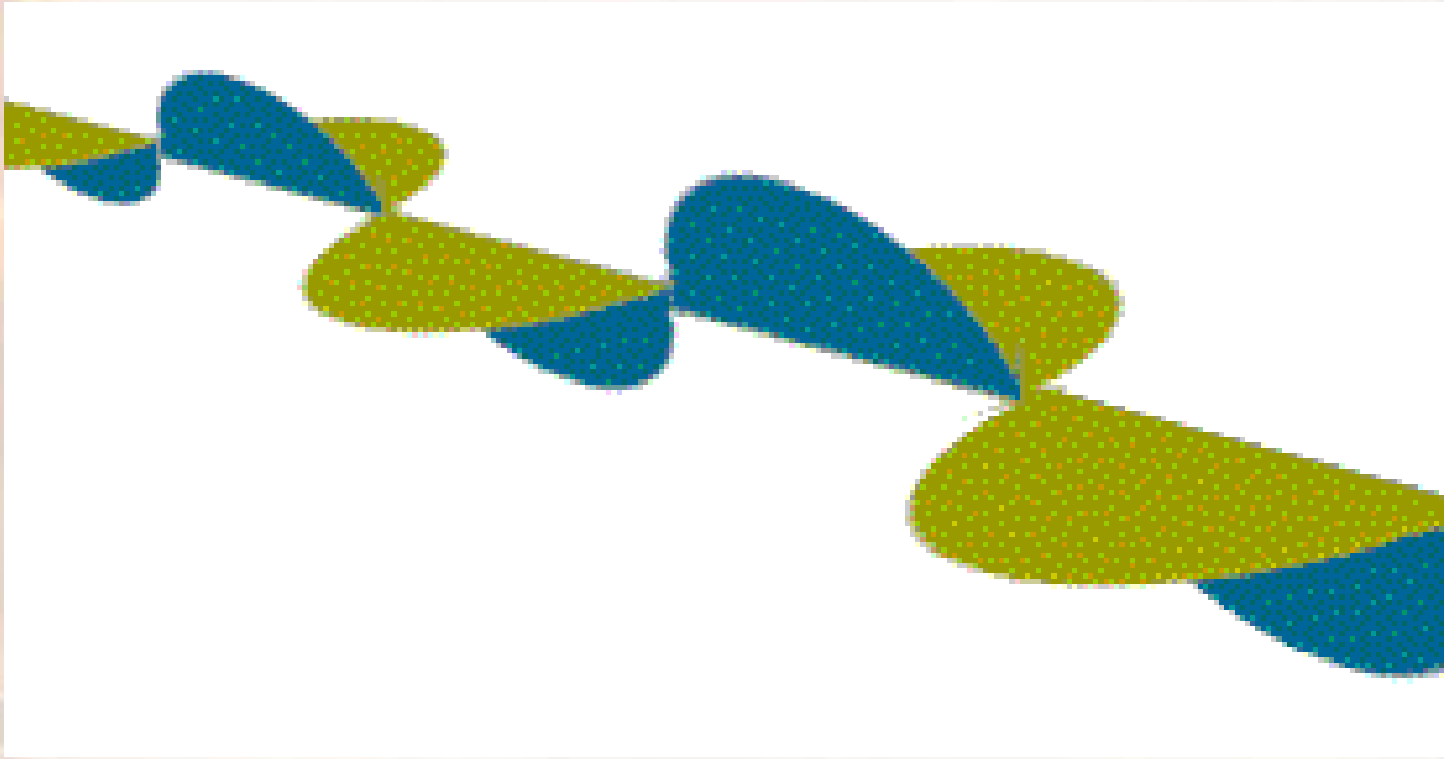
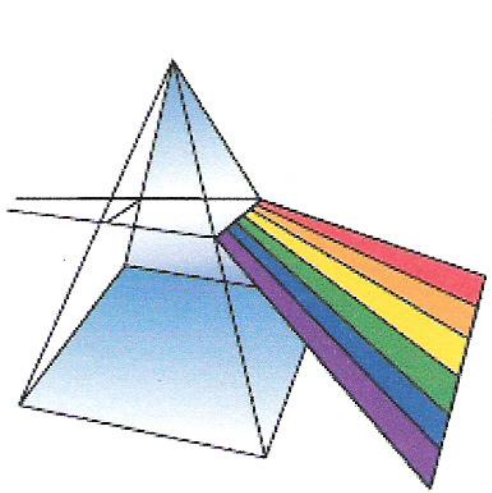
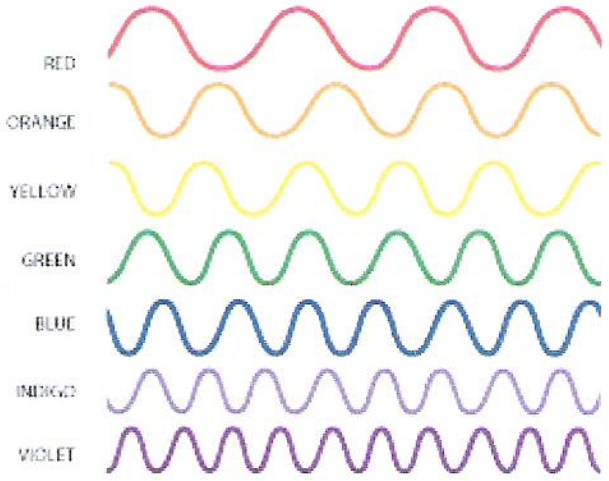
Waves of the Electromagnetic Spectrum

Electromagnetic waves are transverse waves that travel with changing magnetic and electric fields



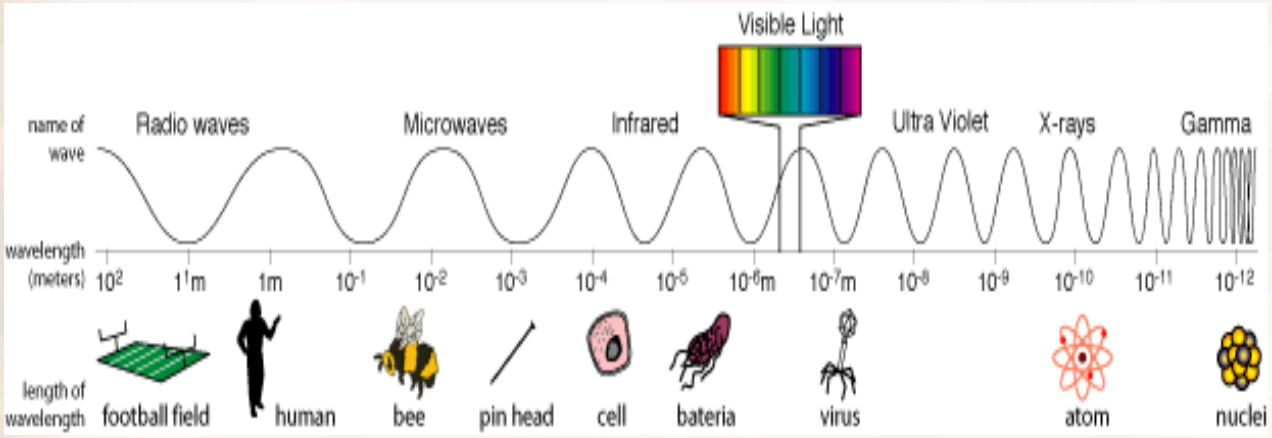
The electromagnetic spectrum is more familiar to you than you might think. For example, the light our eyes can see is the visible part of the EM spectrum which consists of the colors we see in a rainbow.





