Light

Waves…

- Recall that mechanical waves require a medium to transport energy
- Longitudinal the medium moves parallel to the direction of the energy
- Transverse the medium moves perpendicular to the direction of the energy

Waves…

- Electromagnetic waves are waves which require no medium to transport the disturbance, but can travel through a medium
- Electromagnetic waves are transverse and are composed of a vibrating electric field perpendicular to a vibrating magnetic field

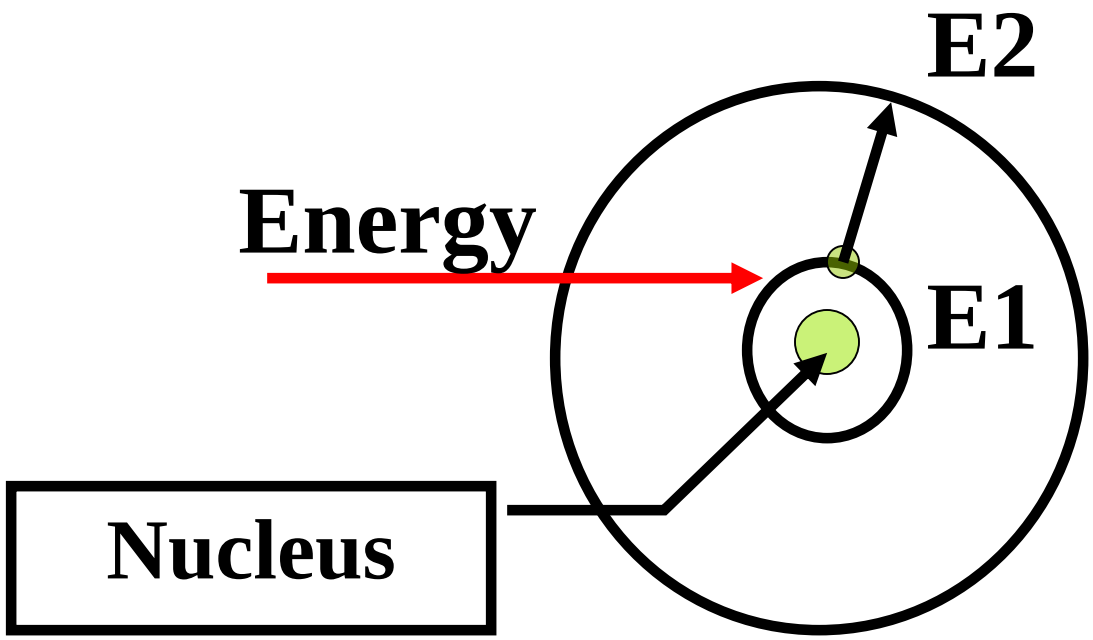
- The speed of light is the same for all electromagnetic radiation.
- You need to remember 300,000,000 m/s

Electron cloud

- Electrons are located in energy levels within the electron cloud of an atom.
- These energy levels represent specific quantities of energy that the electron must have within a particular atom.
- Electrons cannot exist at any other energies in that particular atom.

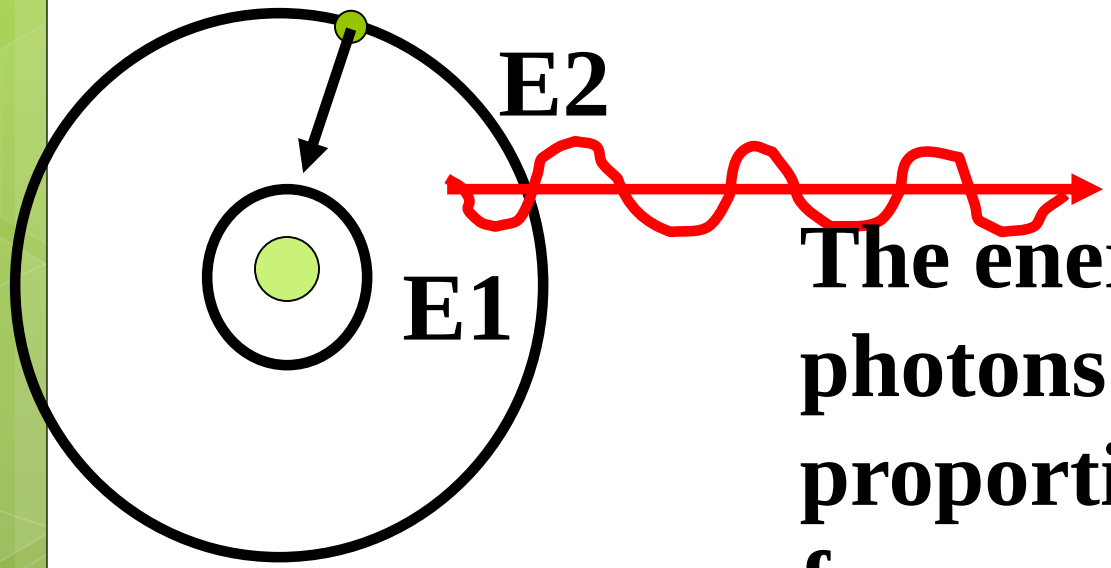
Excitation

An electron absorbs some energy which causes it to “jump” to a higher energy level. This is called excitation.

