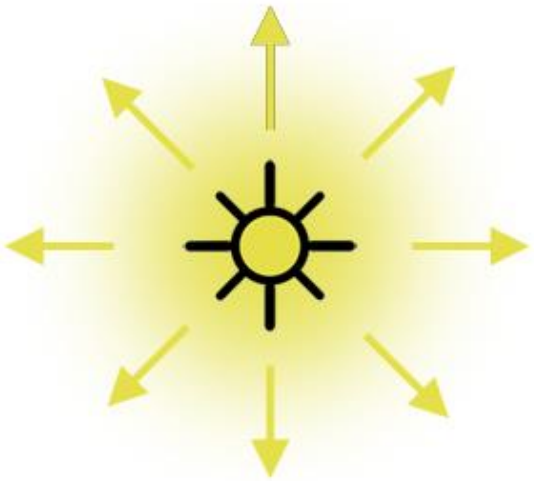
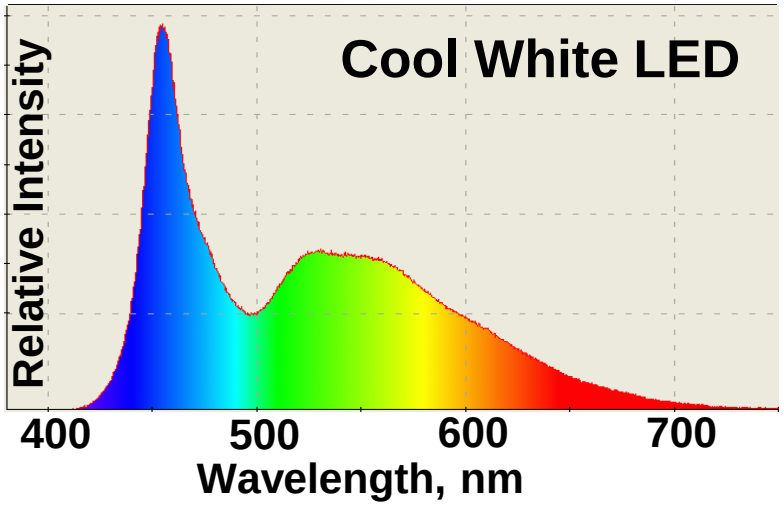
How to Describe Light?

- **"How much?" The intensity of light is the amount of energy falling on a surface per a unit of time.**
  - **The "amount" of photons.**
  - **Most light sources distribute their light equally in all directions, making a spherical pattern; light spreads out and the intensity decreases the farther you get from the source.**



