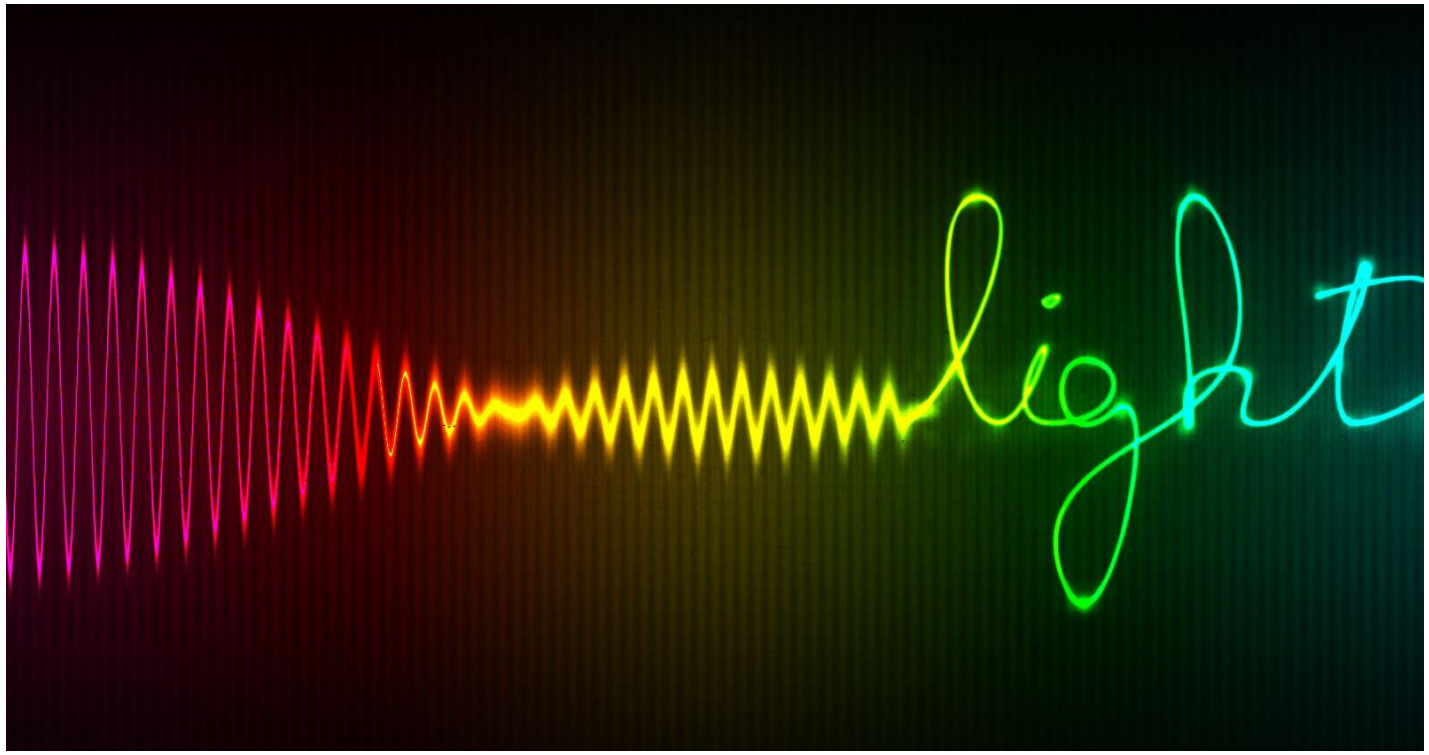



# Astronomy 103

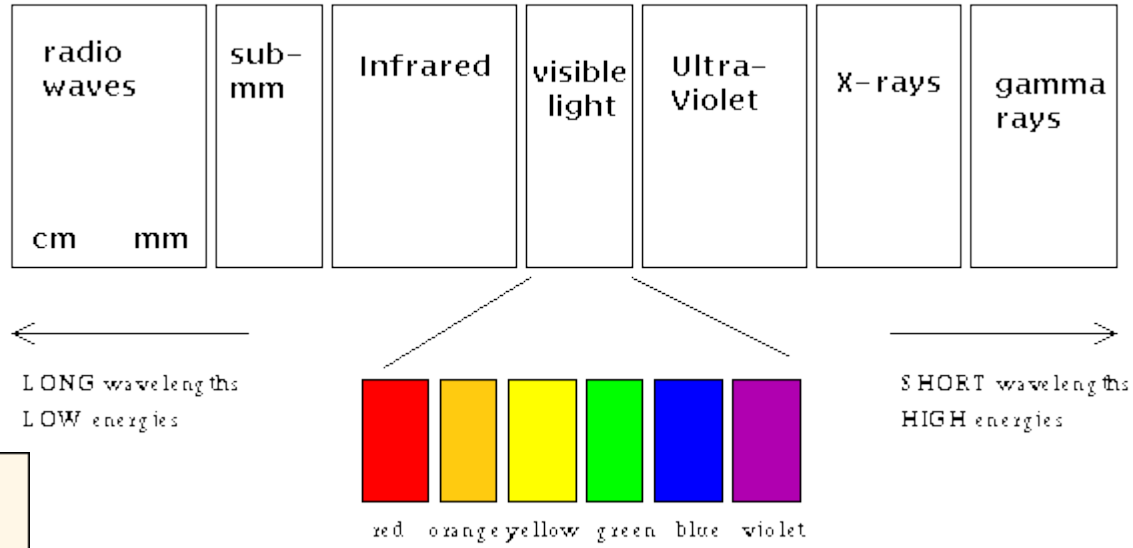
## Week 3

Light: Three Models, Electromagnetic waves, and spectra

# Electromagnetic Spectrum = LIGHT!

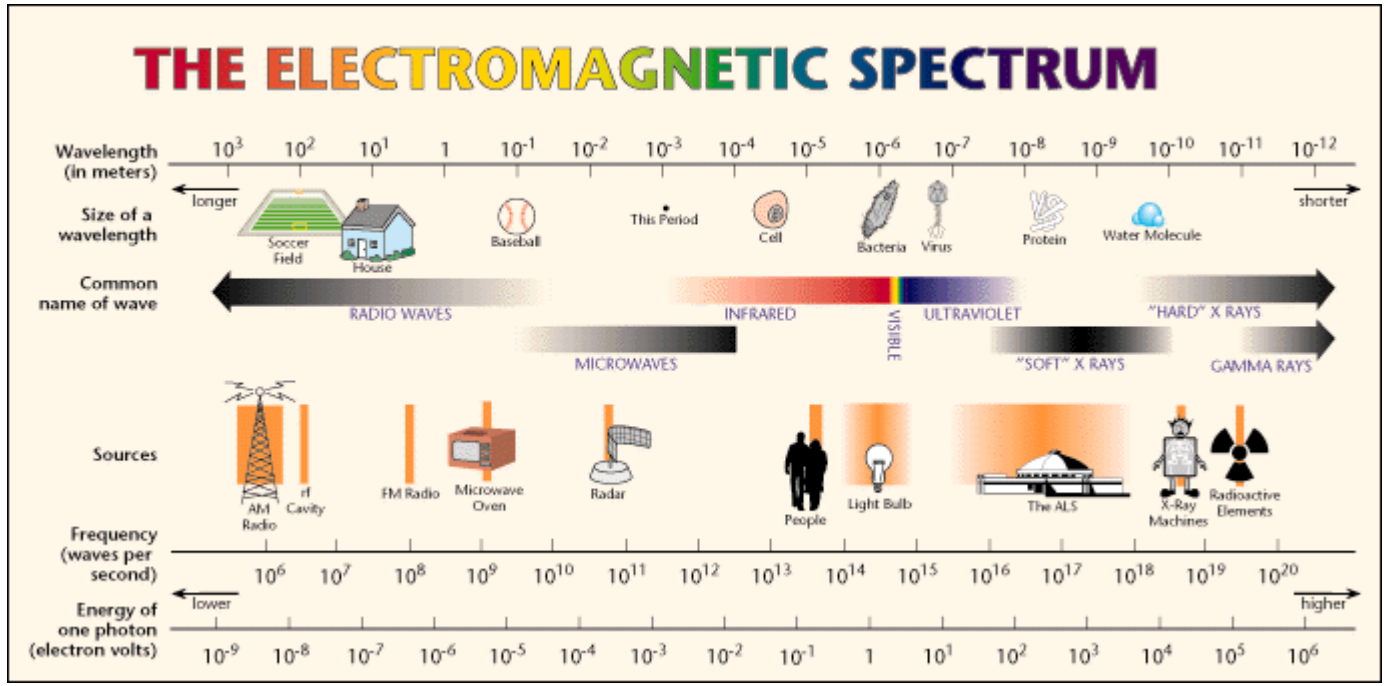
