Module 15: Light

Vocabulary:

Electromagnetic wave: A transverse wave composed of an oscillating electric field and a magnetic field that oscillates perpendicular to the electric field.

The Law of Reflection: The angle of reflection equals the angle of incidence.

Tables:

The Speed of Light in Certain Substances			
Substance	**Speed of Light**	**Substance**	**Speed of Light**
Air (25˚C)	300,000,000 m/sec	Plastic	189,000,000 m/sec
Alcohol	225,000,000 m/sec	Crown Glass	185,000,000 m/sec
Fresh Water	220,000,000 m/sec	Flint Glass	175,000,000 m/sec
Acrylic	200,000,000 m/sec	Diamond	125,000,000 m/sec

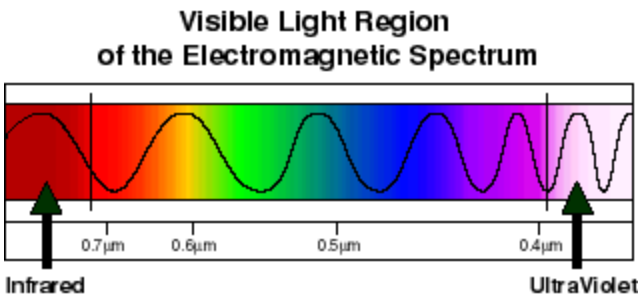
Introduction:

Light is one of the first concepts mentioned in the Bible. Look at Genesis chapter 1.

Genisis 1:1-4a: " In the beginning God created the heavens and the earth. The earth was formless and void, and darkness was over the surface of the deep, and the Spirit of God was moving over the survace of the waters. Then God said, " Let there be light;" and there was light. God saw that the light was good…"

Light is necessary for life to exist. Similarly, for a Christian, His light, which shines in our darkness is necessary to live and thrive as a believer. Science will always draw us back to the Creator of all living things. Light is an amazing example of the creative nature of God which is visible.

Light waves are electromagnetic in nature and are an essential area of study because they are the most common waves in Creation.



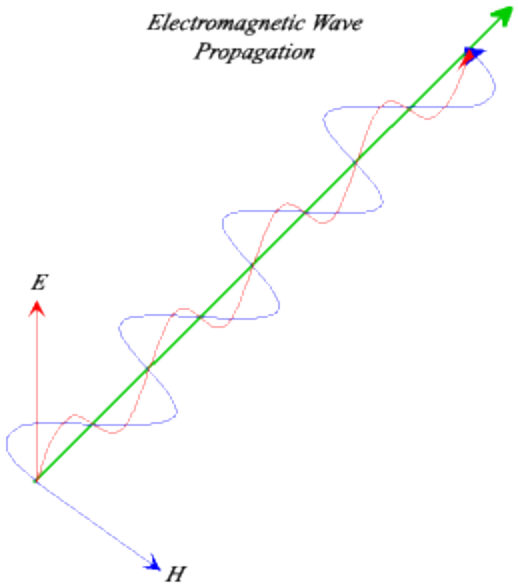
The Dual Nature of Light

A beam of light is a transverse wave composed of electric and magnetic fields that oscillate perpendicular to one another. Light waves are referred to as electromagnetic waves because it is made up of an electric field and a magnetic field. Light is a transverse wave, unlike sound which is a longitudinal wave, that travels in perpendicular motion. The electric field waves travel perpendicular to the magnetic field waves, which also travels perpendicular to the direction of the light.

The beauty of this is that we can see that we need both electricity and magnetism to have light. They can not exist w/o each other. Both waves have to be present and perpendicular to one another for light to exist.

Through history there are multiple theories that have been suggested to explain how light works.

- The Particle Theory
  - Isaac Newton said that light was" a stream of particles moving in the same direction."
- The Wave Theory
  - Christian Huygens disagreed with Newton and suggested light was a wave
  - James Maxwell's experiment in magnetism shows us how light is a wave and he gave us a view of what it would "look" like.



- Quantum-Mechanical Theory of Light
  - Light is viewed as tiny packets of waves. (called photons)

This explains the dual nature of light. Light can be a stream of photon packets (particles) which are broken up or it can be a series of electromagnetic waves(a transverse wave).

- Einstein's Special Theory of Relativity describes the speed of light.
  1. It does not depend on temperature.
  2. It does depend on the substance it paces through.
  3. It is opposite of sound in that it travels fastest through gasses and slowest through solids.
     See Table 15.1 on page 369.

