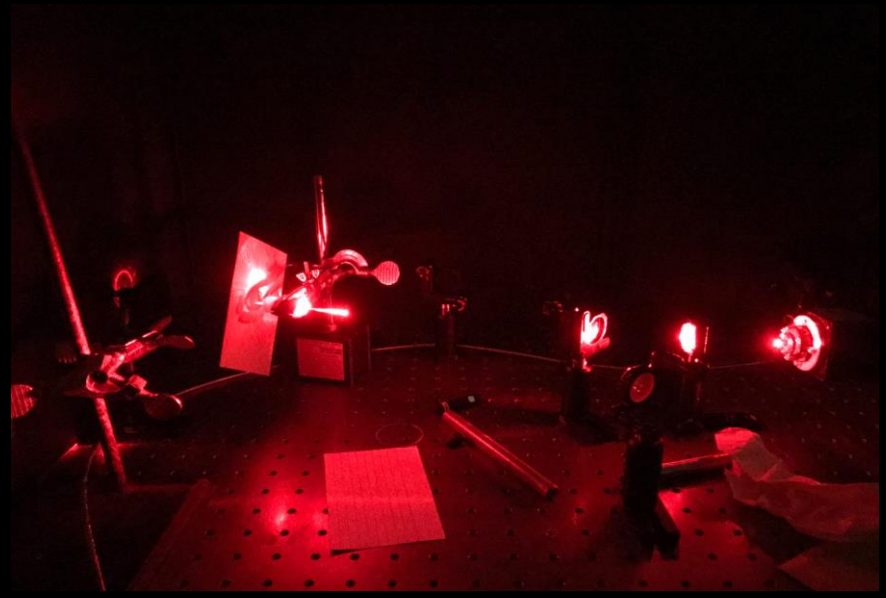
AP Physics

Chapter 22 - 25: Optics and Light



What is light?

- Light is an electromagnetic wave.
- This basically means that it is a wave that is composed of an electric field and a magnetic field.
- It's fields are oriented in a 90^0 rotation from each other.

What is light?

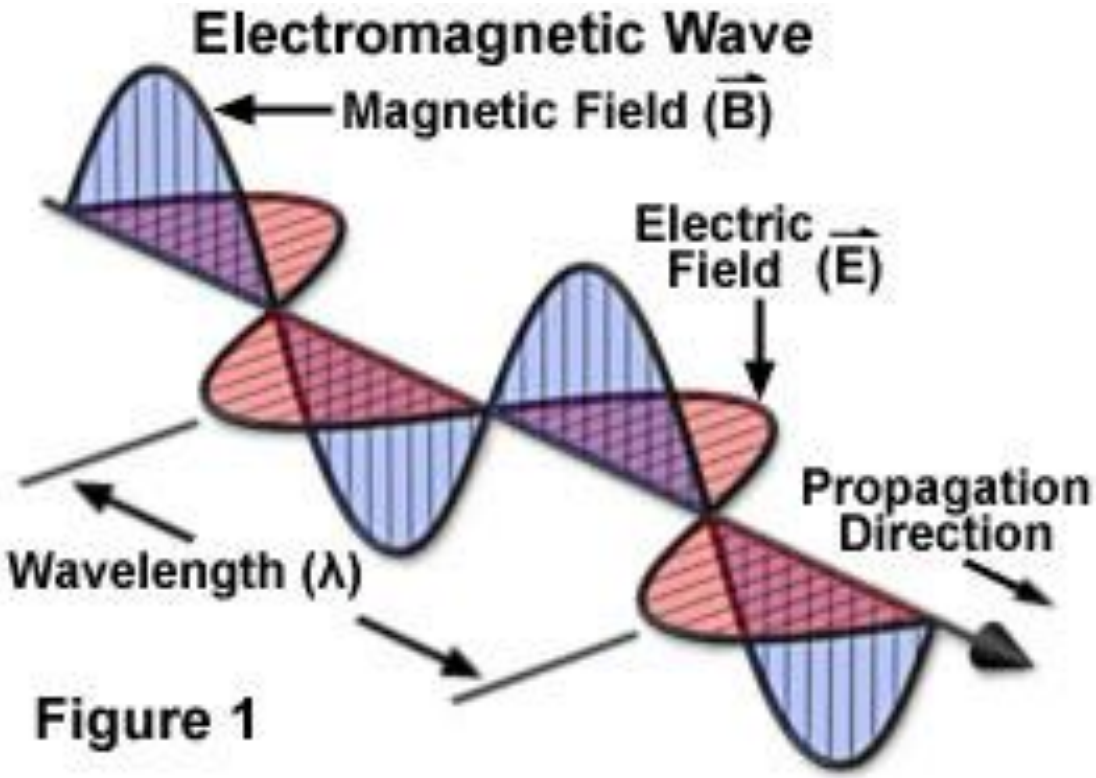
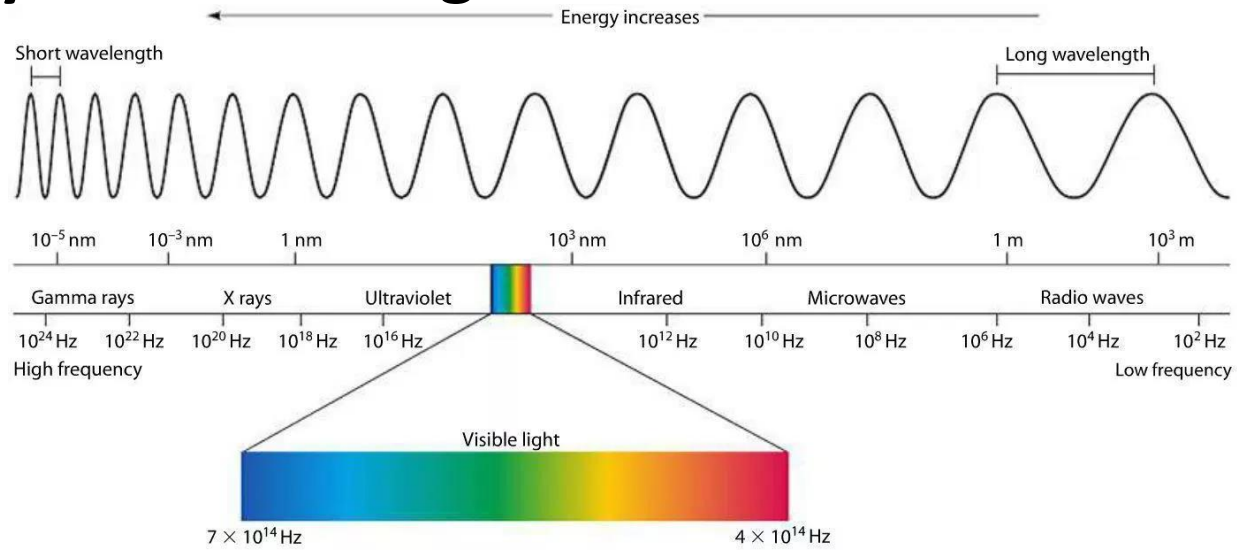


Figure 1

What is light?

It has a spectrum associated with it. This is called the electromagnetic spectrum.

The classification of light in this spectrum depends on frequency and wavelength.



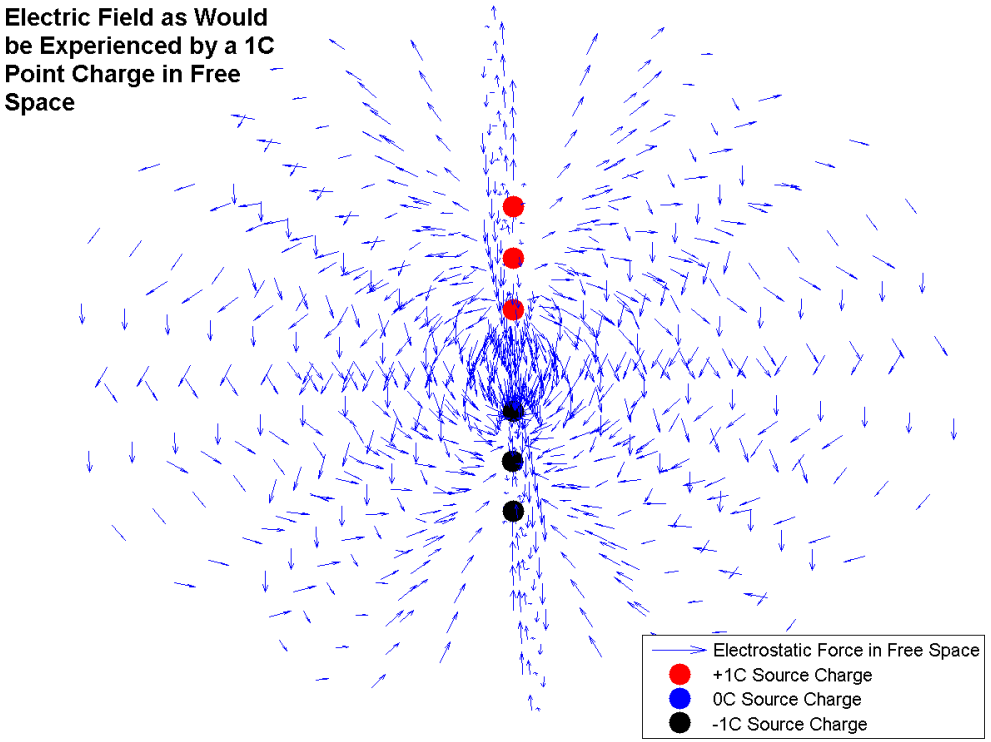
What is light?