**WAVES CARRY ENERGY!**

**But what is a wavelength?**




Taken From: webserver.as.arizona.edu

http://www2.lbl.gov/images/MicroWorlds/EMSpec.gif

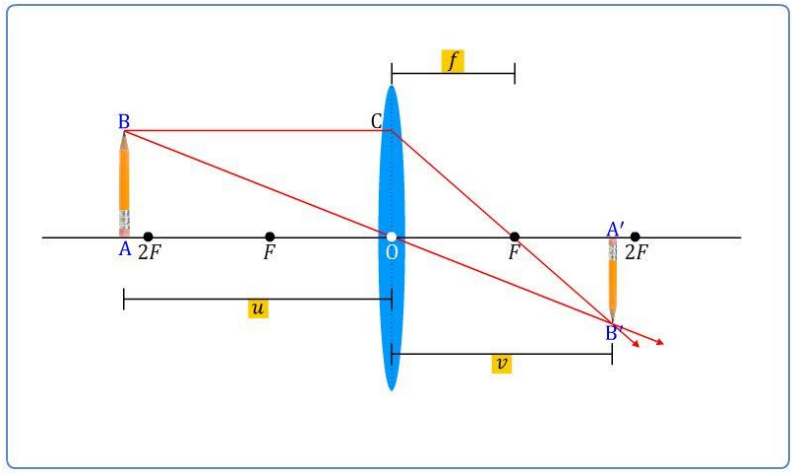



Visible Light is part of the electromagnetic spectrum and the EM spectrum ranges from gamma rays to radio waves.