The Speed of Light in a vacuum represents the maximum speed that can be obtained by any object that has mass. In Einstein's theory nothing with mass can travel faster than the speed of light, which is 300,000,000 meters per second.

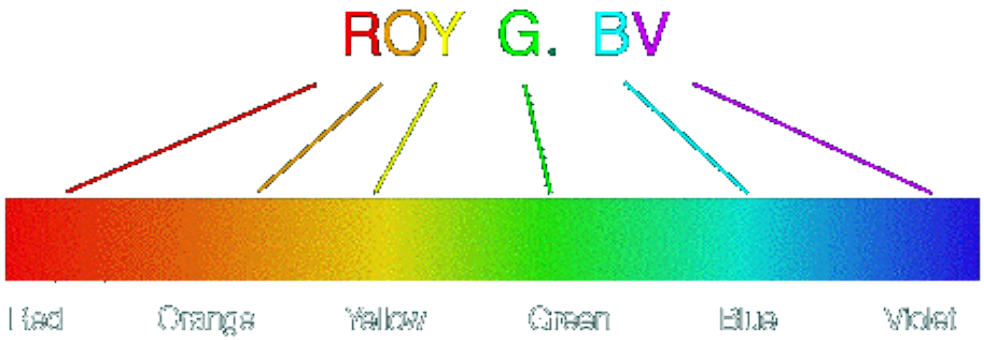
http://www.conservapedia.com/Theory_of_relativity

Wavelength and Frequency of Light

The difference in the wavelength of light is seen in the way that light bends in relation to the colors we see. We see the visible spectrum of light. White light is made of all the colors, in essence it is the light that is not bent into the separate wavelengths.

Looking at a the color spectrum Red has the longest wavelength and violet has the shortest wavelength. The other colors lie in between.

Memorize the Acronym: Roy G. Biv (Red, Orange, Yellow, Green,Blue, Indigo, Violet) to memorize the spectrum of visible light.



The Electromagnetic Spectrum is made up of the following wave types :

- Gamma Rays
- X-rays
- Ultraviolet Rays
- Visible Light
- Infrared Light
- Microwaves
- Television Waves
- Radio Waves

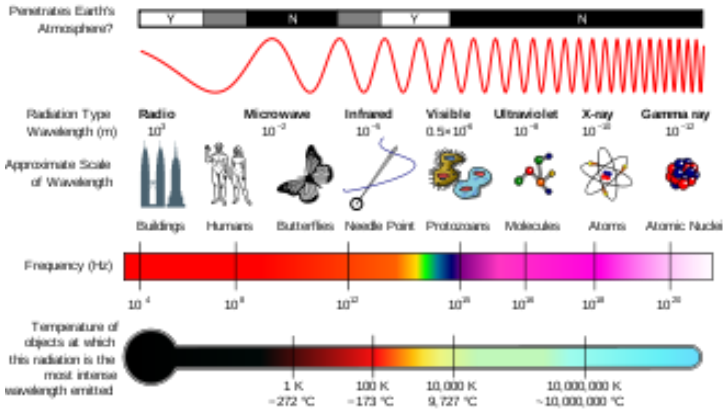
- Gamma Rays, X-rays, and Ultraviolet Rays have wavelengths shorter than Visible light.
    1. Ultraviolet Rays can kill living tissue.
    2. X-rays have more energy than Ultraviolet Rays because the shorter the wavelength and can cause more damage to living tissue.
    3. Gamma Rays, a form of radiation , have even shorter wavelengths.
- Infrared Light, Microwaves, Television Waves and Radio Waves have wavelengths that are longer than Visible Light.
    1. Infrared light emits heat energy.
    2. Microwaves use th elong-wavelength electromagnetic waves to heat up food quickly by absorbing the water molecules in food by causing the food molecules to spin generating heat.

