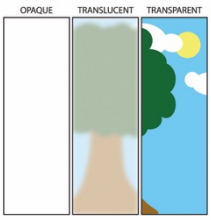
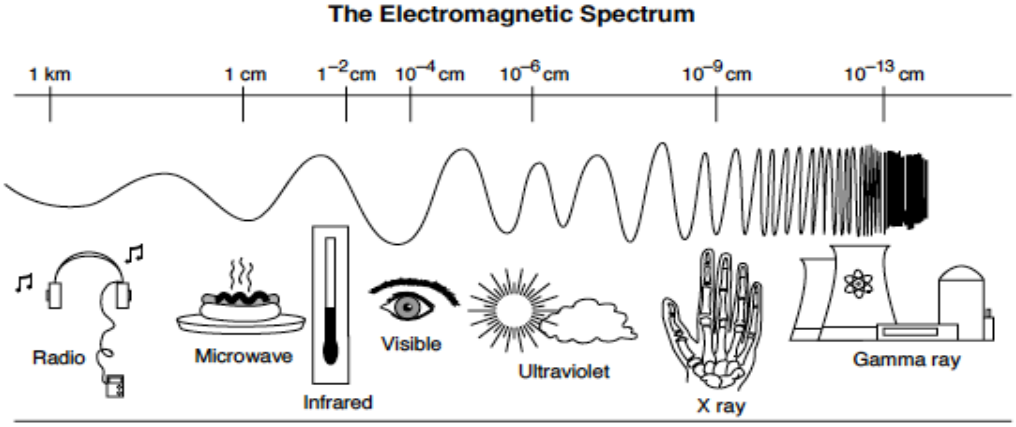
By Suzanne Shera, Author of Lightlab

LIGHTLAB EXTRA SICENCE ACTIVITY 3: Beyond Visible Light



PURPOSE: Expand our knowledge of electromagnetic radiations beyond the visible. We will learn that while some materials are opaque or transparent to visible light, that property can be reversed with invisible radiations. We will also perform a couple experiments to detect some of that radiation.

BACKGROUND: After James Maxwell's confirmation that light is an electromagnetic radiation (see ref #), scientists discovered a whole spectrum of invisible electromagnetic radiation emitted by the sun and atoms on earth. The **visible** rays that humans see form only a small part towards the middle of the electromagnetic spectrum, shown below. Can you name the other radiations from left to right beginning with radio waves, _____, _____, Visible, _____, _____, _____.

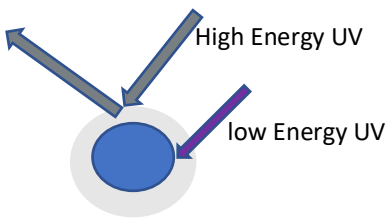


The values on the top line in km and cm indicate the measure of the radiation's wavelength underneath. As you move left to right, the wiggle under that line shows how the wavelength of each radiation gets narrower while its energy gets more concentrated. Gamma rays have the highest energy of all EM radiations while radio waves have the lowest energy.

All of these radiations are emitted by the sun as well as other atoms on earth, and they have different properties of penetrating materials due to their energy. For example,

1. Unlike visible light, **X rays** have energy high enough to penetrate muscle and tissue but not through the bones. That is how we obtain images of bones because the muscles are transparent to **X-rays** even though opaque to **visible** light.

2. The Earth's atmosphere is transparent to sunlight but opaque to the **harmful rays of energetic UV**. It is however transparent to a small amount of **less energetic UV rays** which cause sunburn even on cloudy days.



"The book of nature which we have to read is written by the finger of God." ***Michael Faraday***

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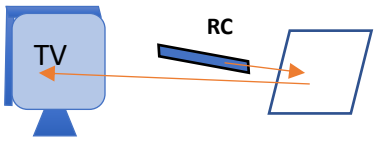
3. Greenhouses are made of **glass** which is transparent to **visible** sunlight but opaque to **Infrared** waves. When sunlight goes through the glass, it is absorbed by the plants and soil which in turn emit Infrared radiation. Since IR radiation can't go through the glass, it is trapped inside the greenhouse which warms up.

EXPERIMENTS WITH INFRARED (IR): This is the color next to Red, which makes the atoms and molecules vibrate generating heat. IR is invisible to humans but visible by various animals.

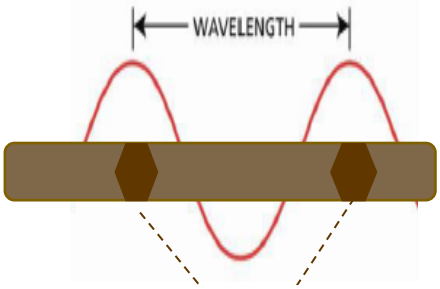
a) **HOW WAS IR DISCOVERED?** The astronomer Herschel (1738-1822) used a prism to split sunlight into rainbow colors and placed thermometers in their path check which was the warmest. He. To his amazement, he noticed that the spot next to the Red was the warmest although no color was visible. He concluded that it must be an invisible radiation, later called InfraRed. You can repeat this if you had the following materials: a prism or CD, sunlight, a screen, 3 thermometers with their tip painted black.

b) **TV REMOTE CONTROL:** Television remote controls use Infrared light to control TV. Infrared can reflect like visible light.
Materials: TV, remote control (RC), mirror (or white paper)
Procedure:
- Hold the paper parallel to TV Screen.
- Hold the remote control pointing towards mirror, opposite from TV
- Push RC controls and watch TV respond to OFF/ON, Volume HIGH/LOW!!



Mirror or white paper

EXPERIMENT WITH MICROWAVE: Measure the wavelength of a Microwave
All light wavelengths are measured from peak to peak. Radio waves are very long while gamma rays are extremely small. Microwaves on the other hand can be measured in cm.
Material: A chocolate bar, microwave oven, plate, ruler
Procedure:
- Take out the turntable of the microwave oven
- Put the chocolate in the center of the back of plate to prevent it from touching the rotating shaft, so it stays still while oven is ON.
- Put the plate in the oven and turn it ON for at least 30sec (varies with oven's power). The chocolate should melt noticeably in two places.
- Take out the chocolate and measure the distance in cm between the two melted spots. Record here: _____ cm. This is the approx. wavelength in your oven's microwave radiation



Melted Spots

References:

1. NASA, "*OPTICS, light, Color and Their Uses* ", EG-2000-10-64-MSFC
2. Suzanne Shera, M.S., "*Lightlab*" chapters 2 and 3
3. LASER Classroom, "*Measure the speed of light with a chocolate bar*"

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