# Three Models of How Light Behaves

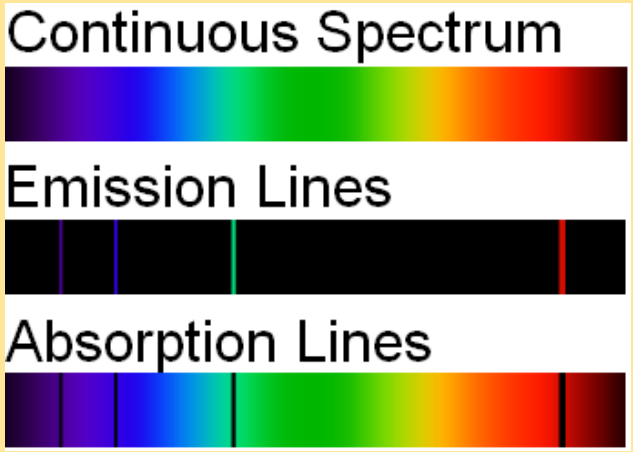
## Ray model

- Describe geometry of light and how it interacts with materials



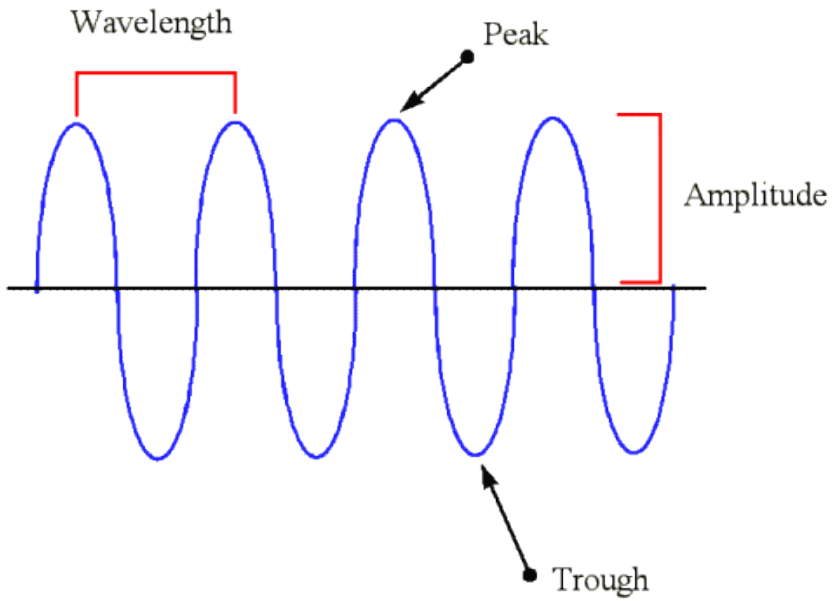

## Particle model

- Help explain spectra and how light is generated



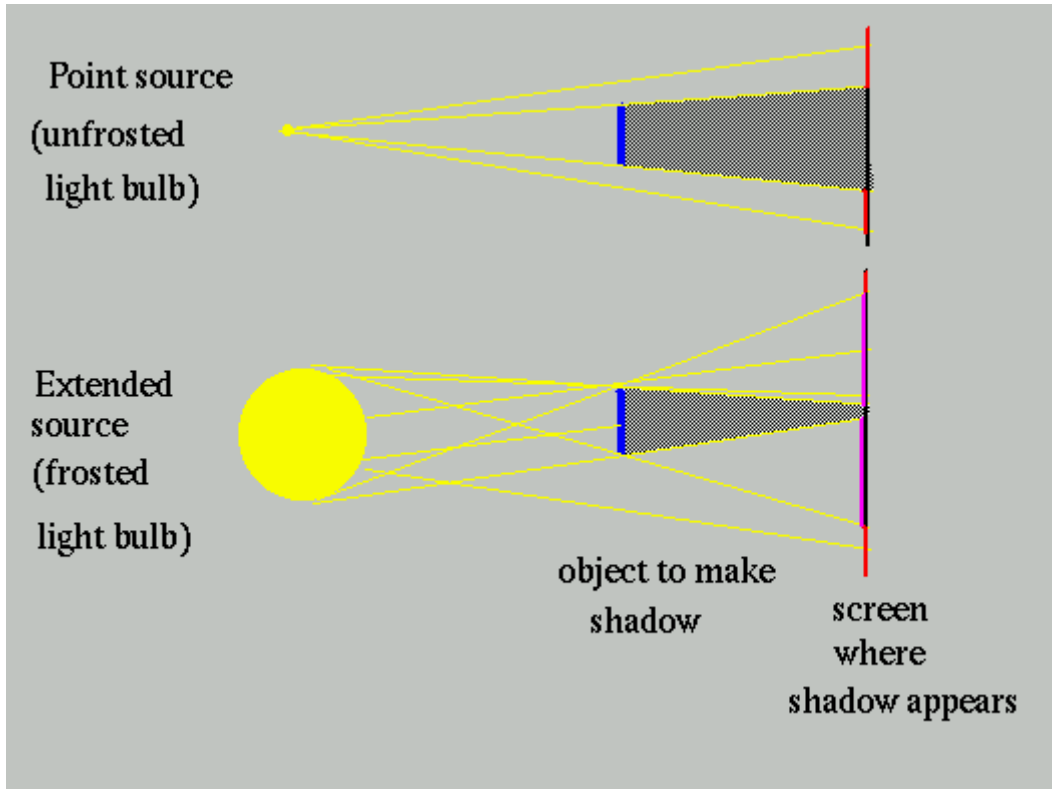

## Wave model

- Explains interference, how light interacts with itself, and how light travels

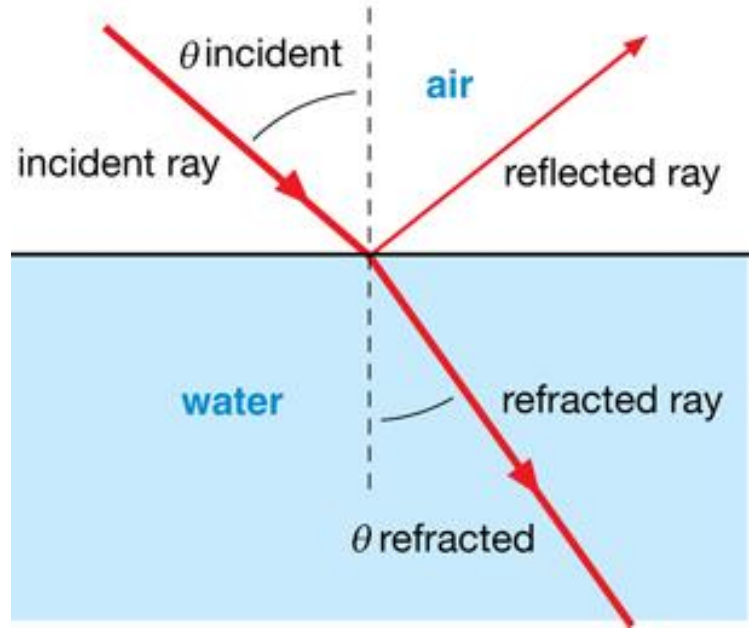



➢ *3 different but complementary models for the behavior of light, to describe different observations.*