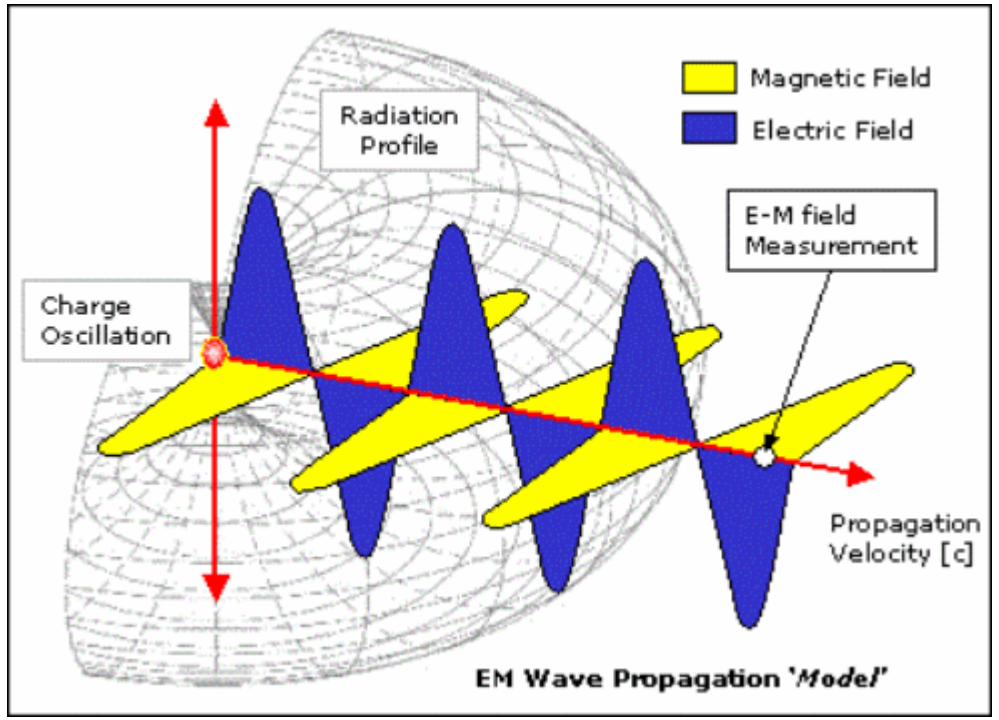
It has all the same properties of waves that we have talked about in the previous section along with some additional properties.

Since it is an electromagnetic wave, it does not need a medium to travel through.

How do we create light?

We can create light by taking a charge and making it oscillate at a specific frequency.





What is light used for?

Pretty much all modern day technology.

- The internet
- Bluetooth
- Radios
- It is how the global warming phenomena can be explained
- Cameras
- MRIs and CAT Scans in the medical field
- All microscopes
- All spectrometry
- Computer screens
- Television
- Satellites
- Microwaves
- Induction Heating Stoves
- EVERYTHING!!!! Not really but pretty much.

Properties of Light

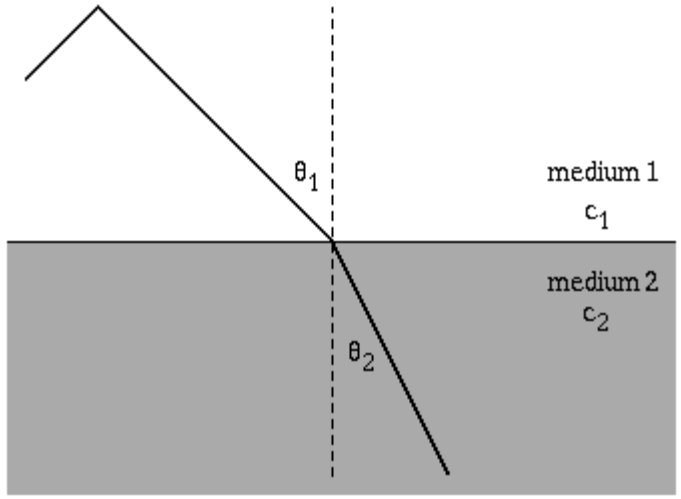
Before we get into the fun stuff there are some properties we need to talk about.

- Refraction
- Diffraction
- Reflection
- Internal Reflection
- Polarization
- Dispersion
- Interference
- Effects of materials on light
- Scattering

Refraction

When light changes mediums it experiences refraction!

This essentially means it changes the angle and speed at which it propagates.

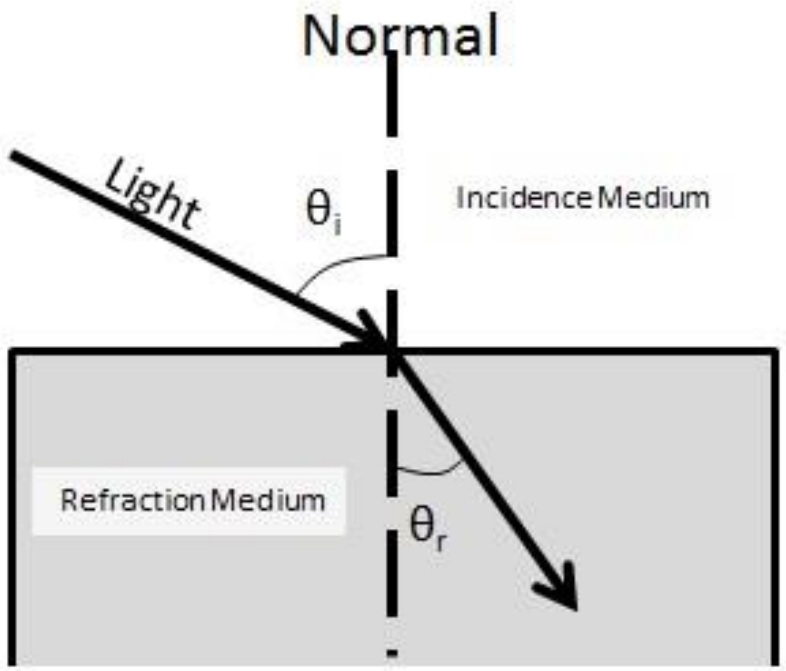


Refraction

This is determined by Snell's law.

$$n_i * \sin\theta_i = n_r * \sin\theta_r$$

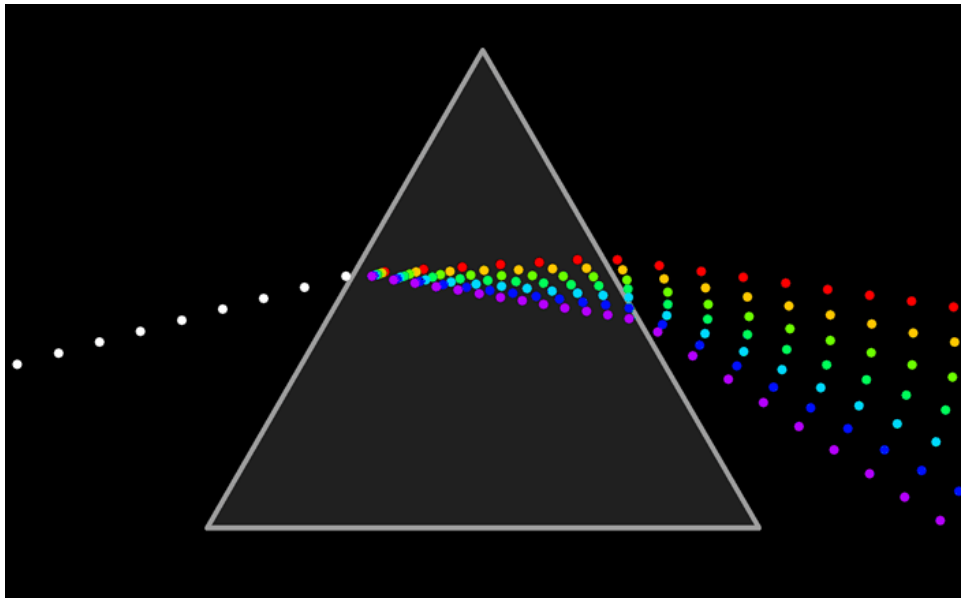
n_i = Index of Refraction of Incidence Medium
n_r = Index of Refraction of Refraction Medium
θ_i = Angle of Incidence
θ_r = Angle of Refraction



Light at shorter wavelengths or at higher frequencies experience more refraction than light with longer wavelengths and smaller frequencies

