Properties of Light

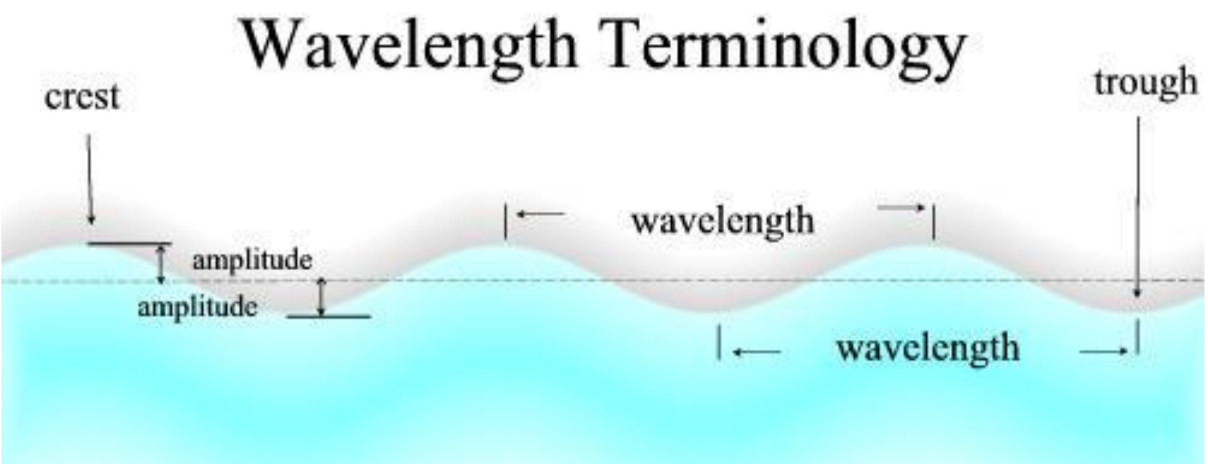
The Wave Model of Light

The **wave model of light** represents light travelling as a **wave**. It doesn't explain everything about how light behaves but it helps us visualize it. Thinking about light traveling in waves helps to explain unpredictable behavior, like when light curves around a opening. When light passes through a small opening, the waves spread out. If the wavelength is short, the waves spread out very little, whereas longer wavelengths spread out more. Wavelength is explored more in the labs for this topic.

Light Waves

Sunsets can be explained using the wave model of light. As light waves from the sun travel through Earth's atmosphere, they strike particles of different sizes, including dust and other elements. The **longer wavelengths of the reds and oranges** tend to pass around these particles, whereas, the **shorter wavelengths of blue and violet**, strike the particles and reflect and scatter. At sunset, the light we see passes through about 700 kms of the Earth's atmosphere. There are many more particles in the atmosphere at this time of the day, due to the activity going on during the day - so many more blue and violet waves are reflected away. Red and orange are the vibrant colors we see at sunset.

When light passes through a small opening, it spreads out around each side of the opening. To explain this, Dutch scientist Christiaan Huygens (1629-1695) suggested that light travels in a wave, not as a stream of fast moving particles.



The high parts of the wave are called **crests**.

The low parts of the wave are called **troughs**.

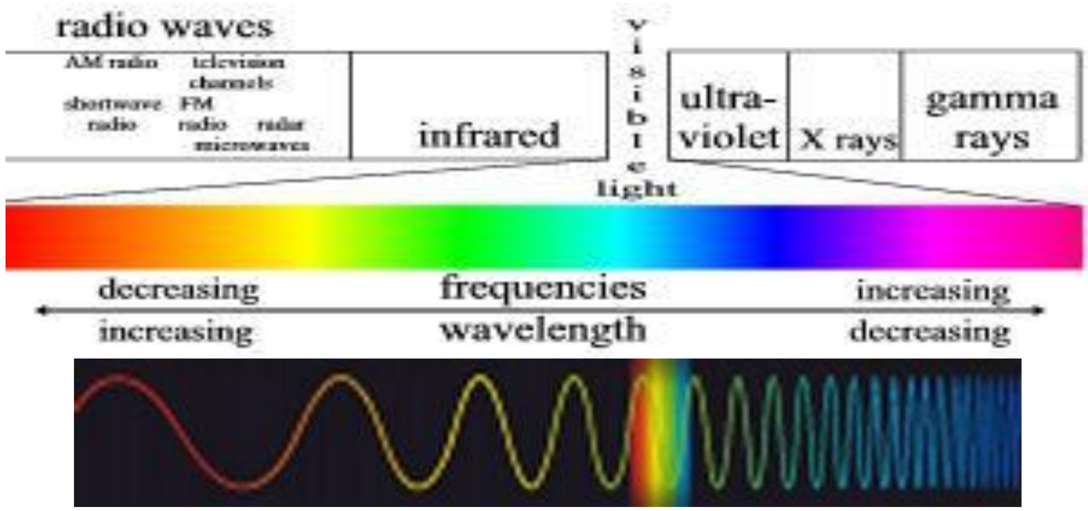
The distance from crest to crest is called **wavelength** (the distance from one complete crest and one complete trough).

