


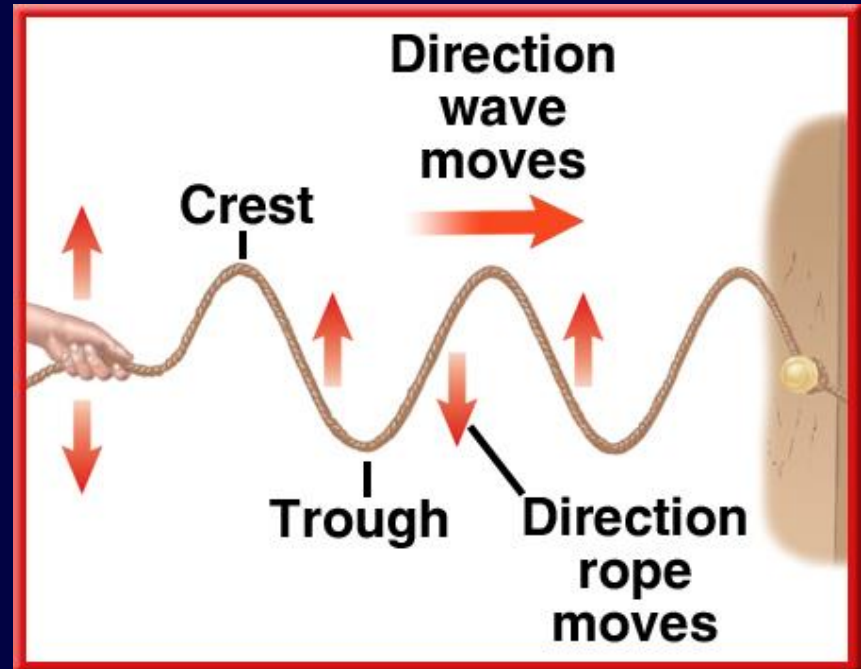
## What are waves?

- Different types of waves carry signals to televisions and radios.
- Sound and light waves move all around you and enable you to hear and see.



## Transverse Waves

- A **transverse wave** causes particles in matter to move back and forth at right angles to the direction in which the wave travels. 
- High points in the wave are called crests. Low points are called troughs.
- The series of crests and troughs forms a transverse wave.



# Electromagnetic Waves

- Light, radio waves, and X rays are examples of electromagnetic waves.
- Electromagnetic waves are transverse waves.
- They contain electric and magnetic parts that vibrate up and down perpendicular to the direction the wave travels.




## Properties of Waves

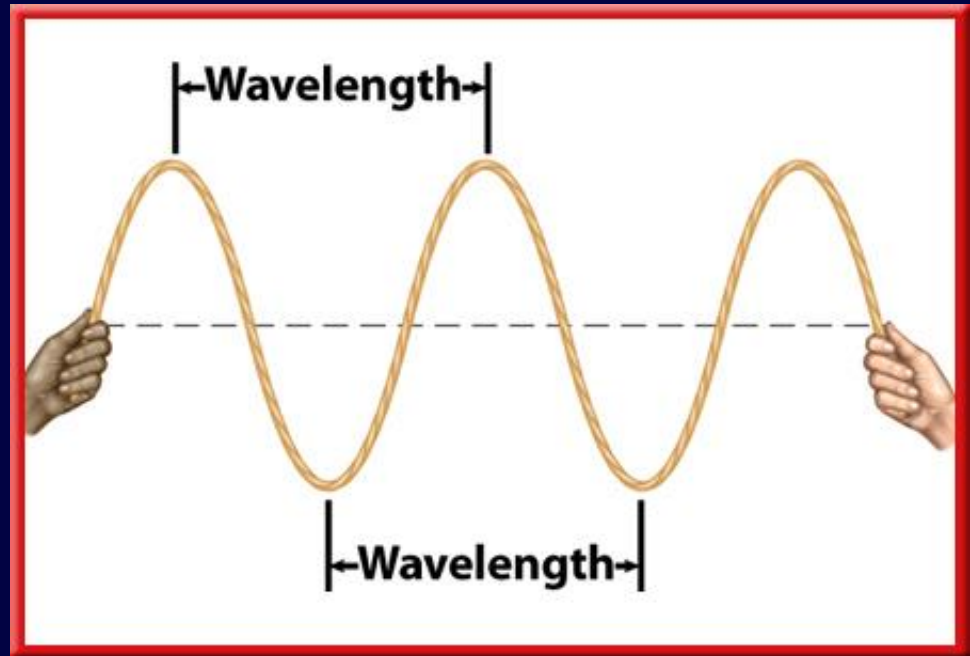
- The properties that waves have depend on the vibrations that produce the waves.
- For example, if you move a pencil slowly up and down in a bowl of water, the waves produced by the pencil's motion will be small and spread apart. NW



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## Wavelength

- The distance between one point on a wave and the nearest point moving with the same speed and direction is the **wavelength**. 



