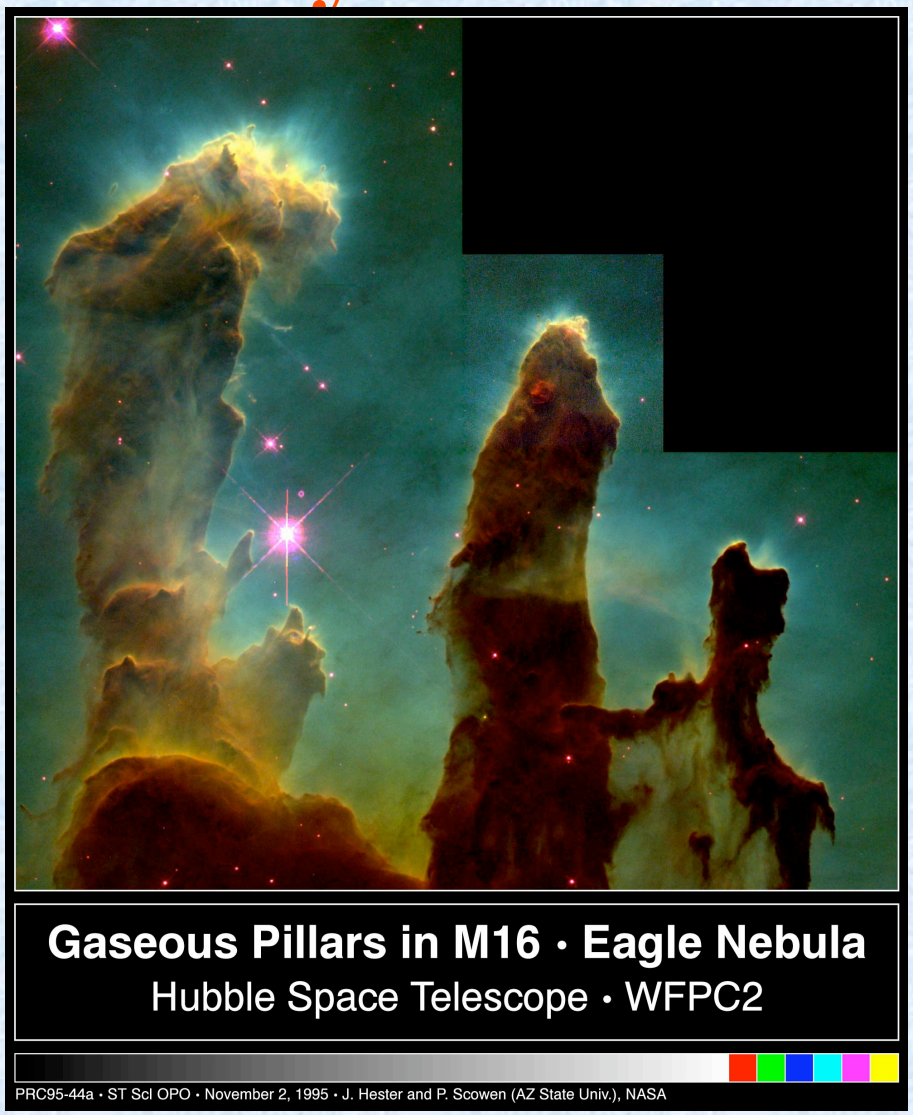
Astronomy 1 – Winter 2011



Lecture 6; January 14 2011

Previously on Astro-1

- Newton's Laws of Motion:
  1. Inertia
  2. Relation between force and acceleration
  3. Action/Reaction
- Inertial and gravitational mass
- Newton's Law of gravity
- The orbits of planets
- Tides

Homework – Due 01/19/11

- On your own: answer all the review questions in chapters 4 thru 5
- To TAs: answer questions 4.41, 4.47, 5.30, 5.33, 5.40, 5.41

Today on Astro-1

- The nature of light
  1. Speed of light
  2. Light is a wave
  3. Light is electromagnetic fields
- Beyond visible light
- Blackbodies and the temperature of light