# Ray Model of Light

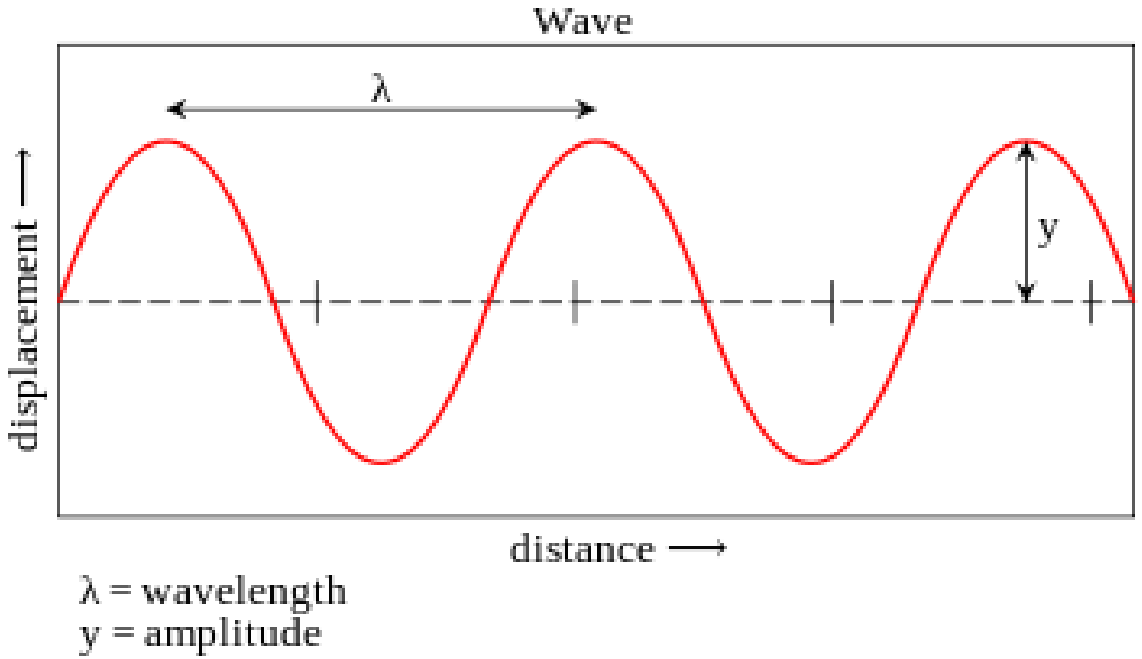


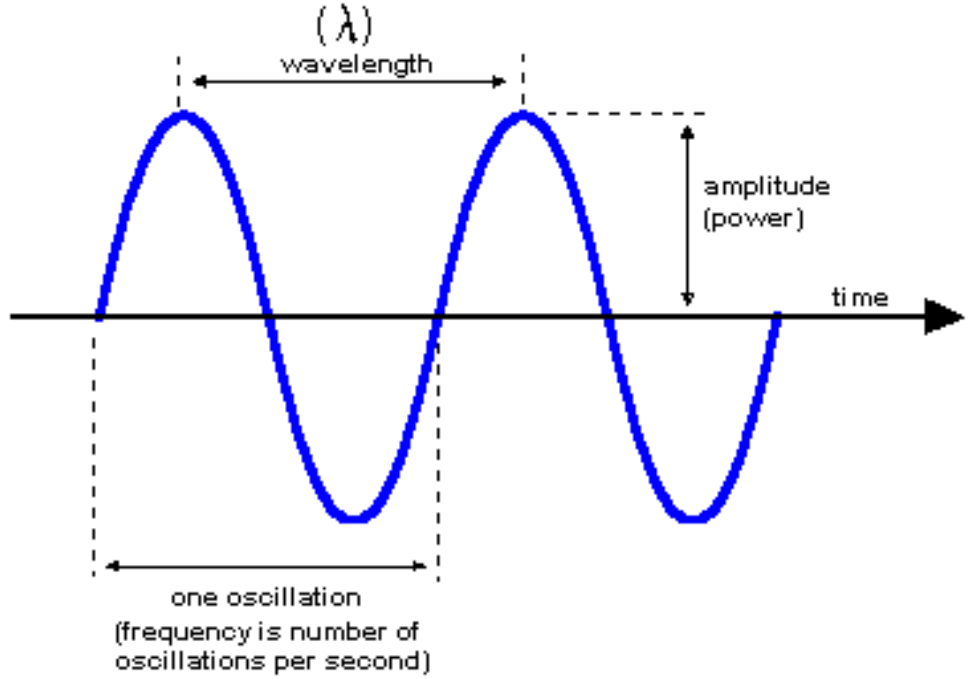

- Light radiates from a source
- Light travels in straight lines
- If light is blocked a shadow is produced
- Light reflects off of surfaces, or refracts into materials




*Later on, we will use the ray model to understand eclipses and to figure out distances to stars and planets*

# Wave Model of Light




- https://www.youtube.com/watch?v=O0PawPSdk28