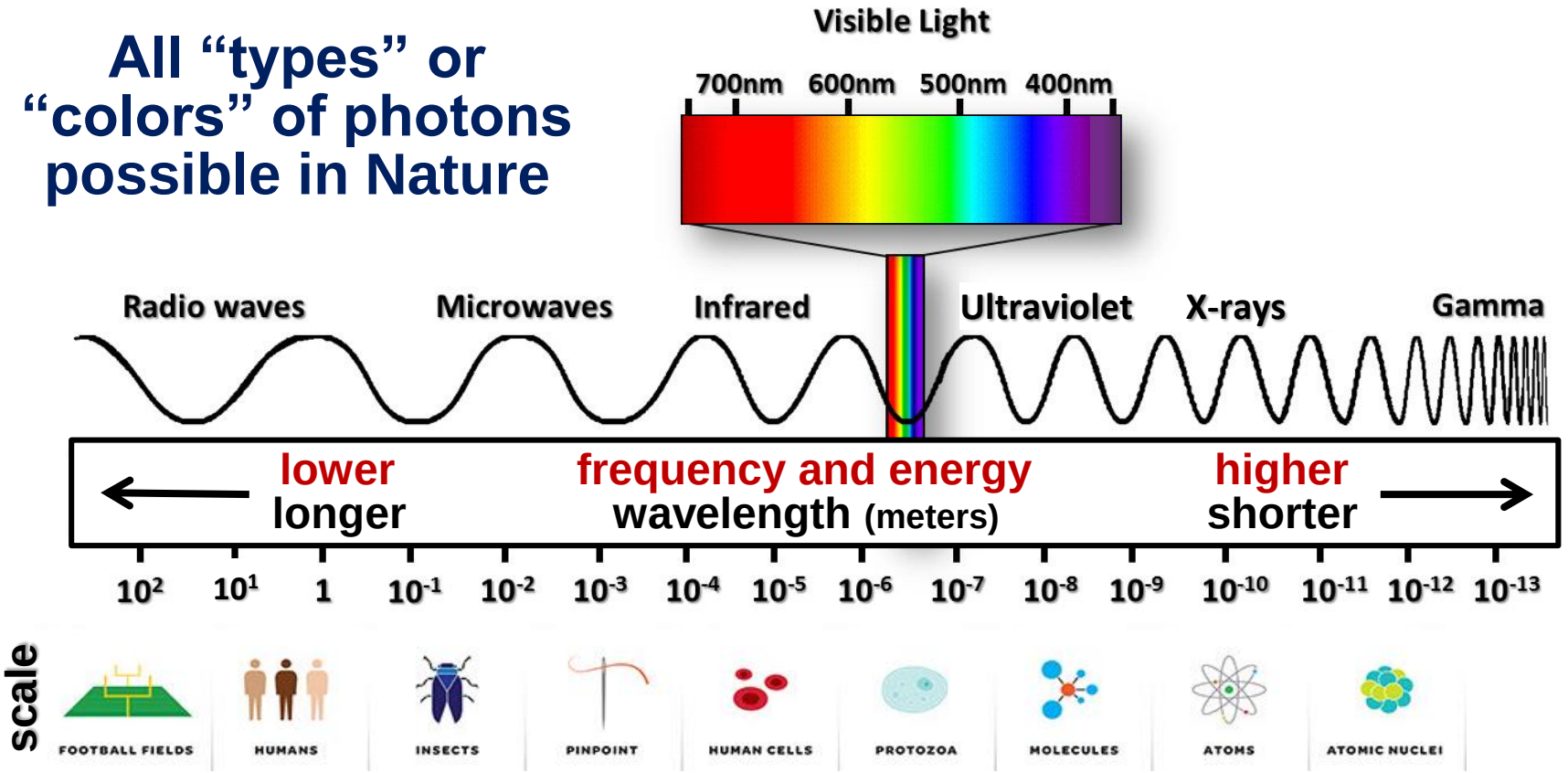
- **"What color?" The apparent color of light is determined by the wavelength(s) of photons.**

- **"How much of each color?" The spectral composition of light is the relative light intensity for each wavelength emitted.**



