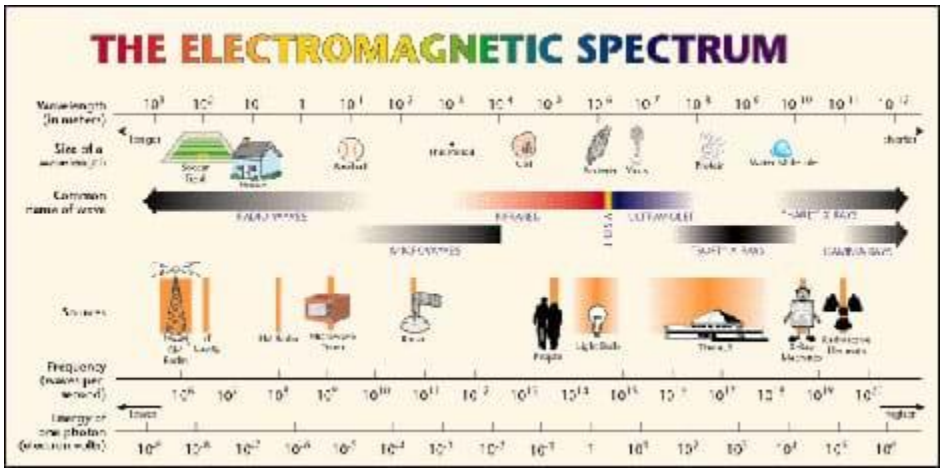
The Electromagnetic Spectrum

The EM Spectrum is the complete (entire) range of EM waves in order of increasing frequency and decreasing wavelength. This means as you look from left to right on a diagram of the spectrum, the wavelengths get smaller and the frequency gets larger. An inverse relationship exists between size of the wave and frequency. Remember: all EM waves travel at the same speed: 300,000km/s.

If you remember the formula for speed, it is the wavelength times the frequency. For the answer to **always** be 300,000km/s, as one number goes up, the other must go down. All EM waves are radiation. It is just that the longer wavelengths do not carry enough energy in them to damage cells. Remember: the higher the frequency, the more energy in the wave!



A diagram of the electromagnetic spectrum.

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Waves in the Spectrum

Radio waves have the longest wavelengths and lowest frequencies; wavelengths range from 1000s of meters to 0.001 m. (The shortest radio waves are microwaves.) Radio waves are used in RADAR (radio detection and ranging), sending sound, pictures (TV), cell phones, cooking and satellite transmissions.

Infrared waves (heat) have shorter wavelengths, from 0.001 m to 700 nm and higher frequencies (a nm is one billionth of a meter). Infrared is used to find people in the dark and in TV remotes.

Visible light is what we can see in the EM spectrum. Wavelengths of visible light range from about 700 nm (red light) to 400 nm (violet light). Visible light frequencies are higher than the frequencies of infrared waves. Notice how visible light is such a small portion of the entire spectrum.

Ultraviolet wavelengths range from about 400 nm to 10 nm; the frequency (and therefore the energy) is high enough with UV rays to penetrate living cells and cause them damage. We need UV rays to produce vitamin D in our bodies. Even though too much can lead to sunburn and skin cancer, UV rays are easily stopped by clothing. UV rays are used for sterilization of materials because they kill bacteria in high enough concentrations. Although humans cannot see UV light, bees, butterflies, some small rodents, and some birds can.

X-rays have wavelengths from 10 nm to 0.001 nm. They have enough energy to penetrate deep into tissues, but are stopped by dense materials, such as bones. Used for examining solid structures (such as looking for cracks in bones and bridges), and for cancer treatments.

Gamma rays have the shortest wavelengths (less than one trillionth of a meter: 10 to the negative 12), therefore the highest frequencies, therefore carry the most energy. These are the most damaging to tissues and can penetrate the deepest. They are hard to stop! You would need a 3–4 foot thick concrete wall to stop them. Gamma rays are released in nuclear power plants, by nuclear bombs, and by naturally occurring elements on Earth. They are sometimes used in the treatment of cancer.

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