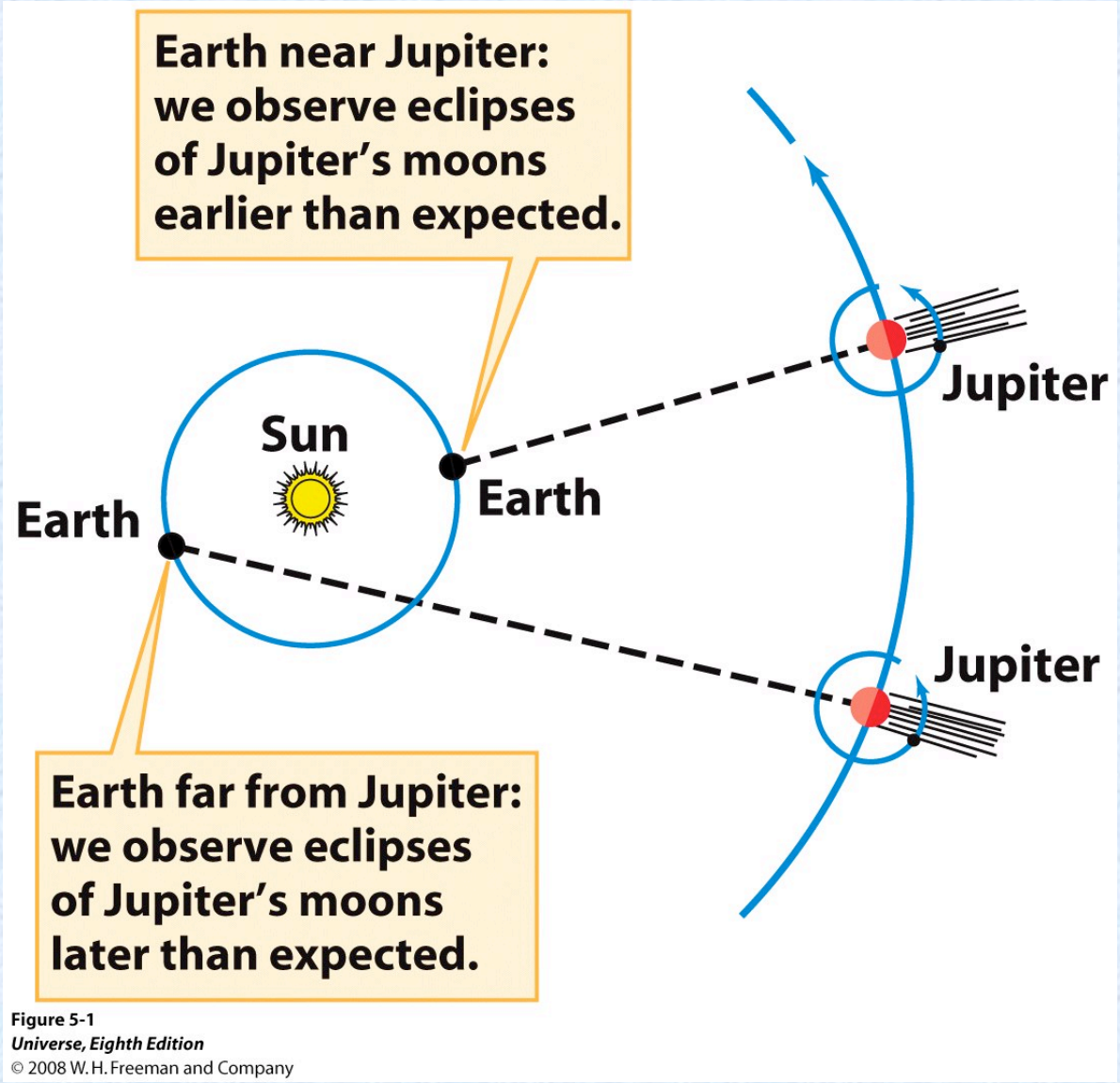


Figure 5-1
Universe, Eighth Edition

Is the speed of light finite? Galileo tried, but couldn't measure it.

In 1676 Ole Rømer noticed that the measurements of the eclipses of Jupiter's moons were systematically off, depending on how distant Earth was from Jupiter. From this he deduced the speed of light (in terms of AU).