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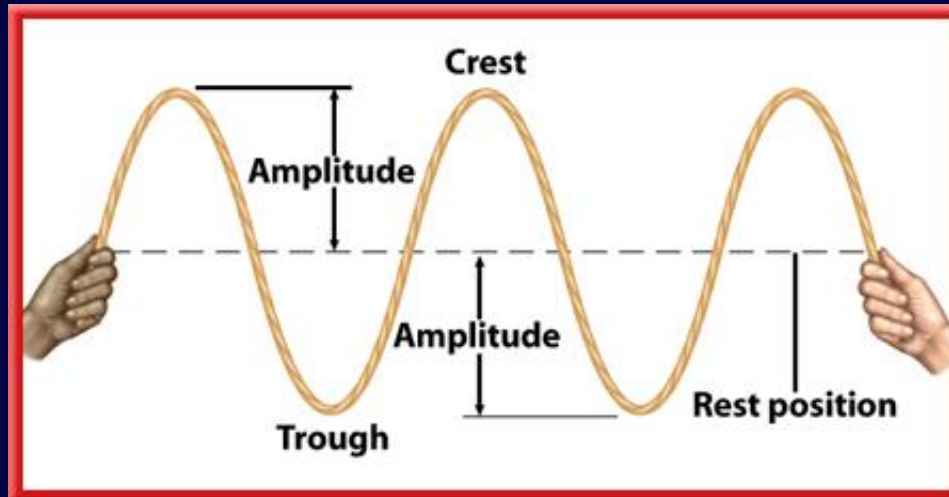
# Frequency

- The **frequency** of a wave is the number of wavelengths that pass by a point each second. 
- If you were watching a transverse wave on a rope, the frequency of the wave would be the number of crests or troughs that pass you each second. NW



## Amplitude of a Transverse Wave

- The amplitude of a transverse wave is half the distance between a crest and trough.
- As the distance between crests and troughs increases, the amplitude of a transverse wave increases.



## Amplitude and Energy

- The vibrations that produce a wave transfer energy to the wave.
- The more energy a wave carries, the larger its amplitude.
- The more energy these waves have, the larger their amplitudes and the more damage they cause as they travel along Earth's surface.





## Waves Can Change Direction

- Waves don't always travel in a straight line.
- Waves can change direction when they travel from one material to another.
- The waves can reflect (bounce off a surface), refract (change direction), or diffract (bend around an obstacle).



