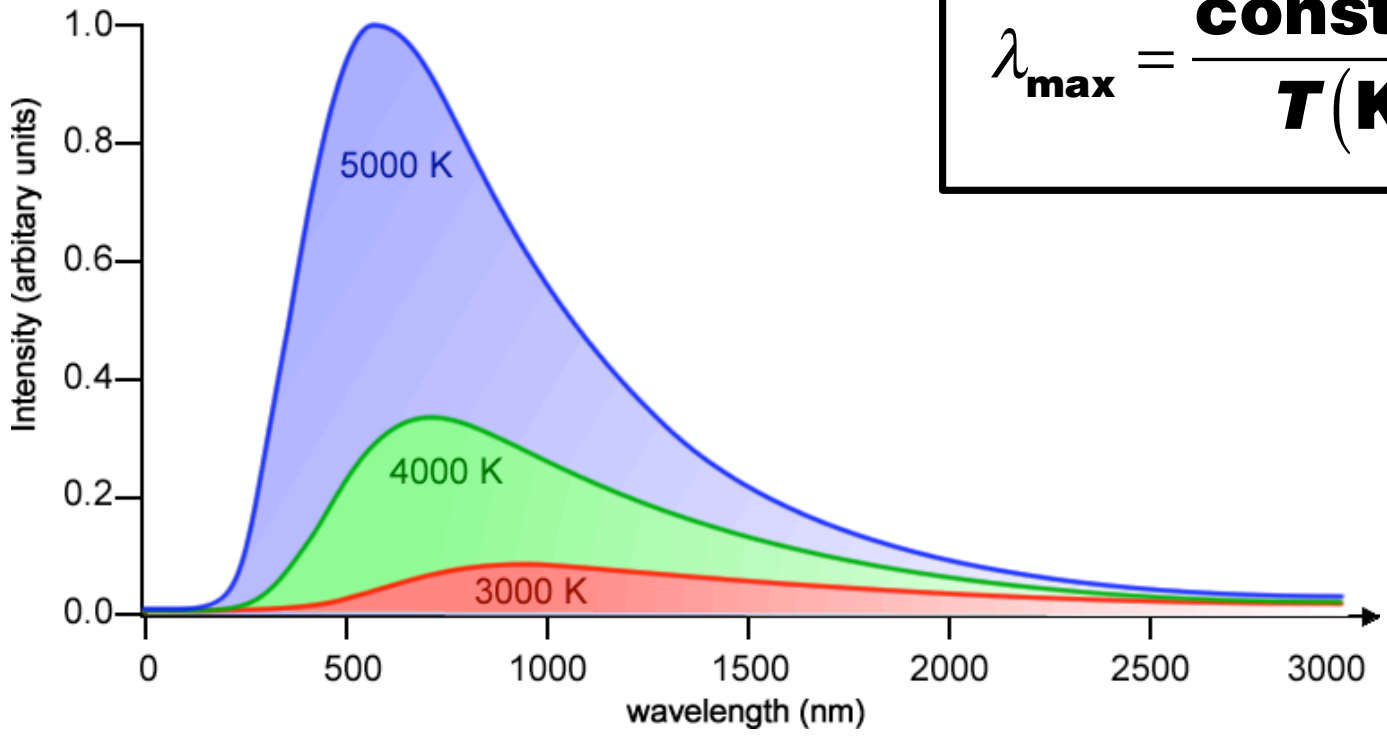
$$E = \sigma T^4$$

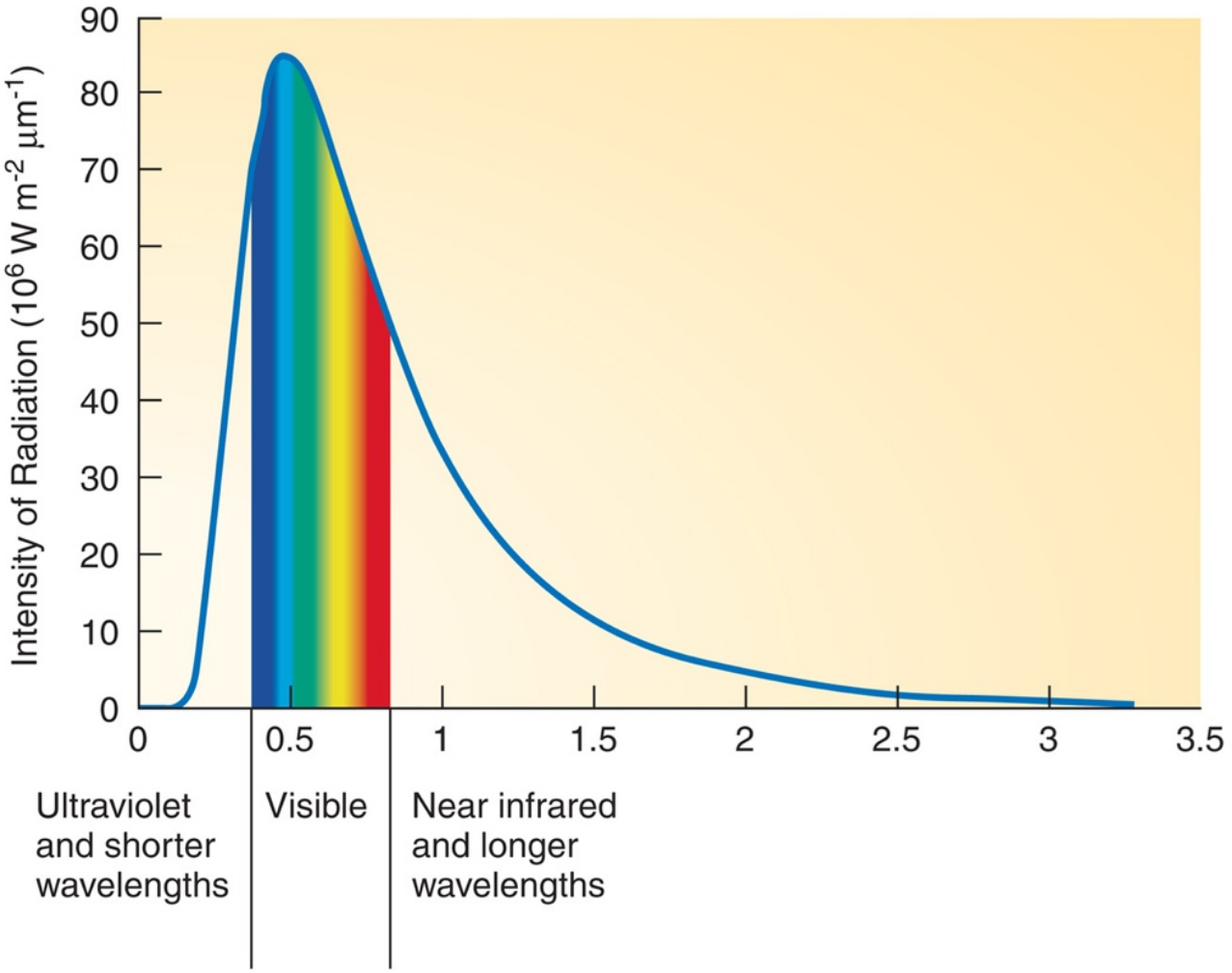


Wien's Law

- **A blackbody emits EMR such that the wavelength of maximum intensity (λ_{max}) is inversely proportional to the blackbody's temperature**