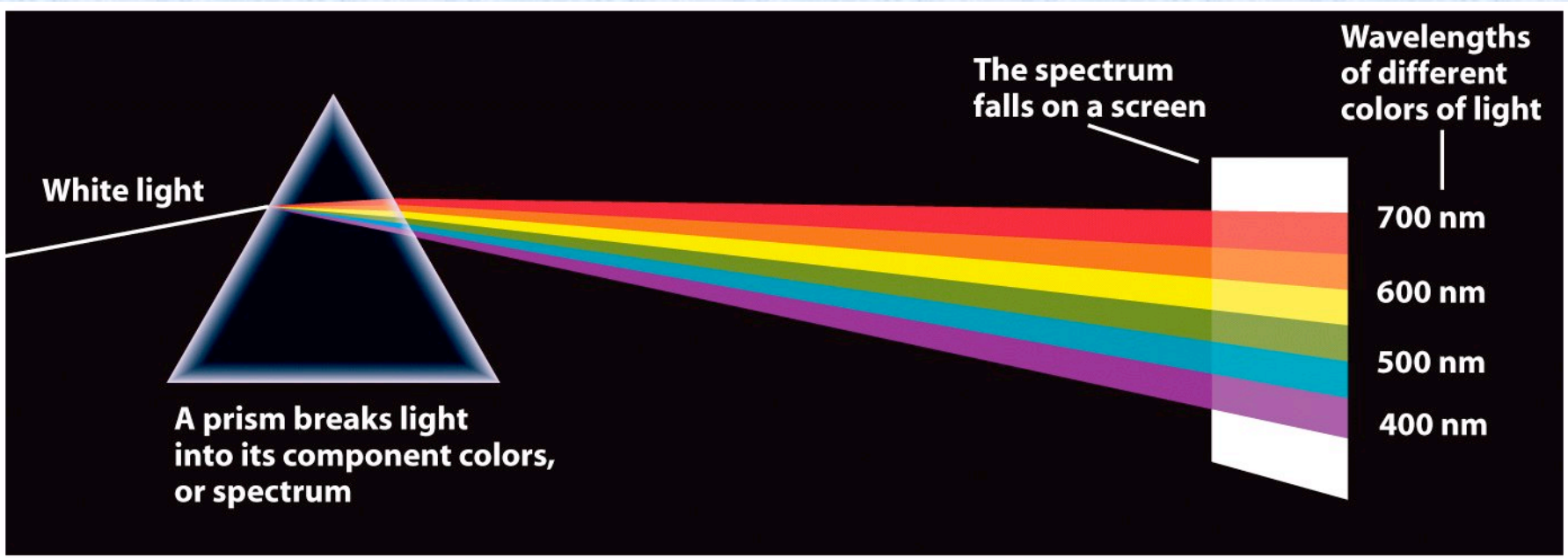


Figure 5-3
Universe, Eighth Edition

Newton's used this experiment to prove that prisms do not add color to light but merely bend different colors through different angles. It also proved that white light, such as sunlight, is actually a combination of all the colors that appear in its spectrum.