## The Loudness of Sound

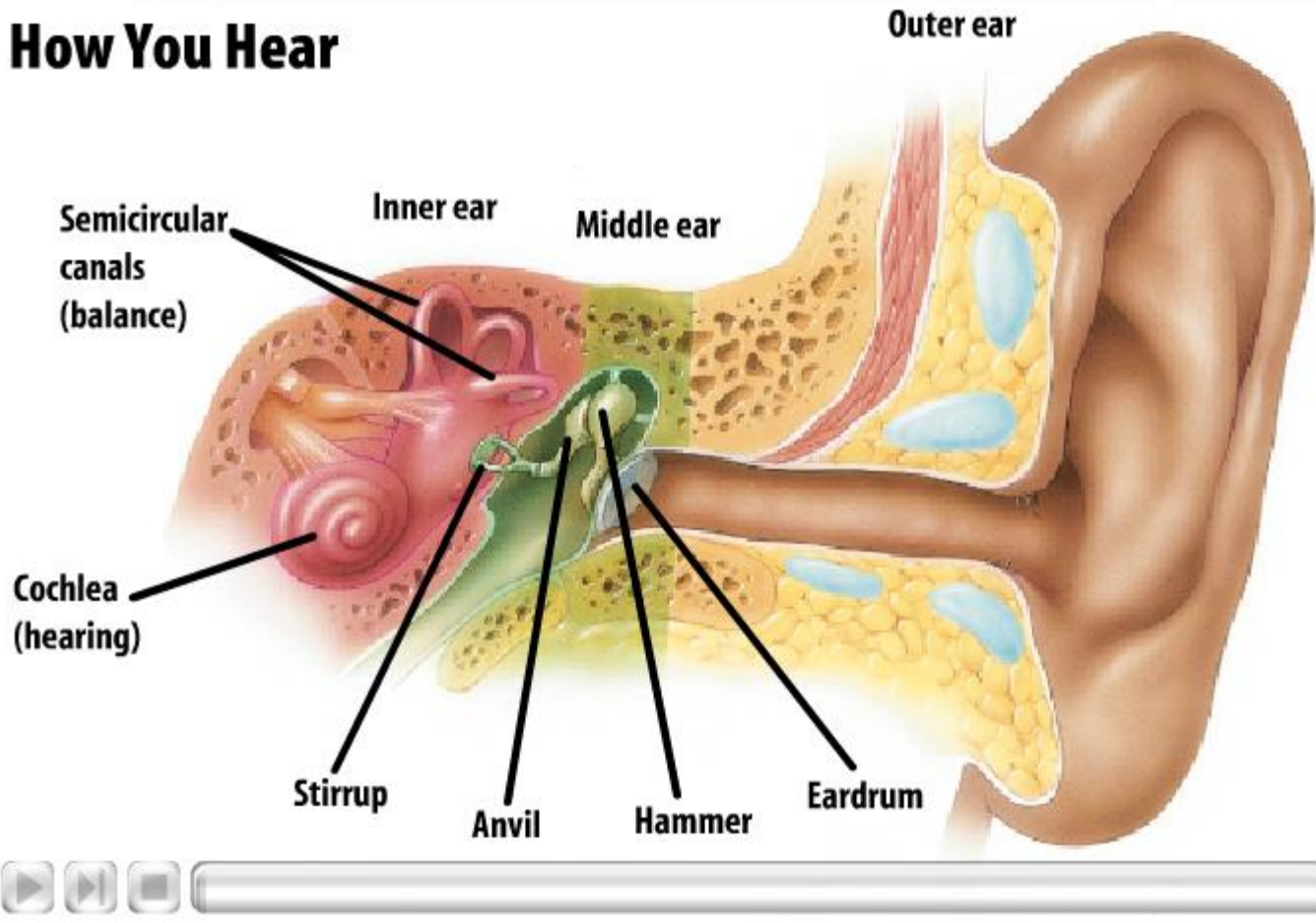
- What makes a sound loud or soft?
- The difference is the amount of energy.
- Loud sounds have more energy than soft sounds.



# Hearing and the Ear

 MAC OSX users click here to view.

## How You Hear



## Waves in Empty Space

- **Electromagnetic waves** are waves that can travel through matter or through empty space. 



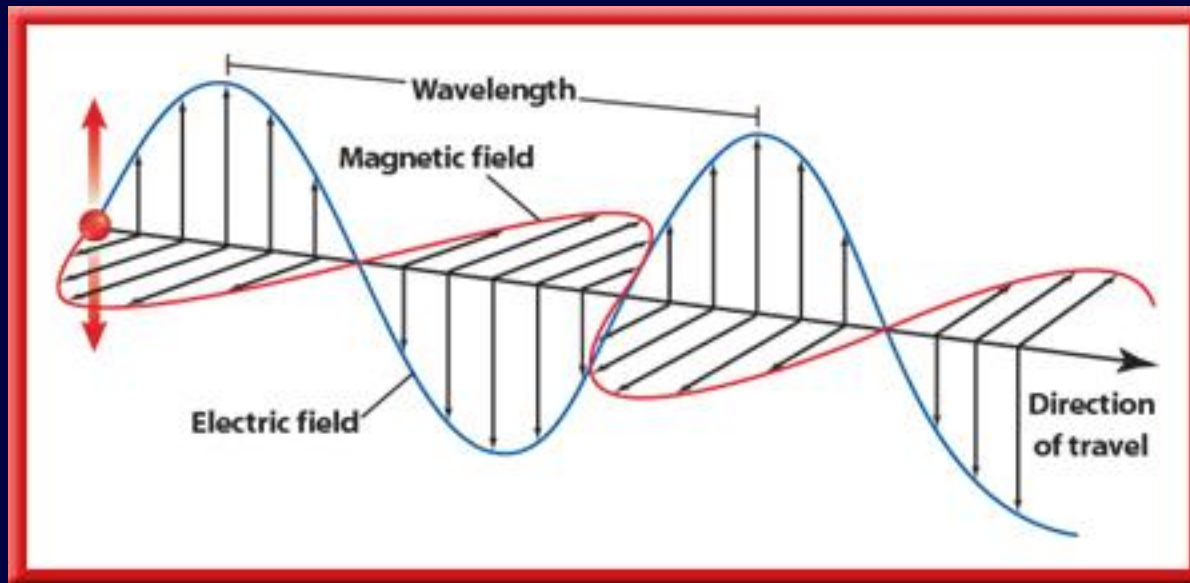
## Properties of Light Waves

- Light waves, and all electromagnetic waves, are transverse waves.
- An electromagnetic wave traveling through matter can cause matter to move at right angles to the direction the wave is moving.