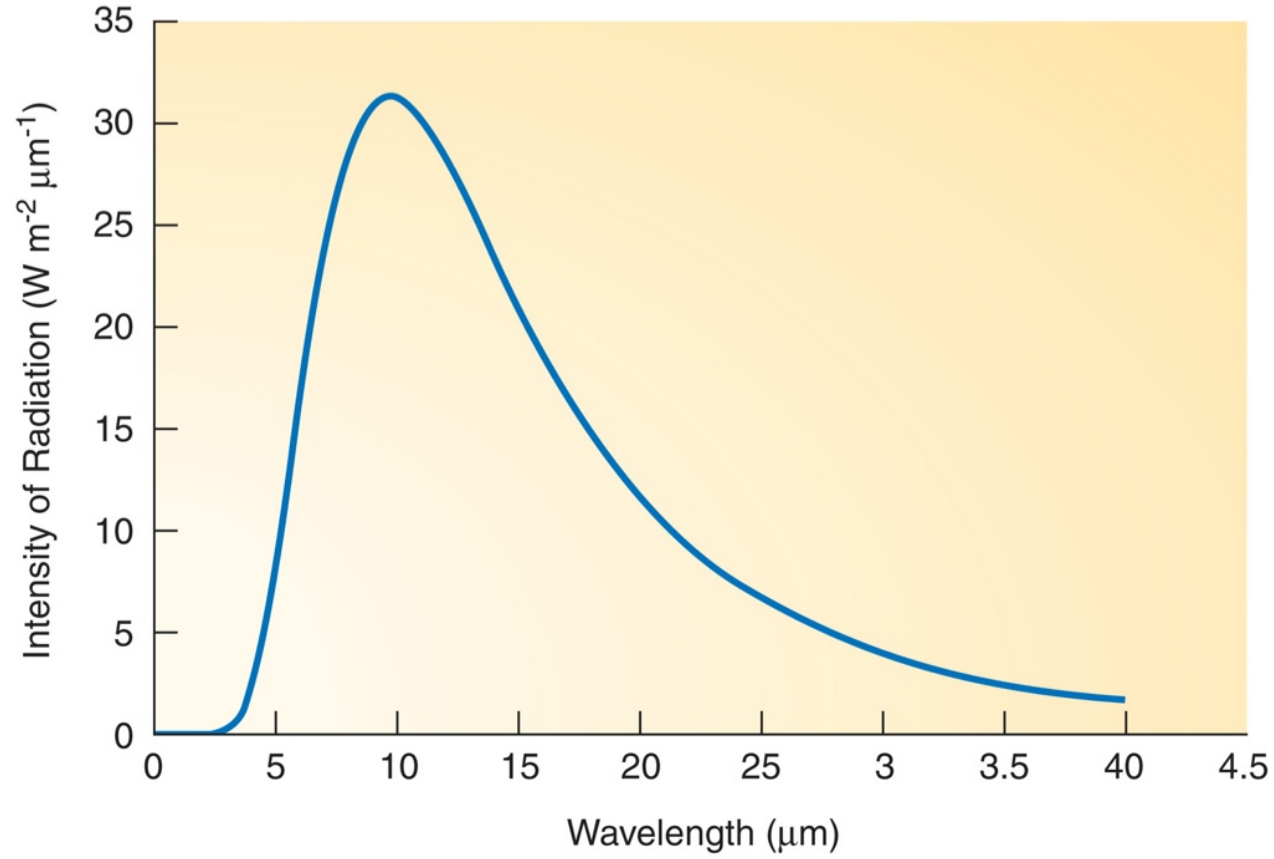
$$\lambda_{max} = \frac{\text{constant}}{T(\text{K})}$$





(a)

Sun
6000 K
λ_{max} = 0.5 μm

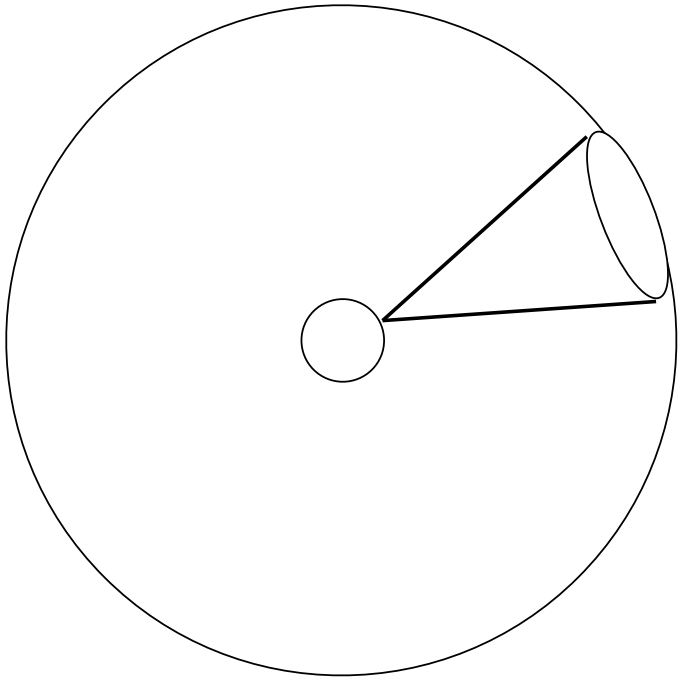


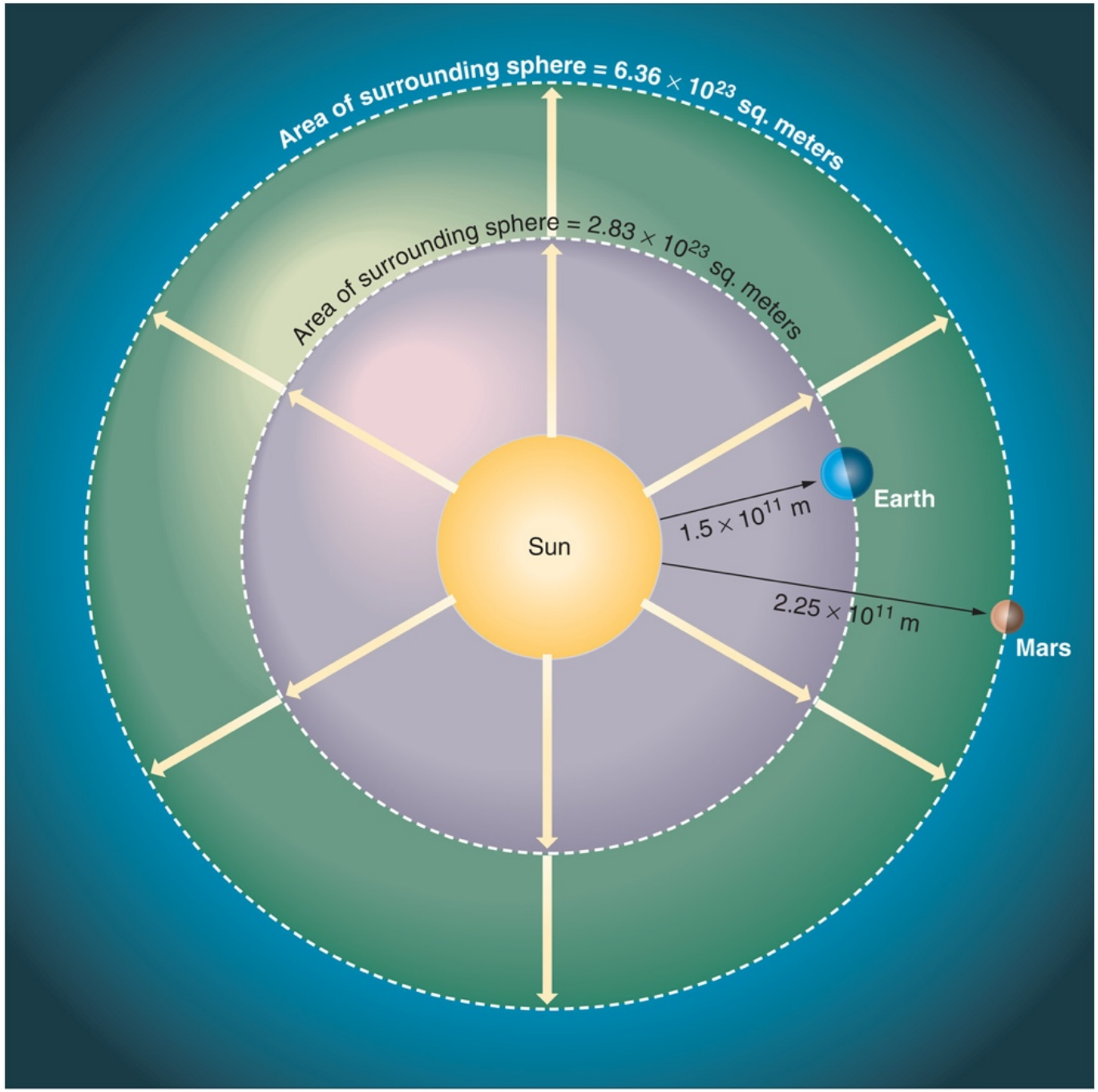
(b)