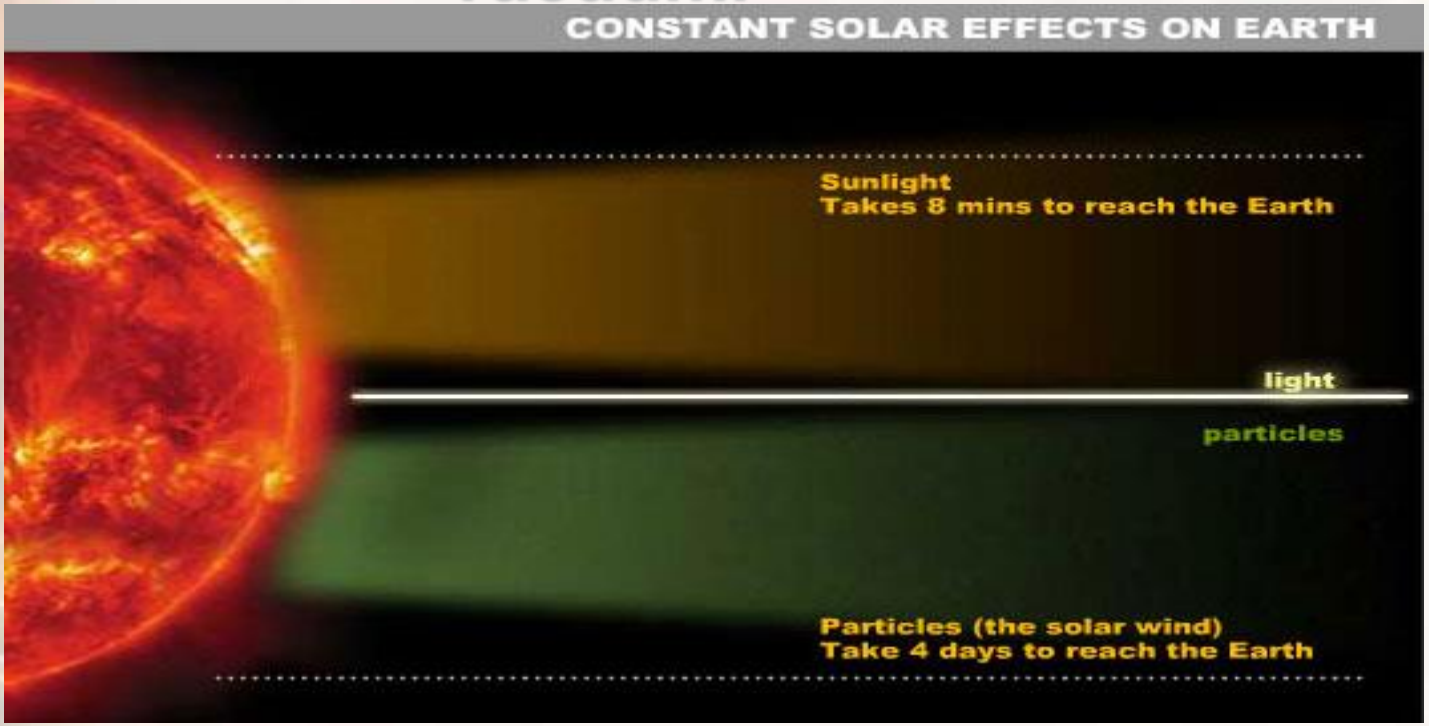
Each of these colors actually corresponds to a different wavelength of light.

Waves in the electromagnetic spectrum vary in size from very long radio waves with wavelengths the size of buildings, to very short gamma rays smaller than the nucleus of an atom.



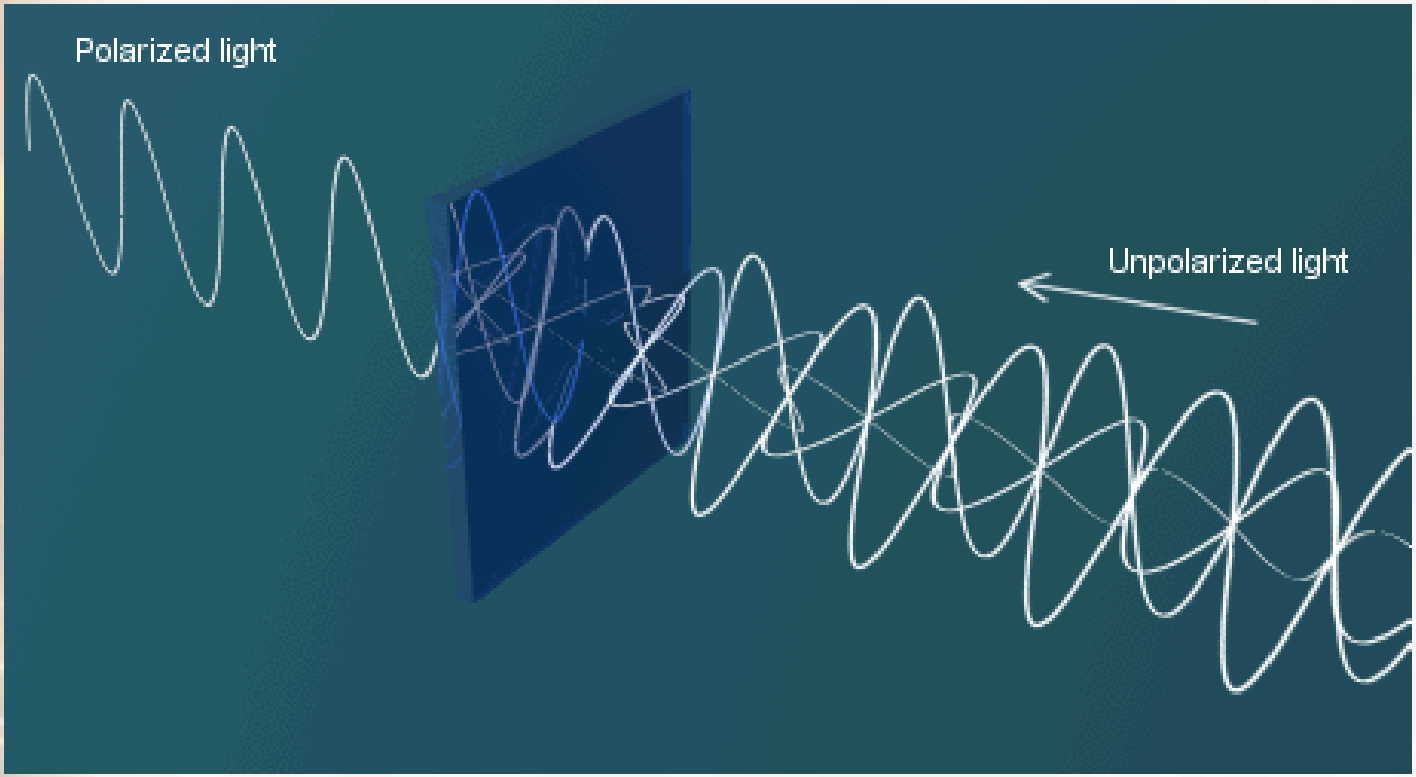
The energy transferred by electromagnetic waves is called *Electromagnetic Radiation*

EM radiation does not need a medium. The sun is an example of a rich source of electromagnetic waves that travel 92,860,000 miles to earth through an empty vacuum.