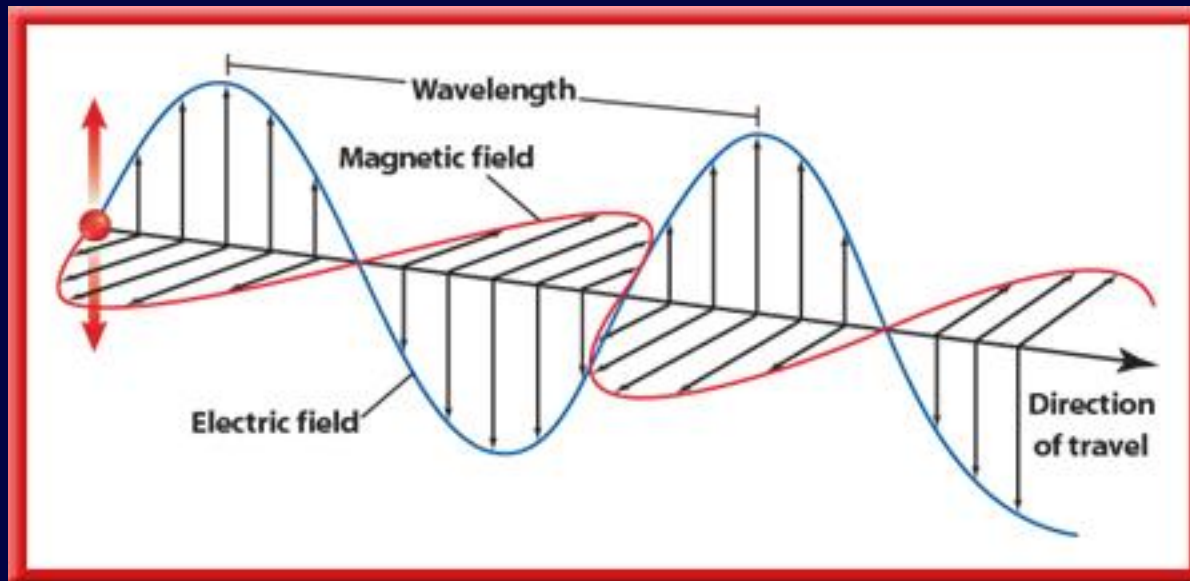
## Properties of Light Waves

- An electromagnetic wave contains an electric part and a magnetic part.
- Both parts are called fields and vibrate at right angles to the wave motion.