Earth
255 K
λ_{max} = 11 μm

Inverse Square Law

- **Radiation power flux from an object decreases as the square of the distance from the object**

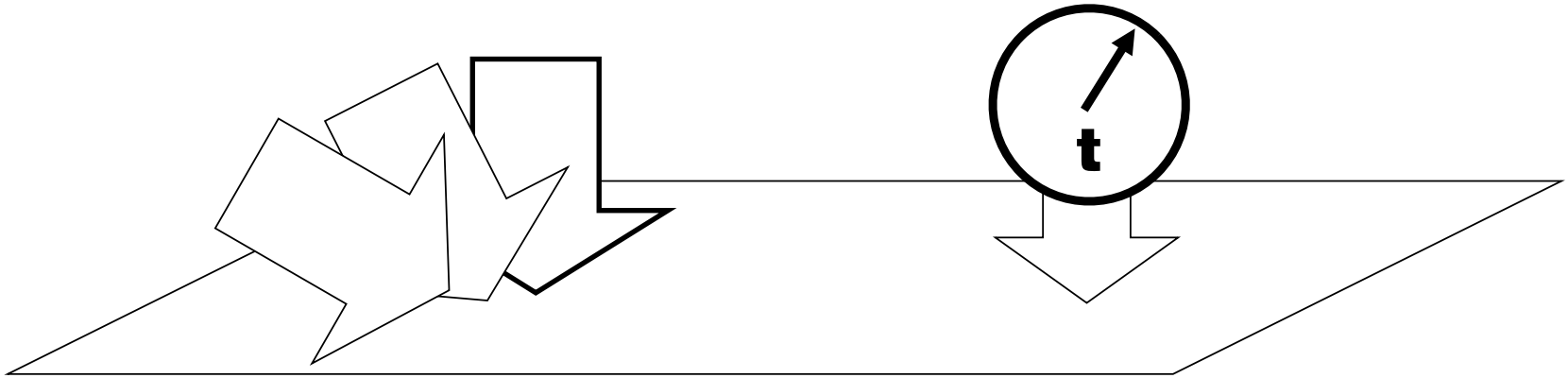



Area of surrounding sphere = 6.36 × 10^23 sq. meters
Area of surrounding sphere = 2.83 × 10^23 sq. meters
Sun
Earth
1.5 × 10^11 m
2.25 × 10^11 m
Mars

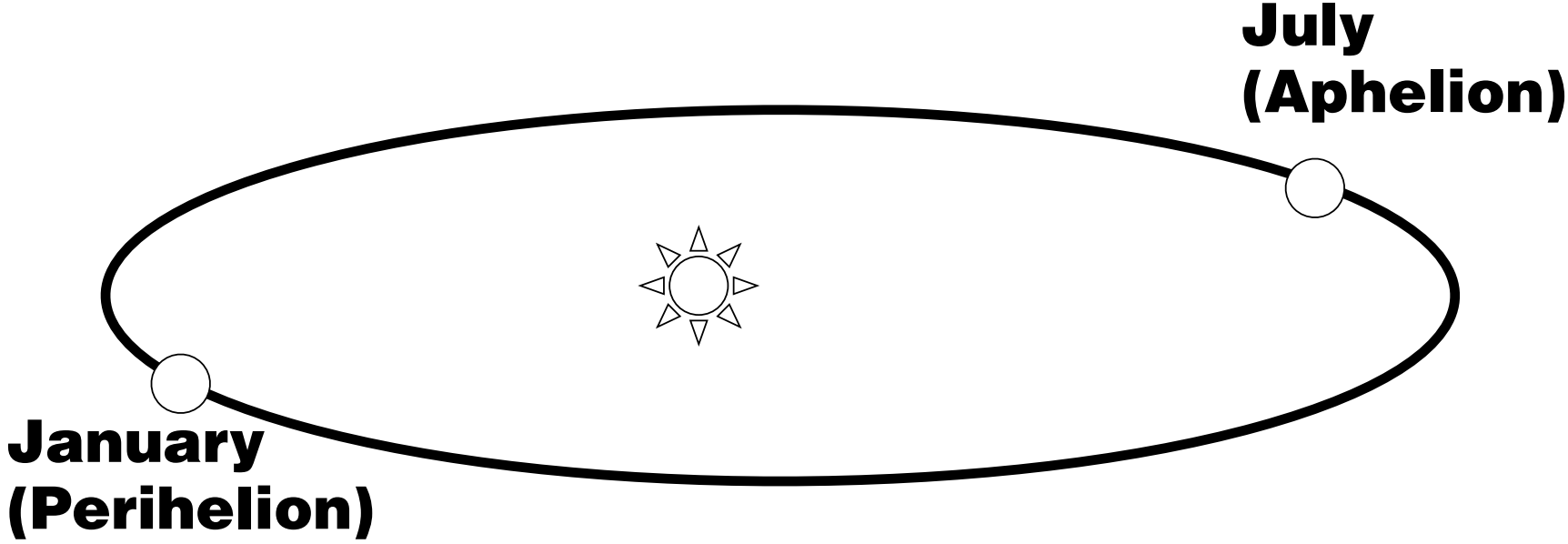
Insolation and Earth Seasons

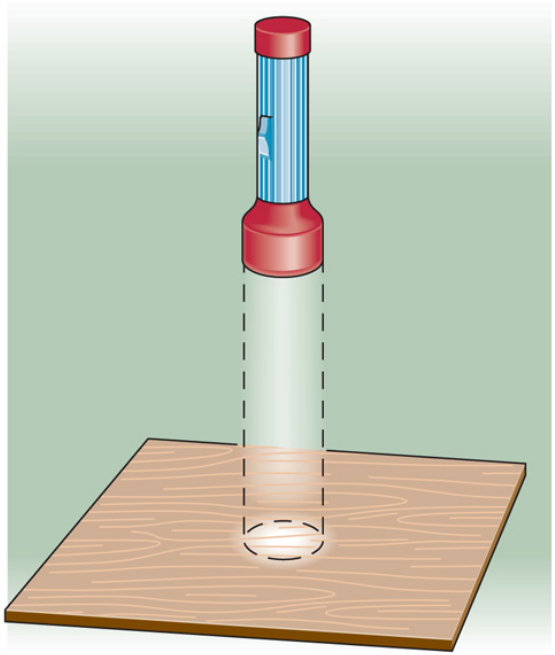
Insolation: cumulative amount of solar radiation energy received by the Earth's surface in one day