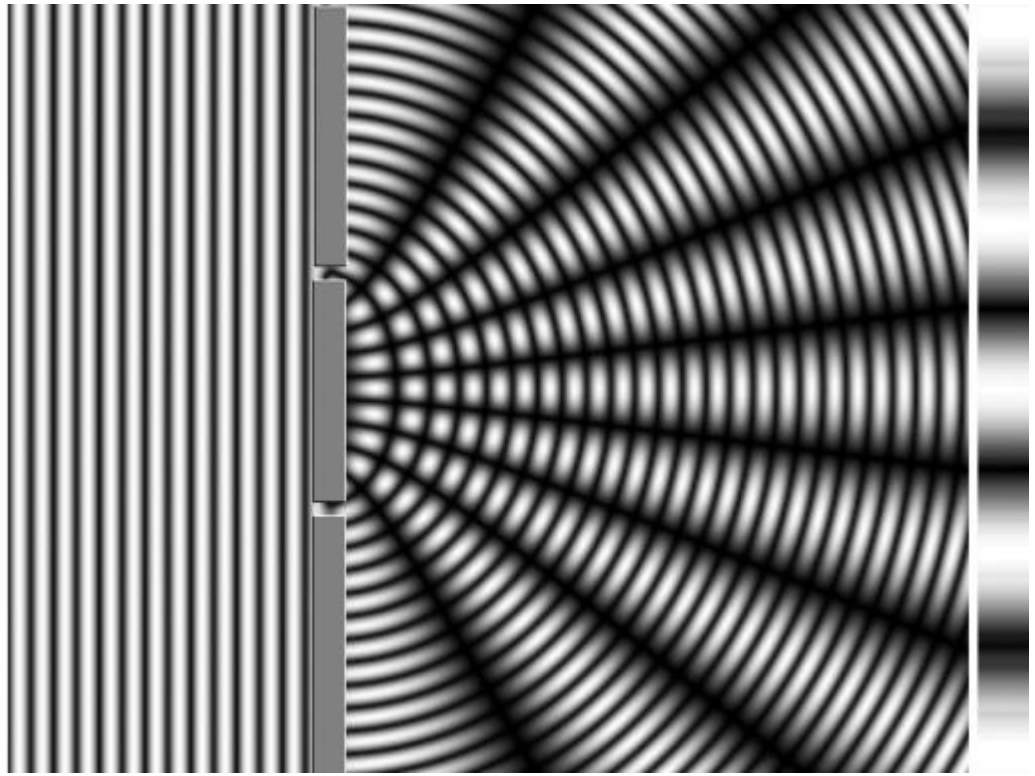
Refraction

This is what creates rainbows and it also explains how prisms are able to separate white light into its component wavelengths.



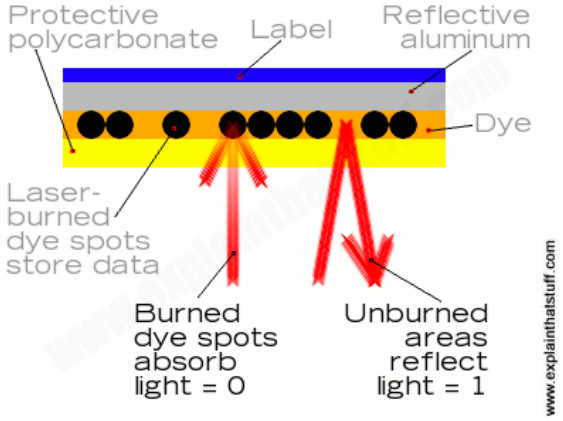
Diffraction

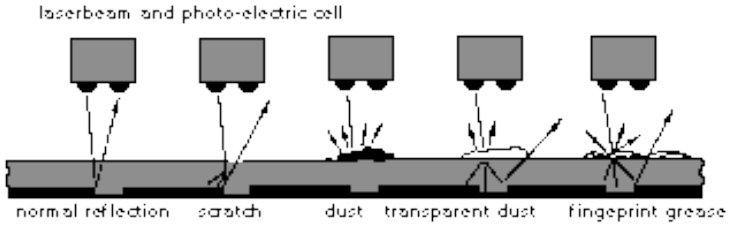
This is a phenomena that occurs when light passes through a narrow slit/aperture or across an edge. This causes interference between the wave forms produced.

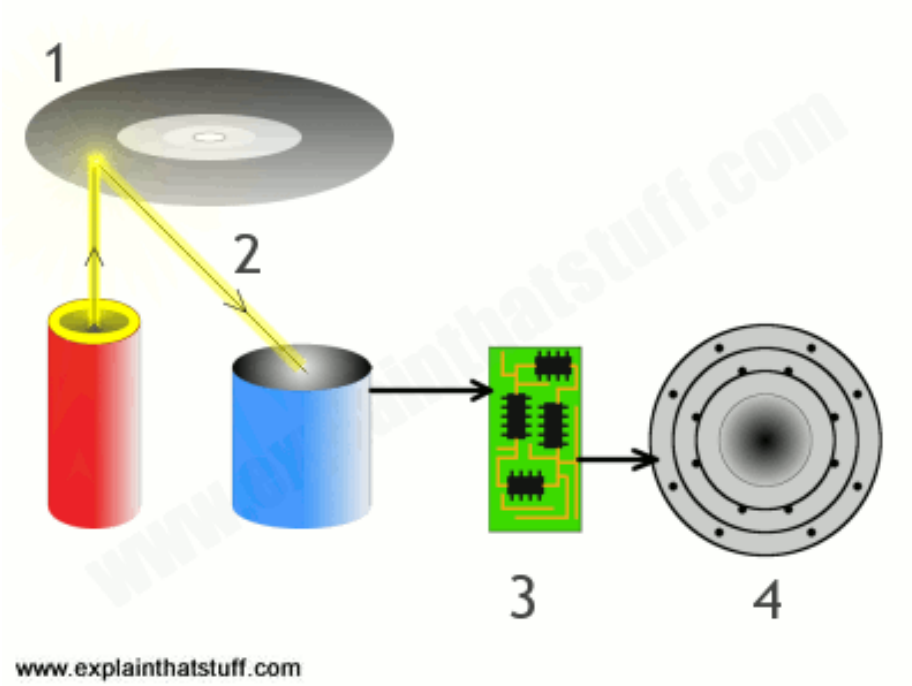


Diffraction

CD's and DVD's are essentially diffraction gratings. They use these gratings as a mean to store and transfer information that can be read through lasers.

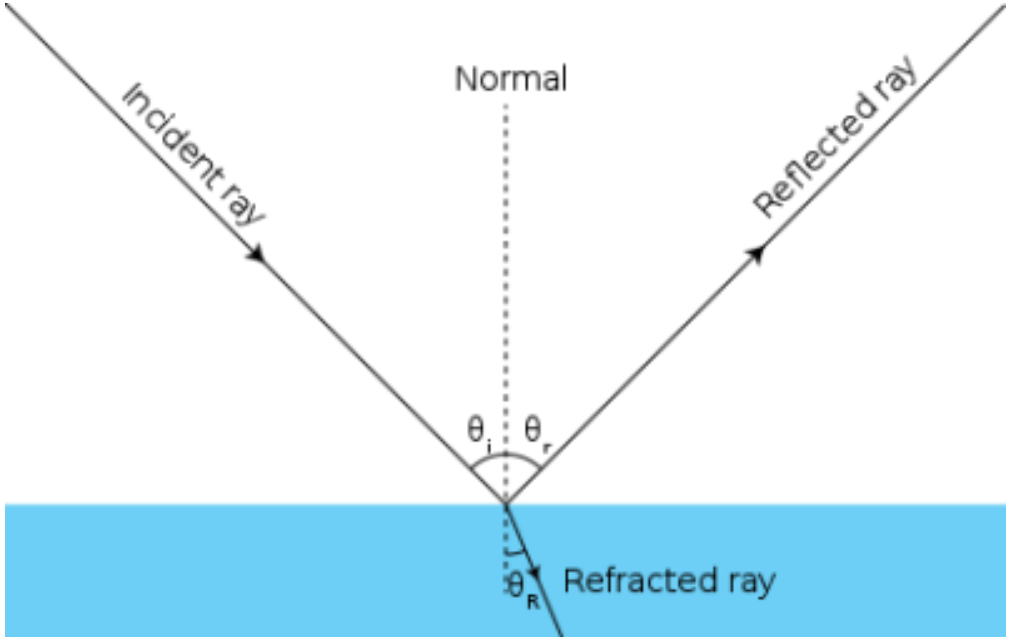






Reflection

Just light any other waves, when light hits another medium some of the wave is reflected or absorbed. Light is special though, and certain mediums can be totally transparent where no light will be reflected.

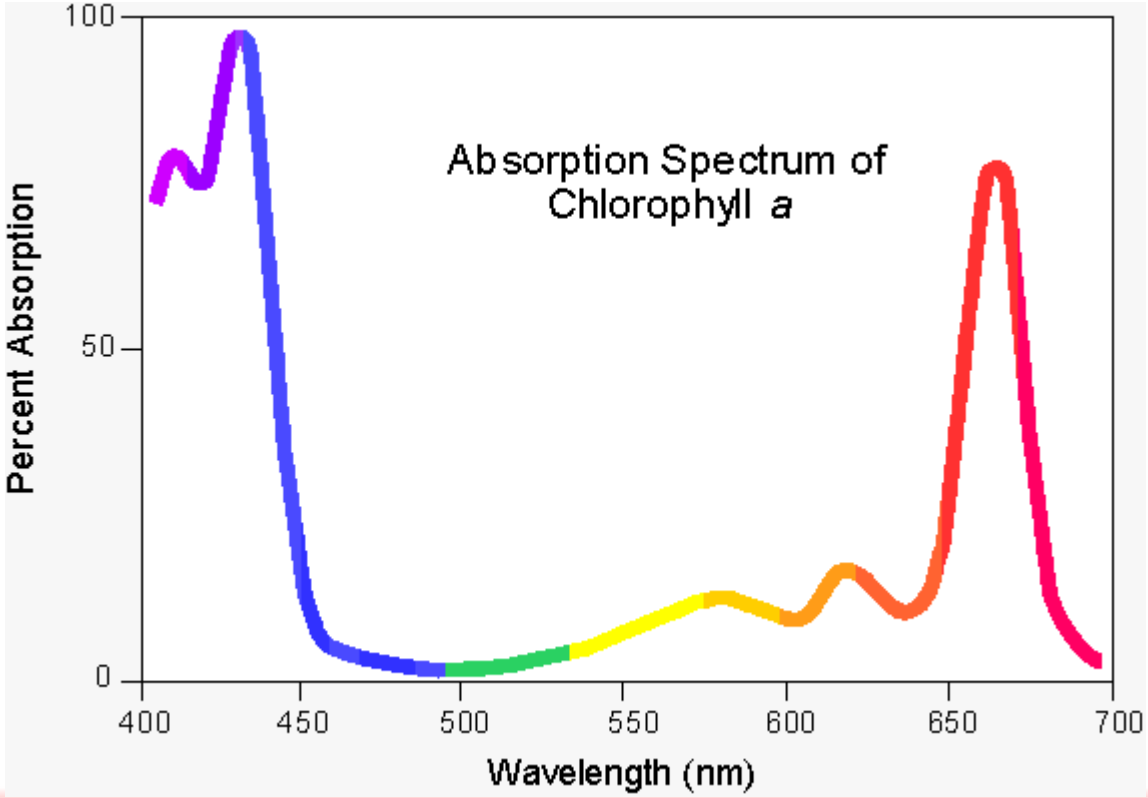


Reflection

- All colors we see work by reflection.
- A red shirt absorbs all colors of light except for red which is reflected and that is what we see.