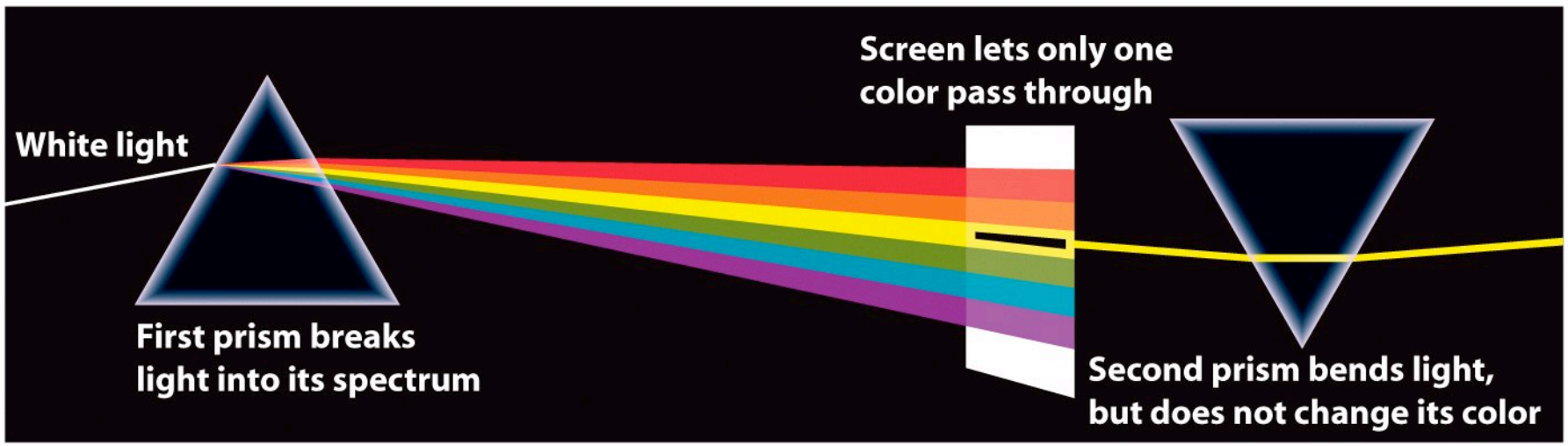
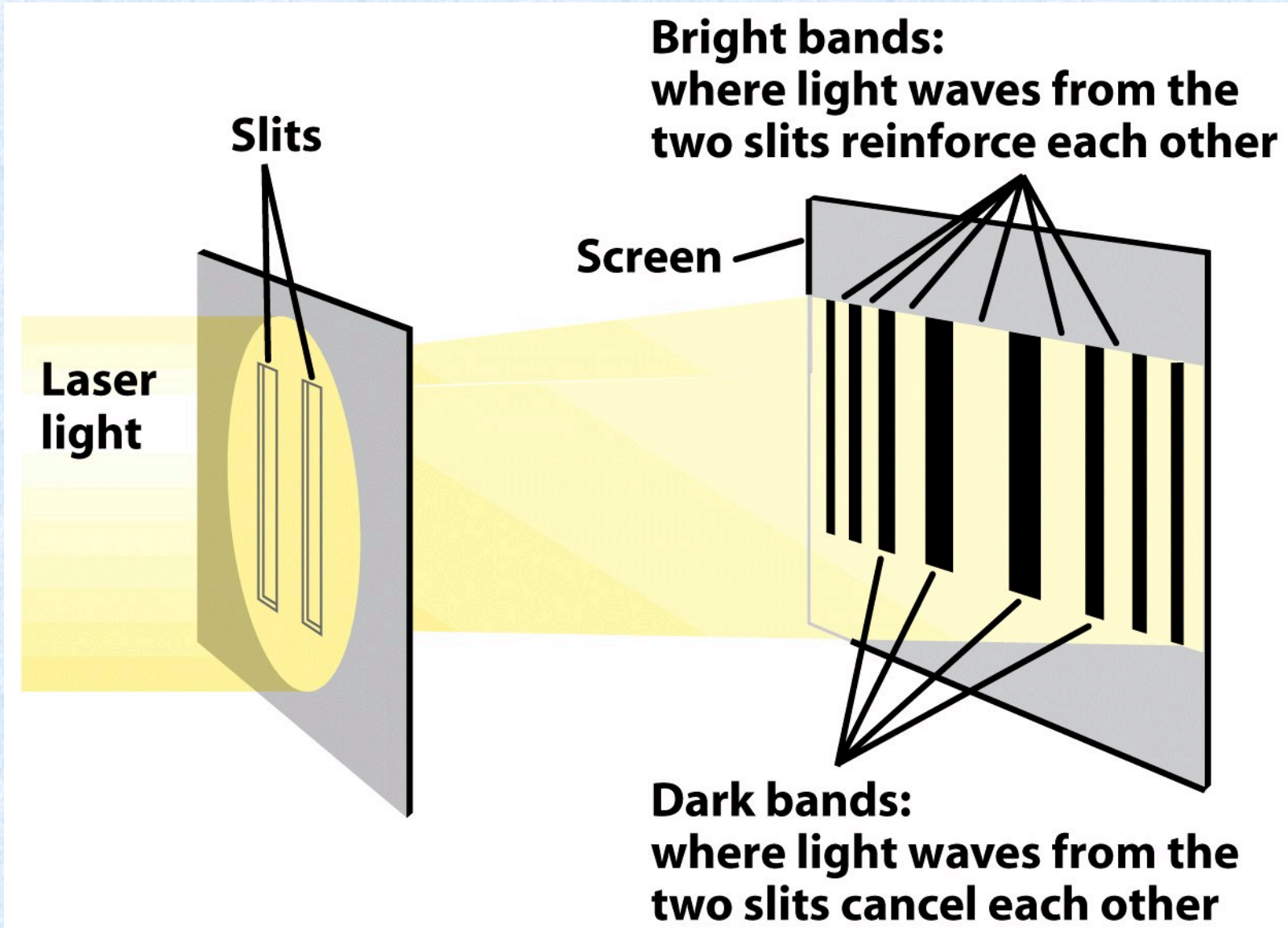
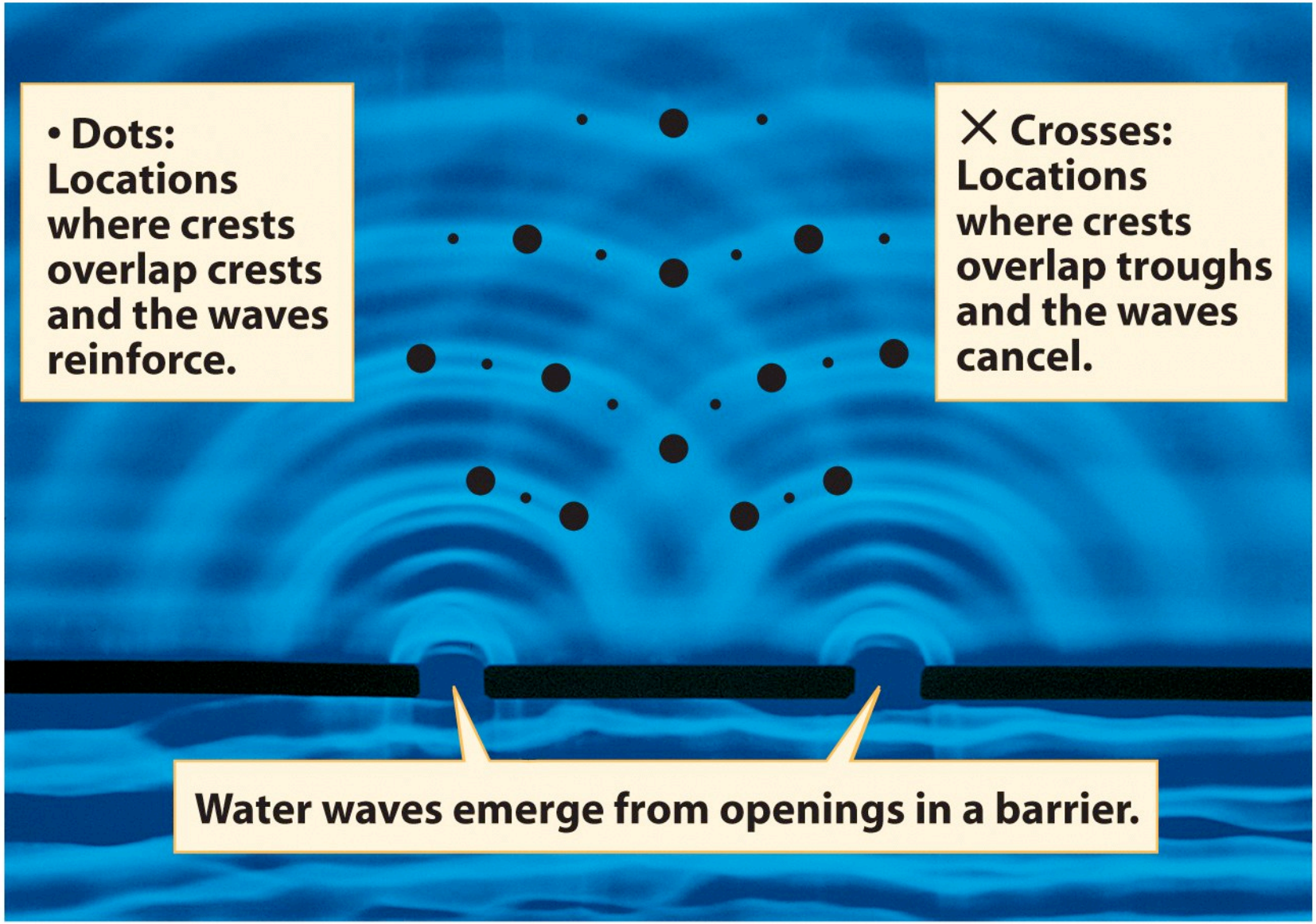


