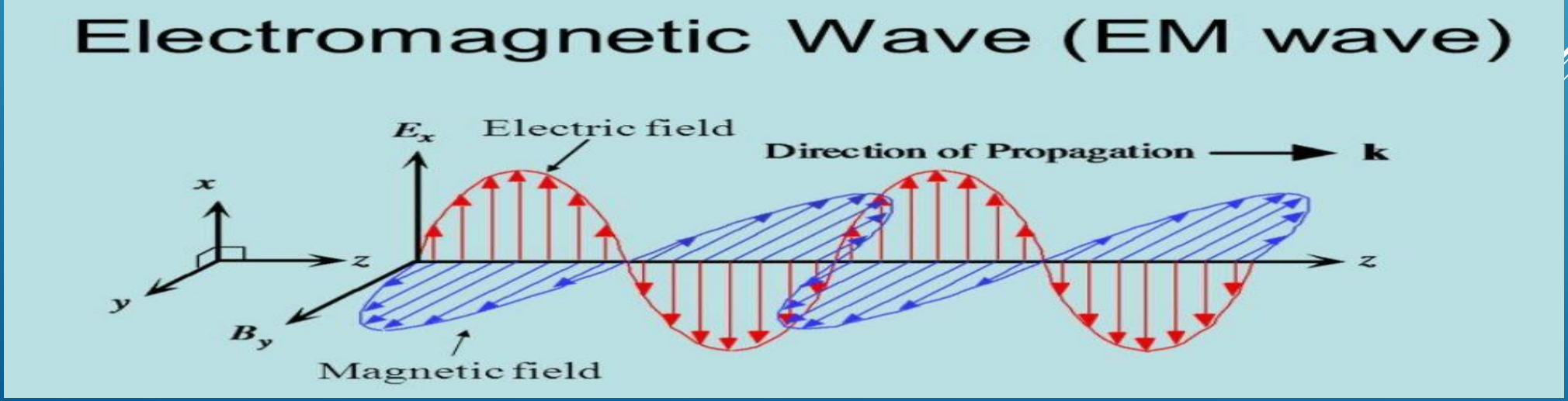
Radiation physics

Lec.2: **Electromagnetic Radiation**

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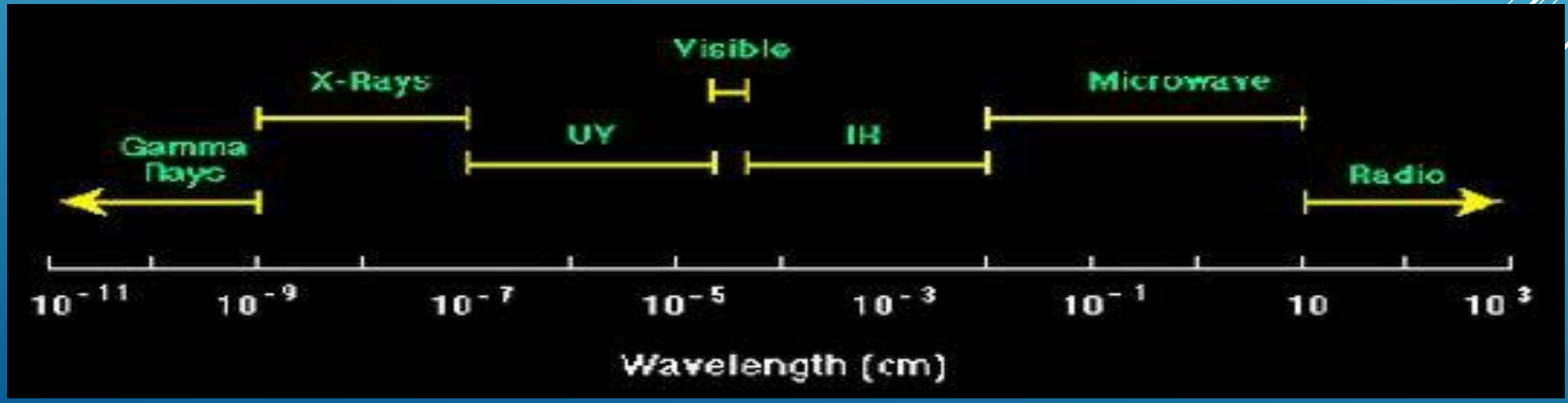
Introduction

- **Electromagnetic radiation (sometimes abbreviated EMR) is a ubiquitous phenomenon that takes the form of self-propagating waves in a vacuum or in matter.**
  It consists of electric and magnetic field components which oscillate in phase perpendicular to each other and perpendicular to the direction of energy propagation.