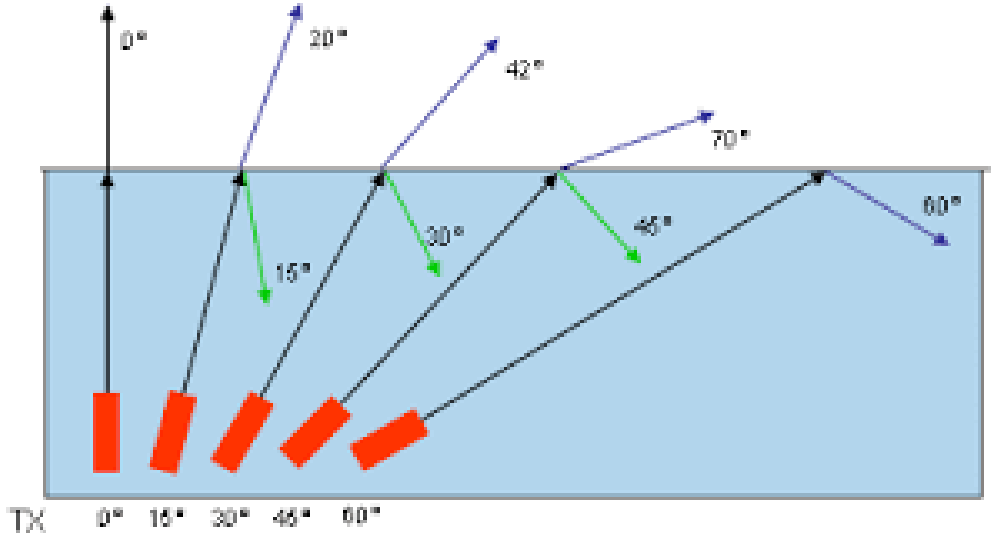
Reflection

- Leaves changing colors has to do with the change in chlorophyll within the leaf. It starts to absorb different wavelengths of light and reflect others.



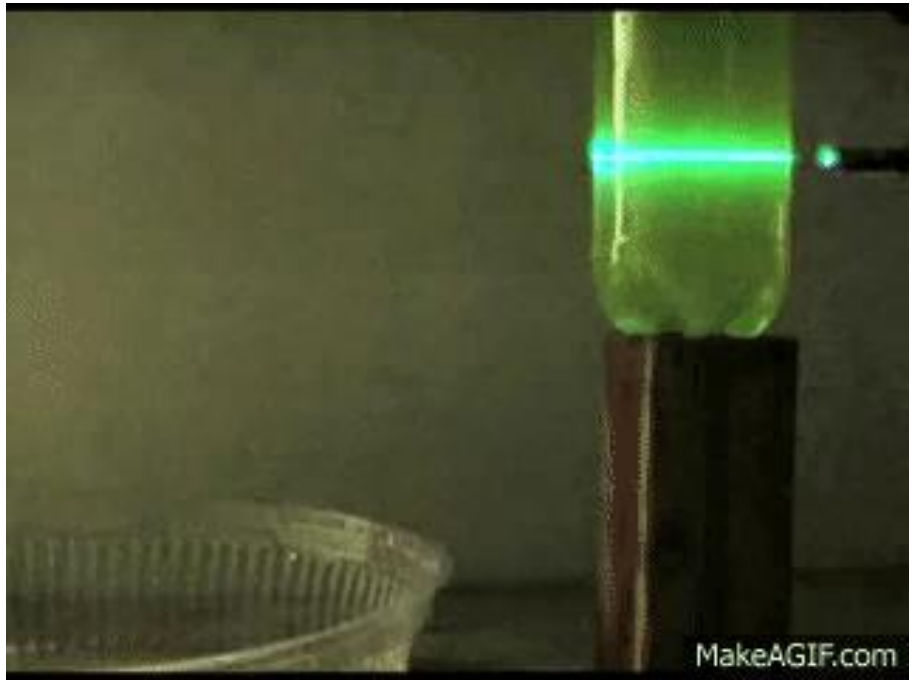
Internal Reflection

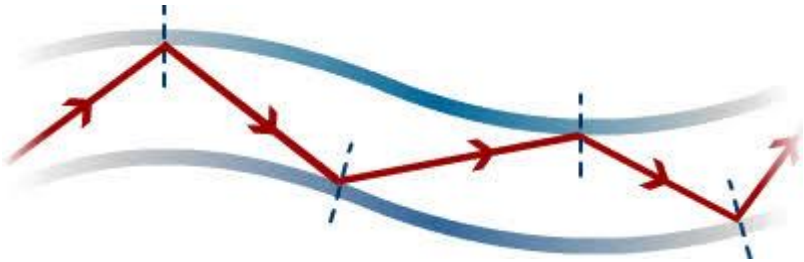
- As light passes through a medium it likes to stay in that medium. When it hits a boundary some of it not most of the light can be reflected off and stays within the medium. When this happens we call it internall reflection.



Internal Reflection

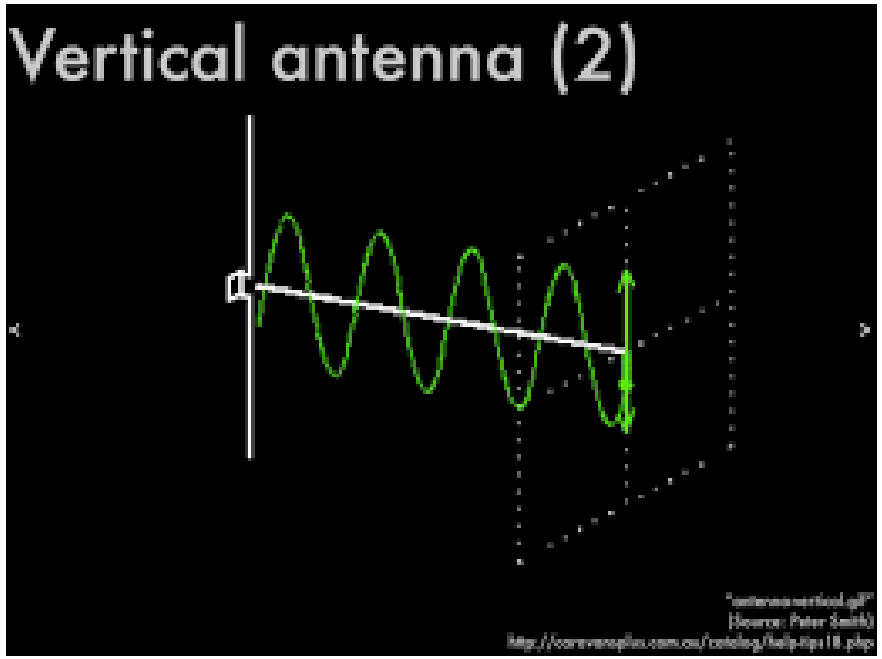
- We can bend light to our will using this property. This is how fiber optic cables work.





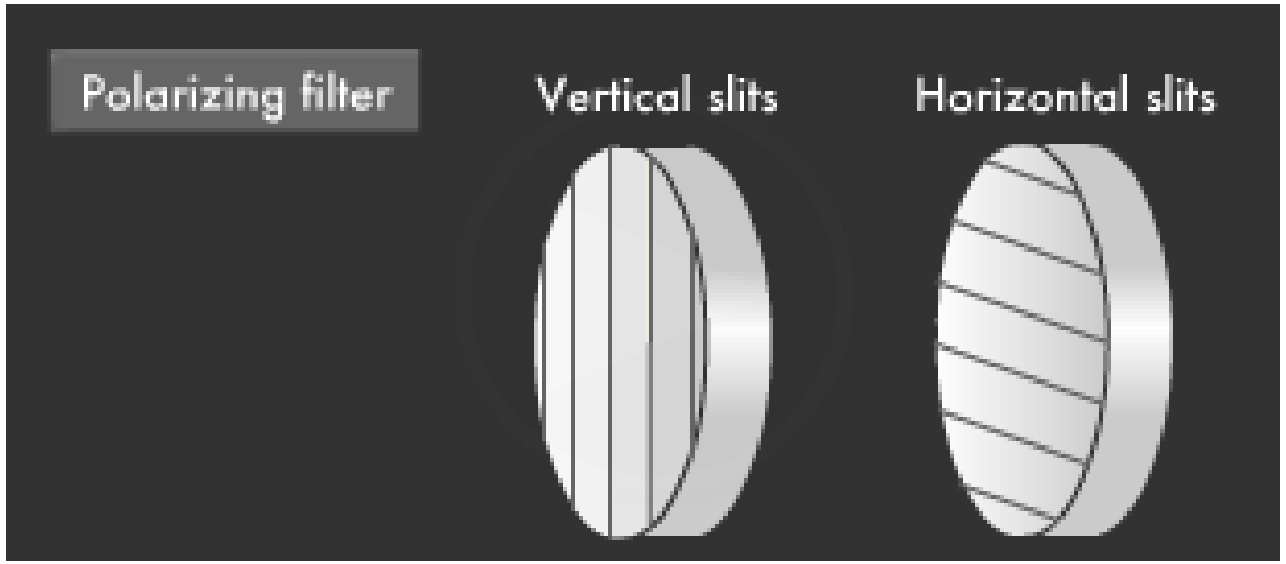
Polarization

- This is a property of light that is used to express the orientation of the electric and magnetic field that light has.