Figure 5-4
Universe, Eighth Edition



An experiment with light

Figure 5-5a
Universe, Eighth Edition



An analogous experiment with water waves

Figure 5-5b
Universe, Eighth Edition

Question 6.1 (iclickers!)

- White light passes through a prism and separates into a spectrum of colors. All of these colors are recombined into a single beam by means of a lens. What color is this beam?
  - A) White
  - B) Black (no light left)
  - C) It will be in the ultraviolet region of the spectrum
  - D) It will be in the infrared region of the spectrum

What about “invisible light?” Around 1800 British astronomer William Herschel passed sunlight through a prism and held a thermometer just past the red end of the visible spectrum. The thermometer registered a temperature increase, indicating there was “infrared” light that we could not see.

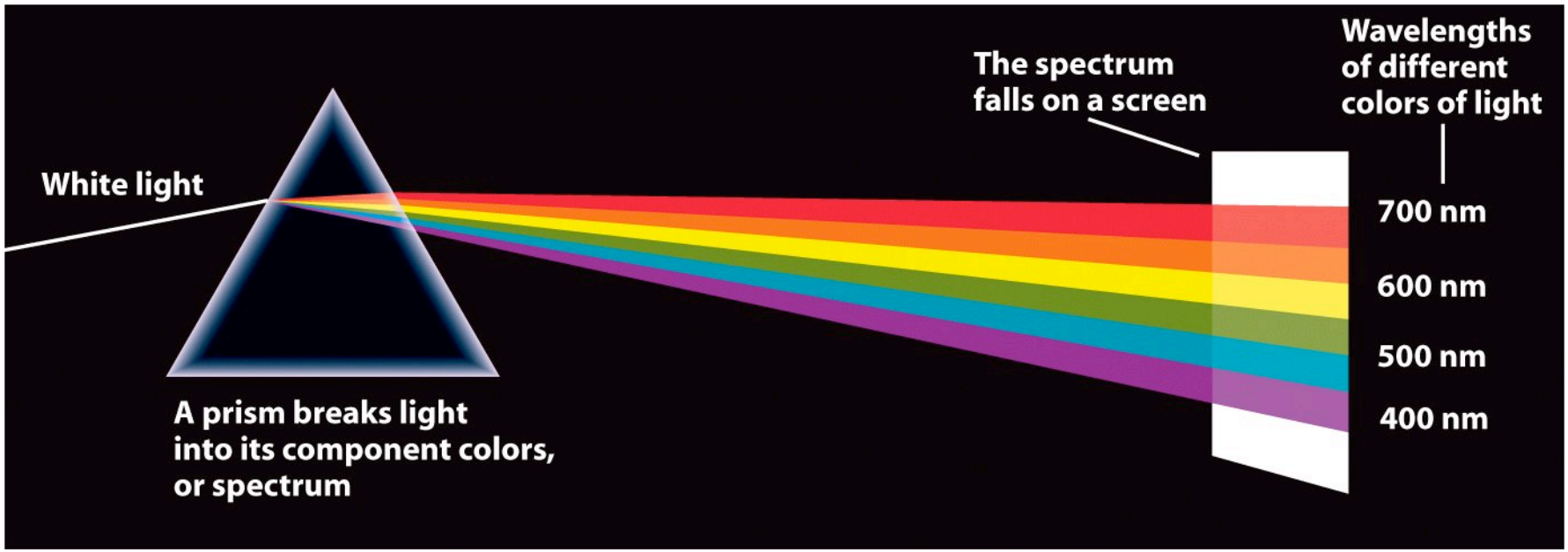


Figure 5-3
Universe, Eighth Edition

But what "wiggles" to make the wave? In 1860 James Clerk Maxwell showed that all forms of light consist of oscillating electric and magnetic fields that move through space at a speed of 3.00×10^5 km/s or 3.00×10^8 m/s. This figure shows a "snapshot" of these fields at one instant.