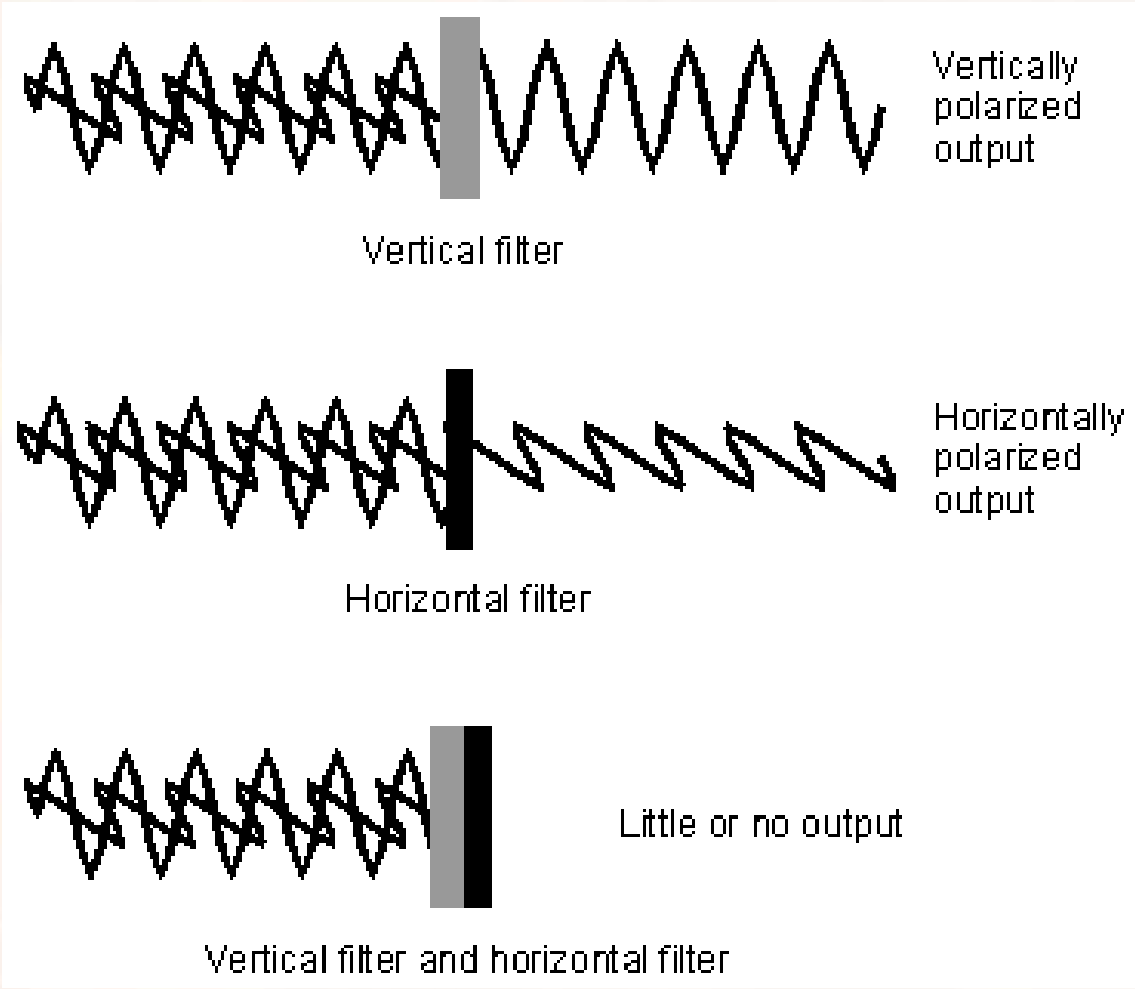


Visible Light, a category of EM Waves, has properties of both waves and particles.

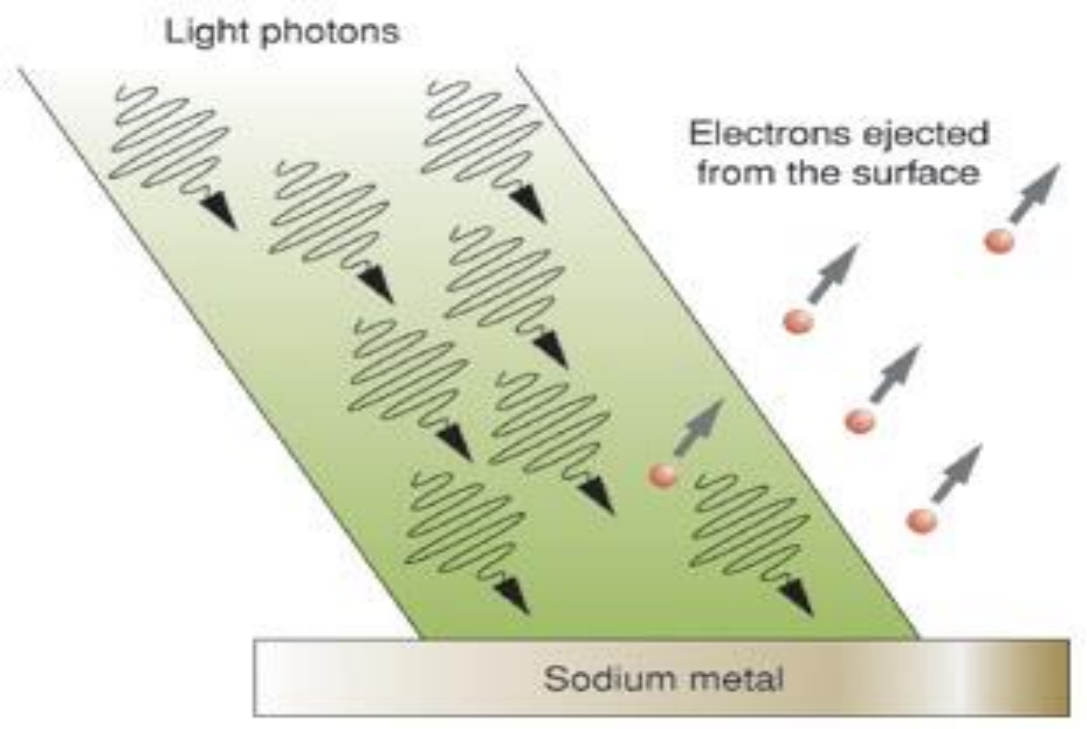
Because of its wave characteristics, we can polarize light by passing it through a polarized lens.



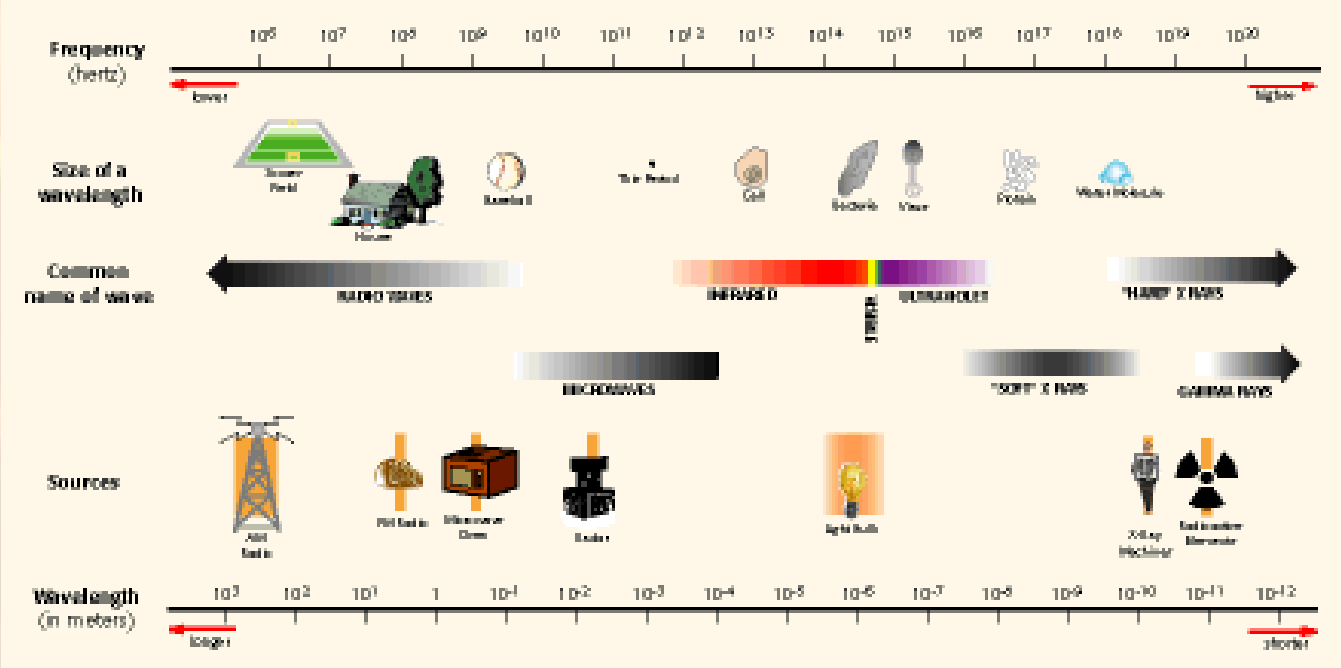
By passing light through a polarized lens, it allows waves that vibrate in only one direction to pass through.