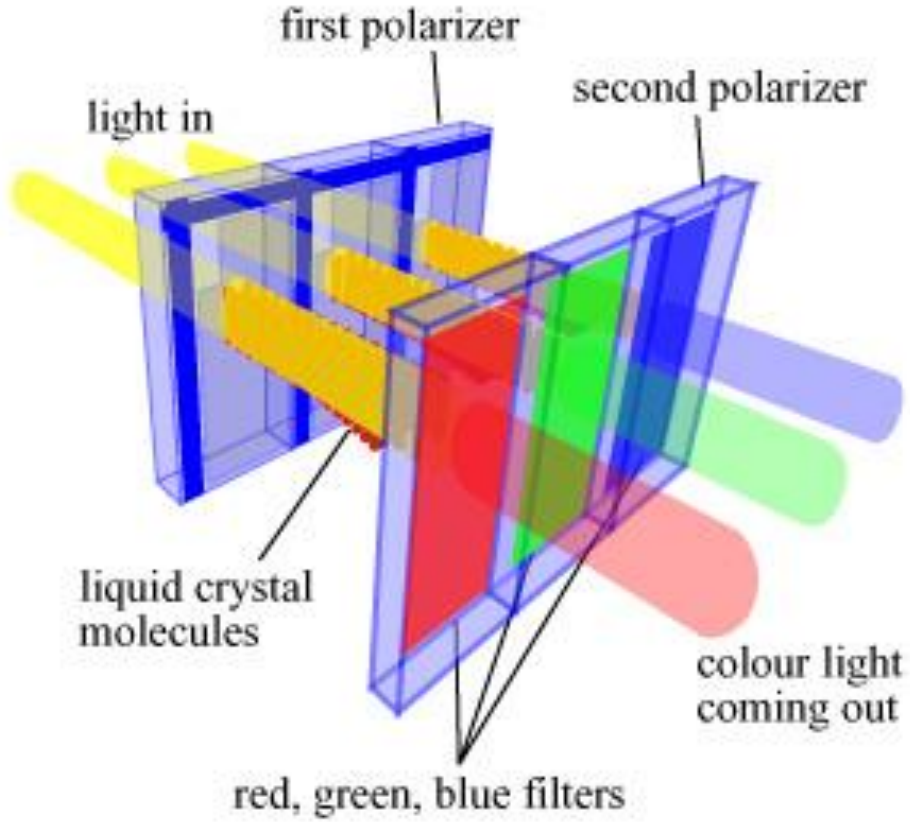
Polarization

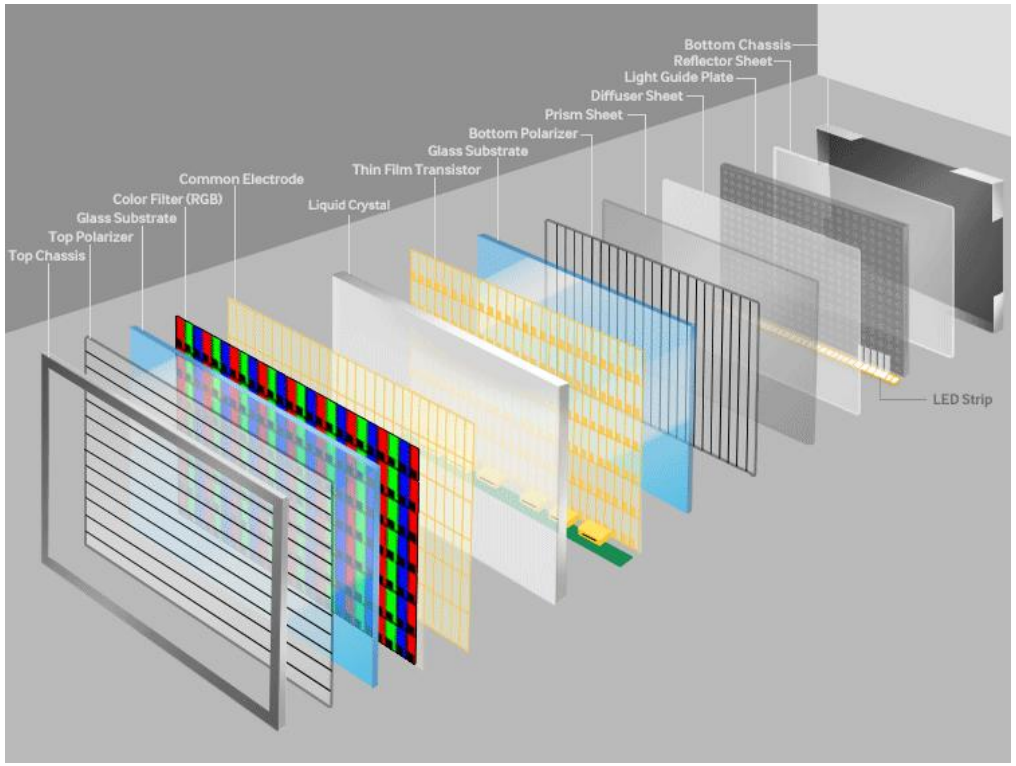
- Polarizers such as polarized sunglasses will block certain orientations of the lights electric and magnetic field and let some light through.



Polarization

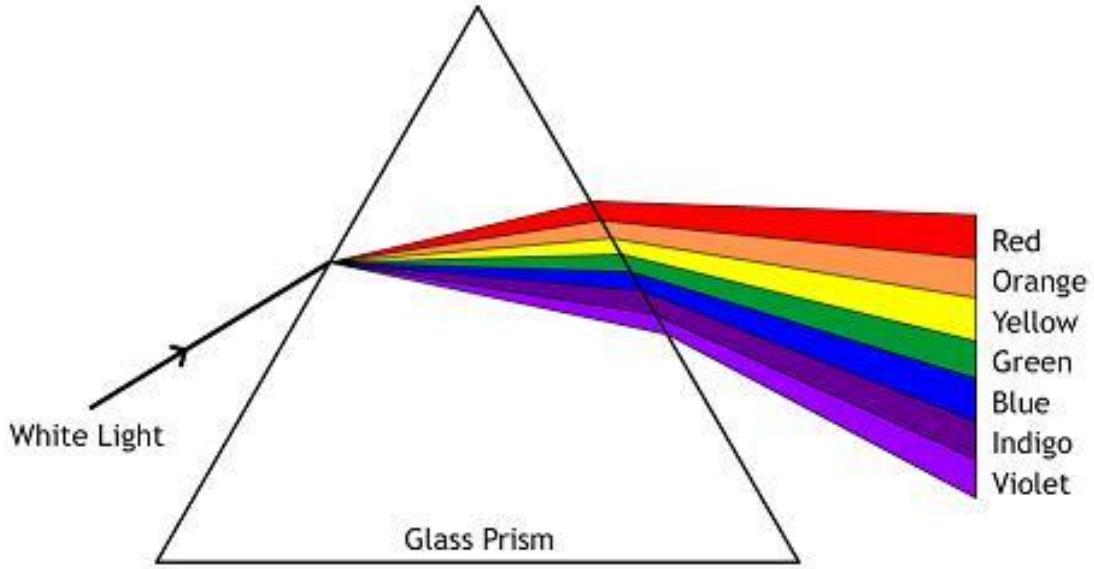
- This is also how your computer screen and iPhone screens work.