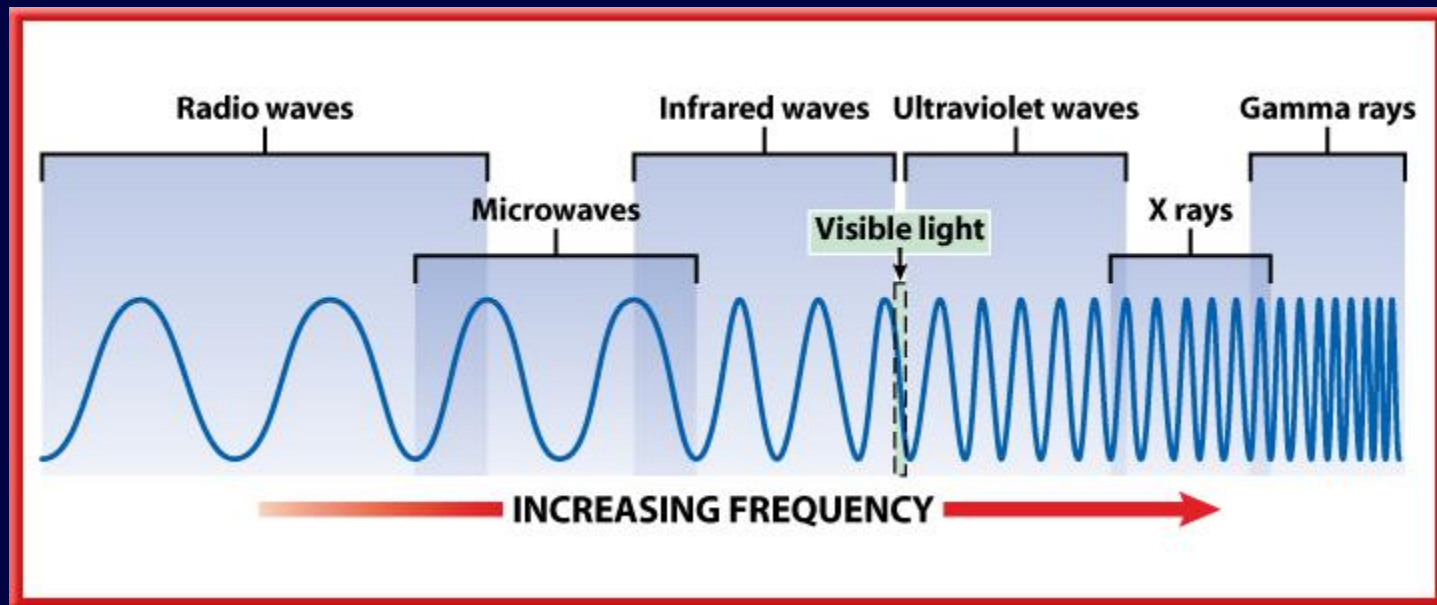
## Properties of Light Waves

- The number of times the electric and magnetic parts vibrate each second is the frequency of the wave.



## The Electromagnetic Spectrum

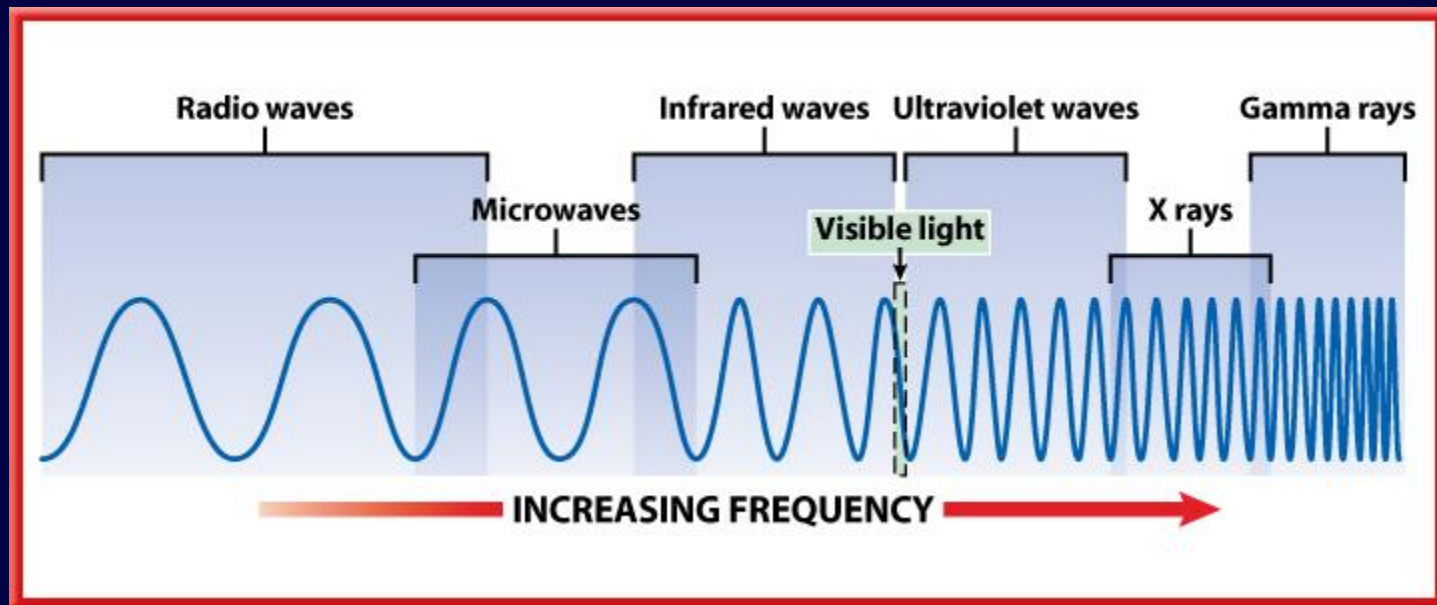
- The **electromagnetic spectrum** is the complete range of electromagnetic wave frequencies and wavelengths. 