The height of the crest or the depth of the trough from rest position is called the **amplitude**.

Frequency is the rate at which the crest and the trough move up and down. The number of cycles in a period of time - which is usually measured in **hertz**, or cycles per second is how frequency is measured.

The Electromagnetic Spectrum

The sun is the most abundant source of direct natural light on the Earth. There are other forms of energy, invisible, that are also supplied by this source. The tiny band of visible light that we see is only part of the entire spectrum of light energy we receive. Called the electromagnetic spectrum, because the light waves, electrical and magnetic fields vibrate as they radiate to earth.



Different colors on the electromagnetic spectrum have different wavelengths (nanometers) and different frequencies (hertz).

Applications Of Electromagnetic Radiation

Radiation is a natural part of our environment. Humans have always lived on earth in the presence of radiation. Natural radiation reaches earth from outer space and continuously radiates from the rocks, soil, and water on the earth. Background radiation is that which is naturally and inevitably present in our environment. Levels of this can vary greatly. People living in granite areas or on mineralized sands receive more terrestrial radiation than others, while people living or working at high altitudes receive more cosmic radiation. A lot of our natural exposure is due to radon, a gas, which seeps from the earth's crust and is present in the air we breathe.

Radiation is energy traveling through space. Sunshine is one of the most familiar forms of radiation. It delivers light, heat and suntans. We control its effect on us with sunglasses, shade, air conditioners, hats, clothes and sunscreen. There would be no life on earth without lots of sunlight, but we have increasingly recognized that too much of it on our persons is not a good thing. In fact it may be dangerous. So, we control our exposure to it. Sunshine consists of radiation in a range of wavelengths from long-wave infrared to shorter wavelength ultraviolet. Beyond ultraviolet are higher energy kinds of radiation which arc used in medicine and which we all get in low doses from space, from the air, and from the earth. Collectively we can refer to these kinds of radiation as Ion radiation. It can cause damage to matter, particularly living tissue. At high levels it is therefore dangerous, so it is necessary to control our exposure.

Radio Waves

If you could stretch the infrared wave out even further, so it became a few millimeters long, you could get radio waves. Radio waves are around us all the time. Radio waves have a longer wavelength and a lower frequency than visible light. Different types of radio waves have different uses. Signals from radio and television stations, cell phones and even distant stars pass through your body every day.

Remote Imaging Technologies

LANDSAT is a satellite that records how different parts of the light from the Sun reflect back to the satellite. It's most important use is for agriculture, monitoring crops for damage by disease, pests and drought. **RADARSAT** is a telecommunications satellite, which, from time to time, sweeps the ground below it with radio waves, penetrating fog, haze, clouds and rain. Their reflection back to the satellite gives scientists information they can use in their studies of the Earth, monitoring ice floes, search possible sites for minerals, oil and natural gas, monitoring a flood, so that sandbagging efforts can be maximized where it is needed most.

Microwaves have the shortest wavelength and the highest frequency of the all the radio waves. Microwaves have three characteristics that allow them to be used in cooking:

- they are reflected by metal;
- they pass through glass, paper, plastic, and similar materials;
- they are absorbed by foods.

Microwaves are used to detect speeding cars, to send telephone, satellite and television communications, and to treat muscle soreness. Industries use microwaves to dry and cure plywood, to cure rubber and resins, to raise bread and doughnuts, and to cook potato chips. But the most common consumer use of microwave energy is in microwave ovens. **Microwave ovens** have been regulated since 1971.

Ultraviolet Radiation

Just beyond the violet part of the visible spectrum are wavelengths of about 200 nm., known as ultraviolet (UV) radiation. This radiation is very energetic. It causes tanning, but it can also do irreparable damage to us. *UV rays can damage the cornea of the eye (fogging which can lead to a slow loss of vision)*
In more recent years, more UV radiation is reaching us because the ozone layer in the atmosphere (which protects us from the damaging radiation by absorbing the UV rays) is being thinned. This thinning of the ozone layer is speeded-up by the use of aerosol sprays and Freon gas, which break up the ozone particles.

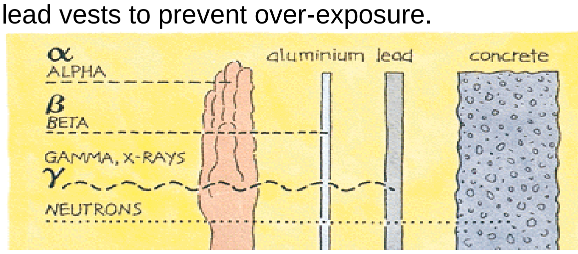
Infrared Radiation

Red light has a wavelength of about 700 nanometers, but it could be stretched out to 100 nm, it would become heat radiation, or infrared radiation. It would become invisible to the eyes, but you could sense it with your skin. Anything that is warmer than its surroundings emit infrared rays.
Practical Applications include:

- motion sensors
- burglar alarms
- heat lamps

X-Rays

Even shorter wavelengths with higher frequencies are the X-rays. These waves pass through tissue (skin and muscle) and are absorbed by the bones. This radiation always stays in the bone and builds up over time. Therefore people who work as technicians taking the x-rays must protect themselves, by leaving the room where the xray is taken and also protect the patient's other areas of the body with lead vests to prevent over-exposure.



