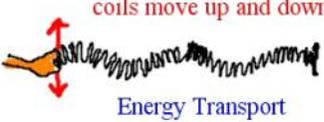
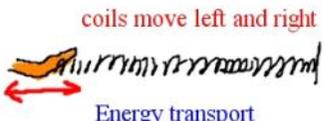


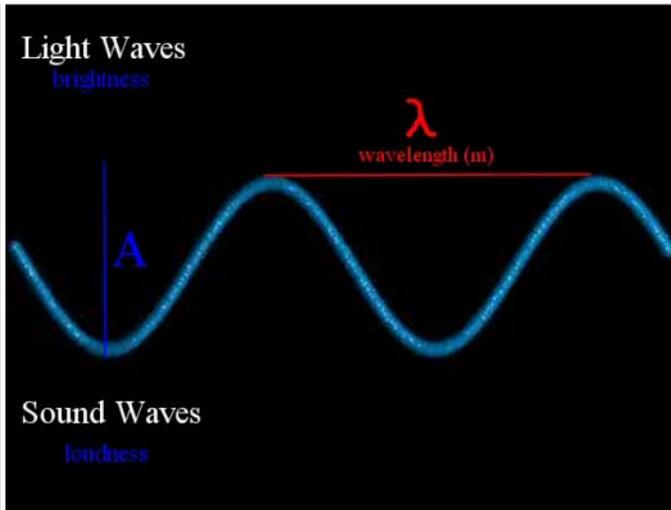
# M 15 Light - revised

Friday, July 16, 2010  
7:15 AM

VoiceThread <http://voicethread.com/share/1923952/>

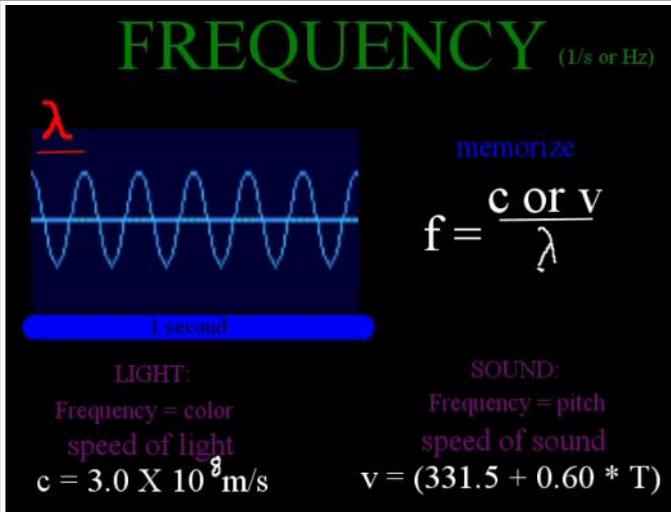
No sound

Slide	Notes
	<p>While sound is quite easy to understand, light is a bit more tricky. Physicist have nearly scratched their heads bald trying to figure it all out.</p> <p>Our topics in this module will be ...</p> <ul style="list-style-type: none"><li>Frequency and wavelength</li><li>Optics</li><li>The Human Eye</li><li>Color</li></ul>
<p>Waves are Classified as either ...</p> <div data-bbox="147 1117 792 1262"><p><b>Transverse Wave</b> ocean waves light waves</p><p>coils move up and down</p><p>Energy Transport</p></div> <div data-bbox="147 1310 792 1455"><p><b>Longitudinal Wave</b> sound waves</p><p>coils move left and right</p><p>Energy transport</p></div>	<p>Let's review a little from what we learned in the last module.</p> <p>Waves can be transverse like we have with ocean waves. They can be longitudinal like we have with sound.</p> <p>Light will be the transverse type of wave, but you will soon find that it isn't limited to oscillating just up and down.</p>

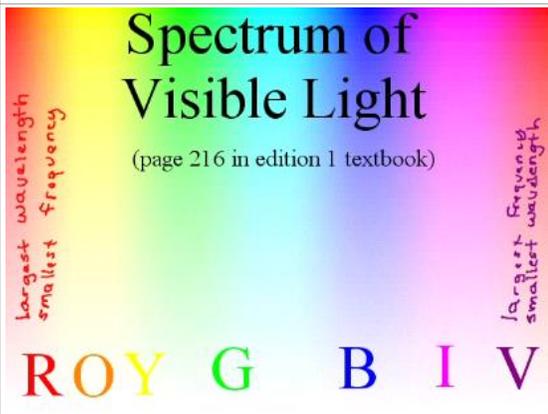


Remember also that waves have amplitude which with light will govern how bright or dim the light is. A big amplitude means that the light will be bright and a small one will mean that the light will be dim. Remember that with sound, the amplitude was a measure of the density of the compression and that governed how loud the sound was.