Electromagnetic Spectrum

All "types" or "colors" of photons possible in Nature

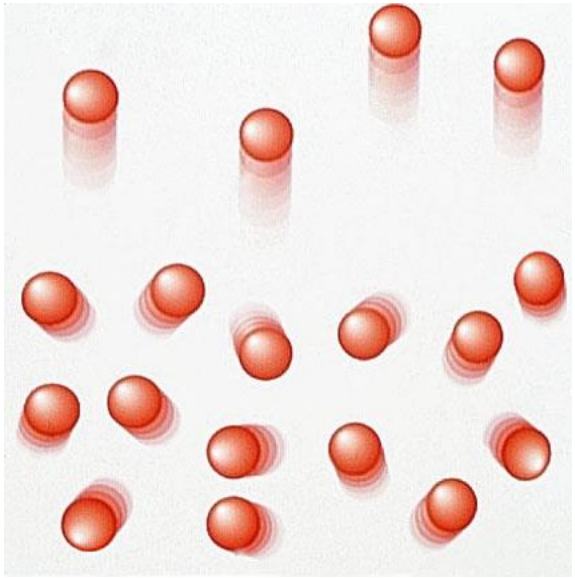


$$\text{Wavelength} = \frac{c}{\text{Frequency}}$$

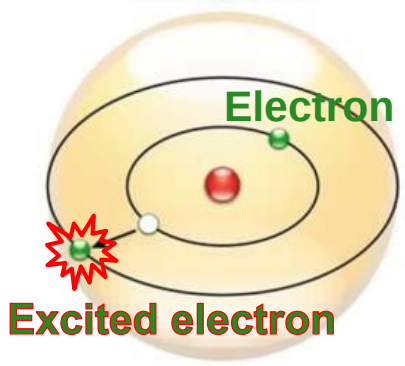
c is the speed of light

Energy ~ Frequency

Gases

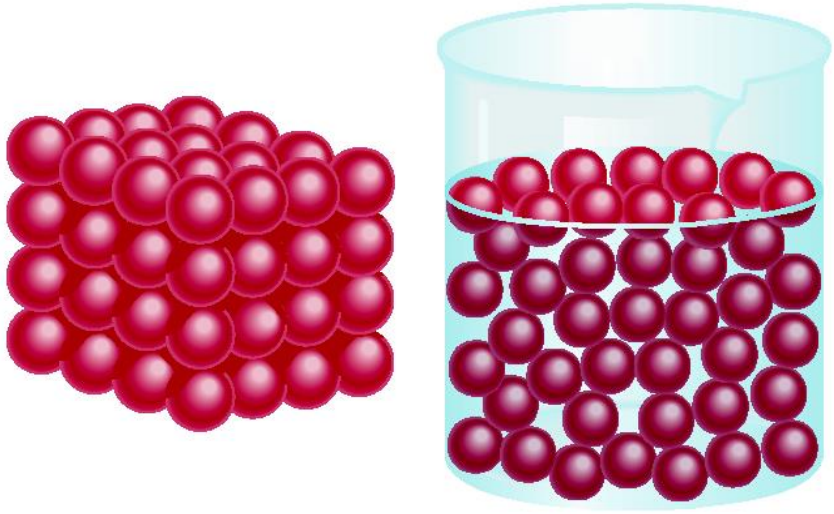