  (just first 2 minutes: for now)

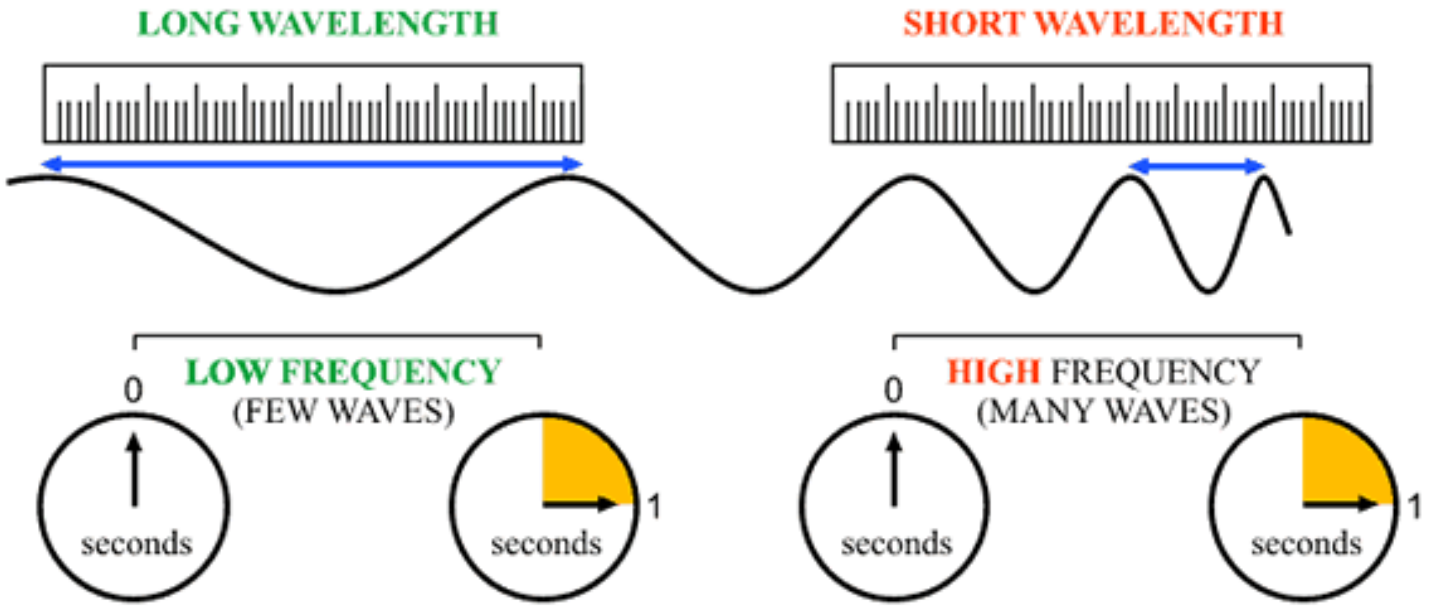
- Light travels in waves, through any medium including the vacuum of space
- Light travels at the 'speed of light' through a vacuum (this is the constant, *c* )

*We will use the wave model to understand colors of objects and to divide electromagnetic energy into different forms that provide different types of useful information about objects*