Light also has a wavelength. The wavelength governs what type of an electromagnetic wave it is. Light is just a tiny fraction of the full spectrum of electromagnetic waves as you will see in a few slides.



Remember that frequency was how many waves pass a given point in a second. Frequency will be what determines color. In sound, frequency determined the pitch of the sound.



I bet that you have learned the ROY G Biv trick for remembering the order of the colors of the rainbow. The r in Roy is red. The O is orange. Y is yellow. G is green, etc.

Lets' look at the equation again [write it in the middle of the screen] ...

$f = c/\lambda$

Notice that the lambda, or wavelength, is in the denominator. That means that frequency and wavelength are inversly proportional. You don't know what that means? All it means is that when one increases the other decreases. Notice that over toward the red that it has the largest wavelength but it has the smallest frequency. It is just the opposite on the other end of the spectrum at the color violet.

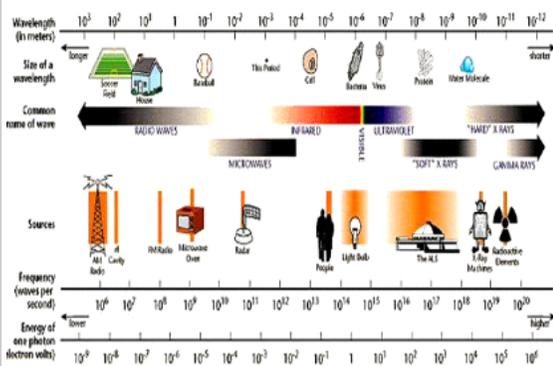
Which has a higher frequency?

Choose one answer.

a. yellow light

b. green light

# THE ELECTROMAGNETIC SPECTRUM



Earlier, I said that light was just a tiny part of a larger electromagnetic spectrum. Here you can see it. That tiny rainbow band is all that light is in this spectrum. Notice all the other things in the spectrum. There are radio waves, microwaves, infrared, ultraviolet, and more. Look at the objects that give us a feel for the size of the wavelengths.

Which has the longer wavelength?

Choose one answer.

a. ultraviolet

b. radio waves

# OPTICS

Optics is the study of how light travels from one place to another and what happens when that light encounters obstacles.

Optics is the study of how light travels from one place to another and what happens when that light encounters obstacles.

phet  
<https://phet.colorado.edu/en/simulation/bending-light>  
 Bending light simulation

# Light behaves like particle and a wave

Optics began as a science with Isaac Newton. He published a book called "Optiks" in which he reported the conclusions to his study. In his book, Newton concluded that light behaved like a beam of particles. This became known as the particle theory of light.

The Dutch physicist Christian Huygens, who lived at the same time as Newton, disagreed. He did experiments that showed that light is a wave. He is the founder of the wave theory of light. By the 1800s, most scientists were convinced that light was a wave. But it is a bit more complicated than that. Watch the following video to get a fun look into the puzzle of the duality of light ... Watch Dr. Quantum Double Slit Experiment at You Tube (5 minutes) at <http://www.youtube.com/watch?v=DfPeprQ7oGc>

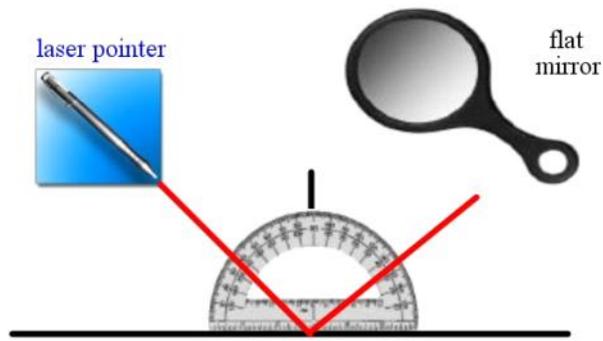
You now have been introduced to the quantum-mechanical theory of light. Light is basically viewed as waves but these waves are not continuous. They are broken up into tiny packets of electromagnetic waves called a photon.