Intensity **Duration**

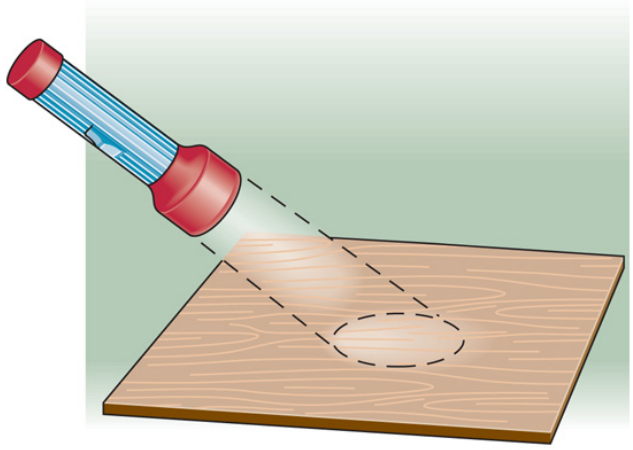


- **Seasons are regular, annual variations in temperature and/or climate**
  - ➡ **Results from variation of insolation during the course of a year**

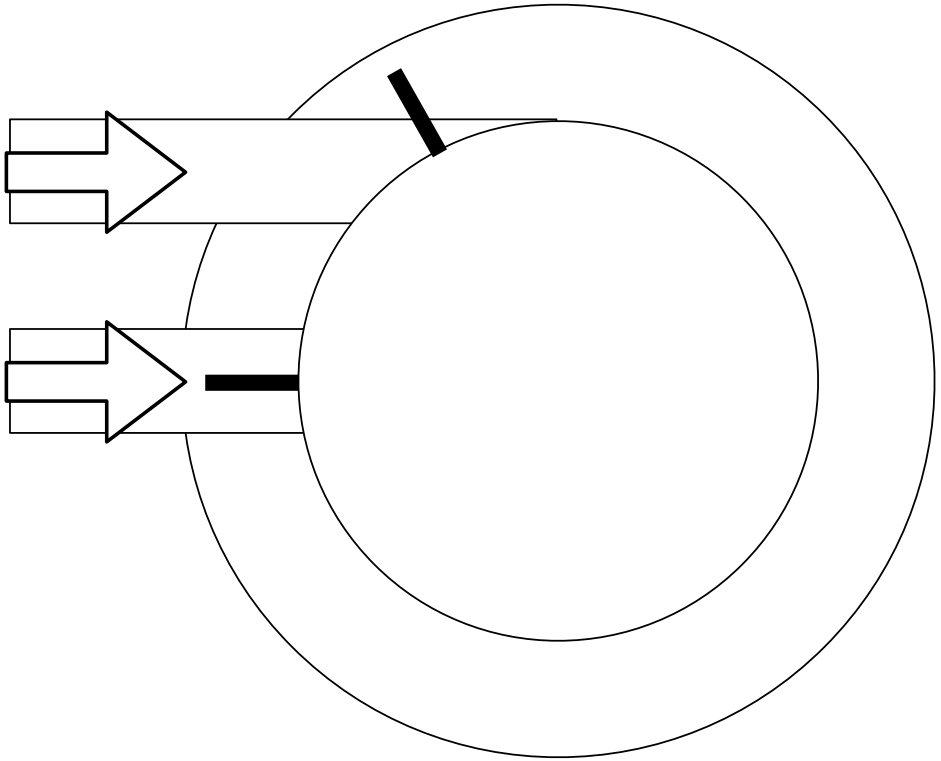




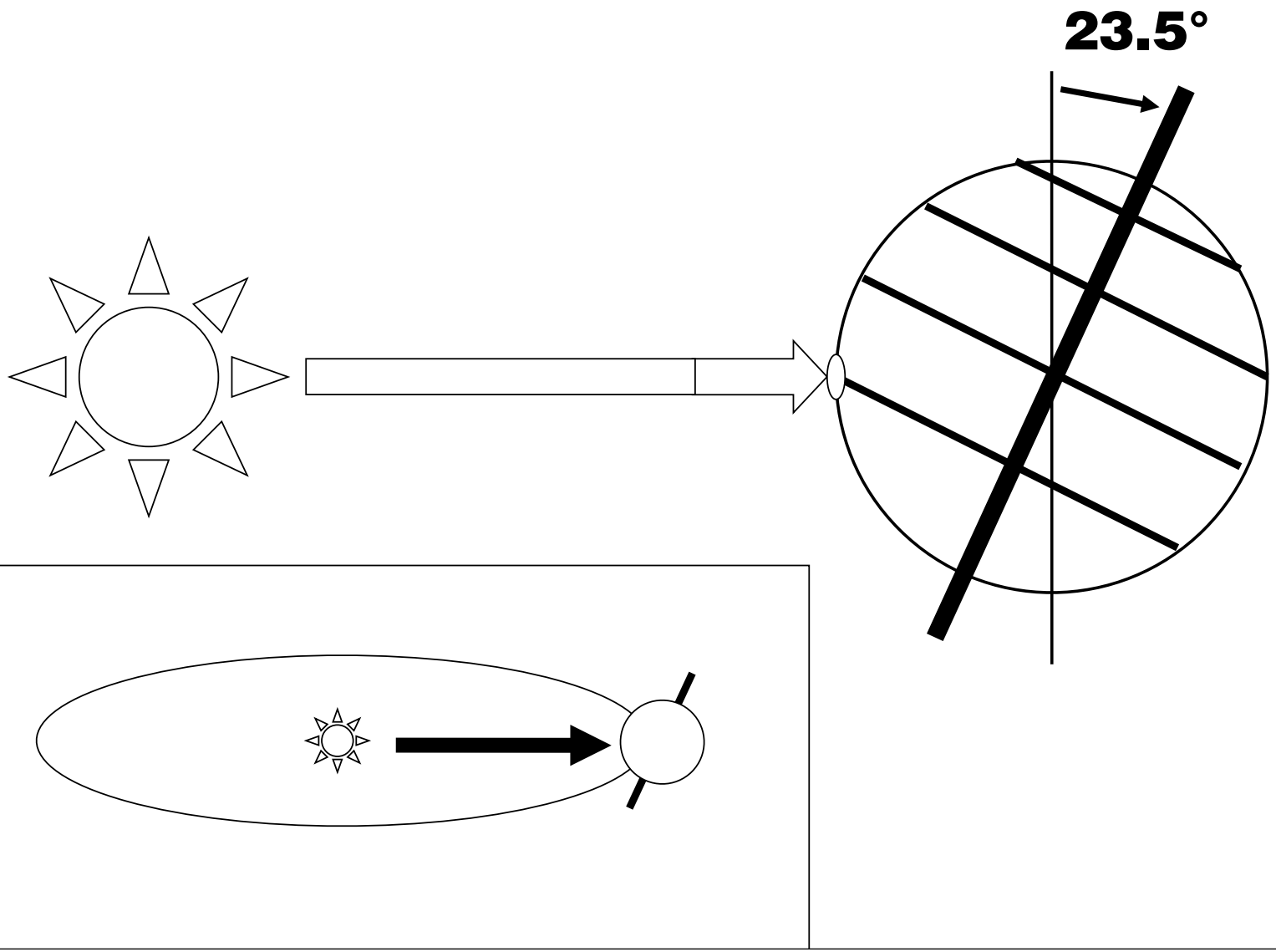
(a)