Light's photoelectric effect demonstrates how it moves similar to a stream of particles. This occurs when photons, tiny packets of energy with mass, cause electrons to move when light hits certain substances.



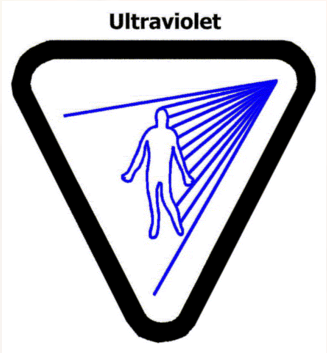
All electromagnetic waves travel at the same speed (186,000 miles per second). Only their wavelengths and frequencies are what set them apart.

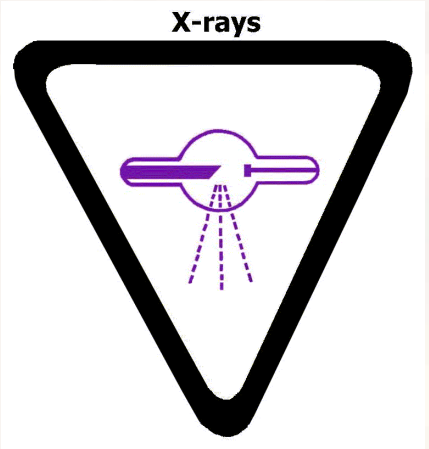


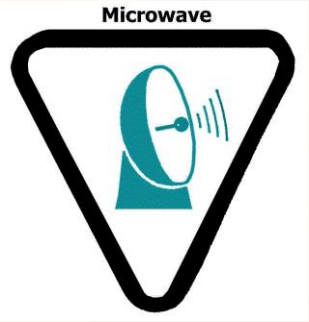
The electromagnetic spectrum is the name for the range of EM waves as they are placed in order of increasing frequency.

The Spectrum is made up of the following categories:

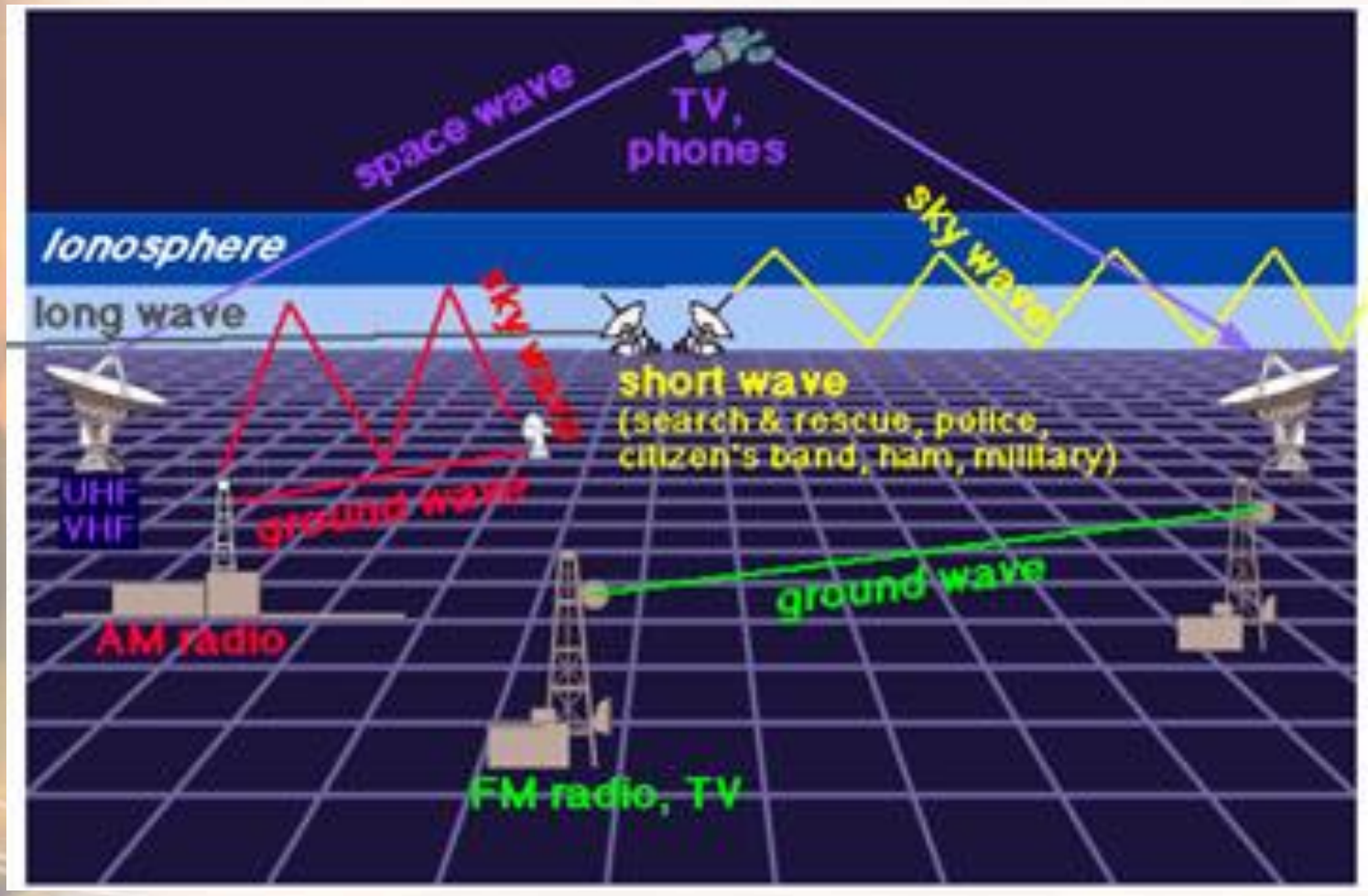
- Radio Waves
- Infrared Rays
- Visible Light
- Ultraviolet Rays
- X-Rays
- Gamma Rays