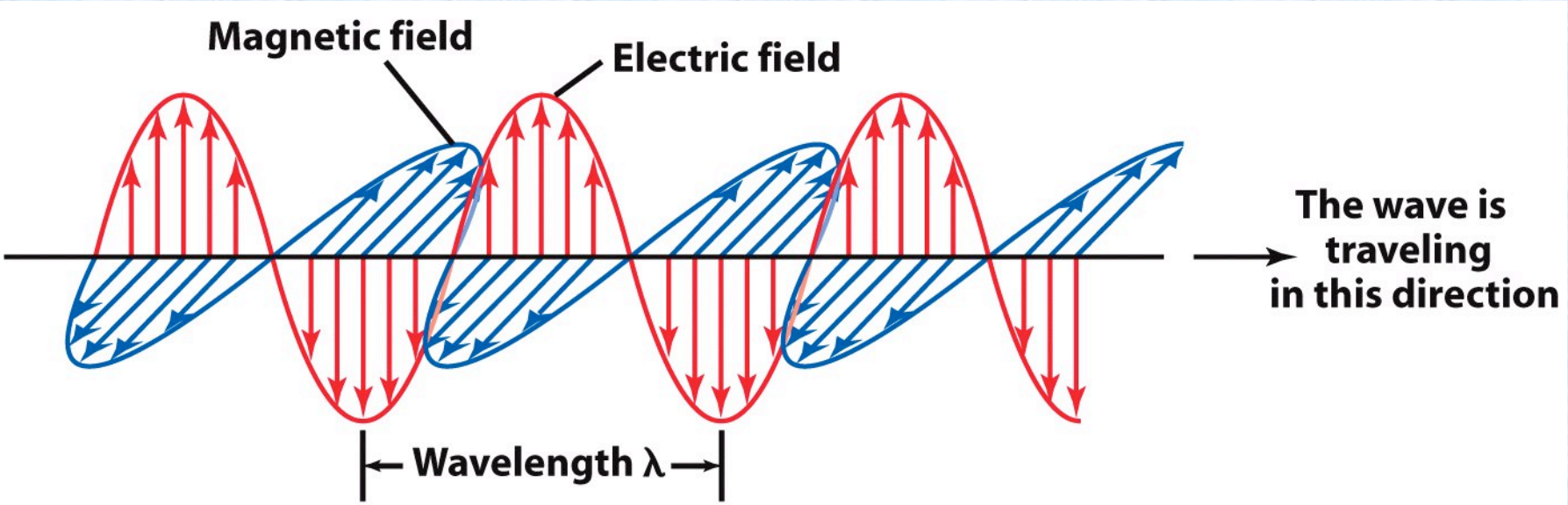
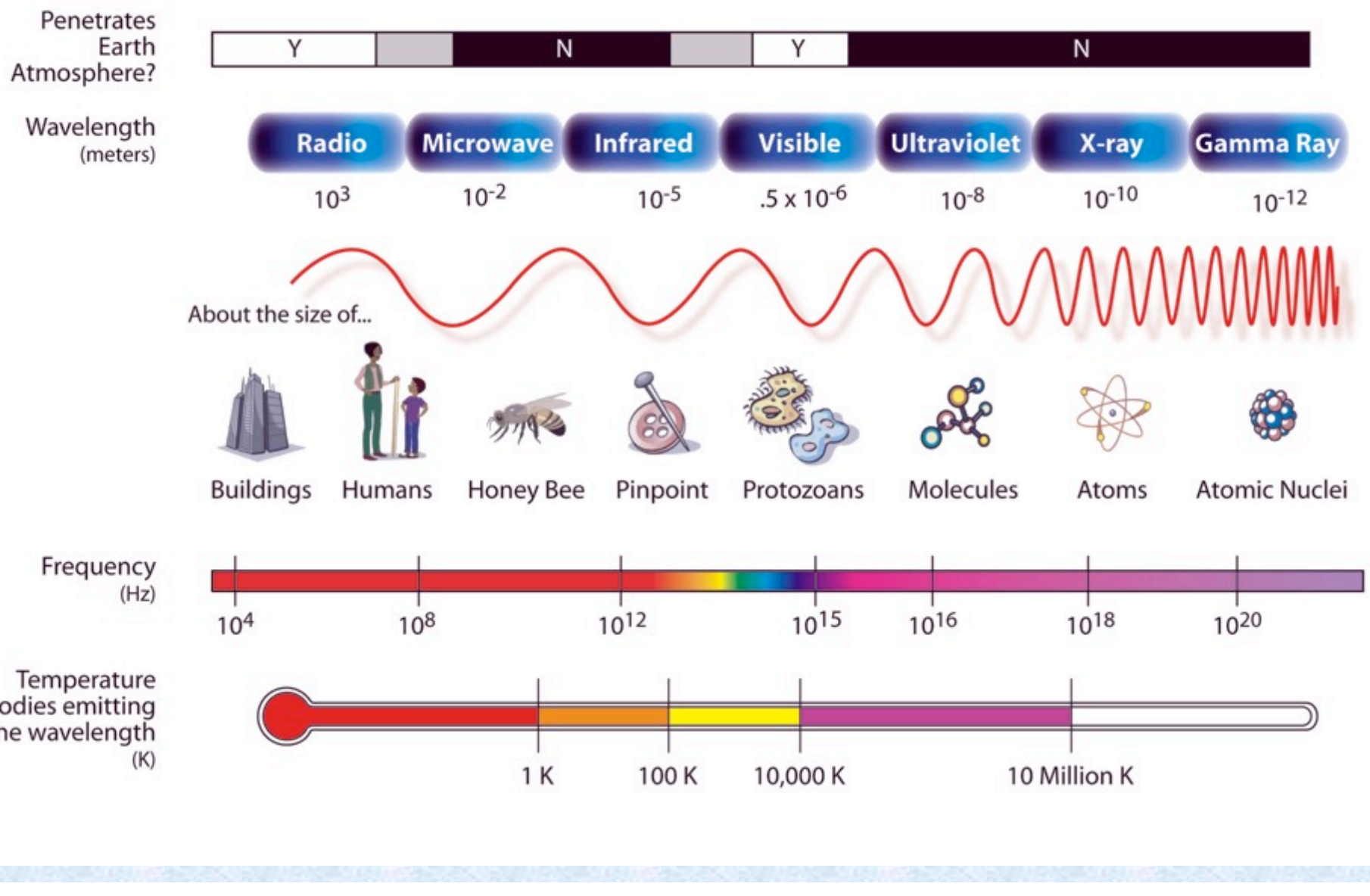