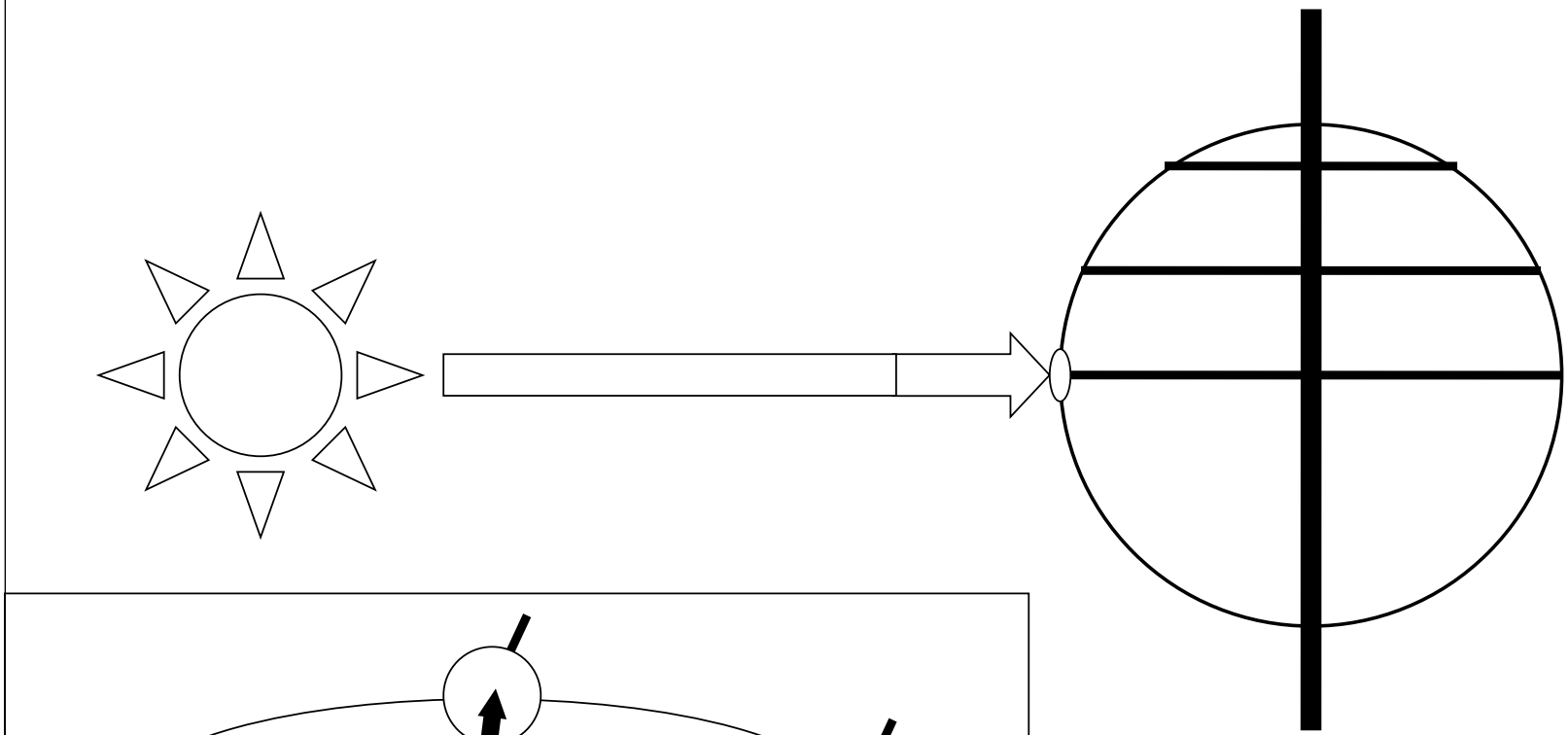
(b)