atoms far apart

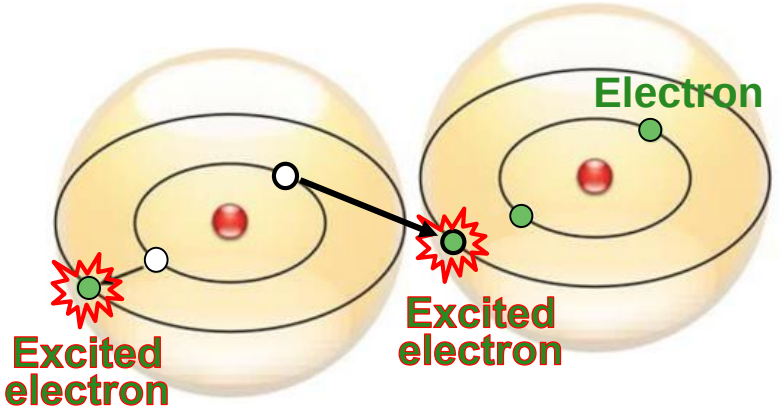


VS

Solids/Liquids



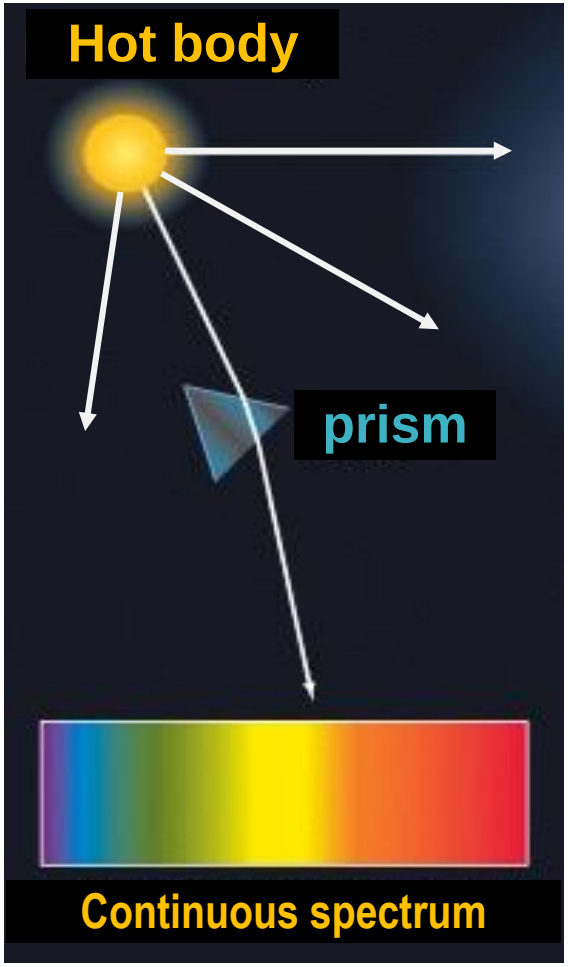
atoms close to each other



Thermal Radiation

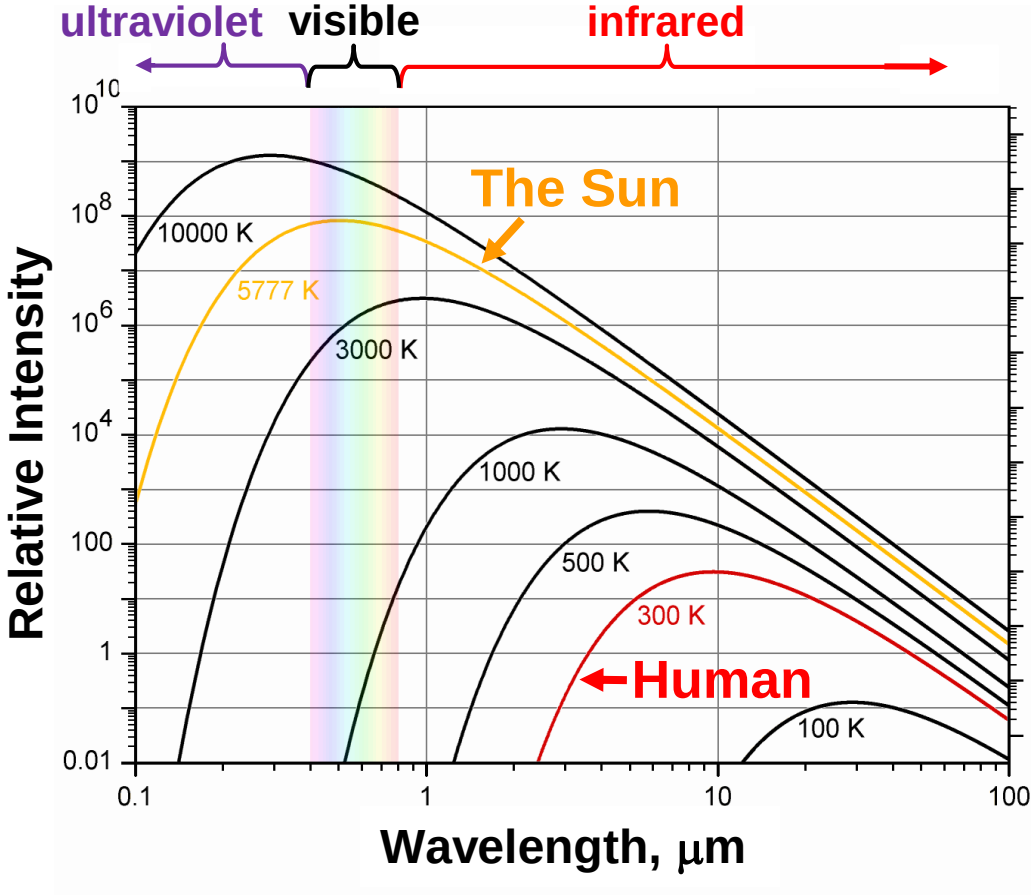
All normal matter emits electromagnetic radiation when it has a temperature above absolute zero.