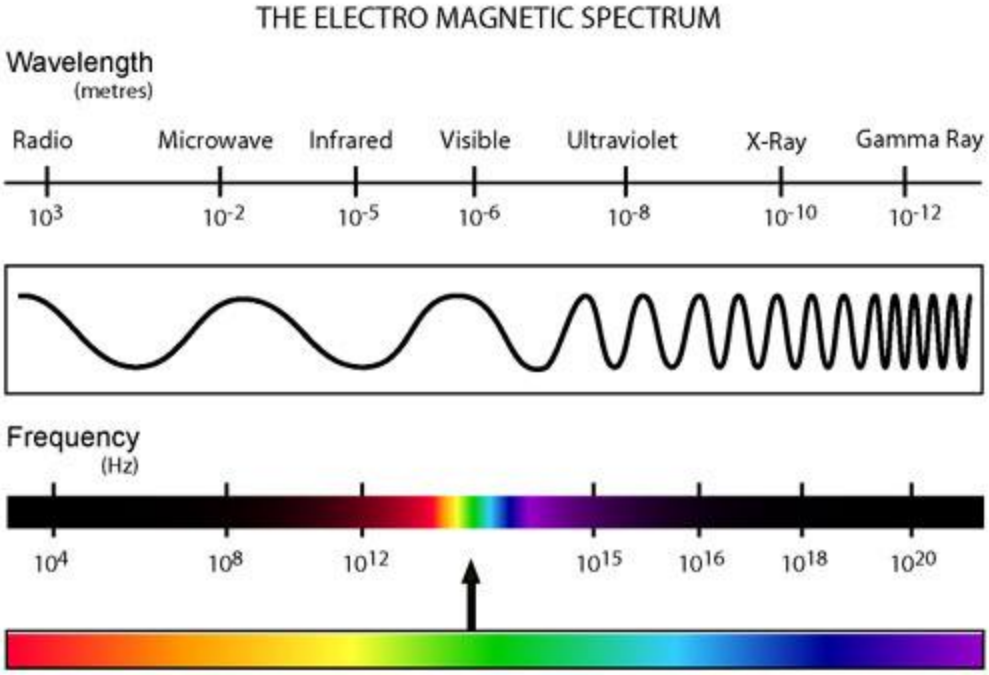
3. Television and Radio waves have the longest wavelength waves in the electromagnetic spectrum and thus transmit the radio and television signals.

- **Study the invention of the Radio and/or the Television to find out how the transmission of these waves are translated into the sound we hear on the radio or the image we see on the TV.**

Go to this website for further study:

http://hyperphysics.phy-astr.gsu.edu/hbase/ems3.html





Reflection:

When light waves bounce off an object it is called reflection. The Law of Reflection states that the angle of reflection equals the angle of incidence.

So reflection is dependent upon the following:

- Angle of incidence: angle of perpendicular line from the incoming light.
- Angle of reflection: angle of perpendicular line from the reflected light.

You need light to see. Without light, images can not be reflected back into your eye. The electrical impulses are then translated into pictures in your brain.

Reflection is the change in the direction of light waves as they bounce off an object or reflect back.

Refraction:

Refracted light waves are essential bent light waves. You can have both reflection and refraction in the same substance. Refraction is responsible for optical illusions.

Refraction is the change of speed and wavelengths of a light wave as it passes through an object.

When light refracts into a substance in which it must slow down, the light ray will bend toward a line perpendicular to the surface it strikes.

When light refracts into a substance in which it speeds up, the light ray will bend away from the line perpendicular to the surface it strikes.

Study Figure 15.6 "The Refraction of a Light Ray" In your text.

- Note what happens in Fiber Optic Cables as light travels through it and use this opportunity to study this topic.
- Rainbows are a result of the bending light in the moisture in the air. The amount of refraction depends on the wavelengths and the amount of light involved.
- Questions:
    - What circumstances need to happen for us to see a rainbow in the sky?
    - Does it matter what time of day it is?
    - Does it matter how much light is available?
    - Does it matter how much moisture is in the air?
    - Does the elevation of the raindrop matter?
    - Where does the light need to be coming from?
    - Is the light reflecting, refracting, both or neither?
    - See Figure 15.8

http://physics.bu.edu/~duffy/py106/Reflection.html

http://www.physicsclassroom.com/class/waves/u10l3b.cfm

Lenses:

The fact that light rays will refract when traveling through transparent objects has proven to be very useful, as in the invention of glasses. The shape of a lens works because of the curvature of that lens. When the shape, type, and amount of curve changes, so does the function and role of the lens.