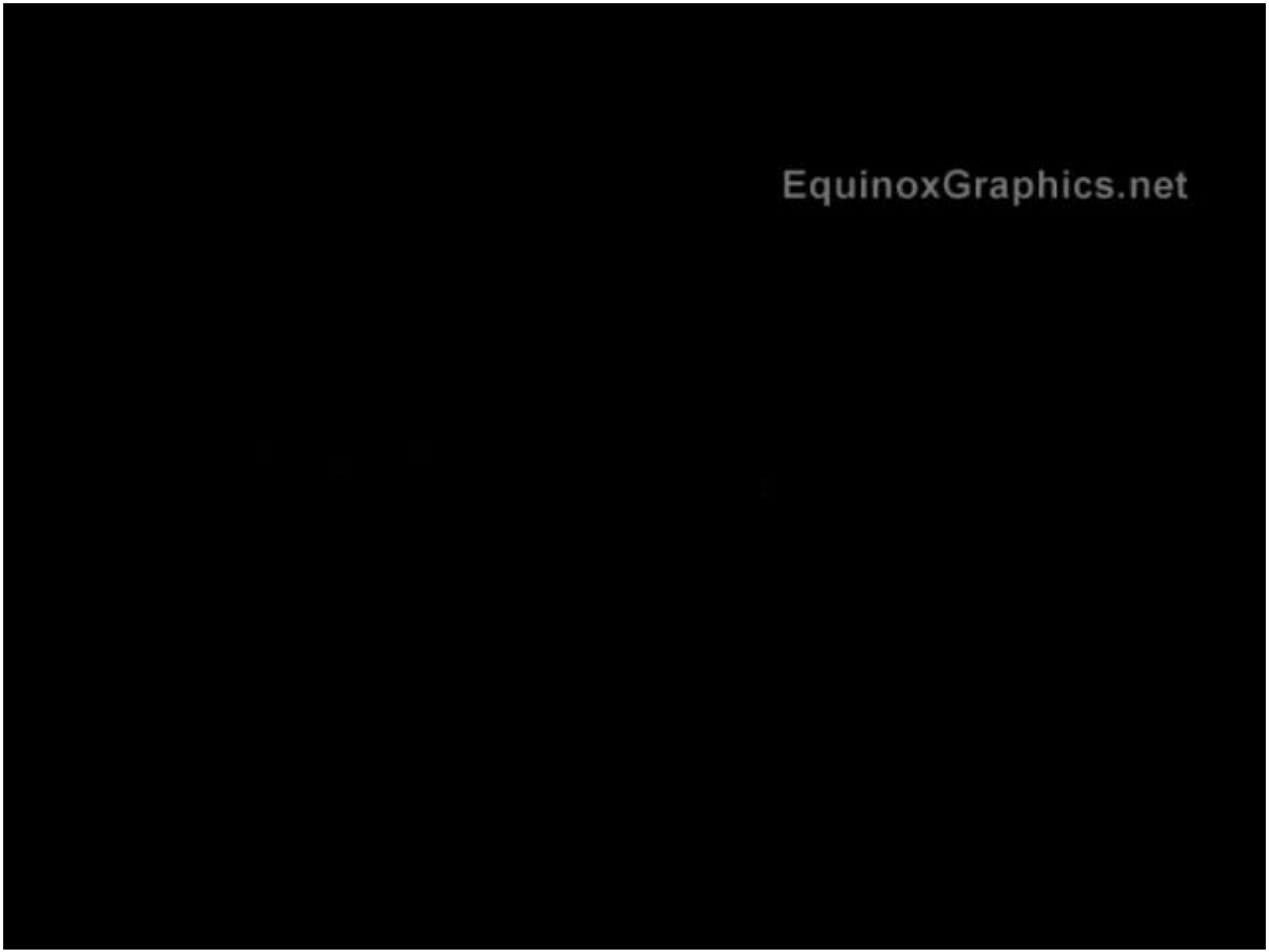


de-excitation

The electron, preferring to be in the lower energy, drops back down to the lower energy level, releasing energy.



The energy is released as photons and is proportional to the frequency of the resulting emag wave.


EquinoxGraphics.net

Electromagnetic Waves

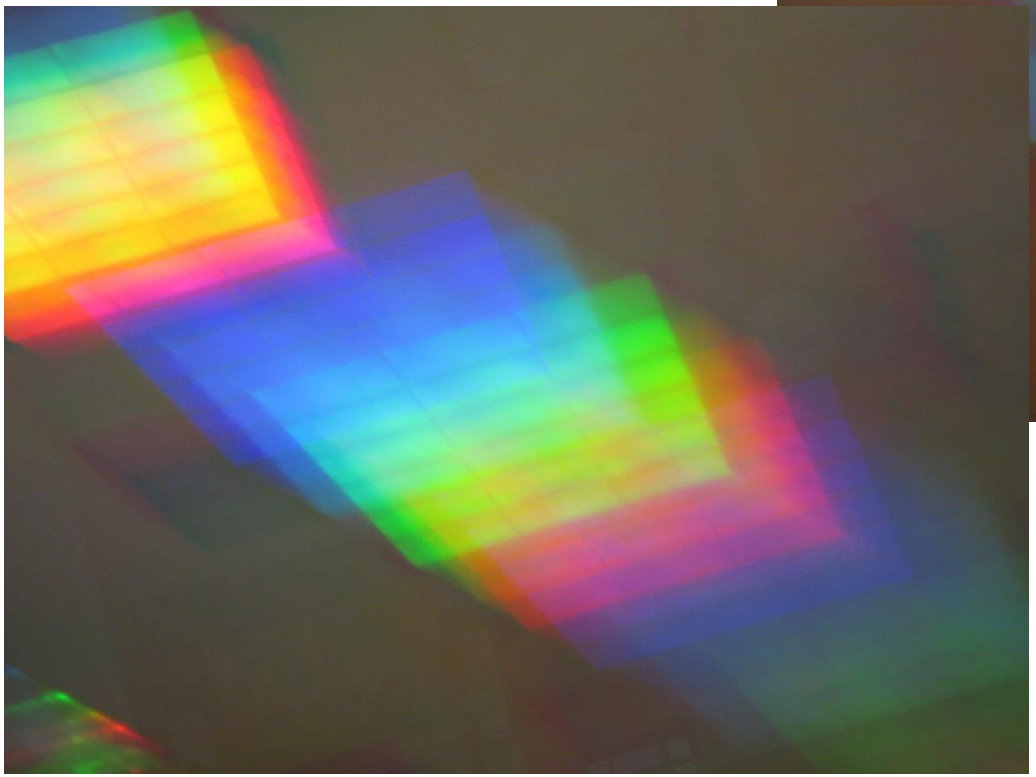
- Are composed of…
  - Photons- massless bundles of energy which have an associated frequency
- Are also known as…
  - Light
  - Radiation
- Light has a wave-particle duality…it has properties of both.

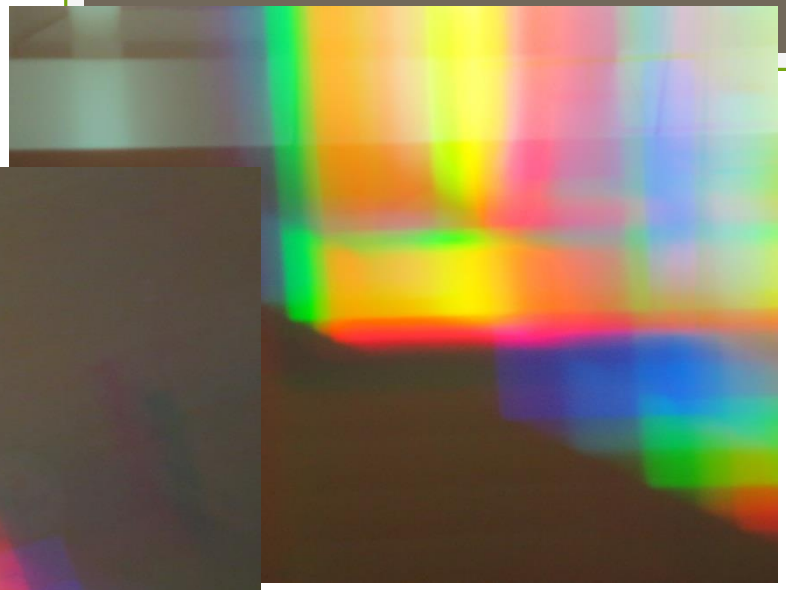
Emission Spectra

- Different electron transitions from high energy levels to low energy levels result in different frequencies of electromagnetic radiation (light if we can see it)
- Hot or electrified gases produce a bright line emission spectrum.