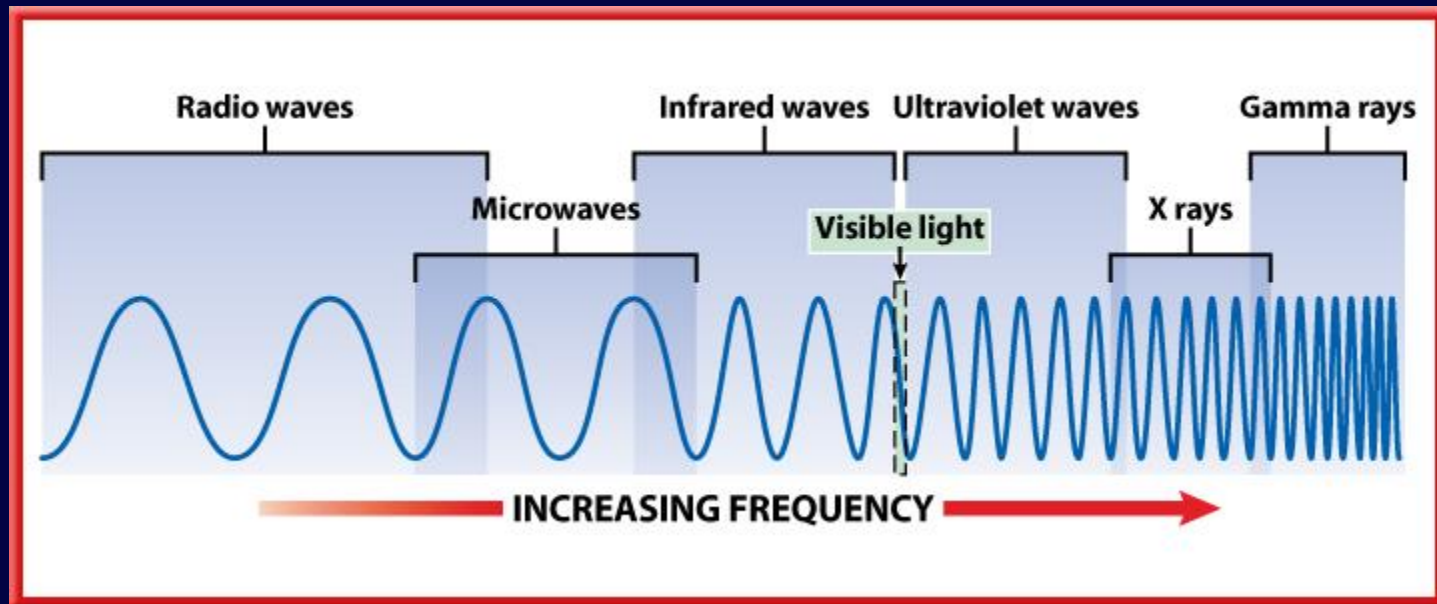
## The Electromagnetic Spectrum

- At one end of the spectrum the waves have low frequency, long wavelength, and low energy.



## The Electromagnetic Spectrum

- At the other end of the spectrum the waves have high frequency, short wavelength, and high energy.




## Radio Waves and Microwaves

- The wavelengths of radio waves are greater than about 0.3 meters.
- Some are even thousands of meters long.
- The shortest radio waves are called microwaves.
- These waves have a wavelength between about 0.3 meters and 0.001 meters.