- **This radiation represents a conversion of a body's thermal (heat) energy into electromagnetic energy, and is therefore called thermal radiation.**
- **When the atoms are in a condensed state (solid or liquid matter), the "hot" electrons can make transitions not only within the energy levels of their own atom, but also between the levels of neighboring atoms (that can be of same or different kind).**
- **This results in a much larger number of possible transitions with corresponding frequencies of radiant energy, producing a continuous color spectrum.**



Thermal Radiation Spectrum

The exact thermal radiation spectrum depends upon properties of the material and the temperature. As the temperature decreases, the peak of the radiation curve moves to lower intensities and longer wavelengths.

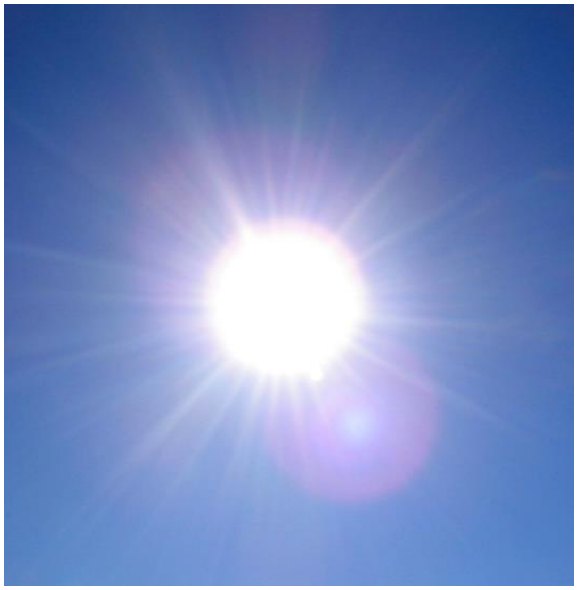


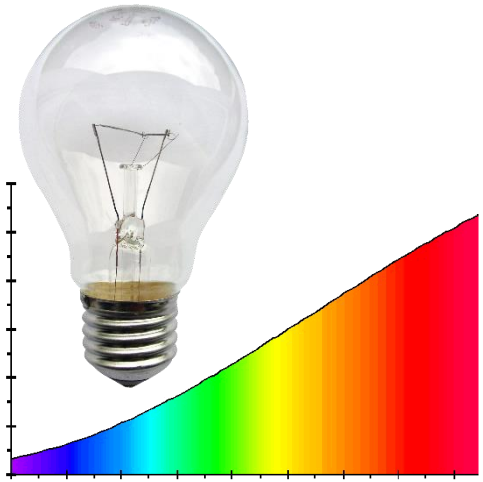
- The temperature at which all solids glow a dim red is about 798 K (~976 F).
- A very hot object would emit a significant amount of energy in the ultraviolet region of the spectrum.
- People are emitters of energy in the infrared region (peak ~9.5μm).

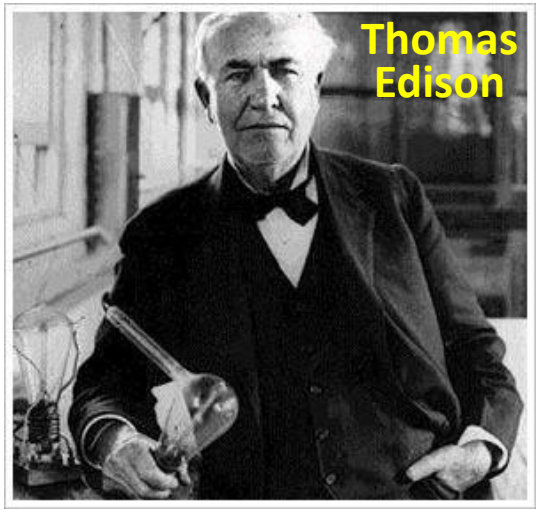
Incandescence

Incandescence (from Latin "glowing white") is a special case of thermal radiation, specifically **emission of visible light by a hot body.**

Sunlight is the incandescence of the "white hot" surface of the Sun.