Bright line emission spectrum

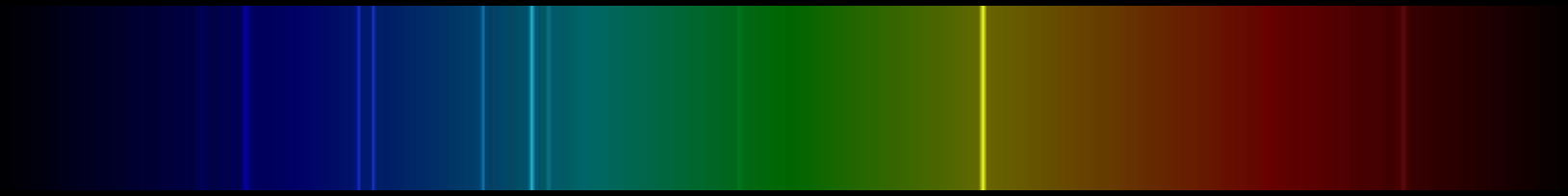
Try it…



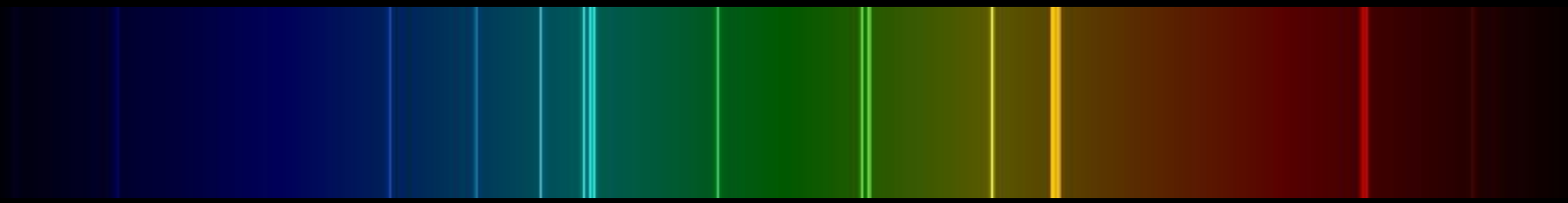


Hydrogen

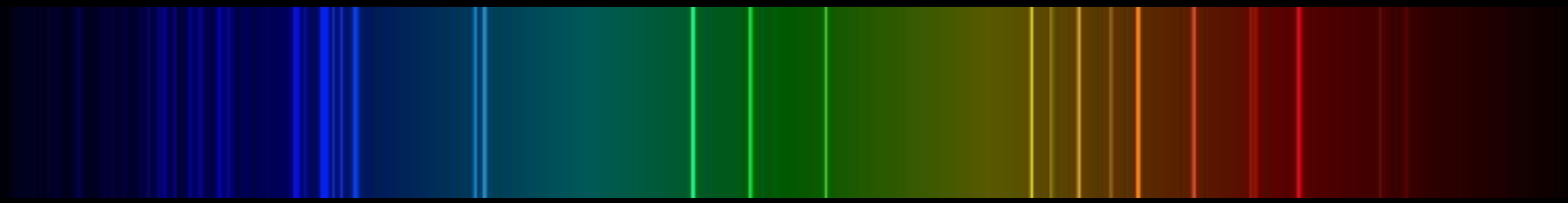
Helium



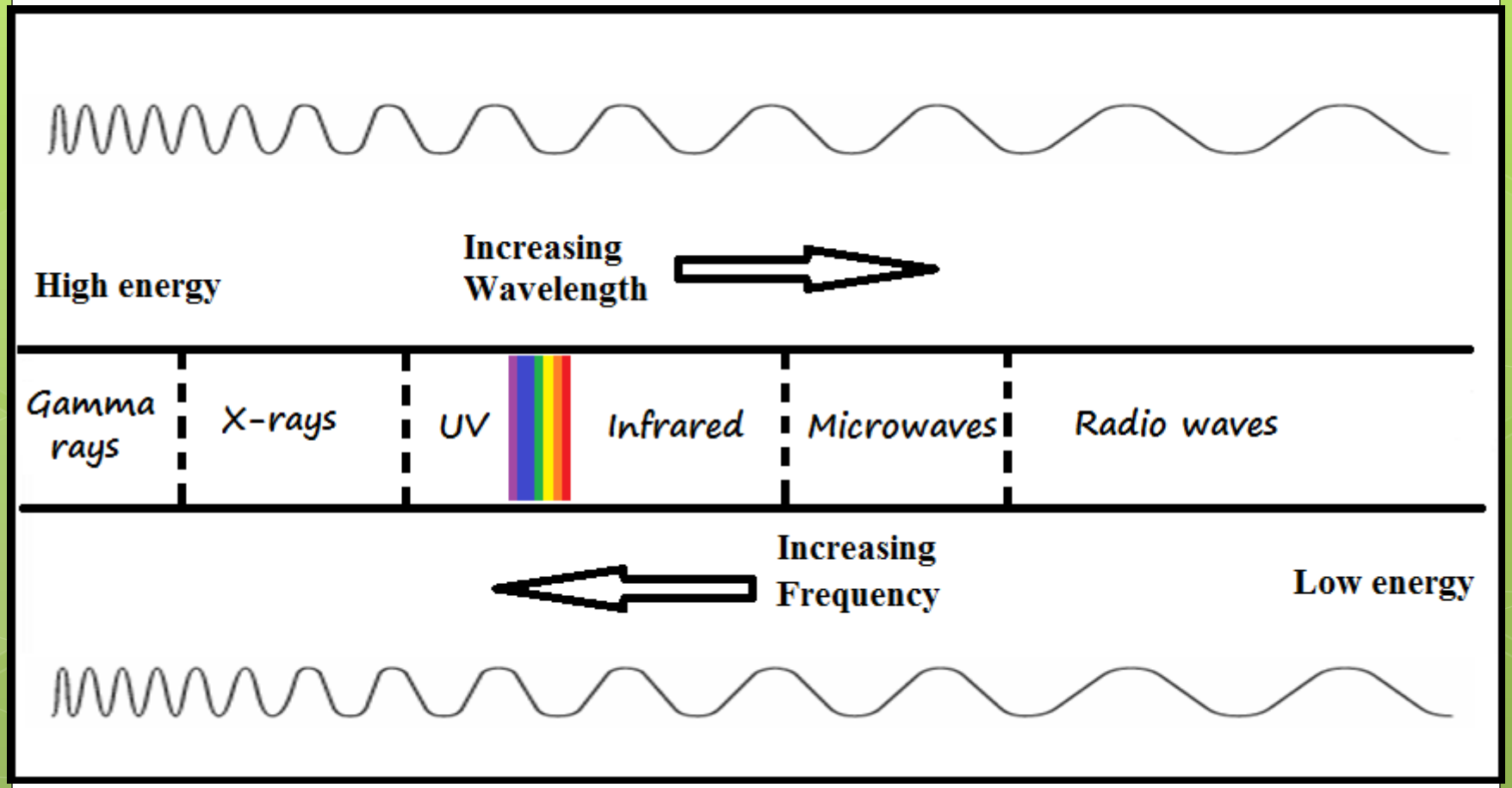
Carbon



Oxygen



The Electromagnetic Spectrum

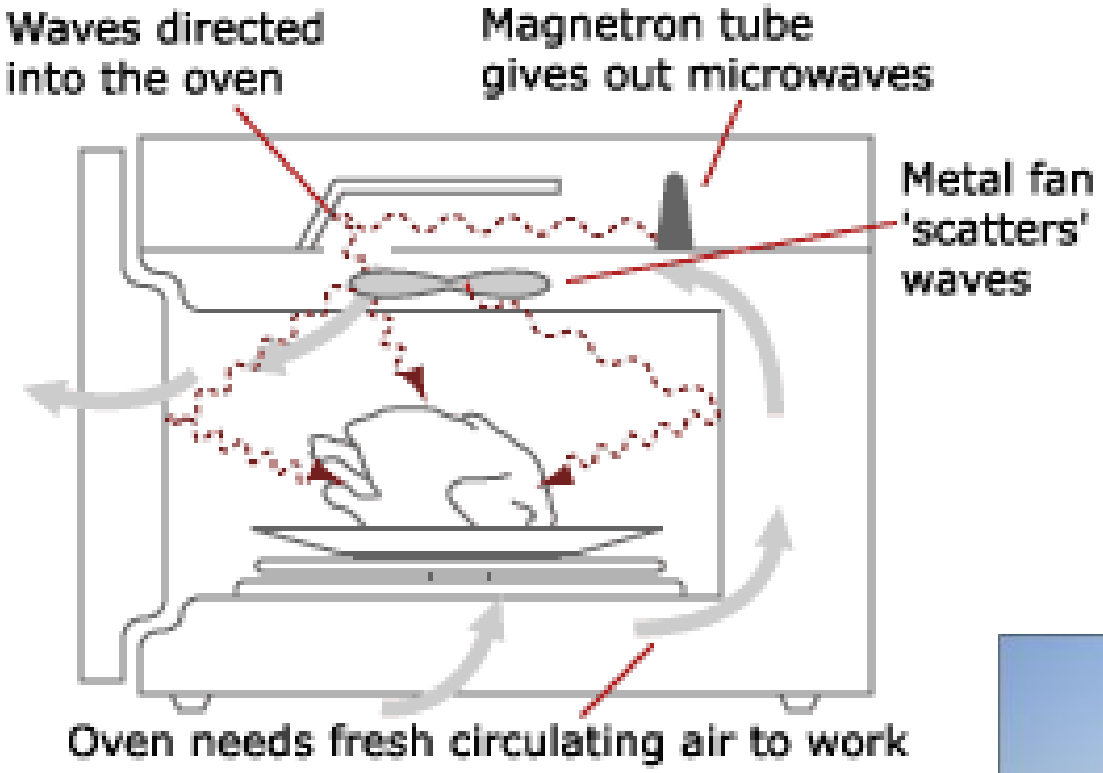


The Electromagnetic Spectrum