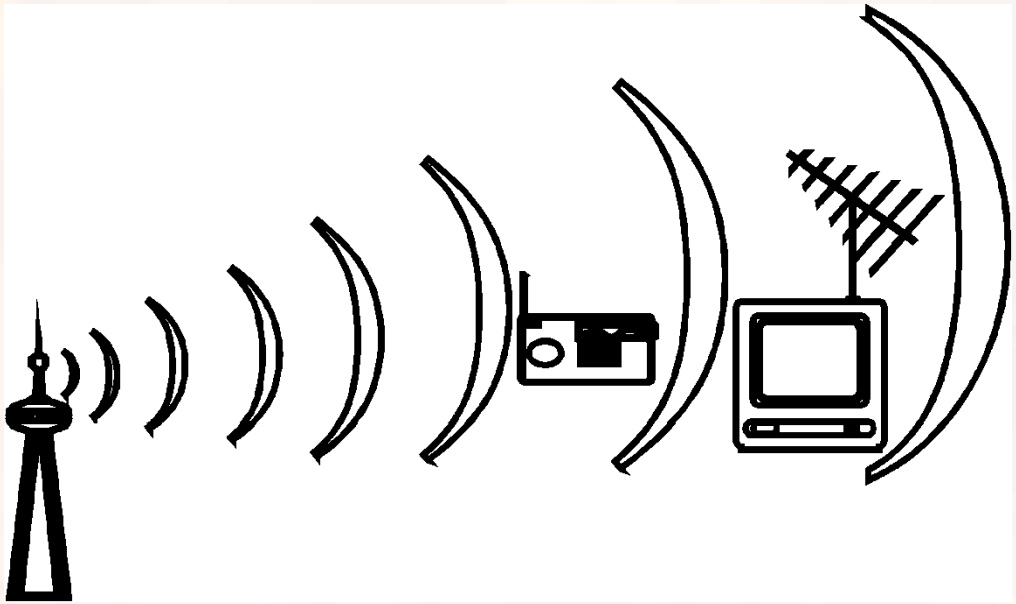


Radio Waves are the EM waves with the longest wavelengths and lowest frequencies. Below are some examples of waves within this category:



Each radio station is on a different *frequency* or channel which keeps it from interfering with other station's broadcasts. There are two types of radio stations: AM and FM.

FM stands for ***frequency modulation*** and AM stands for ***amplitude modulation***.



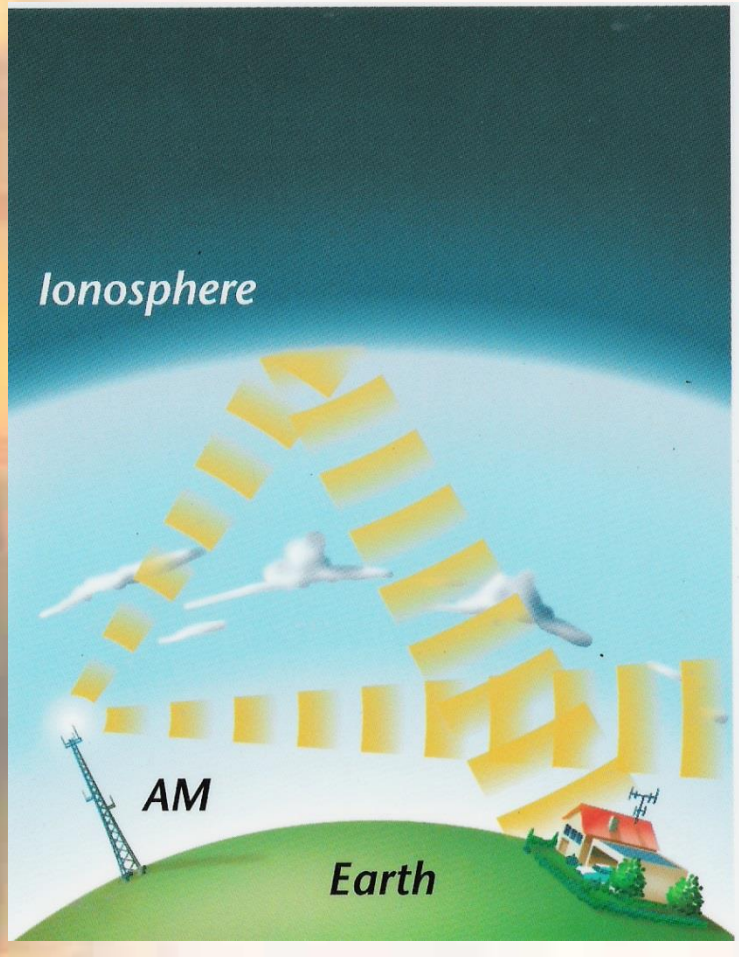
AM Radio Stations

- The strongest AM stations may have 50,000 watts of power and can be heard as far away as 2,000 miles
- AM signals follow the ground when they spread out, but they also go up into the sky.
- When AM signals reach a layer of the atmosphere called the *ionosphere*, they bounce back down to earth, then bounce back to the ionosphere, then back to earth, and so on until the signals become too weak to hear.
- These AM signals go father at night when the sky is especially clear
- AM signals get more interference from static than FM signals.

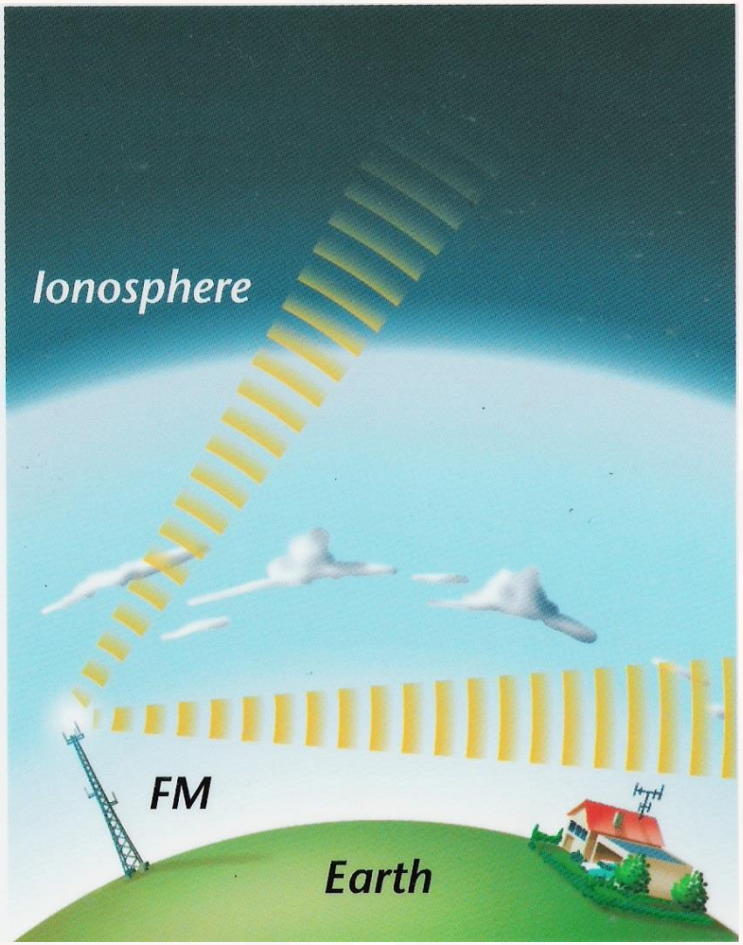
FM Radio Stations

- The strongest FM stations may have 100,000 watts of power, but can only be heard 70 miles away.
- FM signals only go as far as the line of sight, in other words, as far as the horizon. This is why most FM antennas are located on top of a hill, mountain, or very tall building.
- FM signals often have better sound quality than AM.

AM ↓ Signal



FM ↓ Signal



Radio telescopes look toward the heavens at planets and comets, giant clouds of gas and dust, and stars and galaxies. By studying the radio waves originating from these sources, astronomers can learn about their composition, structure, and motion.

Microwaves

Microwaves are the radio waves with the shortest wavelengths and highest frequencies. Two interesting applications of microwaves in today's society are the microwave oven and cellular communication.