# Wave Model of Light

## wavelength, frequency & color

- https://www.youtube.com/watch?v=O0PawPSdk28
(just first 2 minutes: for now)




The frequency and wavelength of light are inter-related. Frequency increases as wavelength decreases. Energy is proportional to the frequency

$$E \propto f \propto \frac{1}{\lambda}$$

Wavelength and frequency also determine light's color:

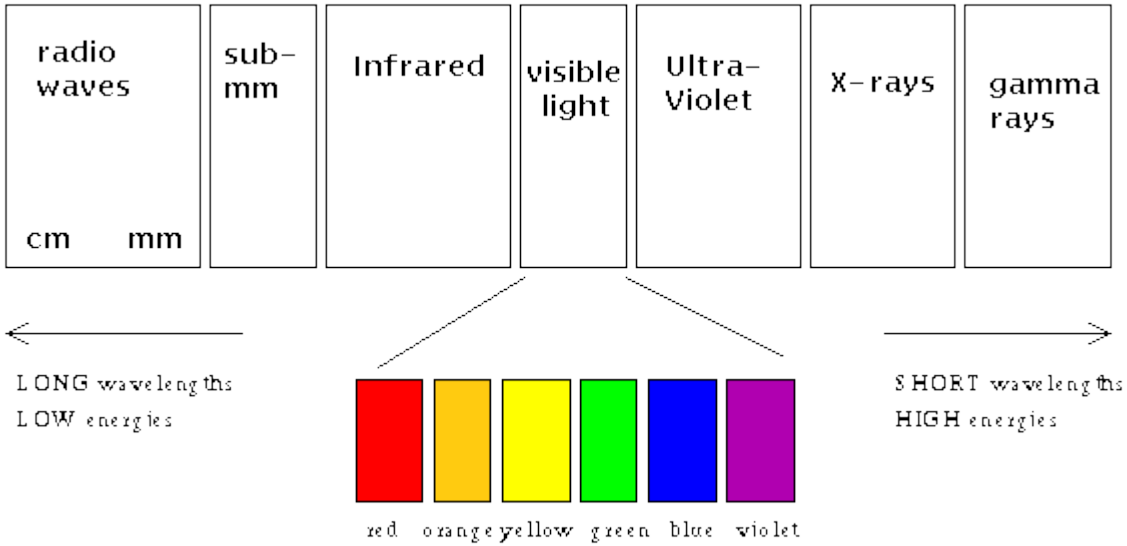
Blue light has shorter wavelengths & higher frequencies than red light.

All light travels at the same speed, which yields another relationship

$$c = \lambda f$$

# Wave Model of Light

## wavelength, frequency & color

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All light travels at the same speed, which yields another relationship

$$c = \lambda f$$

Which of the following forms of light has the *longest* wavelength?

A. Red Light

B. Green Light

C. Yellow Light

D. Blue Light

E. Trick Question: They all have the same wavelength.

Which of the following forms of light has the *longest* wavelength?

**A. Red Light**

B. Green Light

C. Yellow Light

D. Blue Light

E. Trick Question: They all have the same wavelength.

Which of the following forms of light has the *highest* frequency?

A. Red Light

B. Green Light

C. Yellow Light

D. Blue Light

E. Trick Question: They all have the same frequency.

Which of the following forms of light has the *highest* frequency?

A. Red Light

B. Green Light

C. Yellow Light

**D. Blue Light**

E. Trick Question: They all have the same frequency.

Which of the following forms of light has the *highest* energy?

A. Red Light

B. Green Light

C. Yellow Light

D. Blue Light

E. Trick Question: They all have the same energy.

Which of the following forms of light has the *highest* energy?

A. Red Light

B. Green Light

C. Yellow Light

**D. Blue Light**

E. Trick Question: They all have the same energy.

# Particle Model of Light

- Light can be described as particles called ***photons***

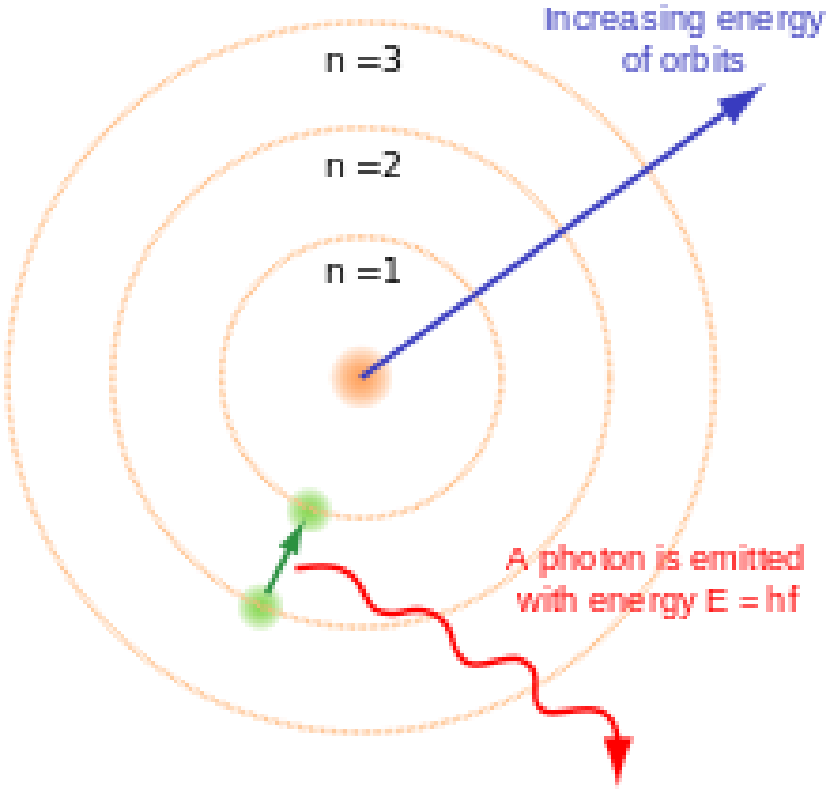
- Each photon carries a *specific* amount of *energy*