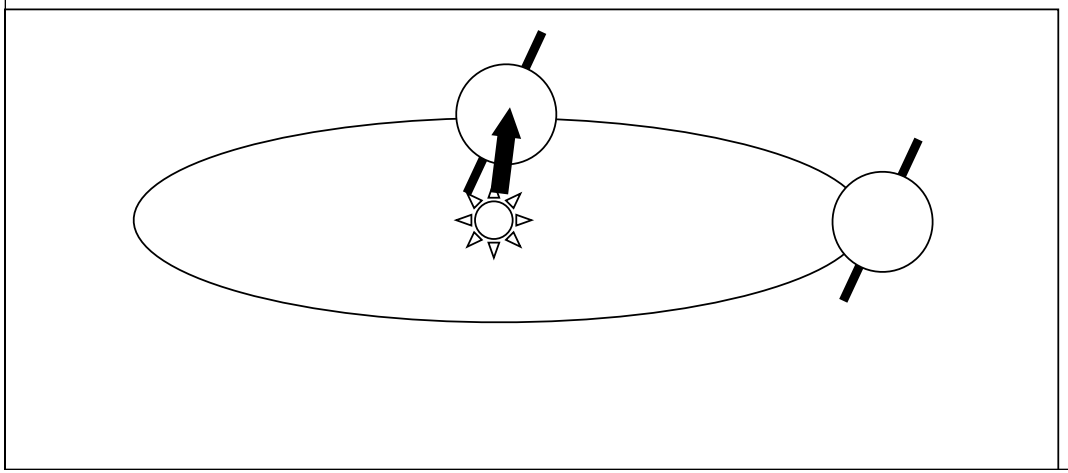


Earth's Tilt in Space

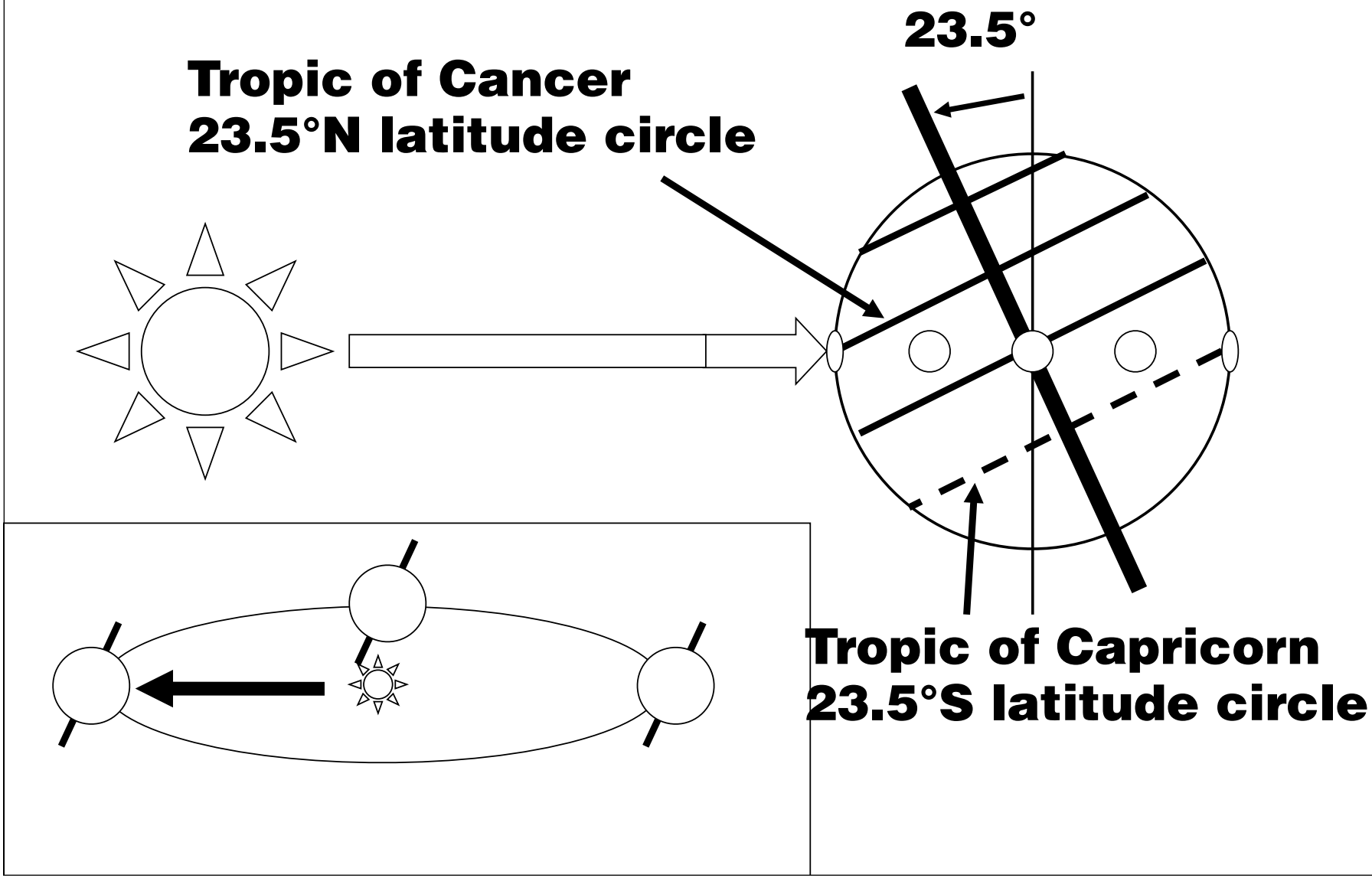


Earth's Tilt in Space



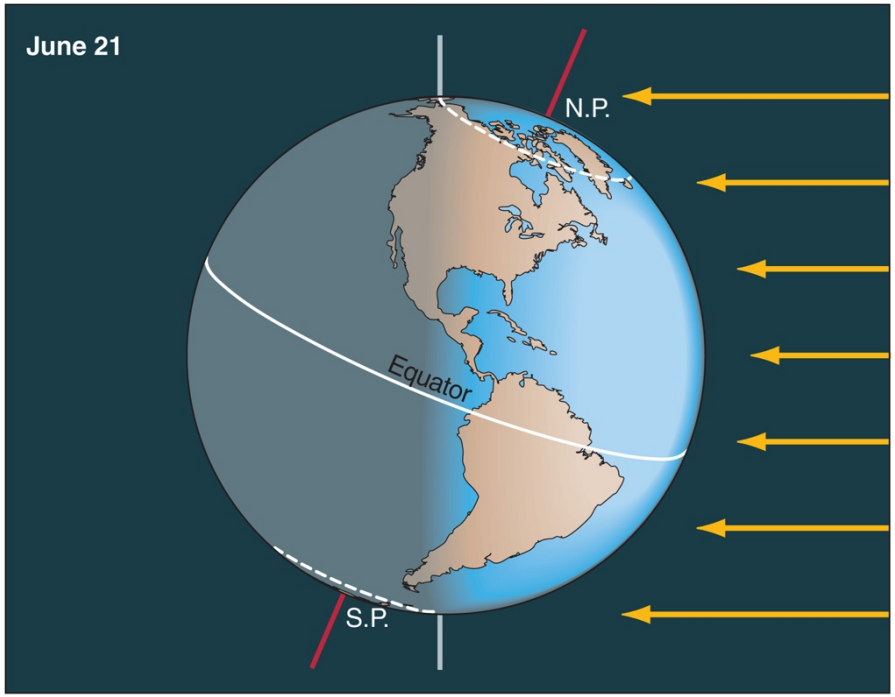


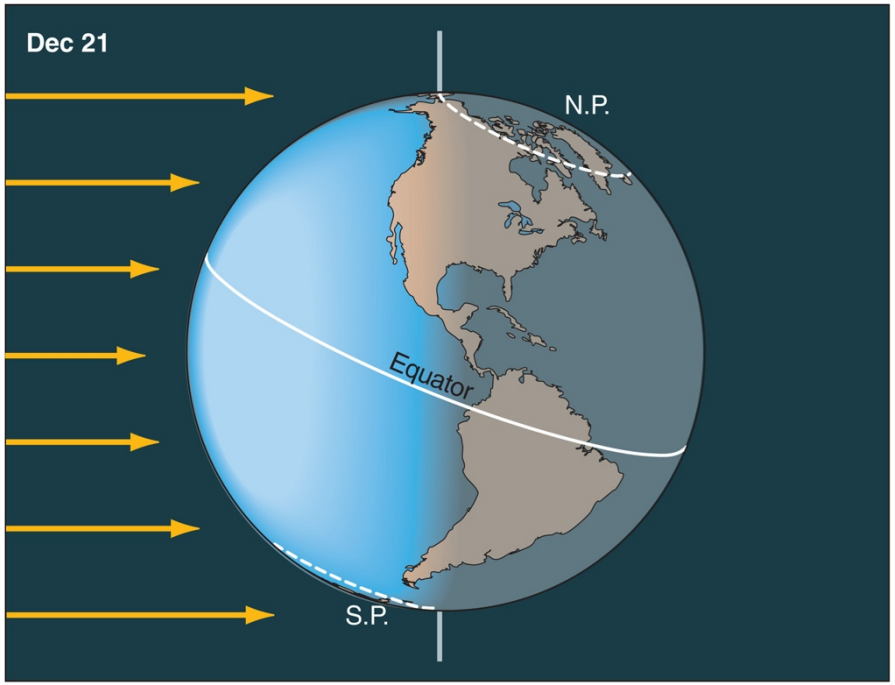
Earth's Tilt in Space



Solstices

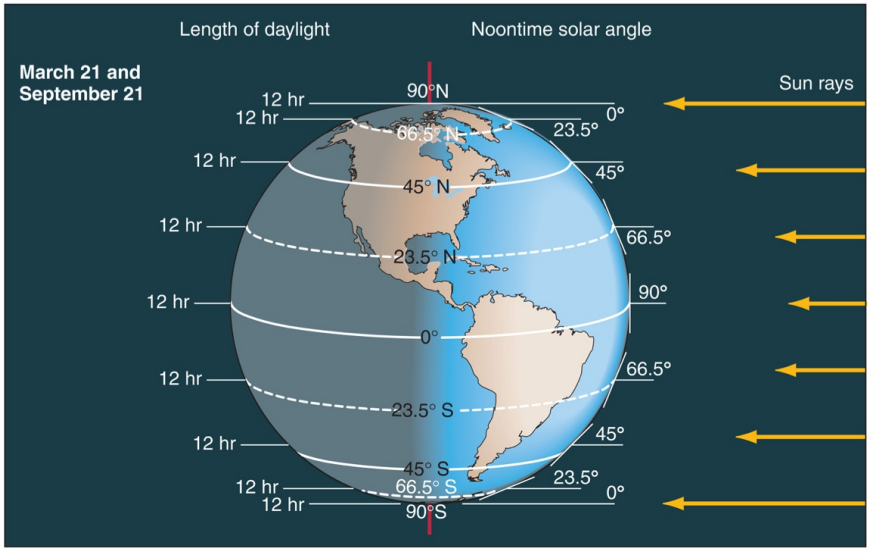
- **North/South Poles are pointed most toward or away from the Sun**
- **Subsolar point is Tropic of Cancer or Capricorn**
  - → **June Solstice: ~June 21, subsolar point Tropic of Cancer**
  - → **December Solstice: ~December 21, subsolar point Tropic of Capricorn**