To get a wave though, you need to have something to vibrate. What exactly gets vibrated? It cannot be air, because light can travel through a vacuum, unlike sound. What scientists have discovered is that light is electricity and magnetism. It isn't quite the way that you understand it when you plug in your computer to an outlet though. James Clark Maxwell discovered that it is a combined set of waves that oscillate perpendicular to each other toward the direction that light is traveling. One oscillation is an electric field and the other is a magnetic field. In order to have light you must have both and they must be perpendicular to each other. This combined wave is called an electromagnetic wave.

Describe light according to the current accepted theory. Be detailed.

Light is made up of individual packets. Each packet is made up of two perpendicular transverse waves: one which is oscillating electrical field and one that is made up of an oscillating magnetic field.

## Lab 12.1: The Law of Reflection



When light bounces off of things it is called reflection. Notice that the angle that light comes in from the laser pointer to the mirror is the same angle that the light bounces back up at as it gets reflected off of the mirror. Science has found this to be consistent, so they made it a law ...

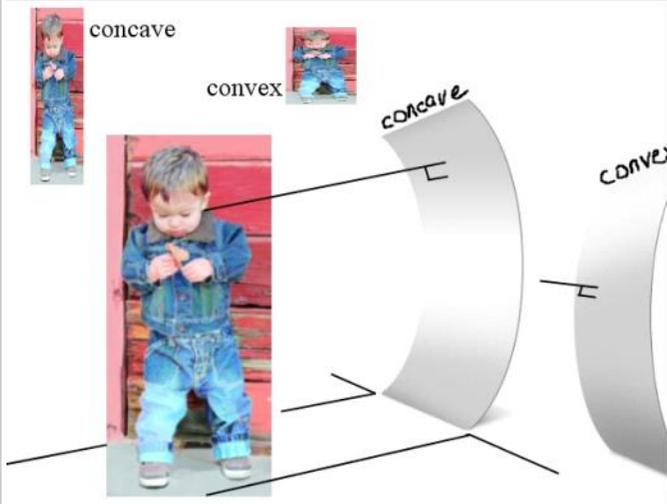
The Law of Reflection is the angle of reflection is equal to the angle of incidence. Incidence just means the light bouncing off.

Have you ever noticed that mirror images have the left and right sides flipped?

The angle of reflection equals the angle of incidence is the definition for what term?

Choose one answer.

- a. Converging Lens
- b. The Law of Reflection
- c. Radio Waves
- d. Electromagnetic Waves



Bendy mirrors can be a ton of fun. You might have seen some of these at an amusement park. The wavy shape makes you look tall and thin in some bends and short and wide in others. The bends are concave if they bend inward in the middle and convex if they bend outward.

phet Geometric Optics simulation

<https://phet.colorado.edu/en/simulation/geometric-optics>  
(refraction, lens, optics)

The speed of sound and light waves change depending on the medium through which they travel.

Less Dense Material	More Dense Material
Sound waves	speed up
Light waves	slow down

Although light is independent of temperature, unlike sound. It does depend on the medium like sound did. Unlike sound though, the more molecules there are, the slower the speed of light as it passes through the substance.

Einstein came up with a theory called the Special Theory of Relativity. In that theory, he stated that the speed of light in a substance is the maximum speed that light can go in that substance. Since light can go  $3.0 \times 10^8$  m/sec in air, that is the fastest that anything can travel going through air. It is sort of like saying that is the speed limit going through air.

The speed of light in glass is 185,000,000 m/sec. If a particle is traveling through air at 200,000,000 m/sec, what will happen to the particle's speed if it enters the glass?

Choose one answer.

