

# Electromagnetic Spectrum

### Light is a Wave

Light is refracted in lenses. Light diffracting around two fingers (look close) causes lines of darkness: destructive interference.  
*Light must be a wave!*



### Light is a Particle

Light can travel through the vacuum of space, but waves can't travel in a vacuum. So *light must be a particle!*



### Light is Both

This contradiction perplexed scientists for many, many years, but the evidence must be believed: **light is both a wave and a particle.**

*Packets of light we call photons.*

### Speed of Light: $3 \times 10^8$ m/sec

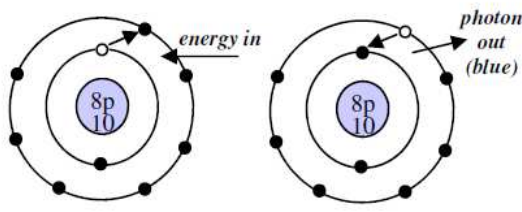
Sound is fast: 340 m/sec, but **light is faster:  $3 \times 10^8$  m/sec!**  
 That's 3 with 8 zeroes or 300,000,000 m/sec.  
 Light can circle the earth 27 times in one second!



Scientists now believe that **nothing can go faster than light.**  
*The speed of light is the ultimate speed limit.*

### Origins of Light and Color

*Photons (light) come from electrons falling from high electron orbits to low orbits. These orbits are also called energy levels.*



Energy can raise an electron to a higher energy level.

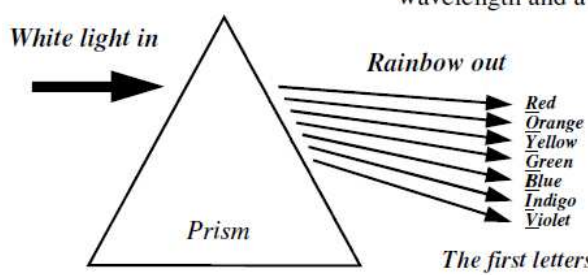
When the electron falls back, a photon is given off: light!

Because each element has a different number of protons, **each element** has slightly different electron energy levels and **gives off different colors.** From their colors we can tell the chemical makeup of stars.

*The sky is blue because oxygen atoms give off blue photons.*

### Visible Light

What we call "visible light" is made up of many different colors. Each color has a different wavelength and a different frequency.



*A prism uses refraction to separate the different wavelengths (colors) of visible light.*

*The first letters spell: ROY - G - BIV*

### Colors have Different Energies

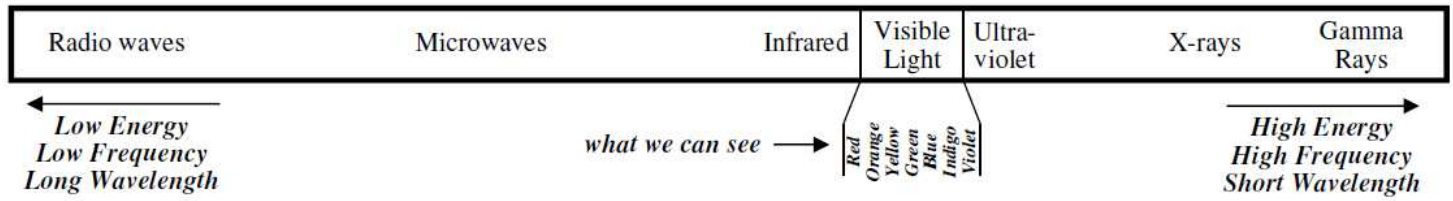


You know that different color flames give off different amounts of heat. Red flames are the coolest and blue flames are the hottest. *As you move from Red to Blue, light GAINS energy.*

*White light is made up of all colors. That is why a white flame is the hottest!*

### EM Spectrum

Visible Light is a *very* small part of the entire Electromagnetic (EM) Spectrum.



**Radio waves** – used to transmit radio and television signals. Wavelengths range from hundreds of meters to less than a centimeter. This is why radio towers have to be so tall.

**Microwaves** – used to cook food and by cell phones. Wavelengths range from 30 cm to 1 mm.

**Infrared** – (invisible heat) 1 mm to 700 nanometers (700 billionths of a meter).

**Visible (white) light** – from 700 to 400 nanometers.

**Ultraviolet light** – invisible wavelengths from 400 nanometers to 10 nanometers. Part of sunlight burns your skin and can cause cancer. The ozone layer protects us from most of the sun's ultraviolet light.

**X-rays** – Used in medicine and industry. Wavelengths are from 10 nanometers to .01 nanometers (10 trillionth of a meter).

**Gamma rays** – the most powerful and dangerous form of radiation. Wavelengths—less than .01 nanometers. Emitted by nuclear reactions, they can break chemical and nuclear bonds.

1. Photon	A. The fastest speed in the universe: the speed of light.	1. Radio waves	A. Electromagnetic waves we feel as heat.
2. $3 \times 10^8$ m/sec	B. An orbit of electrons. To move from low to high requires energy.	2. Infrared	B. Dangerous EM waves that have very high energy and come from nuclear reactions.
3. Prism	C. All light: visible and invisible.	3. Ultraviolet	C. EM waves that have very low energy and long wave lengths.
4. Light	D. Used to separate white light into its colors.	4. X-rays	D. EM waves that can pass through skin and have short wave lengths.
5. EM Spectrum	E. A single particle or packet of light.	5. Gamma rays	E. EM waves with more energy than visible light and can cause sunburns.
6. Energy Level	F. A wave that can travel through a vacuum.	6. Microwaves	F. Long wavelengths; used in cell phones.
Is light a wave or a particle. Prove your answer:		Put these three in order from slowest to fastest:  Light waves; sound waves; water waves.  _____	
Where does light come from?		Put these from shortest to longest wavelengths Radio waves    Ultraviolet    X-rays    Visible    Microwaves  _____	

1. What is the speed of light?
2. What variable do we use for the speed of light?
3. When energy goes into an atom is light produced?
4. What is the speed of radio waves with a wavelength of 4.2 m?
5. What do scientists call all light, both visible and invisible?
6. Which has higher frequency: red or blue light?
7. Which has a longer wavelength: red or blue light?
8. Three light bulbs are above a circle.

If all of them are off, what color is the circle?

What color if all are on?

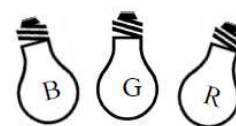
What color if B and R are on?

Which have to be on to produce magenta?

Which have to be on to produce green?

Which have to be on to produce yellow?

Which have to be on to produce black?



What color?