  *Photon = a packet of energy*

- Photon energy is related to the wave of light by:

$$E \propto f \propto \frac{1}{\lambda}$$

- Photons are generated (emitted) or used up (absorbed) as electrons move between different orbitals in atoms

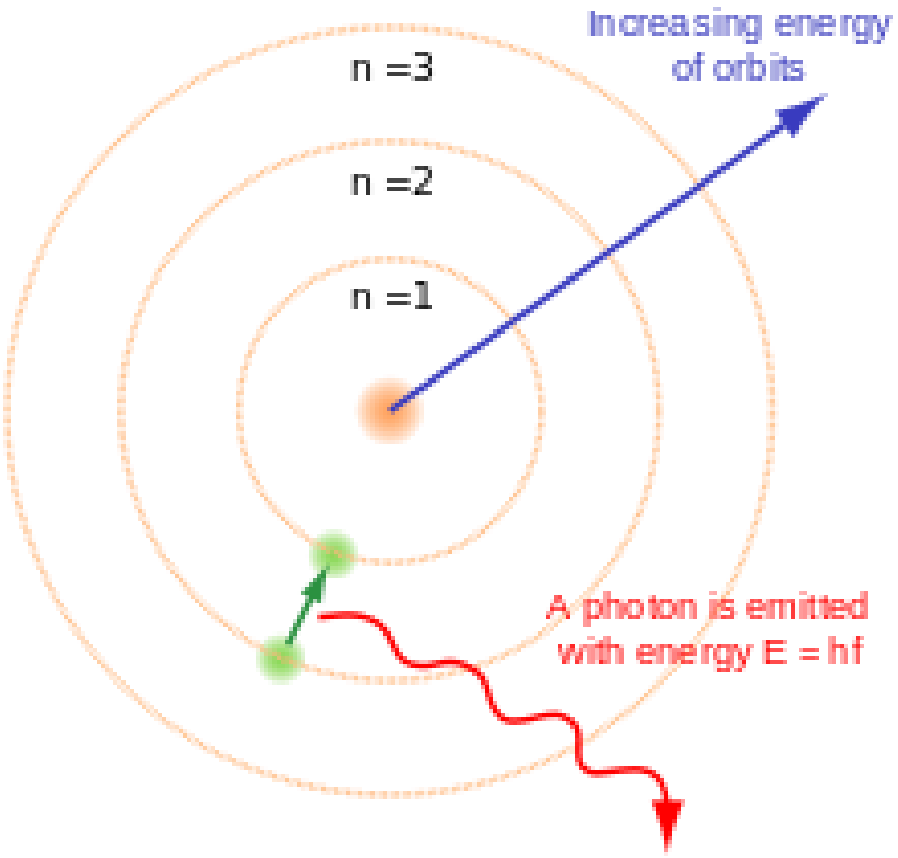



*We will use the particle model of light to understand what things in the universe are made of*

# Particle Model of Light

$$E \propto f \propto \frac{1}{\lambda}$$

- If an electron loses energy, the atom emits light with that same energy
- If the atom absorbs light (or energy), the electron will move to a larger orbit.