The types of lenses are:

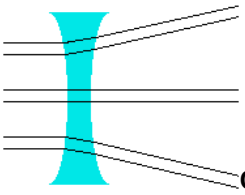
- Converging Lenses
  - Horizontal light rays converge (come together) at one focal point.
  - Have a convex shape
- Diverging Lenses
  - Light rays are bent outward and diverge away from one another.
  - Have a concave shape

http://science.howstuffworks.com/innovation/everyday-innovations/lens.htm

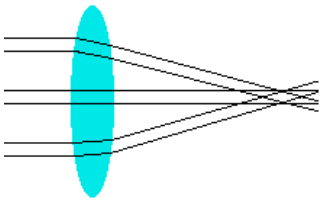
http://electronics.howstuffworks.com/camera2.htm

This is a great website for the study of lenses and the human eye.

http://www.mysciencesite.com/optics4.html



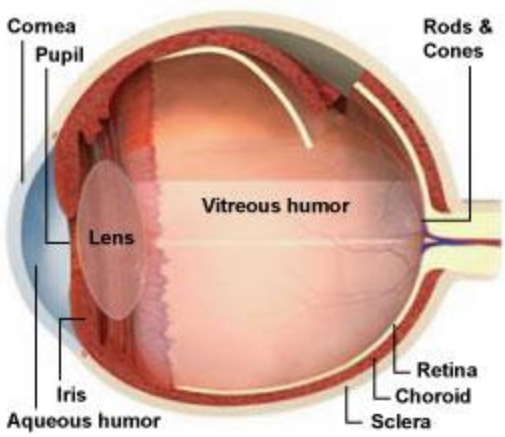
Concave



Convex

The Human Eye:

The way that God created our eye to focus on light demonstrates the way a convex lens operates.



The way God designed the eye reveals the complexity of creation and minimizes the possibility for chance formation or random evolution.

Let's look at the processes:

- The cornea protects the eye from abrasions and refracts light which enters the eye.
- The iris regulates how much light enters the eye.
- The pupil will focus the by a converging lens onto the retina.
- The ciliary muscle will squeeze or expand to keep the image focused.

- Why do people need glasses?
- What is the difference between nearsightedness and farsightedness?
- Which lens is used to correct these problems?

http://www.livescience.com/3919-human-eye-works.html

How we Perceive Color:

Color is determined by the frequency of the light waves. The retina is equipped with cone cells and rod cells. Cone cells are sensitive to color depending on the frequency in wavelengths.

- Low frequency translates to red light.
- Medium frequency translates to green light.
- Higher frequency translates into blue light.

The cone cells transmit the frequencies to your brain which creates the image in your mind that reveals the colors you are seeing.

Adding and Subtracting Color:

Cone cells are sensitive to only 3 colors: Red, Blue and Green.

Red, Blue and Green are Primary Colors.

When they are added together they can create virtually any other color.

Look at figure 15.2 which shows how this works.

When we see colors in objects, we see the reflected color while the other colors are absorbed.

Subtractive primary colors are: Cyan, Magenta, and Yellow.

Great article on how the eye exemplifies Intelligent Design:

http://www.answersingenesis.org/articles/arj/v4/n1/retina-design

Websites:

http://www.physicsclassroom.com/Class/light/

http://www.physicsclassroom.com/calcpad/light/

http://www.physicsclassroom.com/Class/light/u12l1a.cfm

On Your Own Questions:

15.1 – Which of the pictures (on page 370) is the best illustration of the quantum-mechanical theory of light? (A, B, or C)

15.2 – Suppose a photon is traveling through air. If the particle suddenly hits a lake, what will happen to its speed?

15.3 – Without looking at Figure 15.2 or Figure 15.3, order the following colors in terms of increasing frequency: yellow, indigo, red, green.

15.4 – if radio signals are really made up of electromagnetic waves, why doesn't a radio station's antenna glow when it transmits its signals?

15.5 – Draw the path of the light ray in the diagram below to show where the light eventually hits the screen: (see book page 377)

15.6- The following is a diagram of how a light ray travels from substance A through substance B: (see book 382)

15.7 – A man is spear fishing. He looks into the water and sees a fish in front of him. When he aims his spear, should he aim it at the fish, in front of the fish, or behind the fish?

15.8 – Consider the two lenses pictured below. Which one focuses light rays closest to the lens?

a.  b. 

15.9 – Suppose you have two flashlights. You cover the first with green cellophane and shine it on a mirror. When you look at the mirror, you see a green spot of light. If you were to then take the second flashlight, cover it with red cellophane, and shine it on the same part of the mirror on which the green spot is still shining, what color would you see?

15.10 – Suppose you took a red shirt and put it in a dark room. Then, suppose you took a flashlight and covered it with green cellophane as described above. If you were to go into the dark room and shine the green cellophane-covered flashlight on the red shirt, what color would you see? Assume the dye on the shirt uses the subtractive primary colors to make its light.