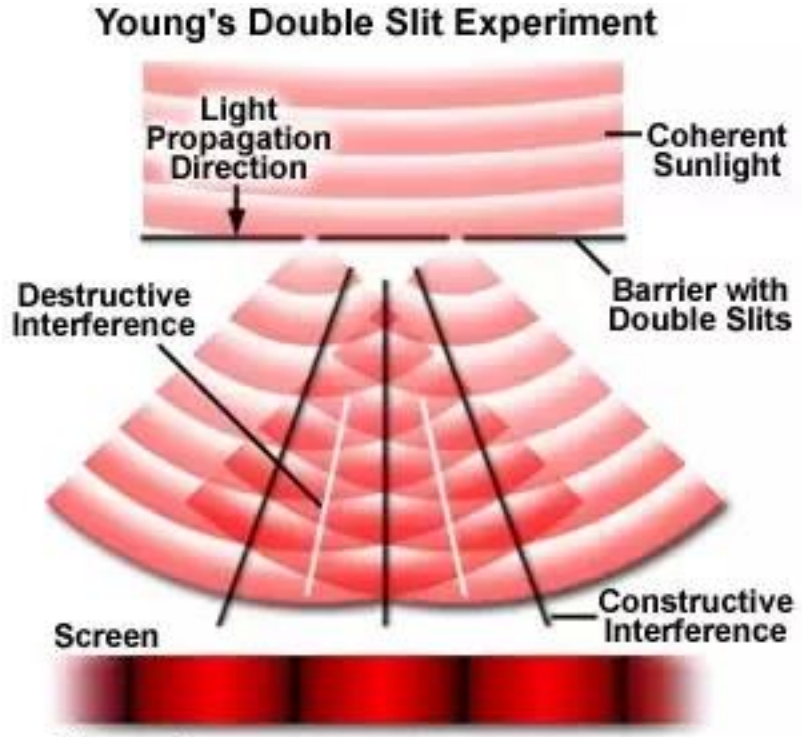
Dispersion

- This is a property of light that is used to explain how light is broken up into its wave components.



Interference

- Light also behaves like all other waves in the fact that it has constructive and destructive interference patterns.

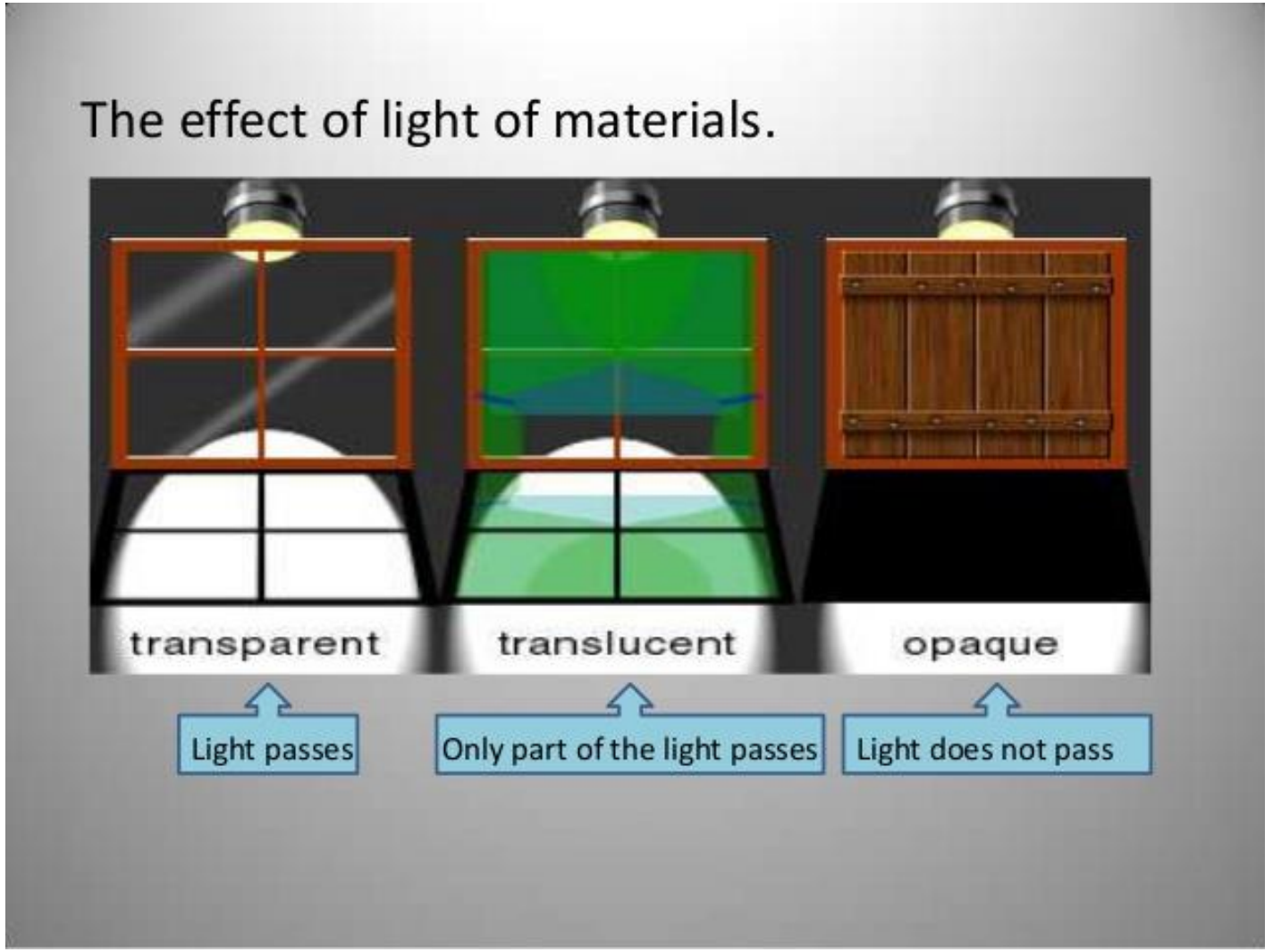


Effects of materials on light

Terms that are commonly referred to that involved reflection.

- Opaque – All the light is absorbed and none is reflected nor does the light travel through it.
- Transparent – All of the light passes through the material
- Translucent – some of the light can pass through the material.

Effects of materials on light



Scattering

When light hits particles it also has the ability to scatter.

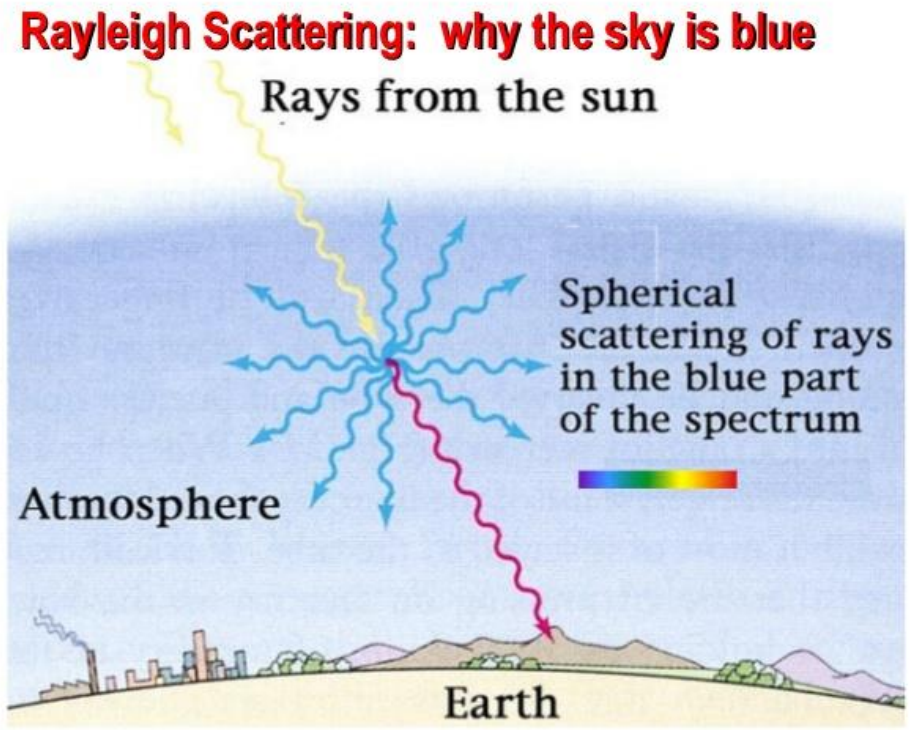
Types of Scattering:

- Rayleigh Scattering
- Mie Scattering
- Non-Selective Scatter

Scattering

Rayleigh Scattering- The scattering of light without a change in wavelength. Lower wavelength light scatters more effectively.

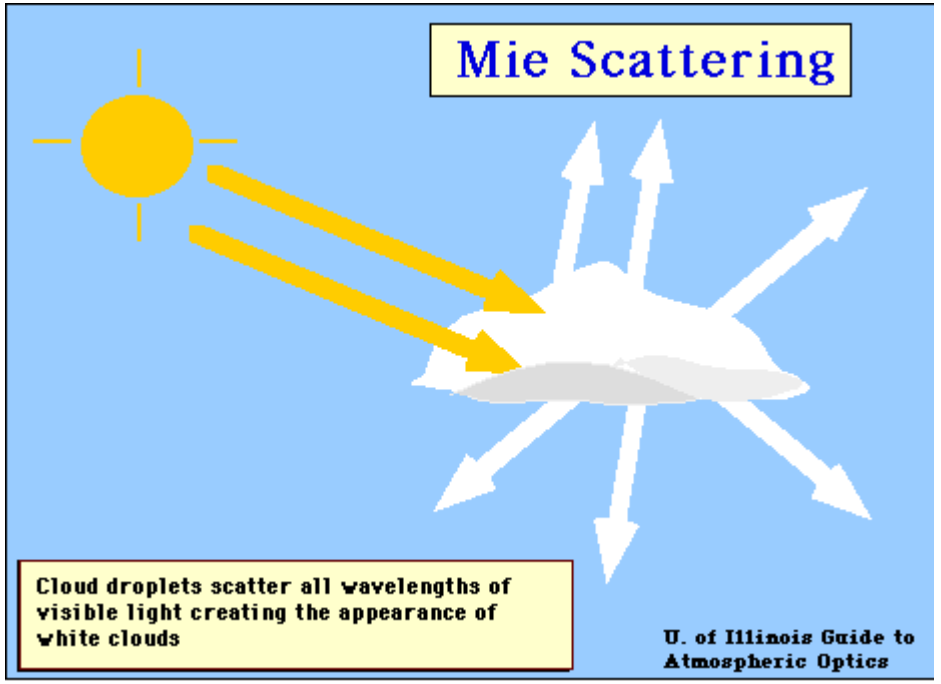
This is why our sky is blue.