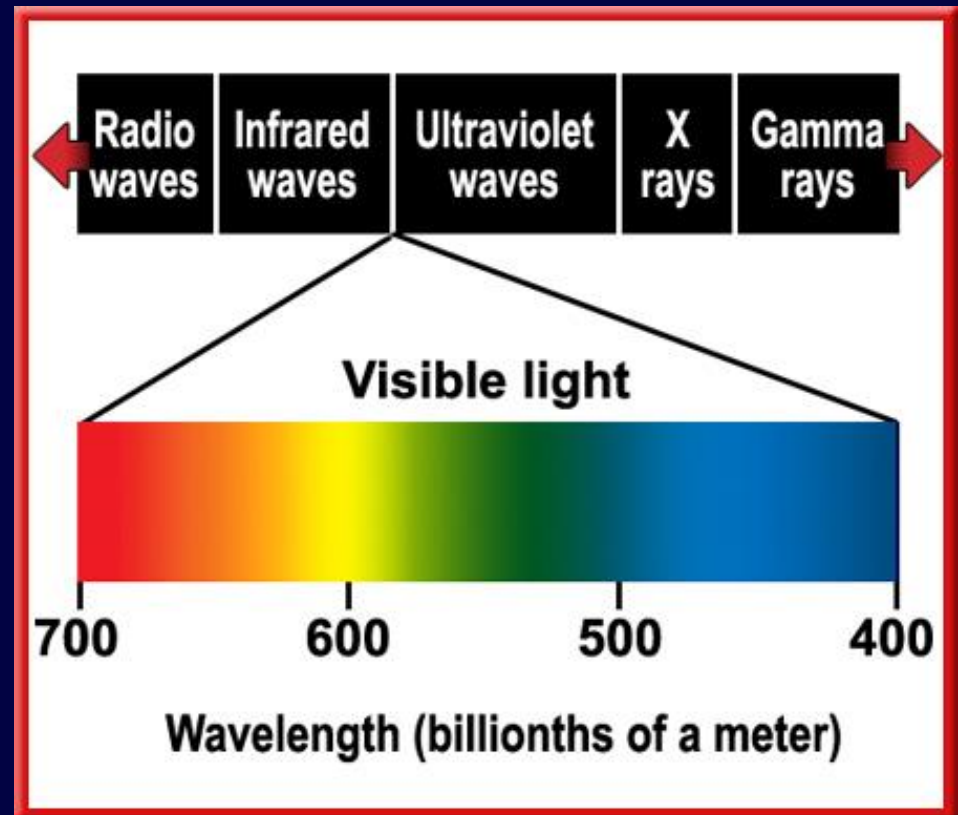
## Infrared Waves

- **Infrared waves** have wavelengths between 0.001 meters and 700 billionths of a meter. 
- All warm bodies emit infrared waves.
- Law enforcement officials and military personnel sometimes use special night goggles that are sensitive to infrared waves. These goggles can be used to help locate people in the dark.




## Visible Light and Color

- The range of electromagnetic waves between 700 and 400 billionths of a meter is the range of wavelengths people can see.



## Ultraviolet Waves

- Electromagnetic waves with wavelengths between about 400 billionths and 10 billionths of a meter are **ultraviolet waves**. 
- Ultraviolet waves carry more energy than visible light waves.
- Sunlight that reaches Earth's surface contains a small fraction of ultraviolet waves.



## X Rays and Gamma Rays



- The electromagnetic waves with the highest energy, highest frequency, and shortest wavelengths are X rays and gamma rays.
- X rays pass through soft tissues, but are blocked by denser body parts, such as bones.



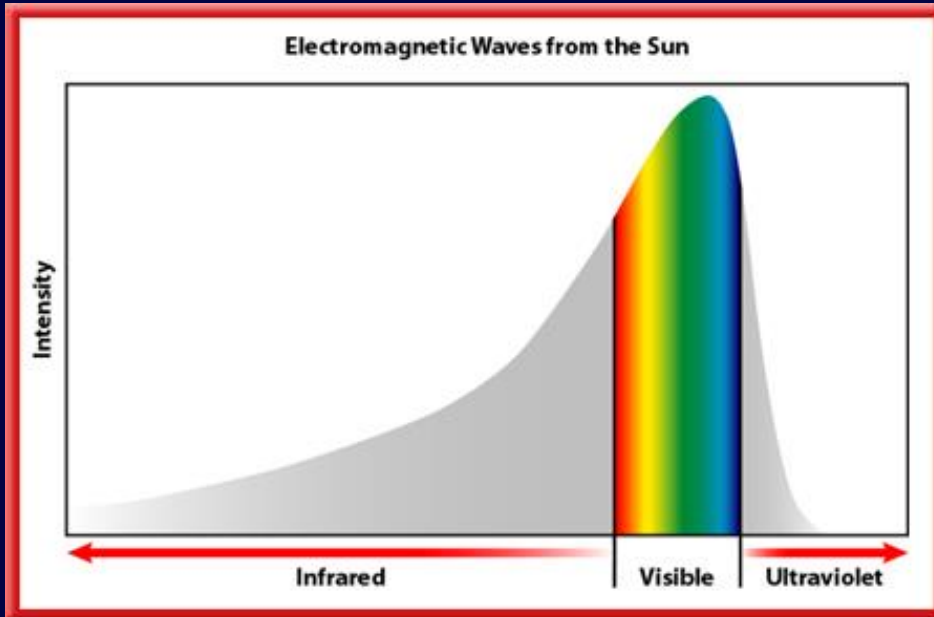
## X Rays and Gamma Rays

- Gamma rays are even more energetic than X rays.
- One use of gamma rays is in the food industry to kill bacteria that might increase the rate of spoilage of food.