Figure 5-6
Universe, Eighth Edition

All light is electromagnetic radiation. Maxwell wrote 4 equations that describe all the basic properties of electricity and magnetism.

THE ELECTROMAGNETIC SPECTRUM



(a) Mobile phone: radio waves

(b) Microwave oven: microwaves

(c) TV remote: infrared light

(d) Tanning booth: ultraviolet light

(e) Medical imaging: X rays.

(f) Cancer radiotherapy: gamma rays

Figure 5-8
Universe, Eighth Edition

Frequency and wavelength of an electromagnetic wave

$$\nu = \frac{c}{\lambda}$$

ν = frequency of an electromagnetic wave (in Hz – a Hertz is one cycle per second)
c = speed of light, 3×10^8 m/s
λ = wavelength of the wave (in meters)

Example: What is the frequency of visible light at 540 nm?

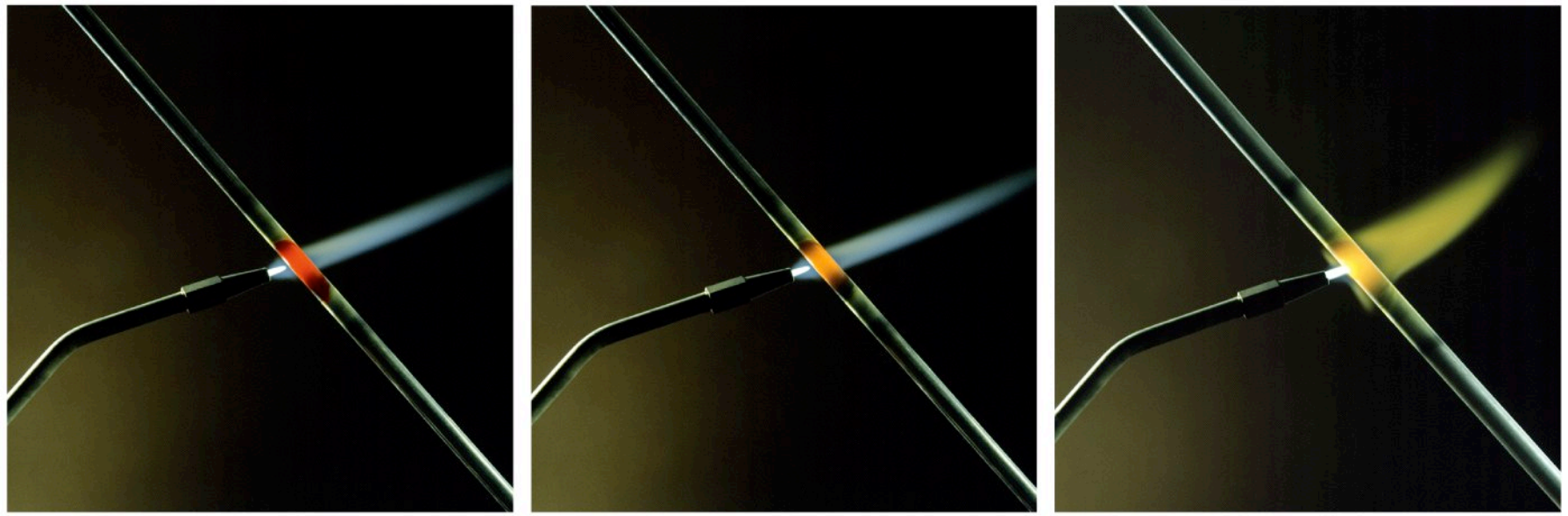
$$540nm\left(\frac{1m}{10^9 nm}\right) = 5.4\times10^{-7} m$$

$$\nu = \frac{3\times10^8 m/s}{5.4\times10^{-7} m} = 5.6\times10^{14} Hz$$

Question 6.2 (iclickers!)