- ***Radio Waves*** *– radio, radar, TV signals*

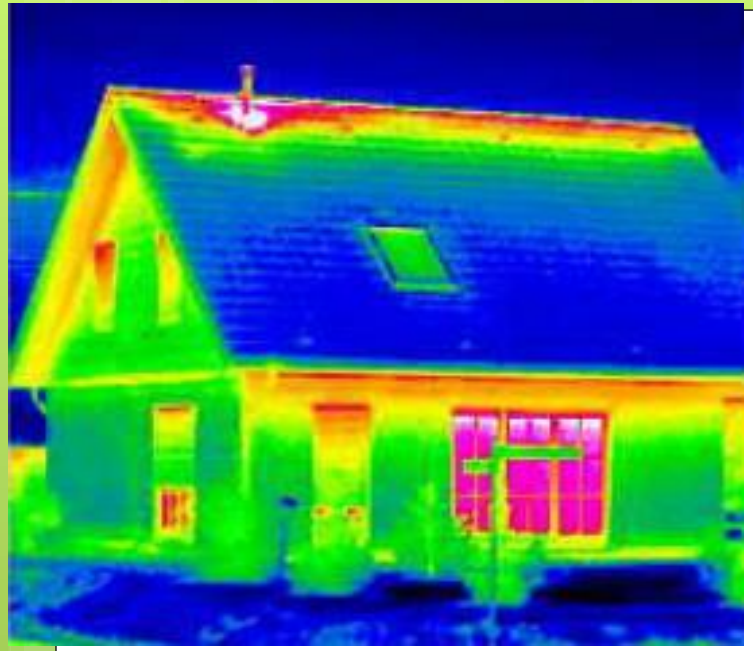
The Electromagnetic Spectrum

- ***Radio Waves*** *- radio, radar, TV signals*
- ***Microwaves*** *- used to cook, cell phone*


Waves directed into the oven
Magnetron tube gives out microwaves
Metal fan 'scatters' waves
Oven needs fresh circulating air to work