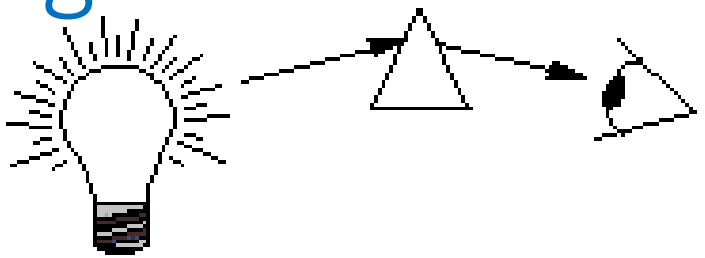


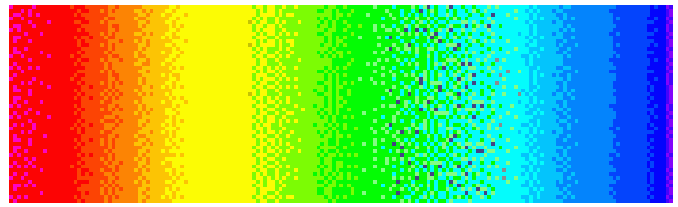

- Scene from "**Hiding in the Light**" Cosmos (Netflix) time **30:05 – 37:30**

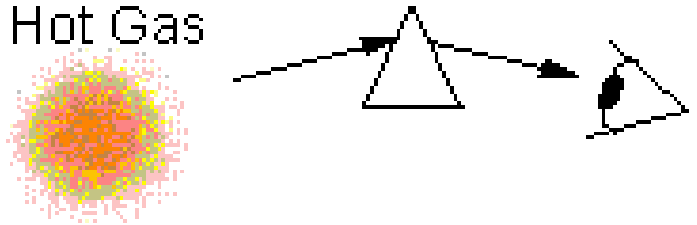
# Particle Model of Light

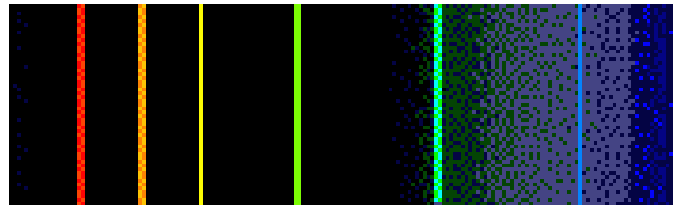
We measure the photons coming from objects

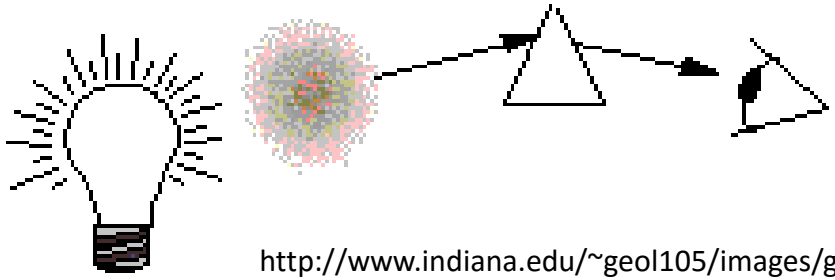
***= spectra***

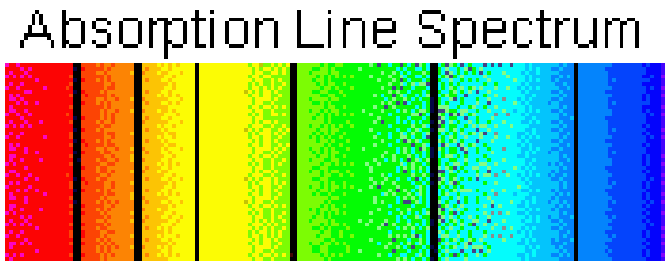




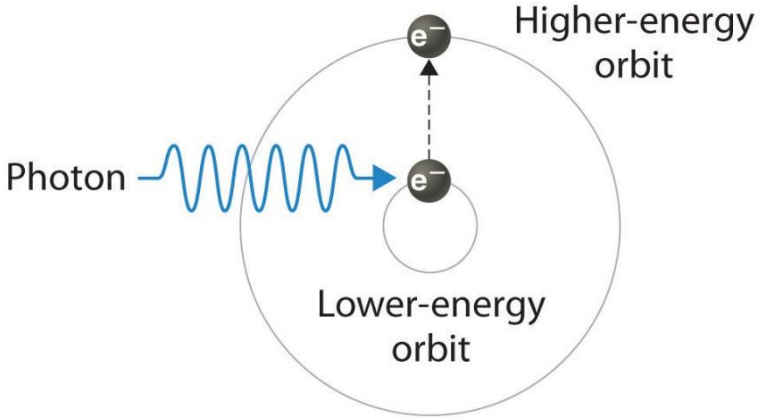




http://www.indiana.edu/~geol105/images/gaia_chapter_1/em_abs.gif

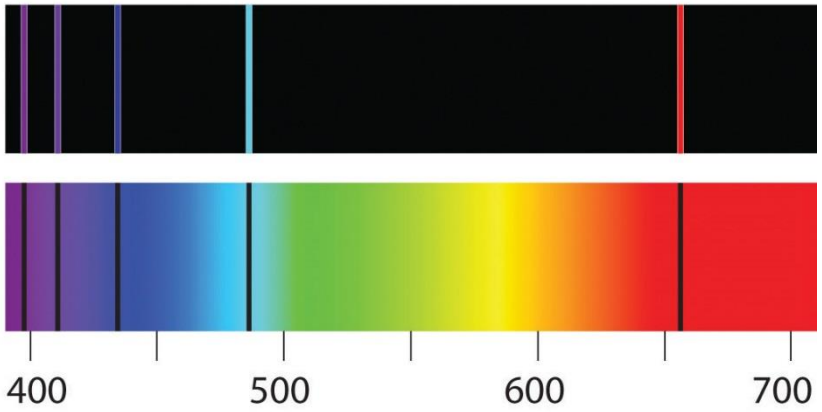
- Continuous Spectra
- Emission Spectra
- Absorption Spectra

- http://phet.colorado.edu/en/simulation/discharge-lamps

# Spectra




**(a) Electronic absorption transition**




**(b) $H_2$ emission spectrum (top), $H_2$ absorption spectrum (bottom)**

- http://www.astronomynotes.com/light/s8.htm