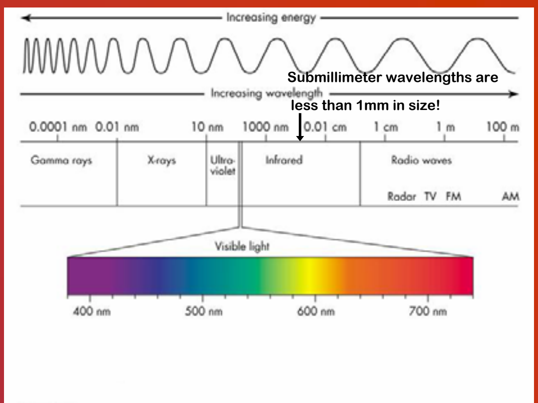
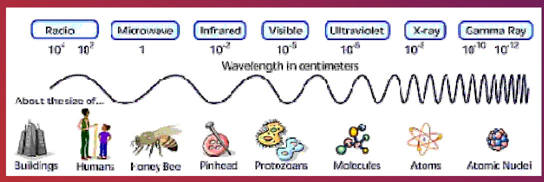
# The Nature of Light

**Radiation** is energy that travels and spreads out equally in all directions as it "radiates" or travels away from the source producing that energy. Big radiation sources in space, like stars, produce enough energy that is radiating light over vast distances. The further the light source is, the fainter it is to observe. In fact the further the light goes the intensity of that light will decrease by the square root of the distance that light has traveled. This mathematical relationship between the intensity of light and the distance it travels is known as the **Inverse Square Law**: Intensity = 1 / distance$^2$

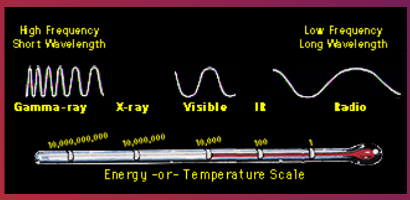
In science, the nature of light is classified by the **electromagnetic spectrum**, which is a continuum or a range of all types of radiation. All light travels or propagates in the form of a wave called electromagnetic waves. Electromagnetic radiation can be described in terms of a stream of photons, which are massless particles each traveling in a wave-like pattern and moving at the speed of light (299,792,458 m/s or 186,282 miles/second). Each photon contains a certain amount of energy, and all light is essentially just photons. The only difference between the various types of electromagnetic radiation is the amount of energy found in the photons. Radio waves have the lowest energy photons, microwaves have slightly more energy than radio waves, infrared photons have a bit more, still increasing energy slightly the next is visible, (what the human eye sees), then ultraviolet (what causes our body tissue to damage), even more energized photons are X-rays, up until the most energetic of all the radiation is gamma-rays.




All these diagrams of the electromagnetic spectrum show the relation ship between wavelength, temperature and energy.




The more energy, the hotter the source, the shorter the wavelength and the higher the frequency. The colder a source is, the longer the wavelength and the lower the frequency.




Frequency = Speed of Light / Wavelength

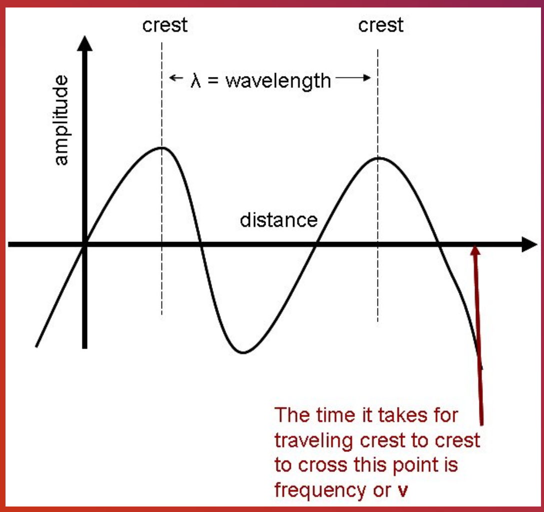
$$\nu = c / \lambda$$

(Hz or Cycles per Second are the basic unit of Frequency)

Wavelength = Speed of Light / Frequency

$$\lambda = c / \nu$$

(Micron, 1/1,000,000 of 1 meter or $10^{-6}$m, is the basic unit for measuring the wavelength)




## Usage Examples

***Radio waves*** are used to transmit radio and television signals. Radio waves have wavelengths that range from less than a centimeter to tens or even hundreds of meters. FM radio waves are shorter than AM radio waves. For example, an FM radio station at 100 on the radio dial (100 megahertz) would have a wavelength of about three meters. An AM station at 750 on the dial (750 kilohertz) uses a wavelength of about 400 meters. Radio waves can also be used to create images. Radio waves with wavelengths of a few centimeters can be transmitted from a satellite or airplane antenna. The reflected waves can be used to form an image of the ground in complete darkness or through clouds.

***Microwave*** wavelengths range from approximately one millimeter (the thickness of a pencil lead) to thirty centimeters (about twelve inches). In a microwave oven, the radio waves generated are tuned to frequencies that can be absorbed by the food. The food absorbs the energy and gets warmer. The dish holding the food doesn't absorb a significant amount of energy and stays much cooler.

***Infrared*** is the region of the electromagnetic spectrum that extends from the visible region (about 700 nanometers) to about one millimeter, in wavelength. Infrared waves include thermal radiation. For example, burning charcoal may not give off light, but it does emit infrared radiation which is felt as heat.

***Visible light*** is the rainbow of colors humans can see. It is the portion of the electromagnetic spectrum with wavelengths between 400 and 700 billionths of a meter (blue at 400 to red at 700 nanometers).

***Ultraviolet*** radiation has a range of wavelengths from 400 billionths of a meter to about 10 billionths of a meter. Sunlight contains ultraviolet waves which can burn your skin.

***X-rays*** are high energy waves which have great penetrating power and are used extensively in medical applications and in inspecting welds. X-ray images of our Sun can yield important clues to solar flares and other changes on our Sun that can affect space weather. The wavelength range is from about ten billionths of a meter to about 10 trillionths of a meter.

***Gamma rays*** have wavelengths of less than about ten trillionths of a meter. They are more penetrating than X-rays. Gamma rays are generated by radioactive atoms and in nuclear explosions, and are used in many medical applications. Images of our universe taken in gamma rays have yielded important information on the life and death of stars, and other violent processes in the universe.