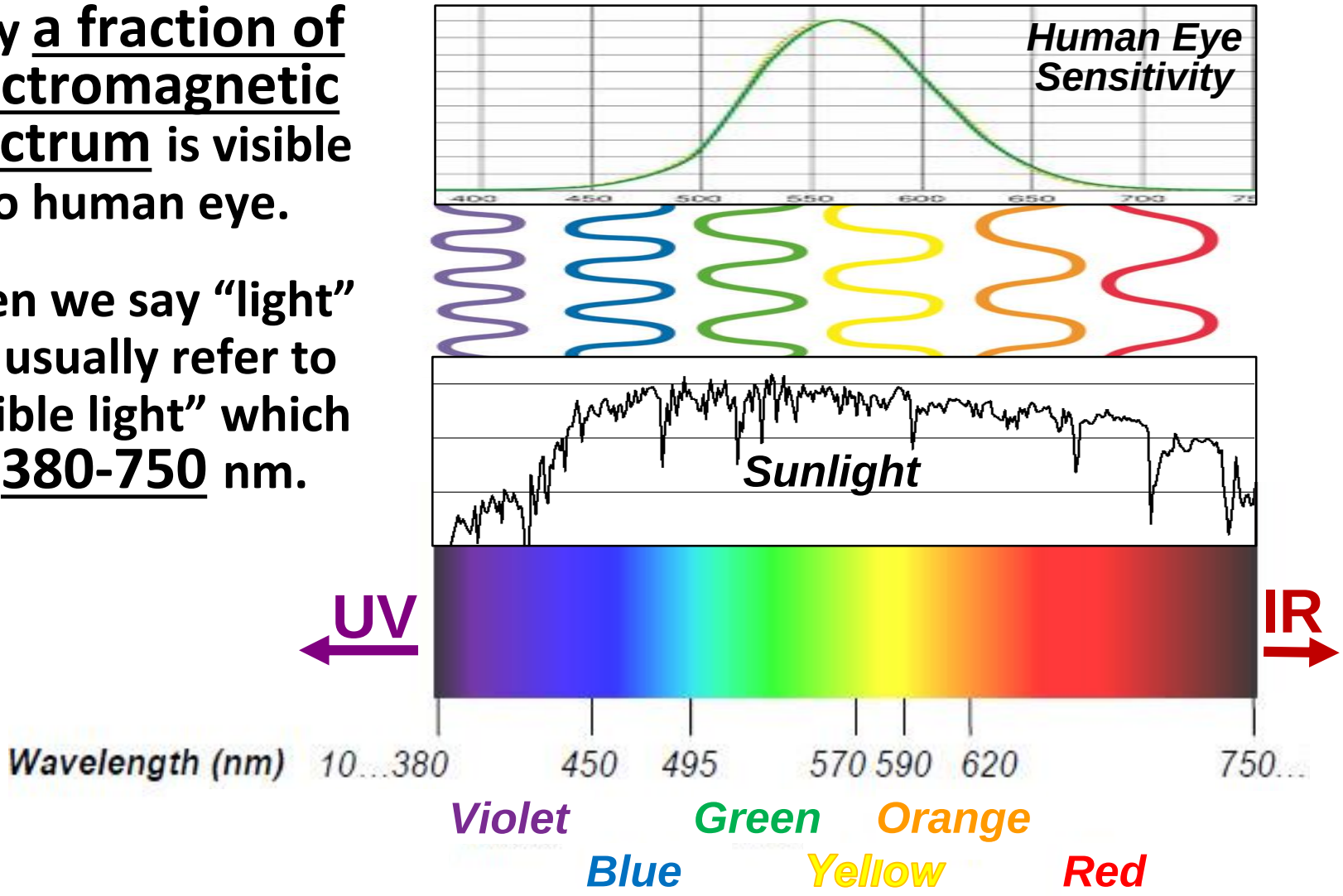
Incandescent bulb:

- electricity passes through a thin piece of metal wire called a filament
- the filament heats up and gives off thermal radiation composed of ~5% visible light and **~95% heat**…
- …**very low energy efficiency**!