Gamma Rays

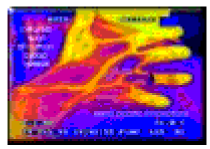
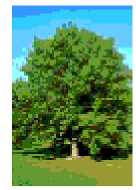
Gamma rays have the shortest wavelength and the highest frequency of all the waves in the electromagnetic spectrum. Gamma rays result from nuclear reactions and can kill cells. This can be useful if the cells being destroyed are harmful - like cancerous cells. The cancerous growth of cells and tissue can be radiated, using gamma rays, and is known as **radiation therapy.**

Producing Visible Light

Simply stated, light is the form of energy you can see. This energy can be produced naturally by the sun or fire, or artificially by light-producing technologies, like batteries.
Radiation is the wave like transfer of light from its source in all directions. Light is often called **radiant energy**. Light from the sun is formed by nuclear fusion.

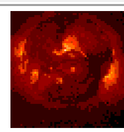
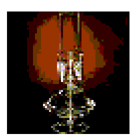
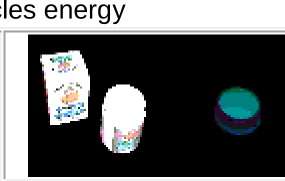
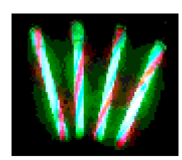
The First Basic Principle of Light

'Light is a form of energy' When light reaches a surface, it can be absorbed and transformed into other types of energy.

… into electrical energy	**… into thermal energy**	**… into chemical energy**
		
Solar cells change light into electricity	**Cameras change light into thermal images**	**Trees convert light energy into food (chemical energy)**

The amount of energy a surface receives depends on the intensity of the light.
The more intense the light, the more light can be absorbed.

Sources of Light

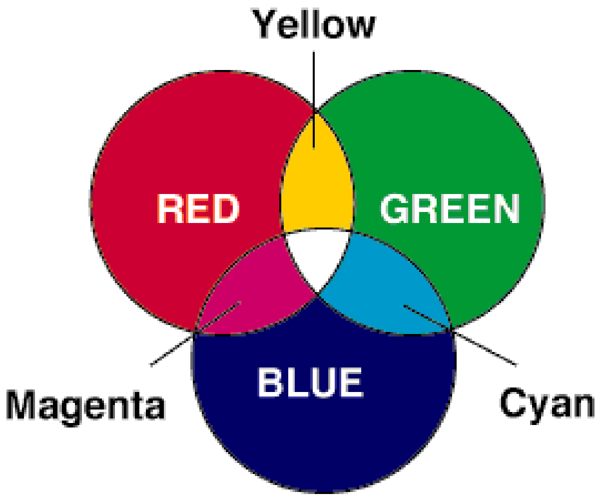
Natural Light Sources		**Artificial Light Sources**	
Sun		**Incandescent** (heat causing a filament of metal to glow - visible light)	
Electrical energy **---»** Thermal energy **---»** Visible light energy			
Candles or Oil Lamps		**Florescent** (ultraviolet light is absorbed by fabric particles, which in turn emit some of the energy as light - glowing)	
Ultraviolet light **---»** Energy absorbed **---»** Visible light energy/particles energy			
Wood (fire)		**Phosphorescent** (light energy is stored and released later as visible light)paint	
Bioluminescence(light produced by living organisms)	 firefly light	**Chemiluminescent** (light energy released by chemical reactions)glow sticks Chemiluminescence Movies (Shockwave/Flash)	
UV Light Technologies Light and Color	Chemical energy **---»** Visible light energy		

Other sources of Light Energy can come from the Earth's minerals including:
THERMOLUMINESCENCE and **TRIBOLUMINESCENCE**

The Colors of Light

The various colors of the **visible spectrum** have slightly different wavelengths and refract by a slightly different amount.

The **Primary colors** of the visible spectrum are **red**, **green** and **blue**.



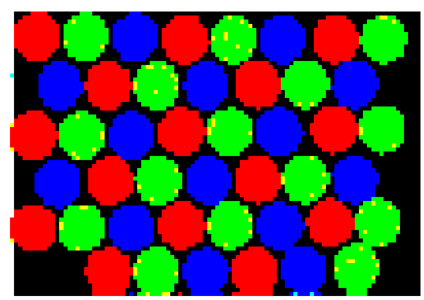
By mixing the correct intensities of the primary colors, you will observe white light.

Secondary colors are cyan, magenta and **yellow**.

The mixing of three colors of light to produce many different colors of light is called the **theory of color addition**.

Television

Television puts the **theory of color addition** into practice. By changing the brightness of the dots that make up the screen many different colors can be produced.



Television fools the eye into seeing colors that are not really there.