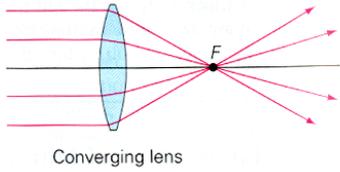
- a. It will speed up
- b. It will slow down

phet Bending Light simulation

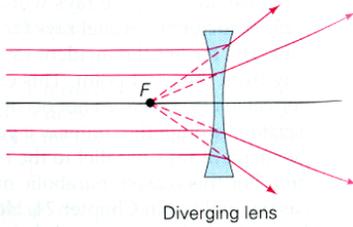
<https://phet.colorado.edu/en/simulation/bending-light>  
(light, refraction, Snell's law)

phet Neon Lights & Other Discharge Lamps simulation

<https://phet.colorado.edu/en/simulation/discharge-lamps>  
(light, electrons)



Converging lens



Diverging lens

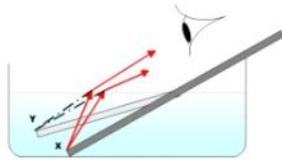
When light travels through different substances, the speed changes and something else does as well, the angle of the light. That angle changes just as it makes the change from one substance to another.

You can see the bends as light enters these two different types of lenses. The lenses are designed to use the angle that light bends and the angle of the lens to focus or diffuse light. Notice that the converging lens converges the light to one point. That one point will be very bright. The other lens will diffuse the light making it appear even and softer.

You want to concentrate light coming from a weak light source by focusing it all on a single point. You will need to use a ...

- Choose one answer.
- a. converging lens
  - b. diverging lens

Lenses, optics, unflavored Jello lenses  
<http://justabitmoore.weebly.com/lenses-and-optics.html>



Water acts like a lens too. Have you ever noticed that a straw seems to bend or be split up in a cup? Look at the illustration and see what I mean.

Refraction is the process of the light bending when it encounters a new medium.

A prism will split white light up in to a rainbow of colors because the bending also depends on frequency.

**Refraction:**  
 The process by which a light ray bends when it encounters a new medium.

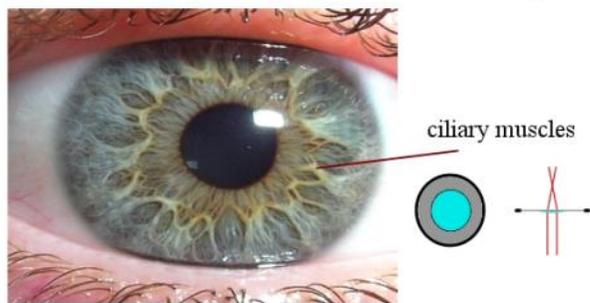


Now let's turn our attention to the human eye.

A camera is a little like a human eye, but it isn't as sophisticated. If you have ever taken a photo, you will know that when you take a picture of something in motion it can come out with motion blur on the photograph. A camera can be hard to focus and you end up with blur too.

The eye though makes hundreds of adjustments in the blink of an eye so that you can change focus and track motion.

The eye can change the shape of the lens in order to keep the image in the same place, regardless of where the image is!



To suppose that the eye, with all its inimitable contrivances for adjusting the focus to different distances, for admitting different amounts of light, and for the correction of spherical and chromatic aberration, could have been formed by natural selection, seems, I freely confess, absurd in the highest degree.

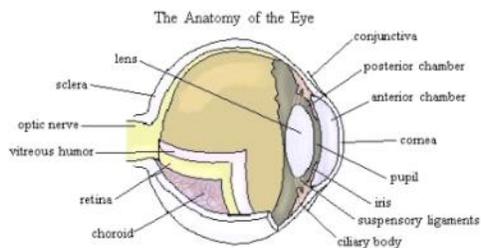
The Origin of Species, Charles Darwin

The eye can change the shape of the lens in order to keep the image in the same place, regardless of where the image is.



When you get to high school, you will eventually dissect an eye. The preserved specimens often will have lenses that become hard, plastic-like, and a cloudy yellow as you see in the hand to the right. But in reality, the lens is like a bag full of water. It is flexible. You can see the lens as a clear baglike shape in the image to the left which is of a non-preserved eye. The diagram shows the lens near the front of the eye. Muscles attach to the edges and they are constantly pulling and relaxing to change the lens shape to allow you to focus.