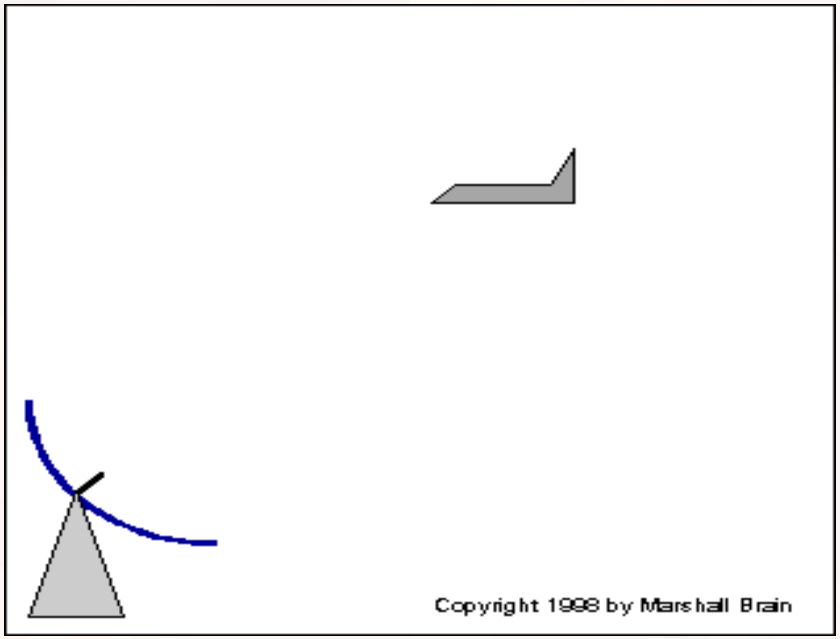
Microwaves are good for transmitting information from one place to another because microwave energy can penetrate haze, light rain and snow, clouds and smoke.

Note the early version of the “hands free” cell phone.

Microwave ovens cook by a different principle than conventional ovens. Microwaves penetrate and interact with food molecules which are made mostly of water. These molecules resonate at the same frequency as the microwave radiation, Consequently, they heat by stimulating the vibration of food molecules.

Radar Waves

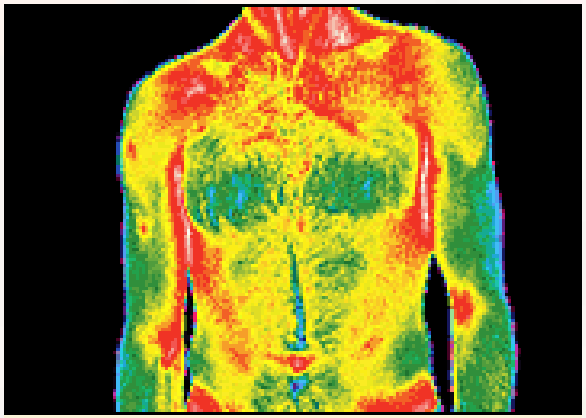
Radar is another short-wave radio signal that has many applications in our world. It is used to locate things. For example, air-traffic control towers send out radar to monitor planes in the air.



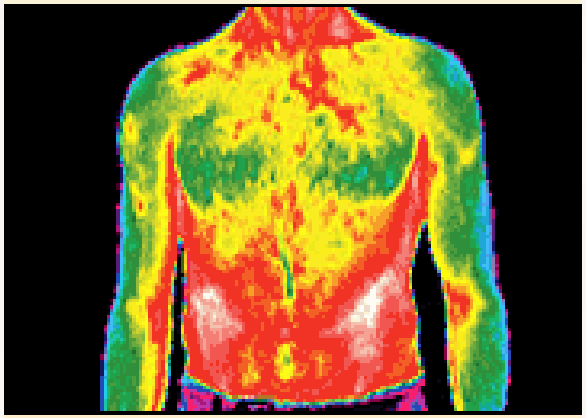
Radar is also used to measure the speed of moving vehicles such as in police radar guns or at race car events. The property known as the *Doppler Effect* is how the speed is calculated. Radar waves are sent out at a known speed and how fast they return is used to calculate the vehicle's motion.

Infrared Rays

Infrared radiation have shorter wavelengths and higher frequencies than radio waves. We can *"Feel"* most frequencies of the infrared spectrum as *HEAT.* In fact, our bodies give off large amounts of infrared in the form of heat.



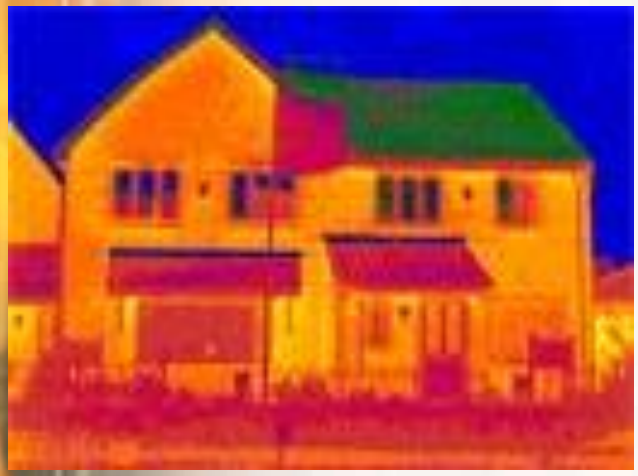
Before



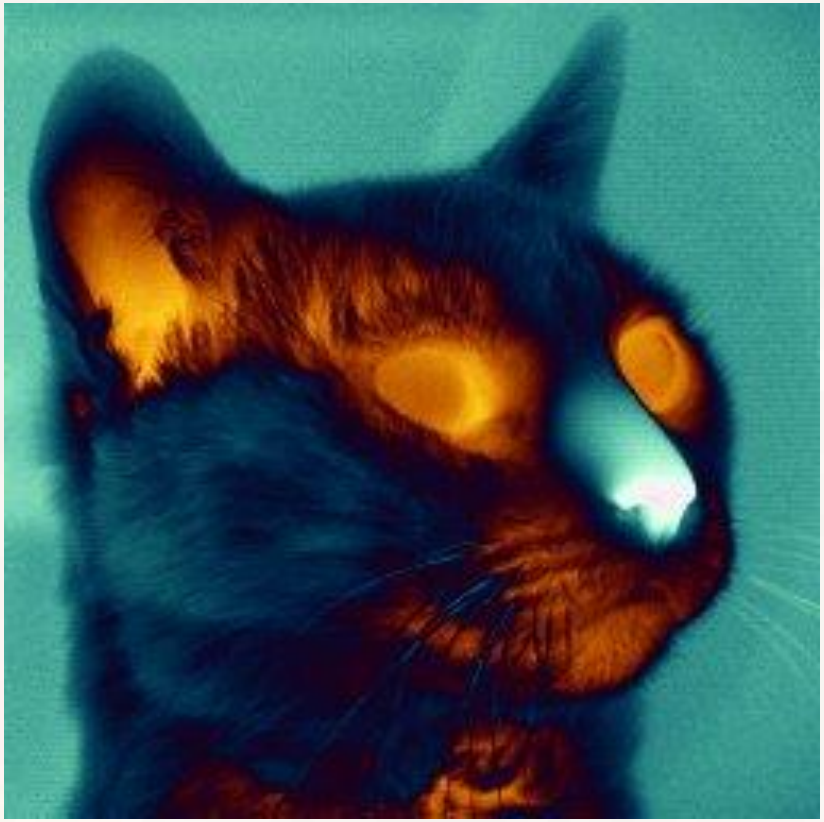
After

Heat lamps use infrared radiation to keep food warm at restaurants, in saunas, and in bathrooms to keep us toasty after a shower.