Scattering

Mie Scattering/Non-Selective Scattering- The scattering of light without a change in wavelength. The light scattered has to have a wavelength similar to or larger than the diameter of the particle is scattered off of.

This is why clouds and most smoke is white.

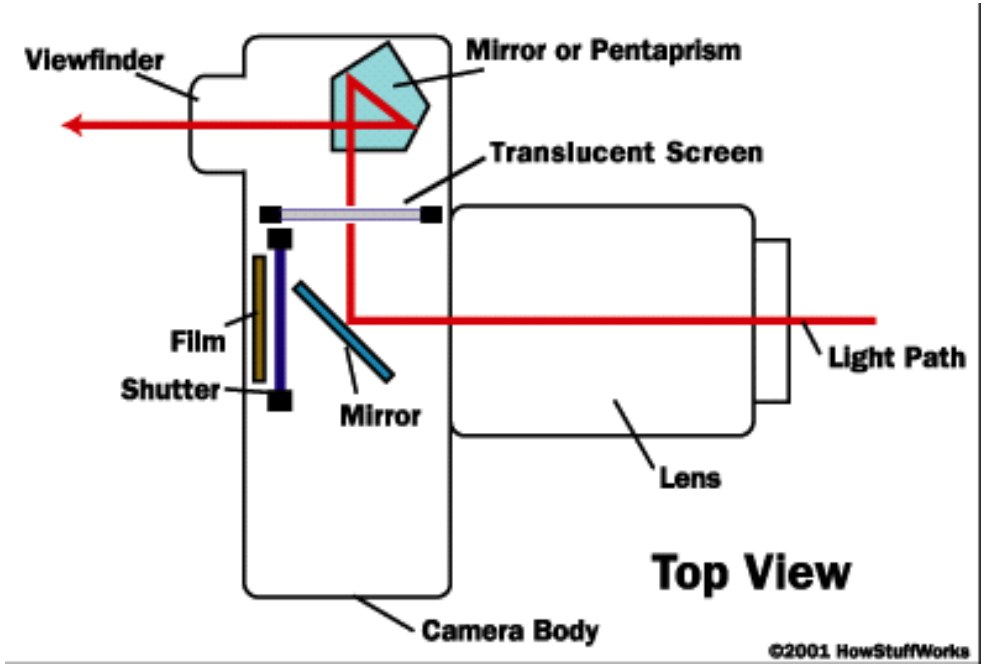


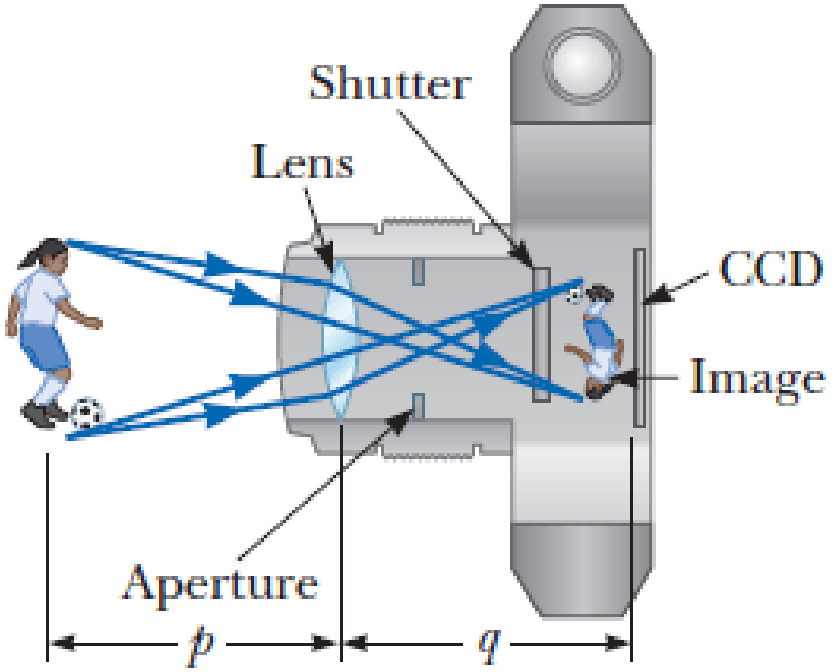
Applications of light

We are going to go through some applications of light and talk about them. We are also going to set up some fun optics labs this week.

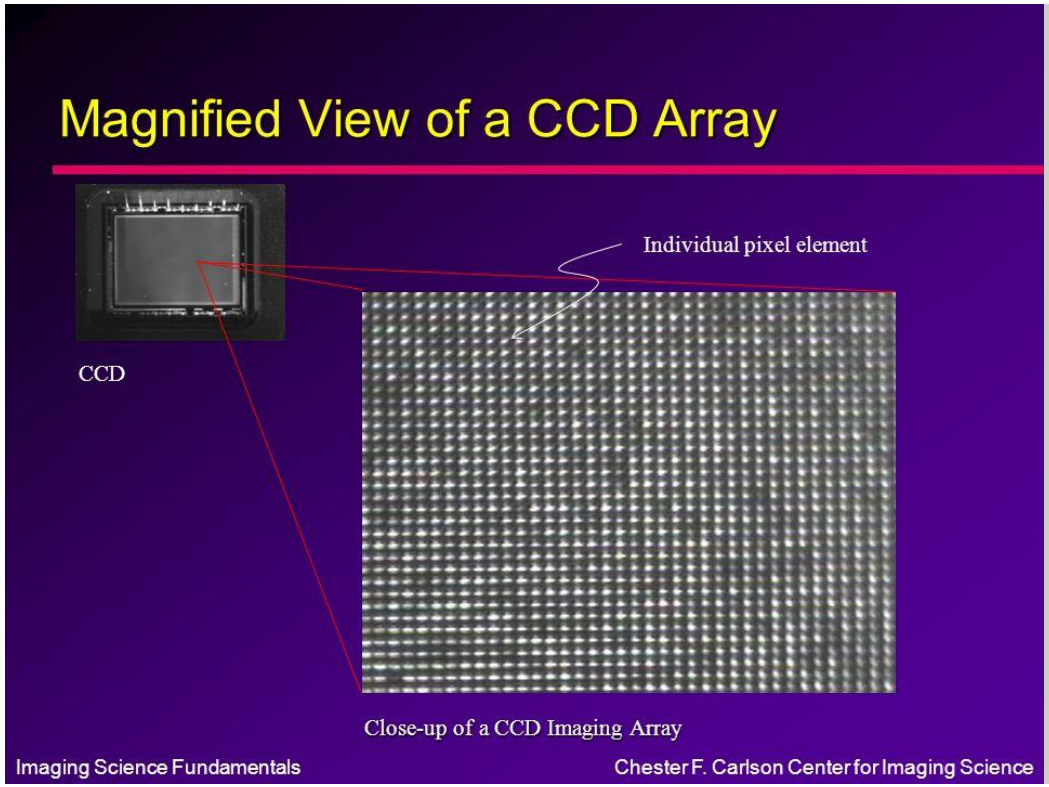
Think about some technologies you want to learn about and we will talk about it in class.