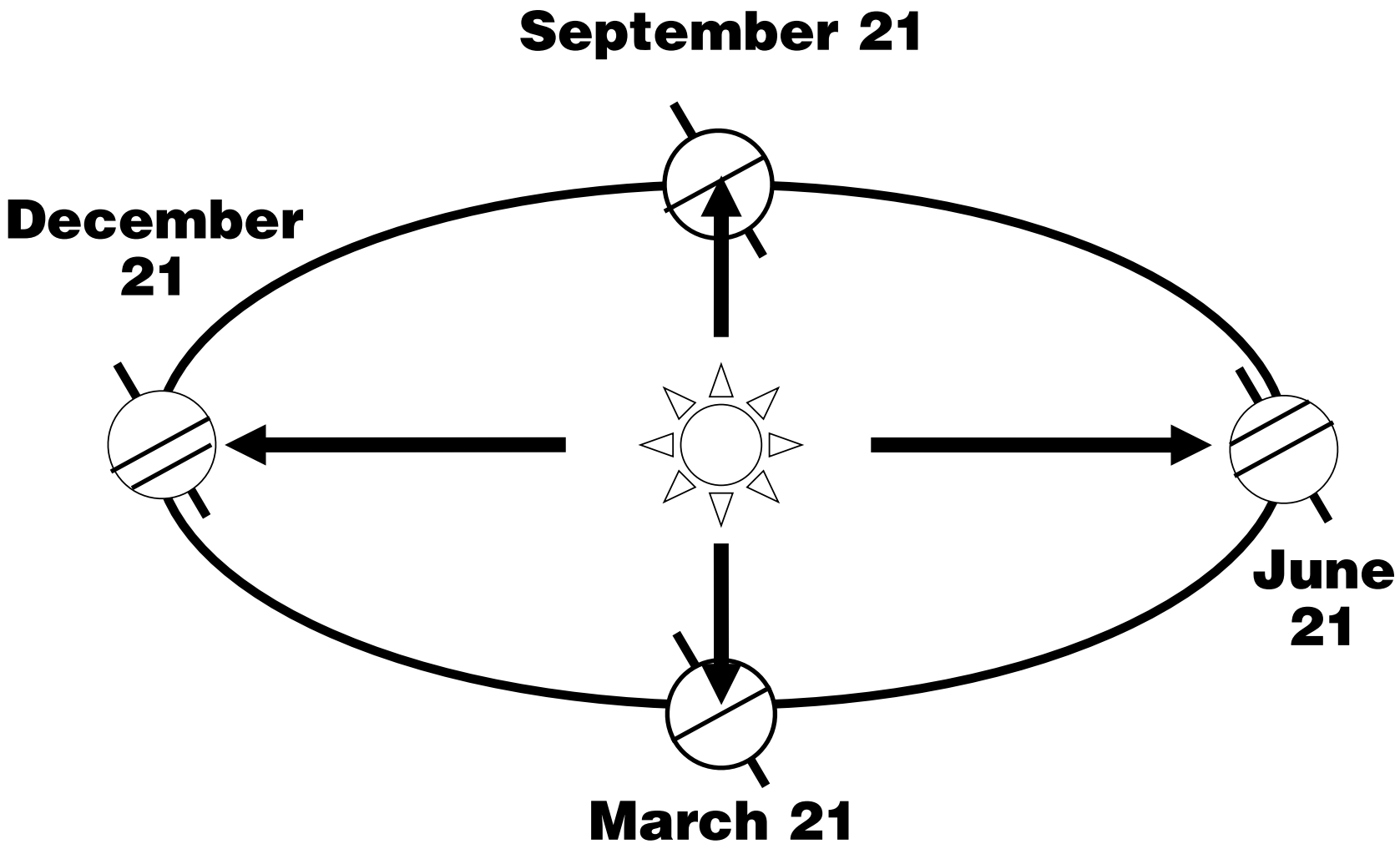


Equinoxes

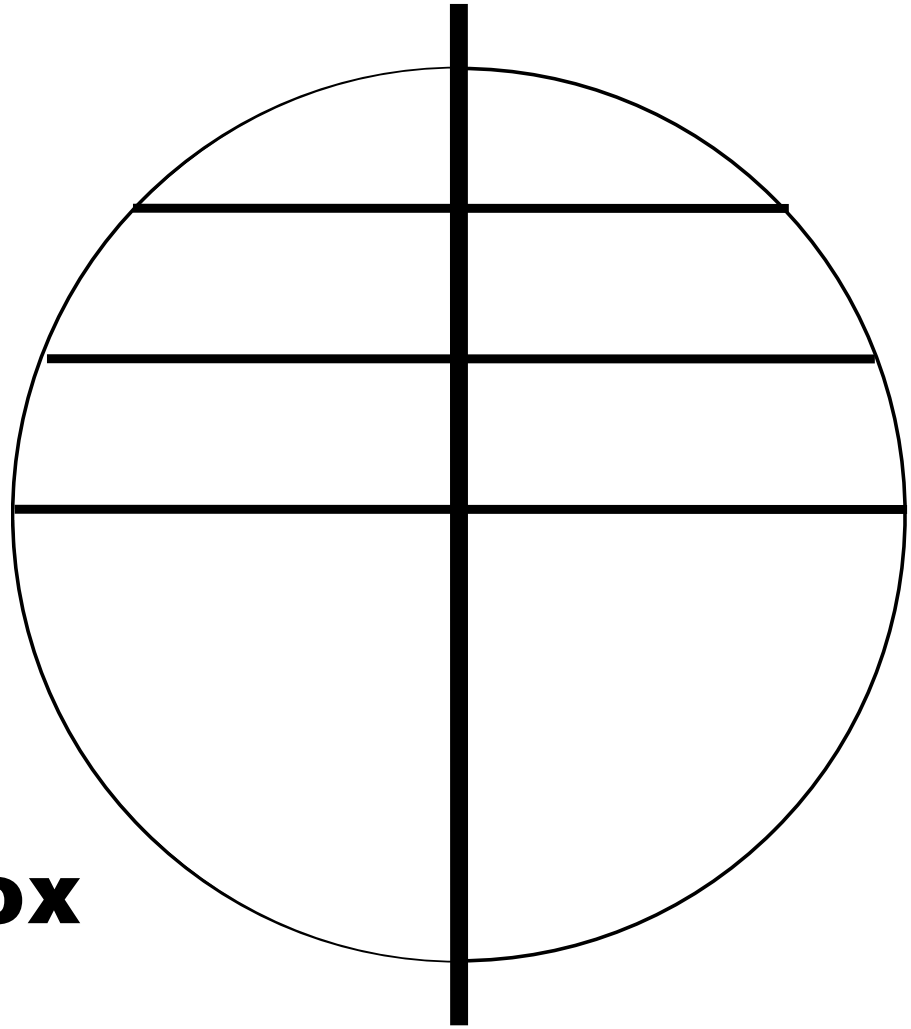
- **Subsolar point = 0° latitude (the Equator)**
- **Directly between solstices**
- **12 hours daylight, 12 hours night**



(a)