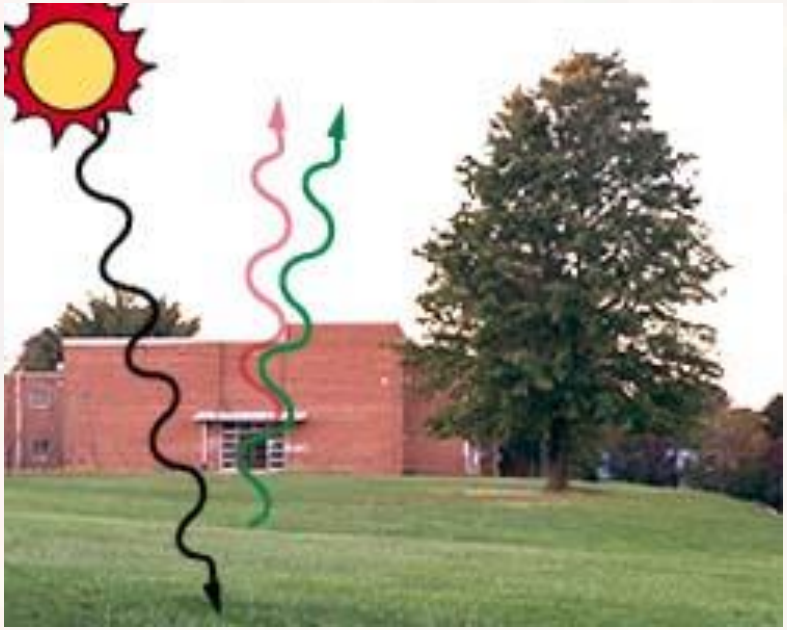
Infrared film can be used to detect heat loss in buildings, create thermograms on people, and even catch criminals trying to avoid night capture.



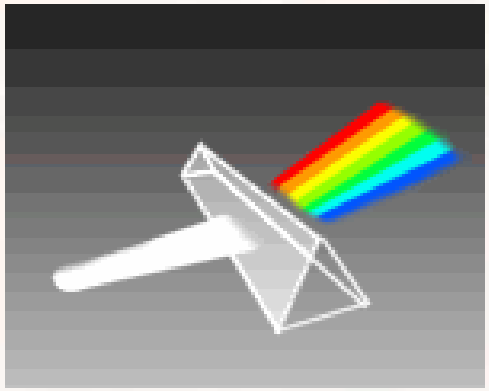
To make infrared pictures like this, special cameras and film detect differences in temperature, and then assign different brightness or false colors to them.



This is a false-color image, just like the one of the cat. False-color images of the Earth frequently use a color scheme where infrared light is mapped to the visible color of red.



Visible Light

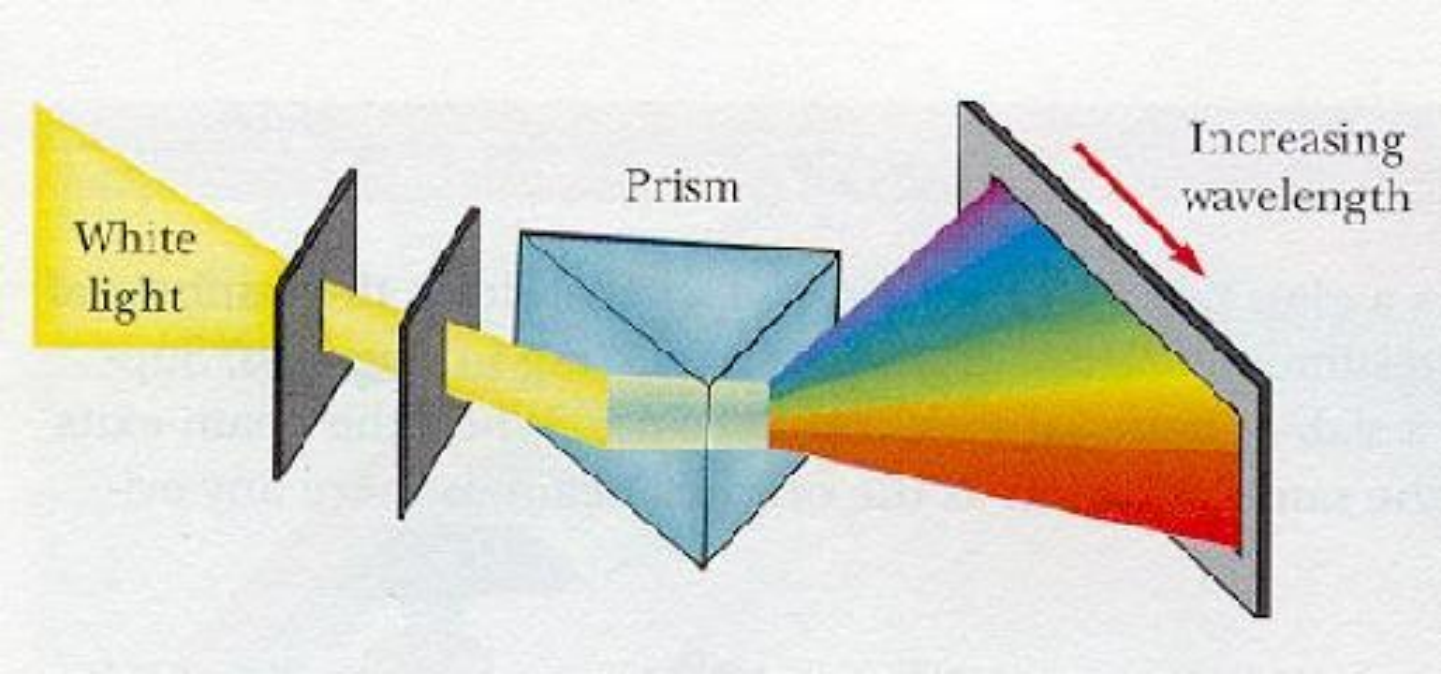


The only part of the electromagnetic spectrum our eyes can see is known as the visible spectrum.

Visible light, as it is also known, has shorter wavelengths and higher frequencies than infrared. The frequencies of visible light we can see are arranged in an order referred to as ROY G. BIV.

Cones, a special type of light-sensitive cell in our eyes, are receivers for these tiny light waves. The Sun is a natural source for visible light waves and our eyes see the reflection of this sunlight off the objects around us.

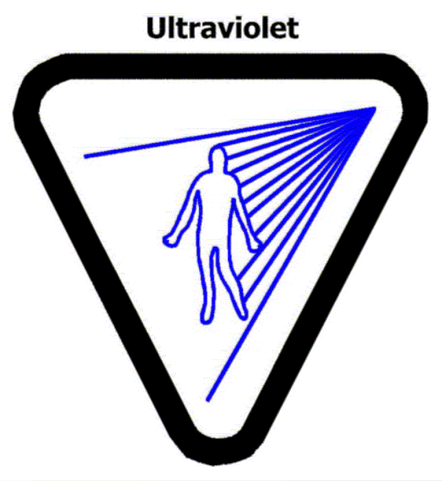
Red has the lowest frequency and violet has the highest of the visible spectrum. Visible light is also called "white light" and the "colors of the rainbow."