The Electromagnetic Spectrum

- ***Radio Waves*** *- radio, radar, TV signals*
- ***Microwaves*** *- used to cook, cell phone*
- ***Infrared*** *- "heat waves", remote control*




NASA/IPAC
95.4
95
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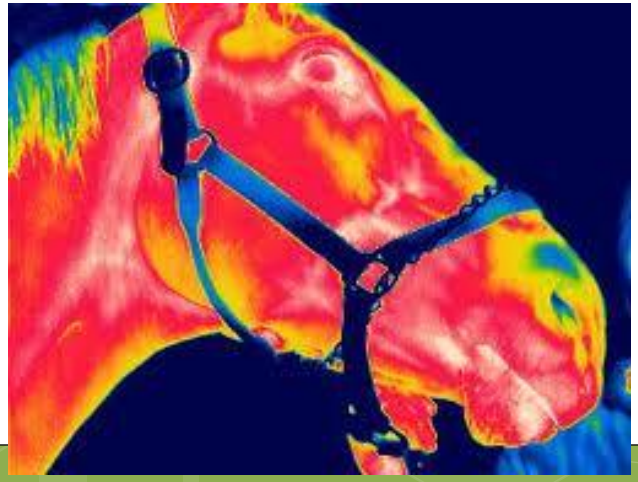
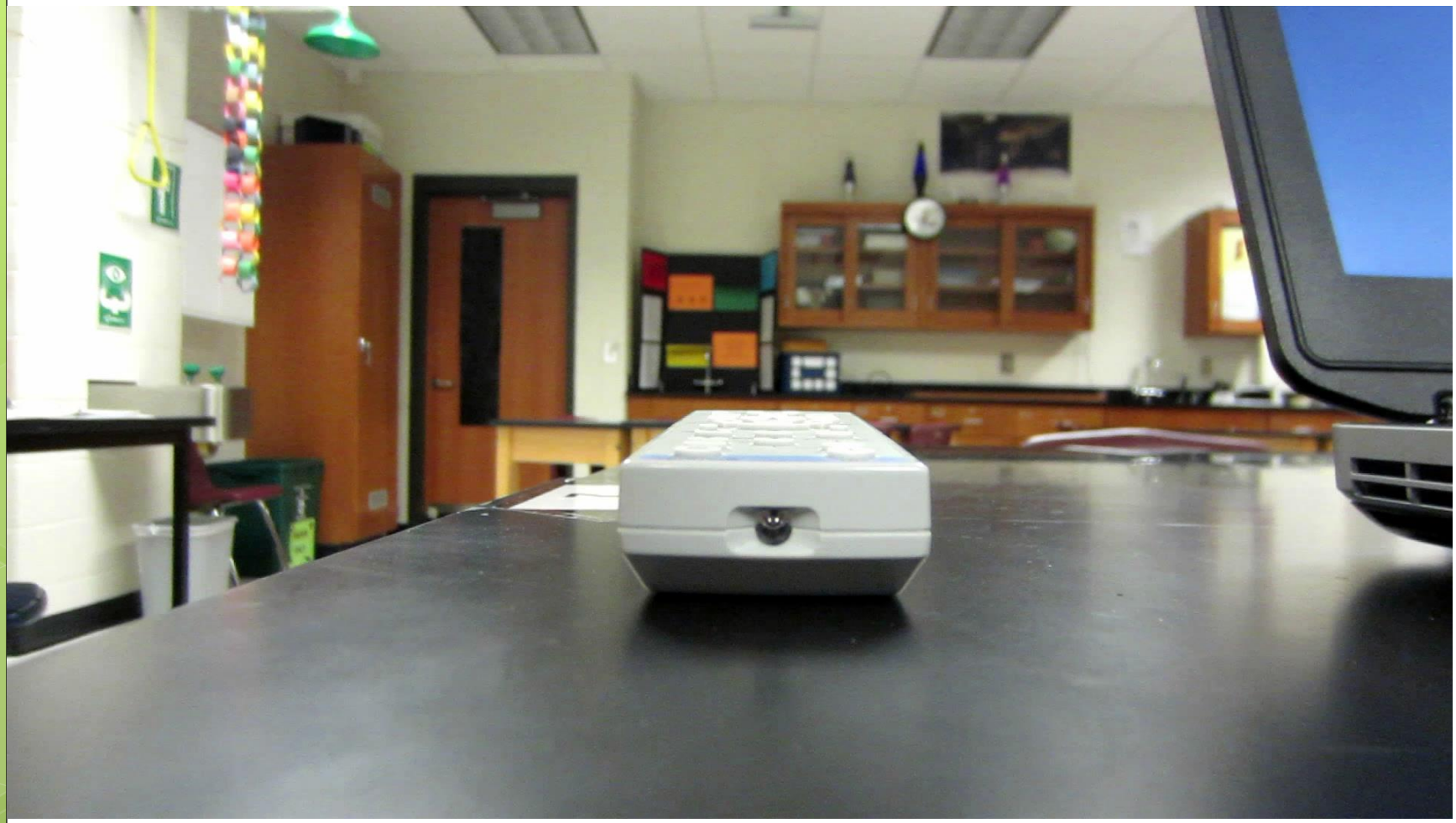
85
80
76.1

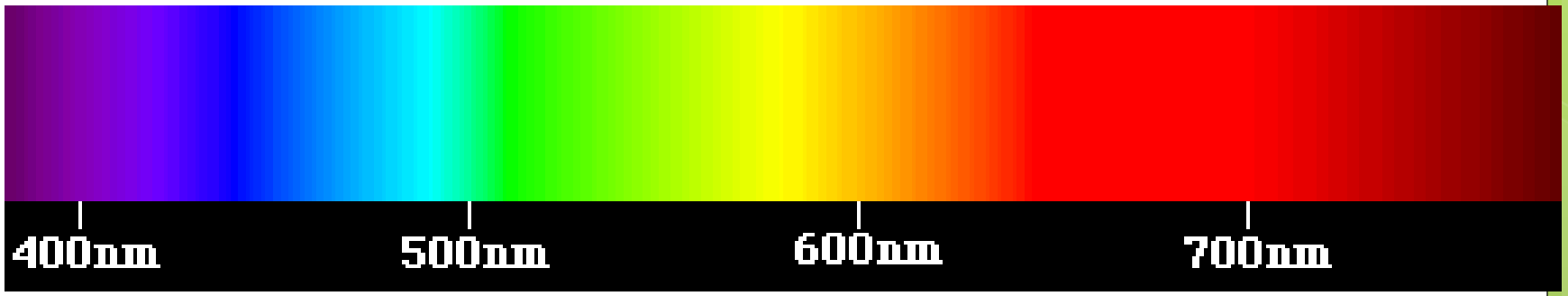




The Electromagnetic Spectrum

- ***Radio Waves*** *- radio, radar, TV signals*
- ***Microwaves*** *- used to cook, cell phone*
- ***Infrared*** *- "heat waves", remote control*
- ***Visible Light*** *- detected by your eyes*

The Visible Spectrum



- The range of electromagnetic waves extending in wavelength from about 400 to 700 namometers (10^{-9} m)…light.

