

# *Electromagnetic Waves*

## The Electromagnetic Spectrum

..... **Read to Learn** .....

### **What is the electromagnetic spectrum?**

The waves that carry voices to your cell phone are electromagnetic waves. So are the waves of energy that toast your bread. Even the X-rays that a dentist uses to check the health of your teeth are electromagnetic waves.

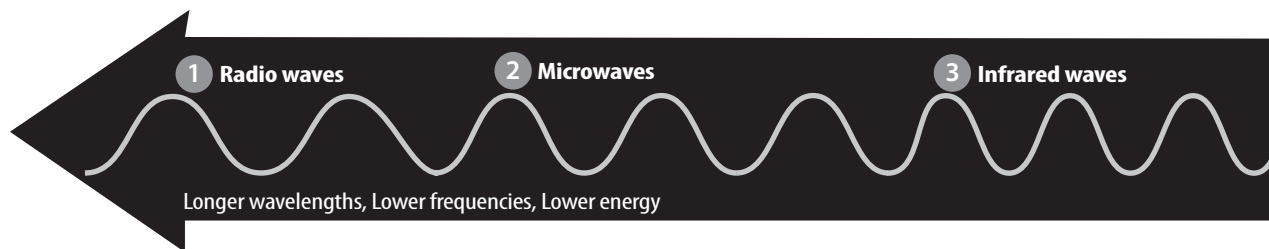
The changing motion of an electric charge produces each type of electromagnetic wave. However, each type of wave has a different frequency and wavelength. Also, each carries a different amount of energy.

Electromagnetic waves might vibrate from a thousand times per second to trillions of times per second. They might be as large as a house or as small as an atom's nucleus. *The electromagnetic spectrum is the entire range of electromagnetic waves with different frequencies and wavelengths.*

### **Classifying Electromagnetic Waves**

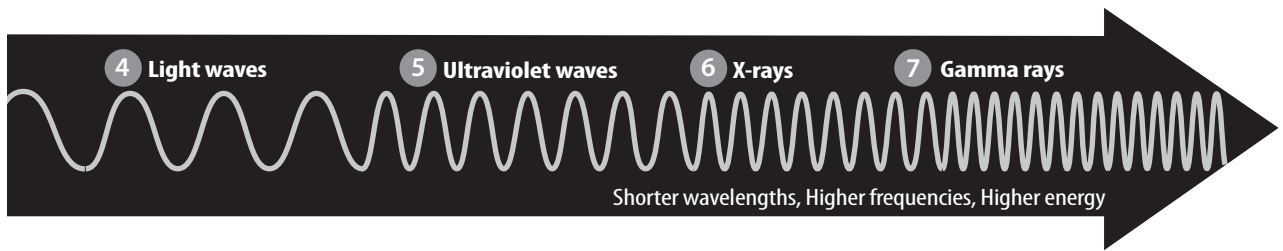
Think about the colors of a rainbow. There are many shades between each color. Each color gradually becomes another. However, the electromagnetic spectrum is organized into groups based on the wavelengths and frequencies of the waves. Like the colors of a rainbow, each group gradually blends into the next.

## Electromagnetic Spectrum



Each numbered description below relates to a numbered wave in the figure above. Notice how the wavelength, frequency, and energy change among waves.

1. A **radio wave** is a low-frequency, low-energy electromagnetic wave that has a wavelength longer than about 30 cm. Some radio waves have wavelengths as long as a kilometer or more. Radio waves are often used for communication. The wavelengths are long enough to move around many objects, but their energy is low enough that they aren't harmful. On Earth, radio waves are usually produced by an electric charge moving in an antenna. However, the Sun and other objects in space also produce radio waves.
2. A **microwave** is a low-frequency, low-energy electromagnetic wave that has a wavelength between about 1 mm and 30 cm. Like radio waves, microwaves are often used for communication. With shorter wavelengths than radio waves, microwaves are less often scattered by particles in the air. Microwaves are useful for satellite communications because they can pass through Earth's upper atmosphere. A cell phone uses microwaves from satellites. Because of the frequency range of microwaves, food molecules such as water and sugar can absorb their energy. This makes microwaves useful for cooking.
3. An **infrared wave** is an electromagnetic wave that has a wavelength shorter than a microwave but longer than light. Vibrating molecules in any matter, including your body, emit infrared waves. You cannot see infrared waves, but you can feel them when you are near a campfire. Your skin senses infrared waves with longer wavelengths as warmth. Infrared waves with shorter wavelengths do not feel warm. A television remote control, for example, sends out these waves.



4. Light is electromagnetic waves that your eyes can see. You might describe light as red, orange, yellow, green, blue, indigo, and violet. Red light has the longest wavelength and lowest frequency. Violet light has the shortest wavelength and the highest frequency. Each name represents a family of colors, each with a range of wavelengths.
5. An **ultraviolet wave** is an electromagnetic wave that has a slightly shorter wavelength and higher frequency than light, and carries enough energy to cause chemical reactions. Earth's atmosphere prevents most of the Sun's ultraviolet rays from reaching Earth. But did you know that you can get a sunburn on a cloudy day? This is because ultraviolet waves carry enough energy to move through clouds and to penetrate the skin. They can damage or kill cells, causing sunburn or even skin cancer.
6. An **X-ray** is a high-energy electromagnetic wave that has a slightly shorter wavelength and higher frequency than an ultraviolet wave. Have you ever had an X-ray taken to see if you had a broken bone? X-rays have enough energy to pass through skin and muscle. But the calcium in bone can stop them. Scientists learn about objects and events in space, such as black holes and star explosions, by studying the X-rays they emit.
7. A **gamma ray** is a high-energy electromagnetic wave with a shorter wavelength and higher frequency than all other types of electromagnetic waves. Gamma rays are produced when the nucleus of an atom breaks apart. They have enough energy to kill living cells. Like X-rays, gamma rays form in space during violent events, such as the explosion of stars.