- Radio waves travel through space at what speed?
  - A) Much faster than the speed of light
  - B) Faster than the speed of light, since their wavelength is longer
  - C) Slower than the speed of light
  - D) At the speed of light 3×10^8 m/s

An opaque object emits electromagnetic radiation according to its temperature. Temperature is a measure of the average speed of the atoms in an object.



(a) Hot: glows deep red (b) Hotter: glows orange (c) Even hotter: glows yellow

Figure 5-9
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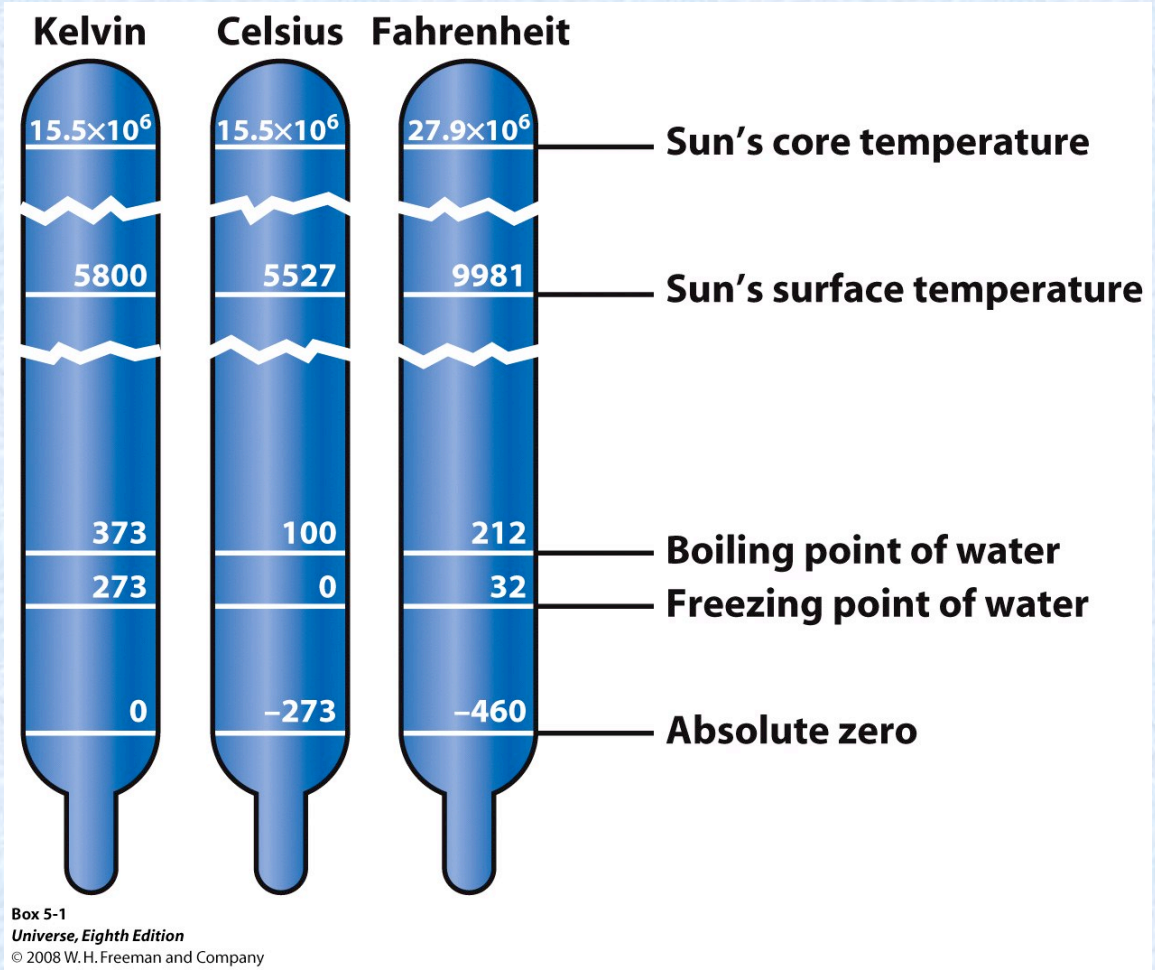
Most things in everyday life (people, furniture, etc.) are too cool to emit light, so you can't see them in the dark.



Box 5-1
Universe, Eighth Edition

$$T_C = \frac{5}{9}(T_F - 32)$$

$$T_F = \frac{9}{5}(T_C + 32)$$

$$T_K = T_C + 273$$

Astronomers use the Kelvin temperature scale. The "degrees" are the same as the Celsius system, only with 273 added, and they aren't called degrees (just K). The are no negative numbers – "absolute" zero is the coldest possible temperature.

Summary

- **What is light?** Light is electromagnetic radiation

The End

See you on Wednesday!

(Monday is a holiday)