The Electromagnetic Spectrum

- ***Radio Waves*** *- radio, radar, TV signals*
- ***Microwaves*** *- used to cook, cell phone*
- ***Infrared*** *- "heat waves", remote control*
- ***Visible Light*** *- detected by your eyes*
- ***Ultraviolet*** *- causes sunburns, kills germs*

The Electromagnetic Spectrum

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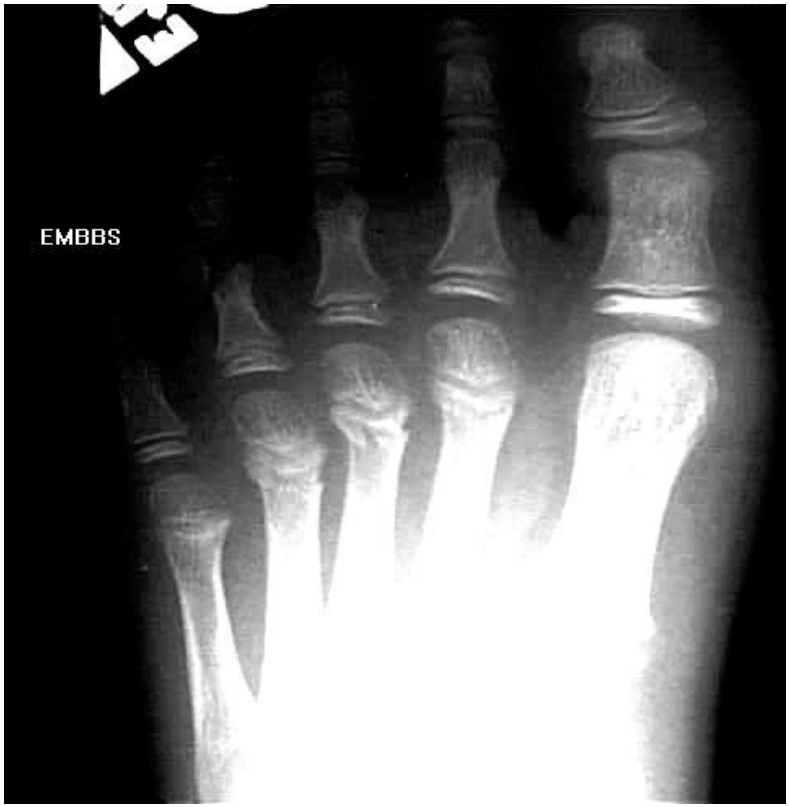
- ***Infrared*** *- "heat waves", remote control*
- ***Visible Light*** *- detected by your eyes*
- ***Ultraviolet*** *- causes sunburns, kills germs*
- ***X-rays*** *- penetrates tissue*


EMBBS


PRIMEX

The Electromagnetic Spectrum

- *Radio Waves - radio, radar, TV signals*
- *Microwaves - used to cook, cell phone*
- *Infrared - "heat waves", remote control*
- *Visible Light - detected by your eyes*
- *Ultraviolet - causes sunburns, kills germs*
- *X-rays - penetrates tissue*
- *Gamma Rays - most energetic, cosmic rays, nuclear radiation, transition of nuclear particles*

Transparent Materials

- Transparent - materials through which light can pass in straight lines
- Usually described as clear, such as window glass or water.
- Also applies to a colored filter which only allows a certain color through, but clearly.

Opaque Materials

- Opaque - materials that absorb or reflect most all light.
- You cannot see though it at all

Translucent Materials

- Translucent - materials through which light can pass, but not in straight lines resulting in objects looking blurry.
- Often the light source is indistinguishable, you just see light.
- A leaf, paper, skin, frosted glass.

Light speed changes?

- As light passes through various matter, it is absorbed and re-emitted
- This results in a slower observed speed through the matter than in empty space
- If the matter is transparent, then the same type of light absorbed by the matter is re-emitted by the matter.

Light speed changes?

- Since different frequency means different energy, different amounts of time are required to absorb and re-emit so the measurable speed of light in a material is frequency dependent.
- Light still travels at 3×10^8 m/s between molecules

Light speed changes?

- Opaque matter: instead of re-emitting the same light, whole molecules resonate and the energy is usually converted to heat energy due to simple collisions.
- Some light may be reflected as well. The frequencies reflected determine the color we see.

Light speed changes?

- A shiny opaque object (usually metallic) is shiny/reflective due to free electrons on the surface absorbing and emitting light from the surface outward.

Transparency of the spectrum

- Transparency depends on the specific frequency of the waves…
- Glass is transparent to visible but is opaque to UV and infrared.
- Are clouds transparent to visible light?
- Clouds are transparent to ultraviolet light (~95%)