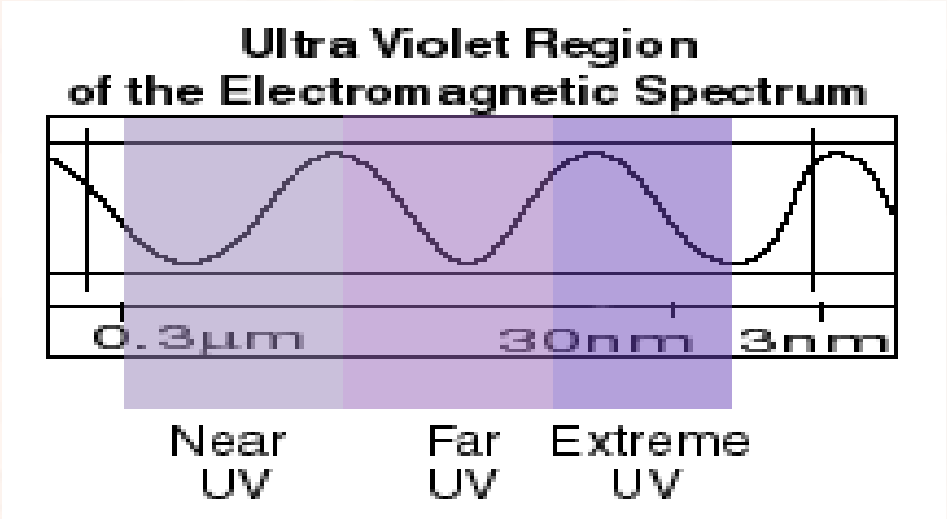
We can see the visible spectrum spread out by their frequencies when a source of white light is passed through a prism or through millions of raindrops.

Ultraviolet Rays

The prefix "ultra" means beyond, so ultraviolet rays are those beyond violet with a higher frequency and shorter wavelength the white light. Ultraviolet rays are also beyond our eyes ability to see.



Scientists have divided the ultraviolet part of the spectrum into three regions: the *near* ultraviolet, the *far* ultraviolet, and the *extreme* ultraviolet. These three regions are distinguished by how energetic the UV radiation is, and by the "wavelength" of the ultraviolet light which is related to energy.



Though ultraviolet waves are invisible to the human eye, some insects like bumblebees can see them. This gives them a different view of flowers when seeking nectar.

Because UV rays carry more energy, they can damage or kill living cells. Long term exposure to ultraviolet rays can cause skin damage and possibly skin cancer.

However, there are beneficial uses for UV rays. Ultraviolet lamps are used to kill bacteria on hospital equipment, food processing plants, and even our goggle sterilizers here at school.

UV rays, in small doses, are actually helpful to humans. Our skin needs exposure to UV rays to help synthesis vitamin D. UV is also used to treat jaundice in new borns.

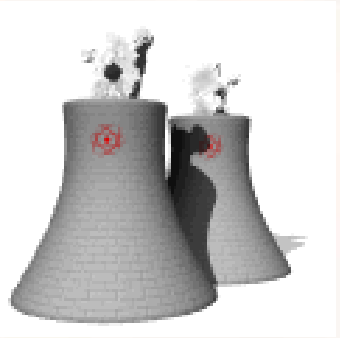
X-Rays

X-Rays are EM waves with very short wavelengths. They are used to make images of bones in the body since they pass right through skin and soft tissue, but are absorbed by bone.

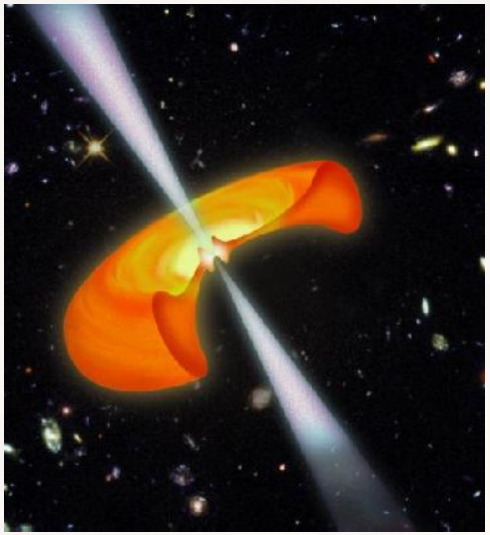
Too much exposure to X-Rays can cause cancer and other mutations. That is why precautions are taken when you receive X-Rays to protect other parts of your body with the lead-lined aprons or girdles.

Note the apron →

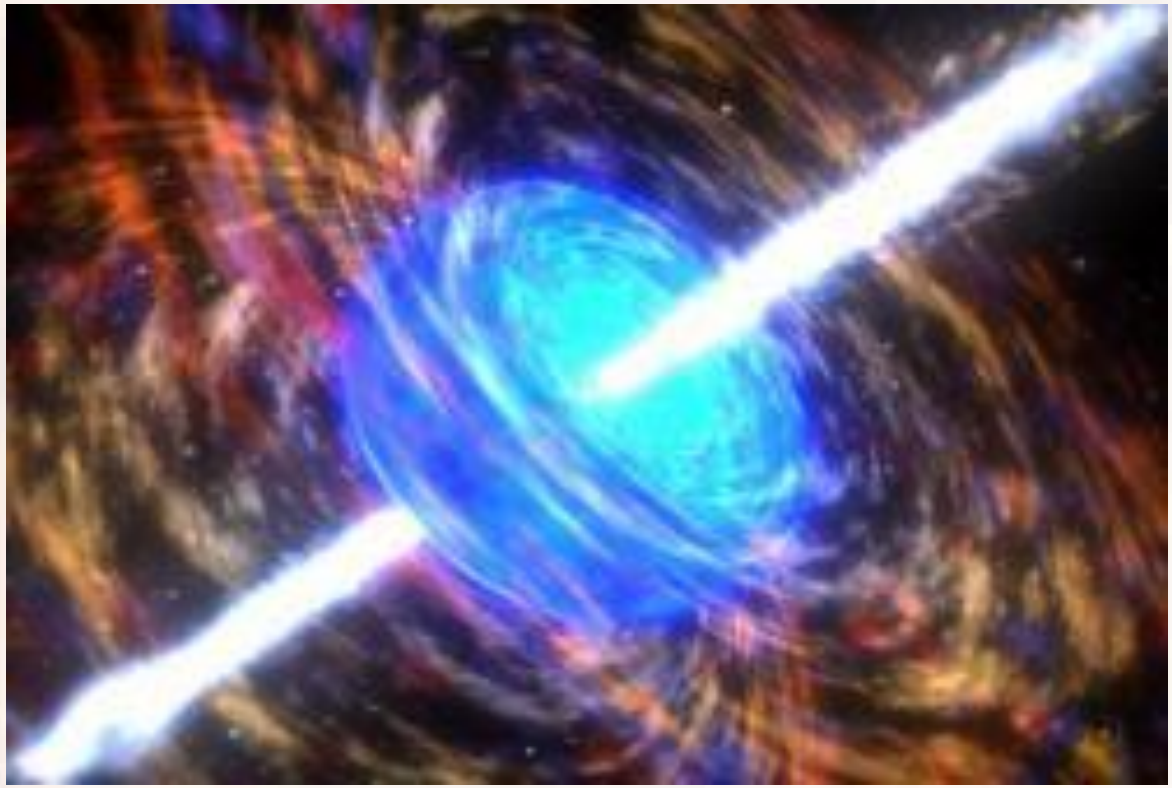
Gamma Rays



Of all the EM spectrum, gamma rays have the shortest wavelengths and highest frequencies. Some radioactive elements and nuclear explosions produce gamma rays. Certain bodies in space also produce gamma rays.



Gamma-ray bursts can release more energy in 10 seconds than the Sun will emit in its entire 10 billion-year lifetime! So far, it appears that all bursts we have observed have come from outside the Milky Way Galaxy.



Used in a controlled environment, gamma rays can be used to treat certain types of cancer. Exposure to gamma rays kills the mutated cells.