As you get in to your 40's, the lens becomes stiffer and the change in focus becomes a little sluggish compared to when you were younger. Many adults that never needed to wear glasses before will begin to find that they need reading glasses for things that are close up.



## Tears

### Foreign Object in Eye:

Antibodies

Enzyme: Lysozyme which is an antibacterial.

### Tears from Emotional Upset:

Manganese:

A chemical depressant

leucine-enkephalin:

an endorphin which helps control pain

adrenocorticotrophic hormone:

A hormone produced by bodies under stress

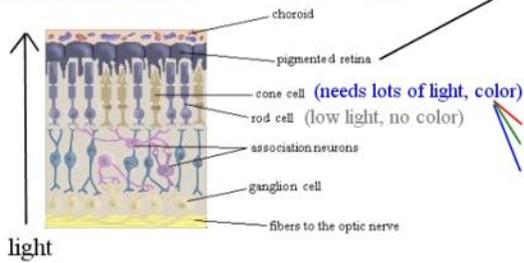


Did you know that the tears you cry when you have something in your eye and the ones you cry when you are emotionally upset are different chemically?

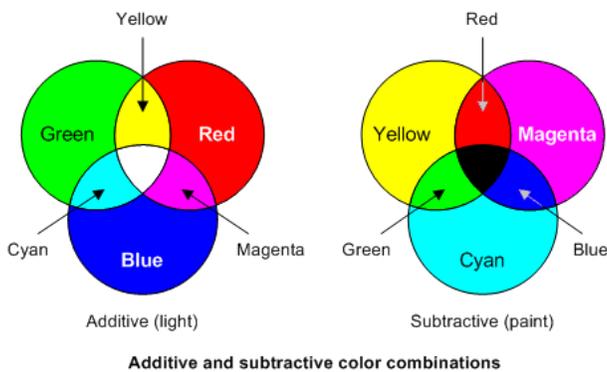
Here is a list of the chemicals.



lots of melanin = black  
why?  
What about Albinos?



The back of your eye is where the image forms up on the retina. It also has nerves that will tell you color information. You need a fair amount of light to see color because the cone cells require it to function. The rods are there so that you can see even in dim light, but you will not pick up color information there.



Color is a fascinating subject all of its own. We will delve a tiny bit in and explore how color is different depending on if you are talking about colored lights or if you are talking about pigment.

Light is additive when it comes to color. When you combine all the colors of the rainbow together, you get white light. If you added all the colors of the rainbow in a paint or pigment you get a gray or a black color. They are opposites because one is additive, that is light, and the other is subtractive, that is pigment.

Notice how the color combinations produce different colors too.

In paints, the pigment absorbs all the colors except what you actually see with your eyes. That is the color that it reflected instead of absorbed. If you mixed all three colors, cyan, magenta, and yellow paints you would be mixing substances that absorb all three colors and reflect none leaving your eye seeing black because no color could escape for you to see. You in a sense made a color black hole. Lol. If you have ever looked at print on paper in a book, you will see that the dark places have a bunch of dots of magenta, yellow, and cyan all very close together all absorbing as much color as they can.

Pasted from <<http://www.divcalculator.com/sp-cvision.shtml>>

Switch over to lights of different color and you have a different story. The additive nature of light means that you have those colors present/ When you mix green, blue, and red lights you are then flooding those colors together making white light. Remember how a prism can take white light and split it up into the rainbow? That is because white light contains all the colors all added together.

Remember that ...  
blue + green = cyan  
red + blue = magenta  
red + green = yellow

What color will you see when ...

You shine a red light on a yellow shirt	<input type="text" value="red"/>
Cyan and magenta ink are mixed	<input type="text" value="blue"/>
Your computer screen makes a green dot and then puts a blue dot in the same place	<input type="text" value="cyan"/>

phet Color Vision simulation  
<https://phet.colorado.edu/en/simulation/color-vision>  
(photons, rainbows, monochromatic light, white light)

Credits

Light Shining CC-BY Zouavman Le Zouave  
[http://en.wikipedia.org/wiki/File:Light\\_shining2.JPG](http://en.wikipedia.org/wiki/File:Light_shining2.JPG)

2011-12 Quiz link:  
<http://www.virtualhomeschoolgroup.com/mod/quiz/view.php?id=17742>