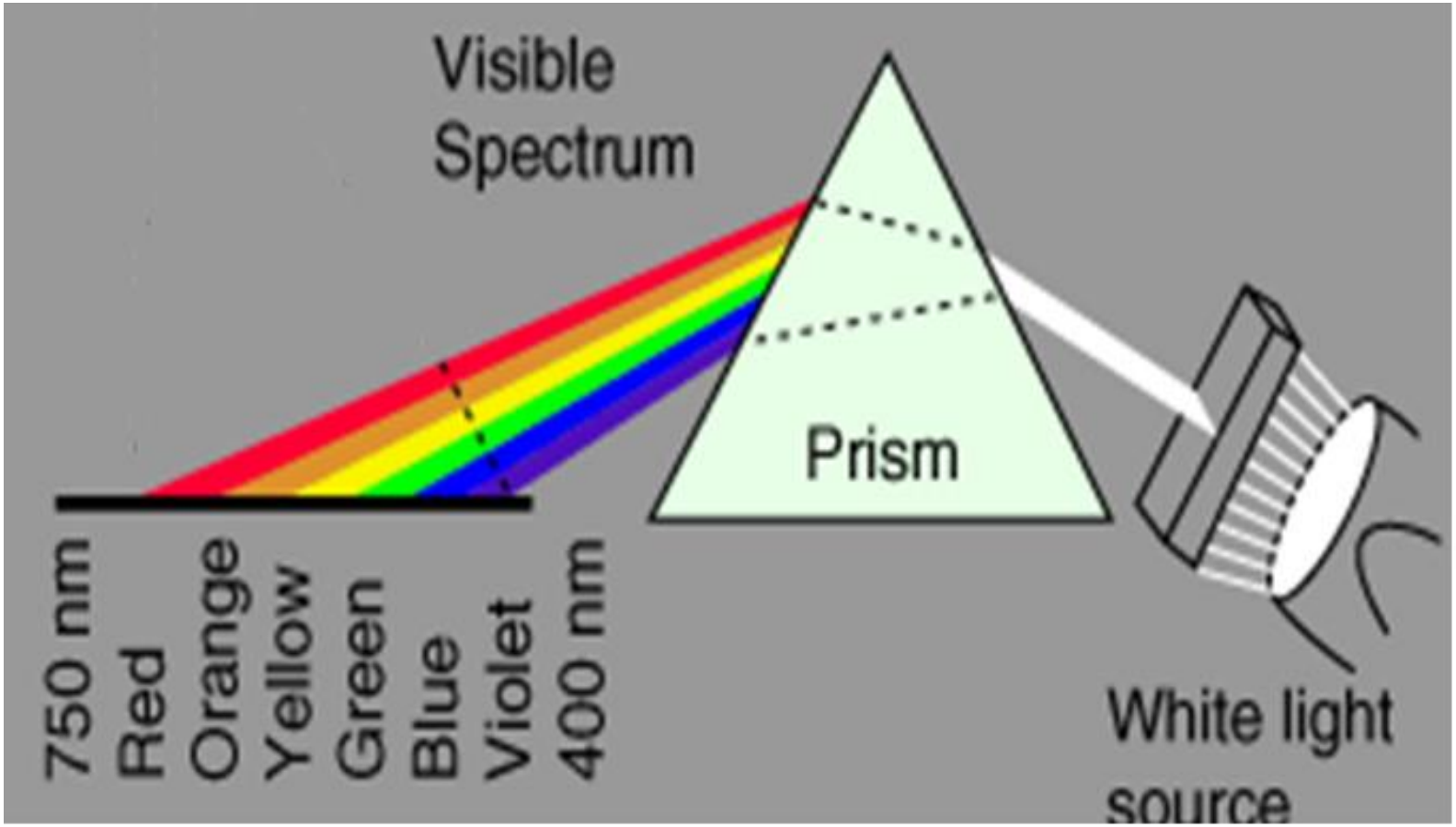
Transparency of the spectrum

- Transparency depends on the specific frequency of the waves…
- Your skin and bones are opaque to…
  - But are transparent to…
- Walls are opaque to…
  - But transparent to…

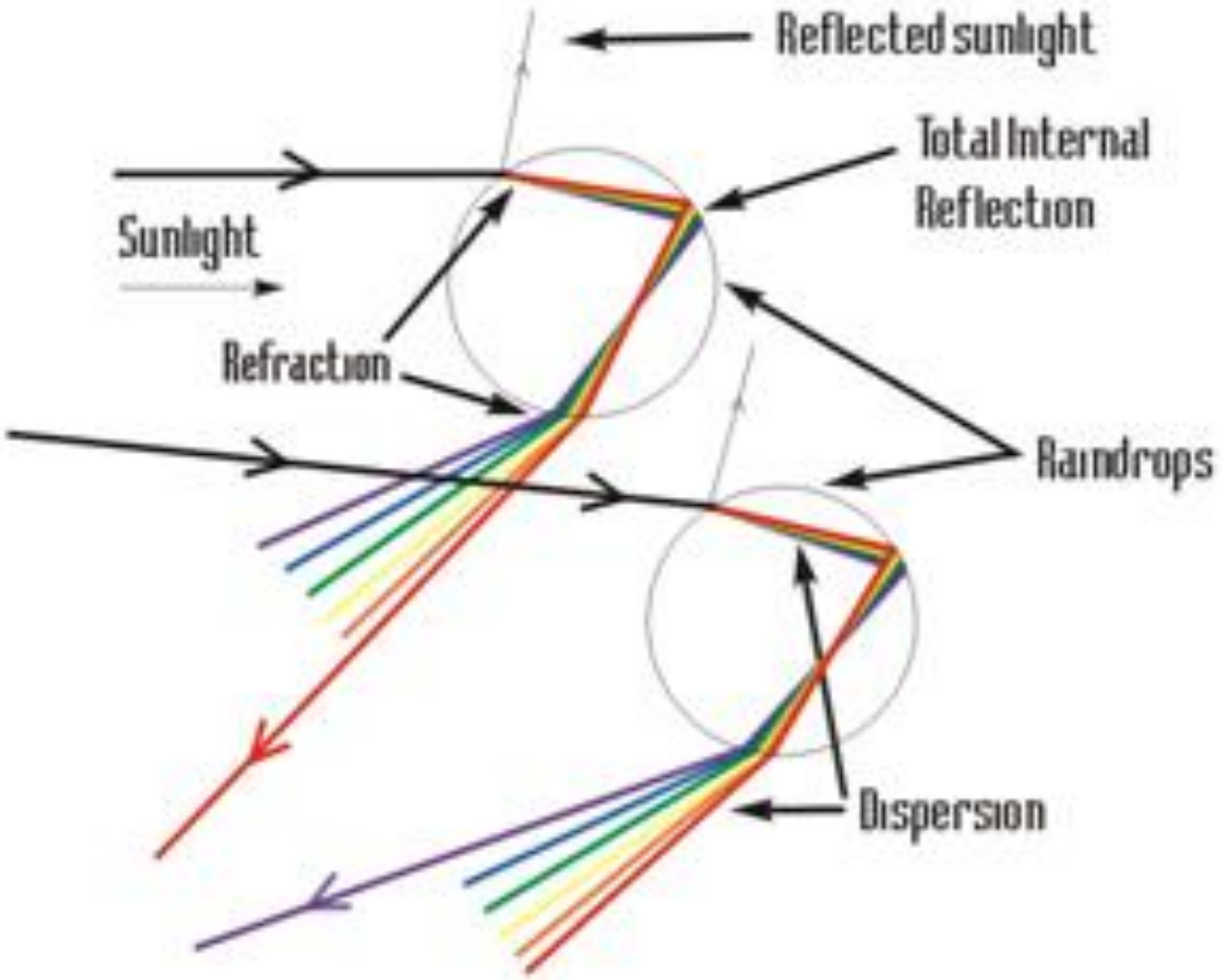
Refraction

- When light travels from one medium to another at an angle (not head on) the change in speed causes it to bend or REFRACT.
- The different colors of visible light differ in frequency, as a result they travel at different speeds in transparent materials.
- Red travels fastest and violet travels slowest. This is the cause of a rainbow as white light passes through glass or water.