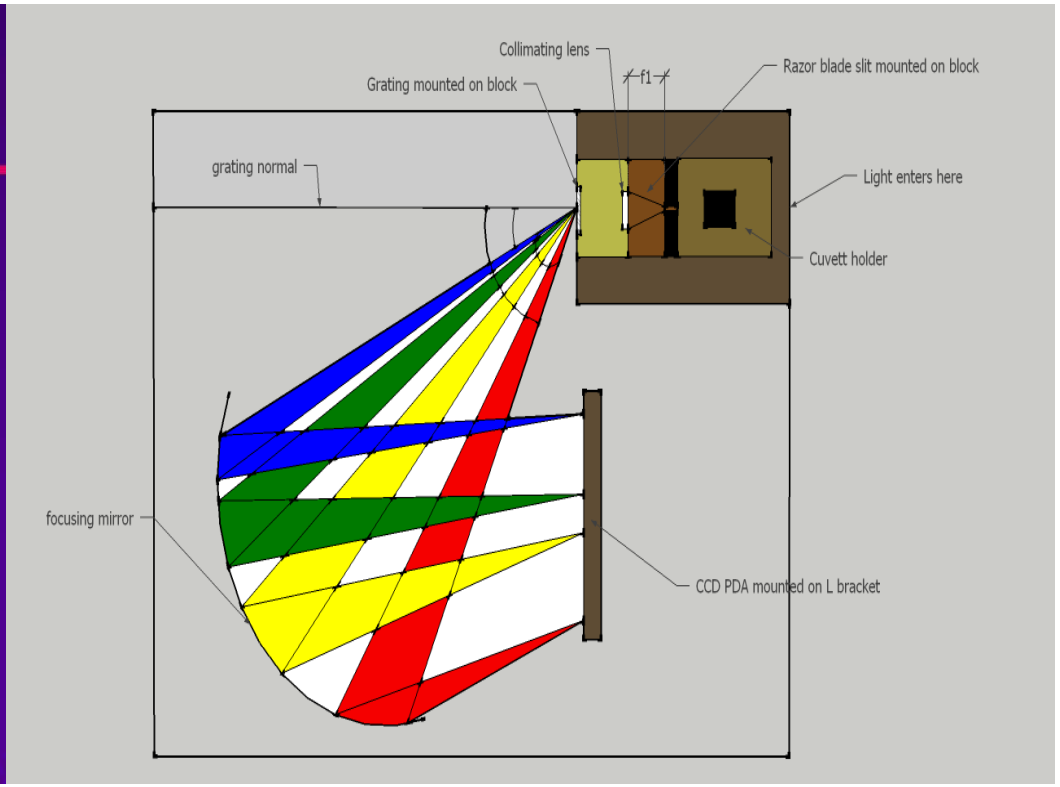
How cameras work



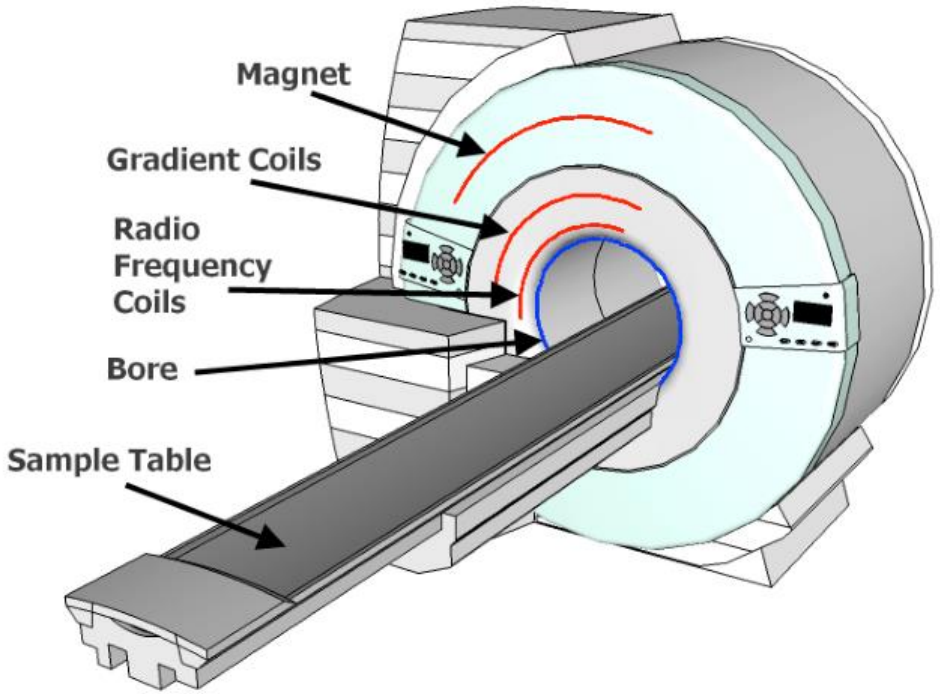


The CCD Array





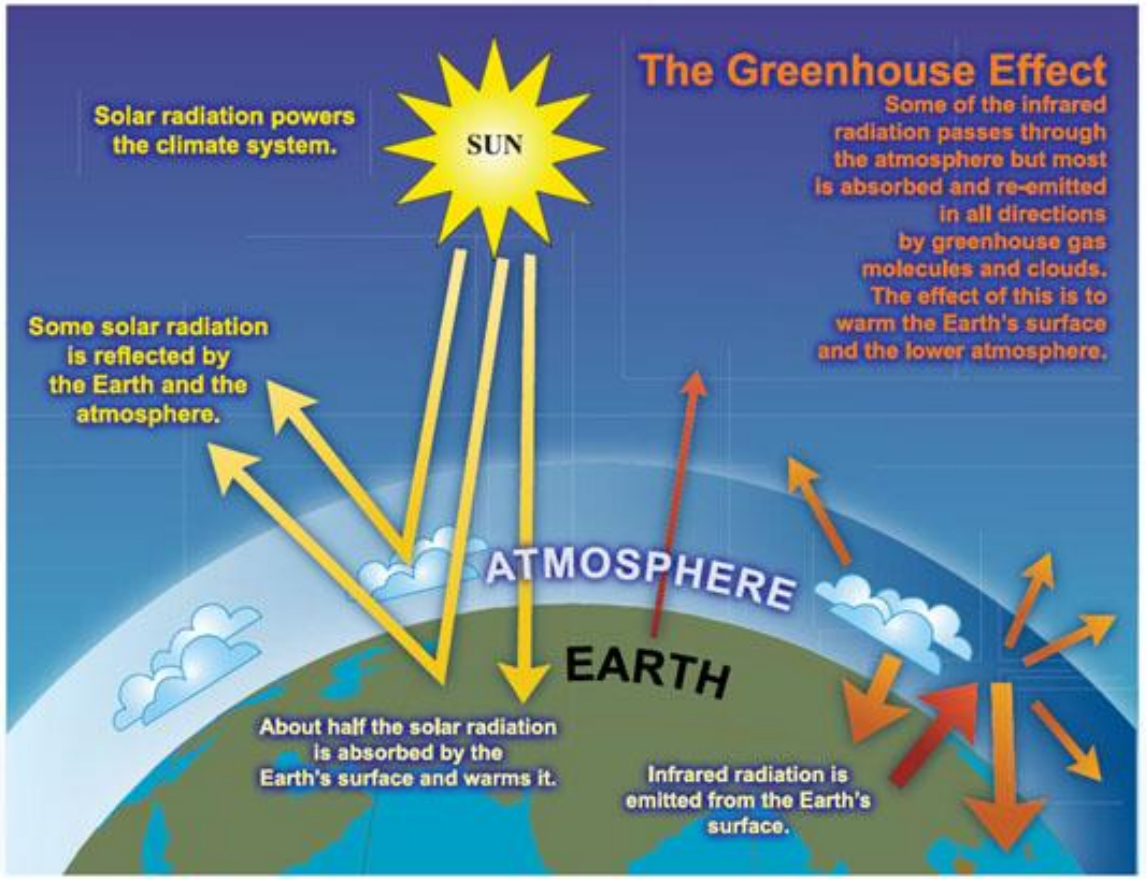
MRIs



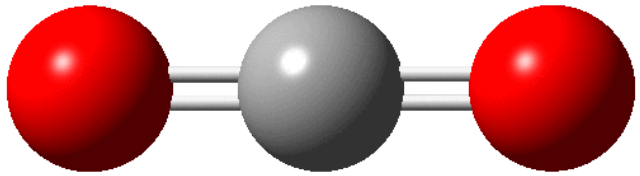
Basically magnetic waves in the radio wave frequency is pulsed at your body. This excites the spin states of the nuclei of the hydrogen and carbon atoms in your soft tissue. The relaxation time of these excited spin states can be measured through a detector and an image can be generated based on the information.

The detectors for MRI's are essentially just coils of wire. Literally.

Global Warming/Heating of the Earth

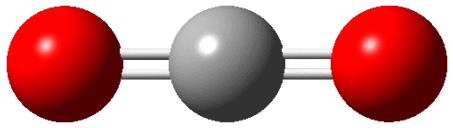


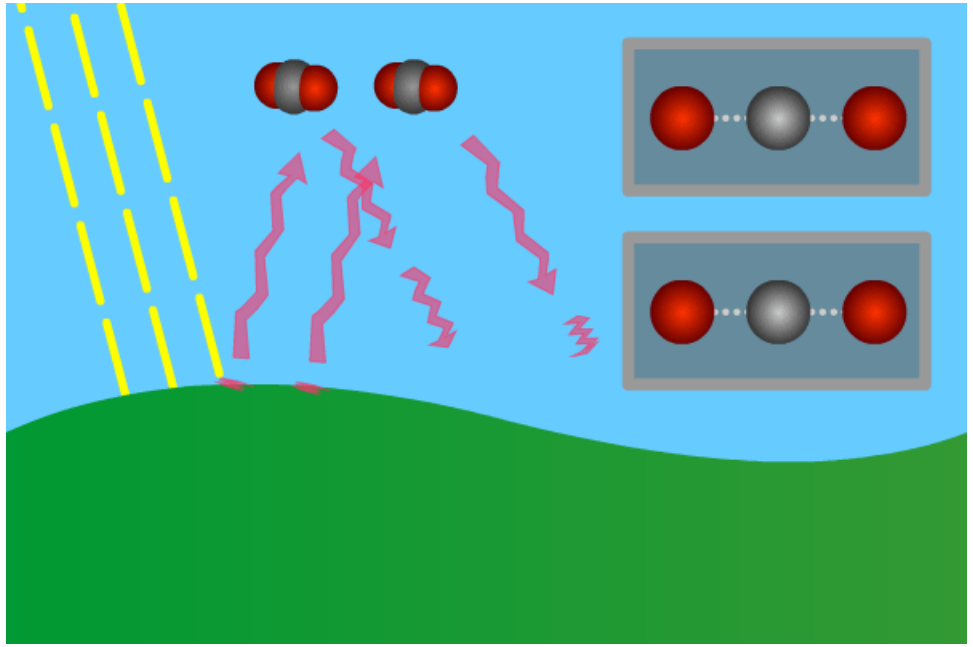
Global Warming Gases



CO2, what is considered the most common green house gas, is able to absorb IR light by its vibrations resonating with certain frequencies of IR/Heat waves.

Global Warming Gases





CO_2, what is considered the most common green house gas, is able to absorb IR light by its vibrations resonating with certain frequencies of IR/Heat waves.