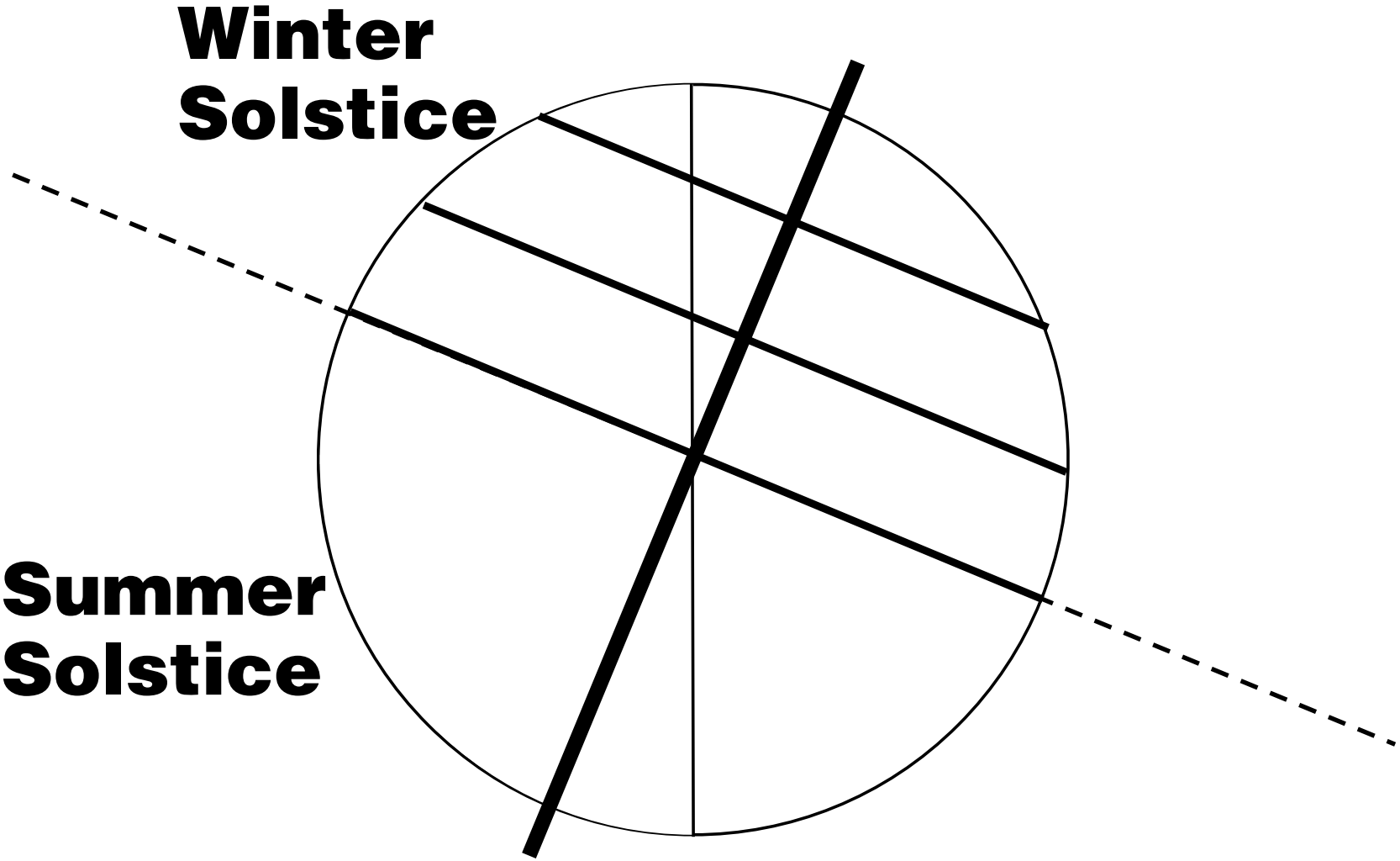

September 21
December 21
June 21
March 21

Seasons and Daylight Length



Equinox

Seasons and Daylight Length



Seasons and Daylight Length

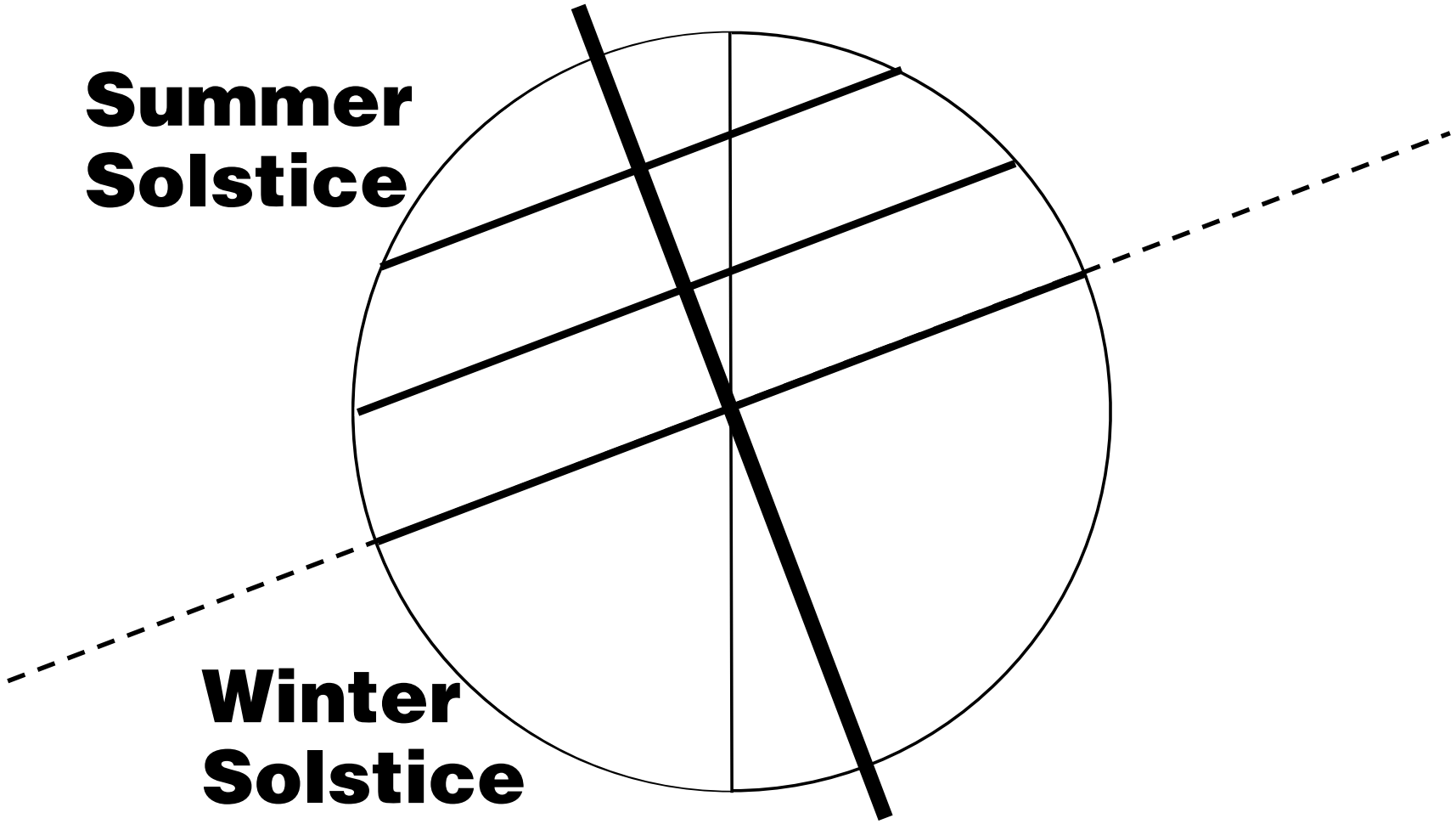


TABLE 2–2 Variations in Solar Angle and Daylength

	Solar Angle at Noon	Length of Day	Total Radiation for Day (Megajoules/m^2)
December 21			
Winnipeg (50 °N)	16.5°	7 hr, 50 min	7.1
Austin (30 °N)	36.5°	10 hr, 04 min	18.6
June 21			
Winnipeg (50 °N)	63.5°	16 hr, 10 min	44.5
Austin (30 °N)	83.5°	13 hr, 56 min	43.9

Seasons and Solar Altitude