Rainbows

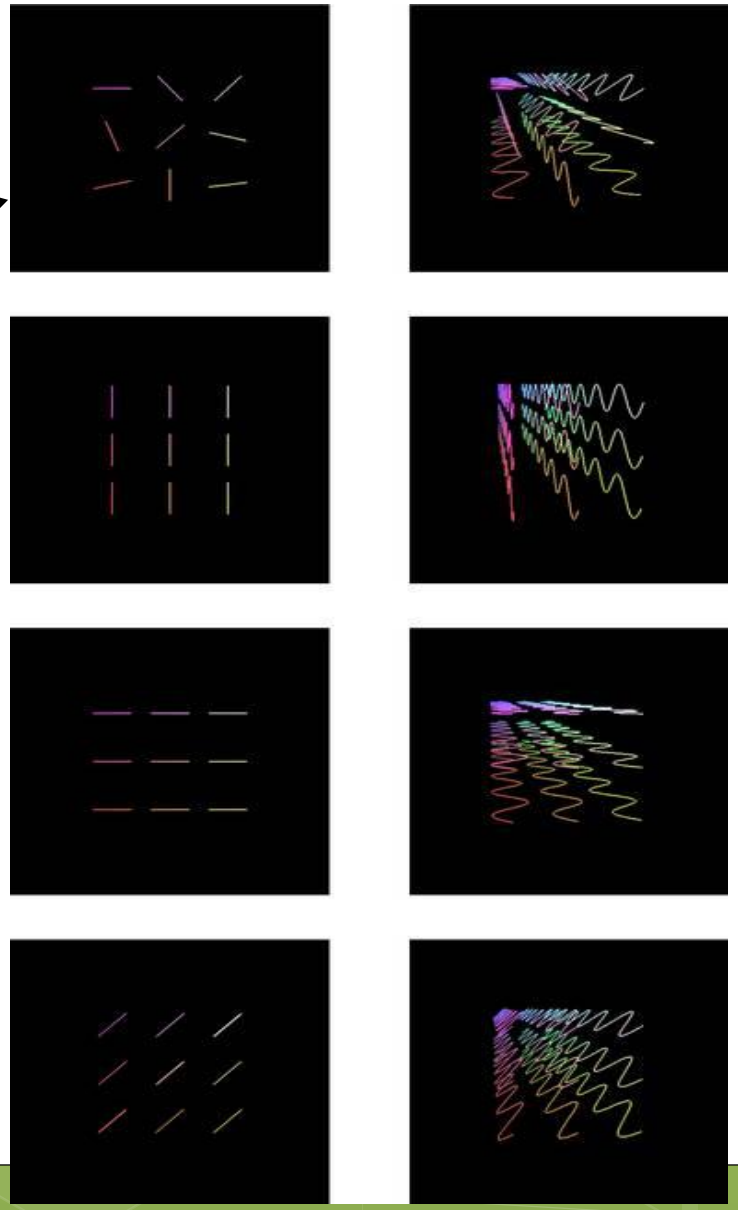

Visible
Spectrum
Prism
750 nm
Red
Orange
Yellow
Green
Blue
Violet
400 nm
White light
source

Rainbows


Reflected sunlight
Total Internal Reflection
Sunlight
Refraction
Raindrops
Dispersion

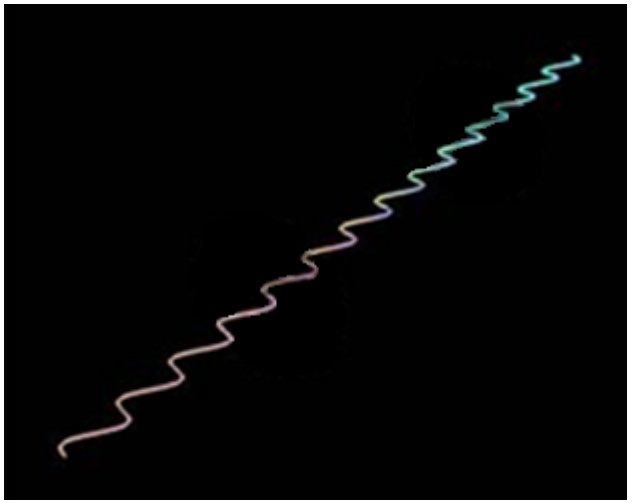
Polarization

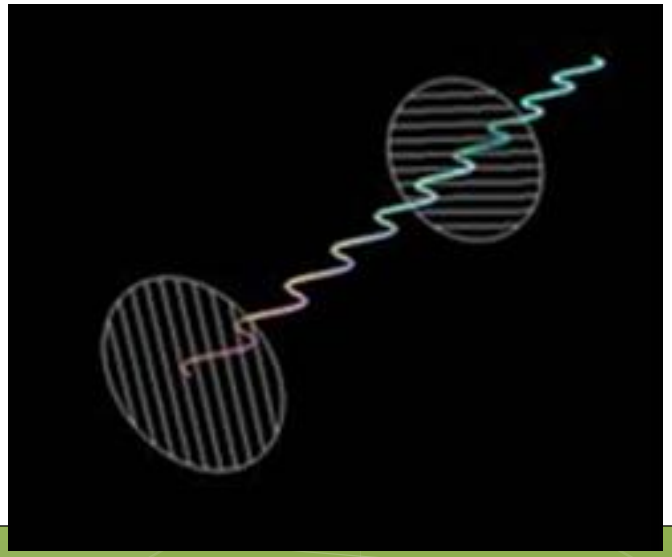
- Light produced by the sun or a light bulb has light vibrating in all planes.
- A polarized filter only allows the light through that vibrates in one plane…vertical, horizontal, diagonal…



Polarization

- Light reflecting off of non-metallic surfaces is naturally polarized parallel to the surface.
- This horizontally polarized light, cannot pass through a vertically polarized filter…sunglasses… they remove the glare





Polarization and 3-D

- A typical 3-D camera is actually two cameras…each lens is spaced to simulate the spacing between typical human eyes
- The film is then projected, from both perspectives, with opposite circular polarizers in front of each perspective.
- The 3-D glasses have opposite circular polarized filters, each allowing one perspective through while blocking the other…just like you see normally.