Visible Light

Only a fraction of electromagnetic spectrum is visible to human eye.

When we say "light" we usually refer to "visible light" which is 380-750 nm.



Luminescence

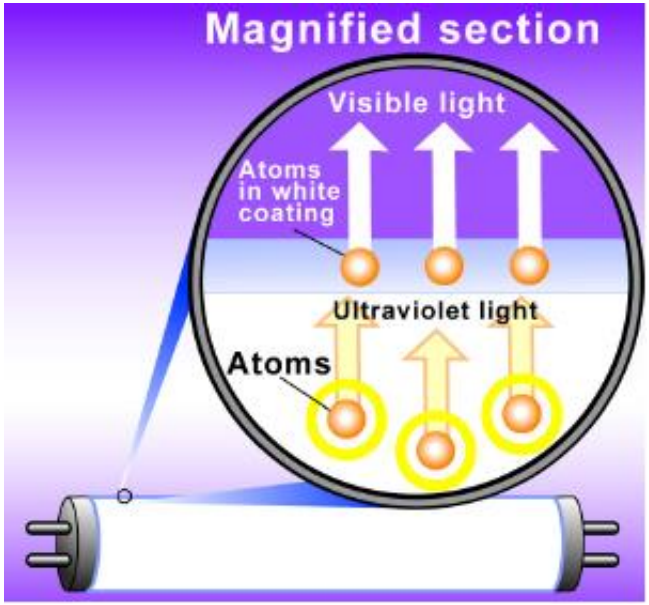
Luminescence is **emission of light** by a substance **not resulting from heat**:

Glow Sticks

- ***Chemiluminescence*** **(including *bioluminescence*), a result of a chemical reaction.**
- ***Electroluminescence*, emission of light due to electric current passed through a substance.**

LED

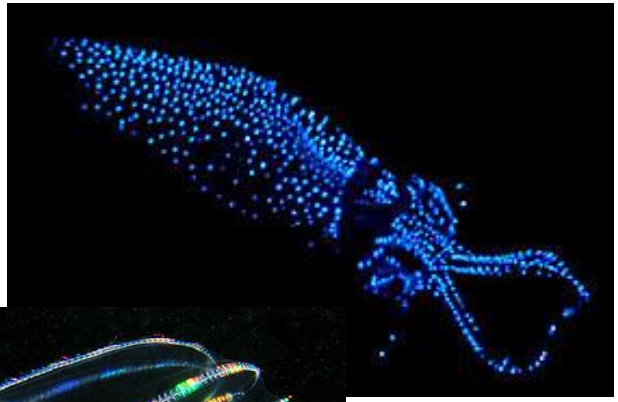
- ***Photoluminescence*** **(*fluorescence* and *phosphorescence*) due to absorption of photons with subsequent re-emission.**
- **Some other types.**

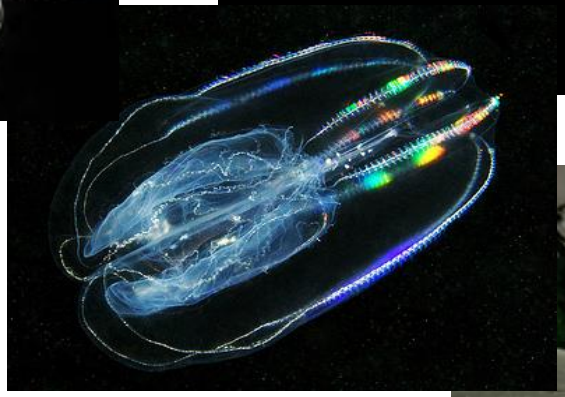


Fluorescent Lamps

Bioluminescence

Bioluminescence is emission of light by a living organism by means of a chemical reaction (type of *Chemiluminescence*).





It occurs widely among animals (many creatures of the open sea, and insects) as well as in some fungi and bacteria.