## Electromagnetic Waves from the Sun

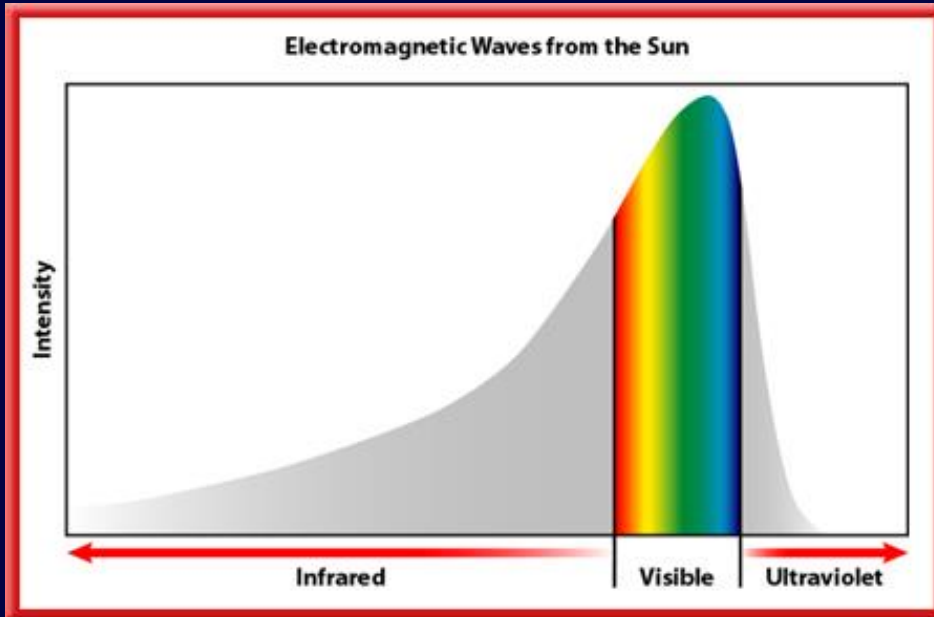


- Most of the energy emitted by the Sun is in the form of ultraviolet, visible, and infrared waves.

- Only a tiny fraction of this energy reaches Earth.



# Electromagnetic Waves from the Sun

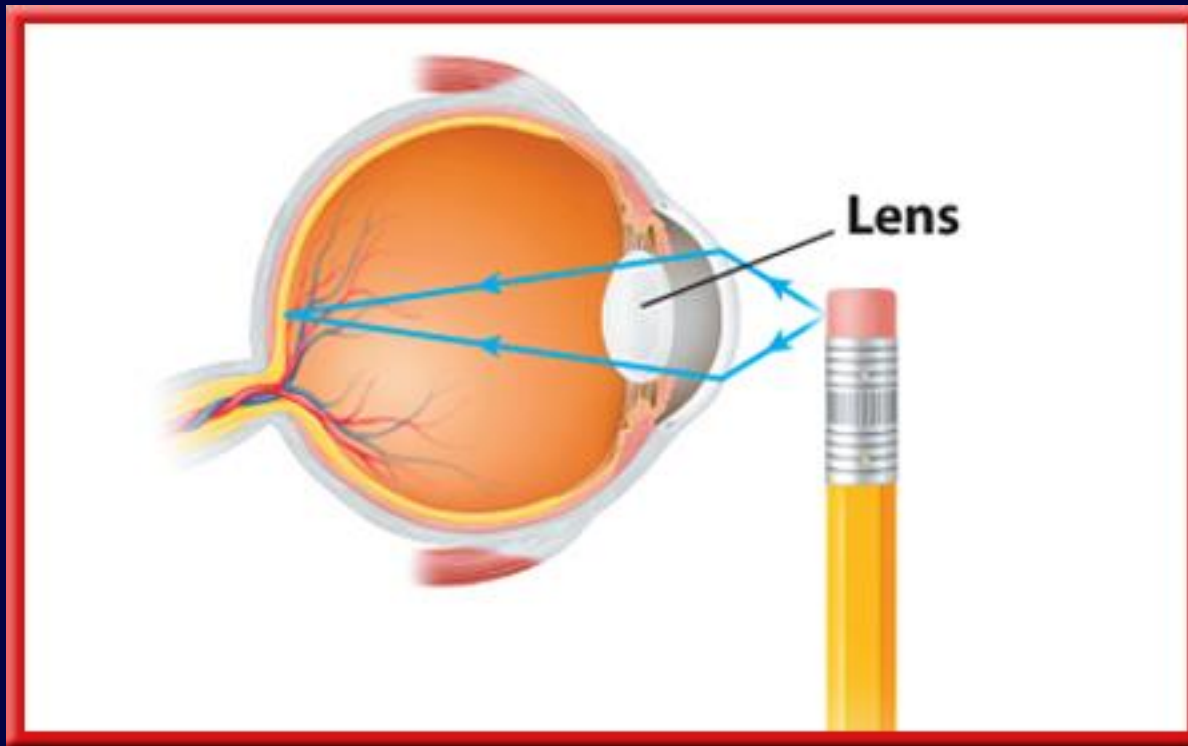


- Most of the ultraviolet waves from the Sun are blocked by Earth's atmosphere.



## The Eye of Seeing Light

- The lens becomes more curved when you focus on an object nearby.



## Why do objects have color?

- When light waves strike an object, some of the light waves are reflected.
- The wavelengths of the light waves that are reflected determine the object's color.
- For example, a red rose reflects light waves that have wavelengths in the red part of the visible spectrum.



## Rod and Cone Cells

- The retina contains over a hundred million light-sensitive cells called rods and cones.
- Rod cells are sensitive to dim light, and cone cells enable you to see colors.