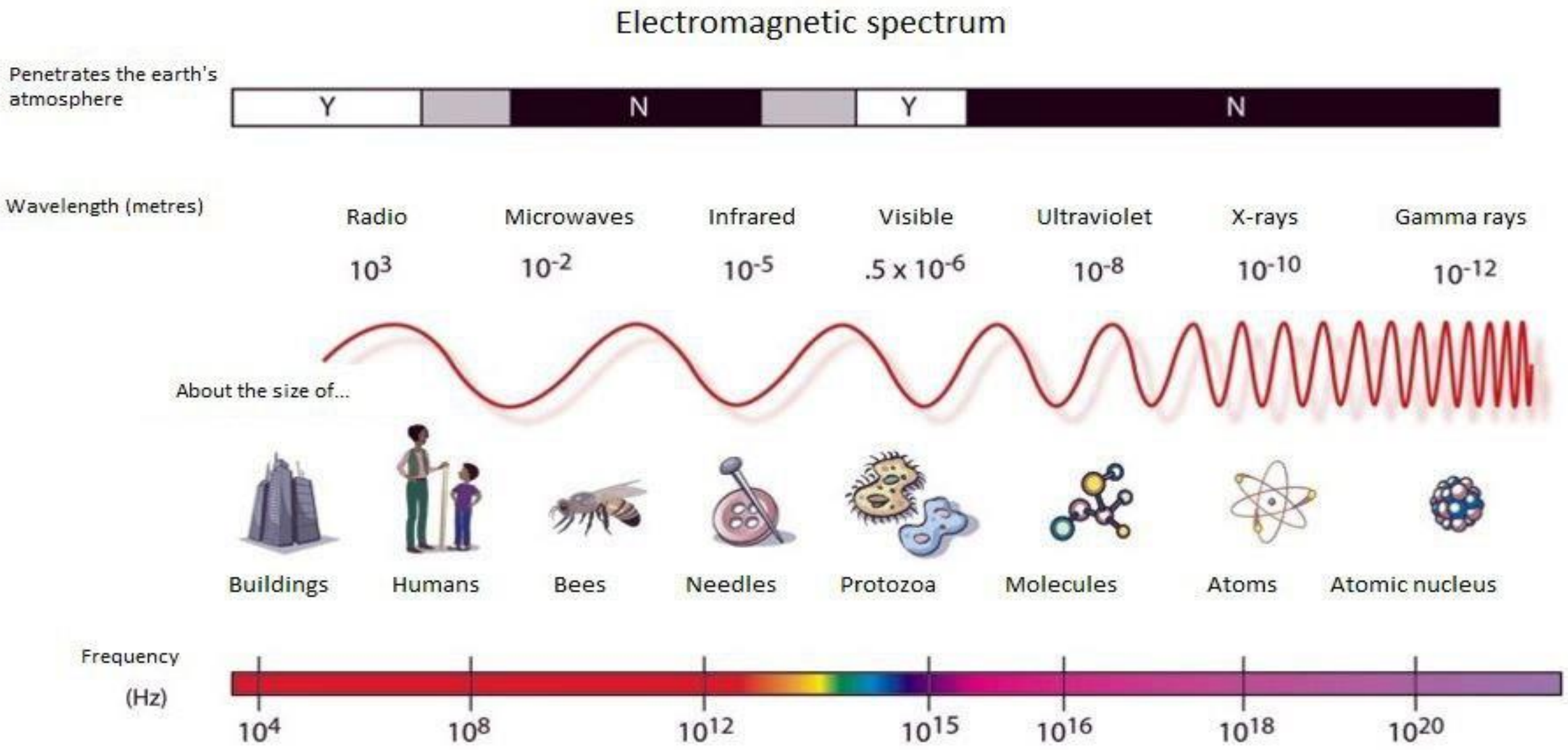
Types of Electromagnetic radiation

Electromagnetic radiation is classified into several types according to the frequency or its wave; these types include (in order of increasing frequency and decreasing wavelength): radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, X-a rays and gamma rays.



- **Radio Waves:** Used for wireless communication, including radio and television broadcasting, cell phones, and Wi-Fi.
- **Microwaves:** Microwave ovens, radar systems, satellite communication, and some wireless technologies.
- **Infrared Radiation:** Infrared is used in night vision devices, remote controls, and as a heat source in some industrial processes.
- **Visible Light:** Used for human vision, photography, and optical communication systems like fiber optics
- **Ultraviolet Radiation:** UV radiation is used in sterilization, fluorescence, and in some types of curing processes (e.g., UV curing of inks and coatings).
- **X-Rays:** Medical imaging, such as X-ray radiography and CT scans, as well as industrial inspection and material analysis.
- **Gamma Rays:** Used in medical imaging (PET scans), cancer treatment (radiotherapy), and in some industrial applications for inspecting the integrity of materials.

Electromagnetic spectrum

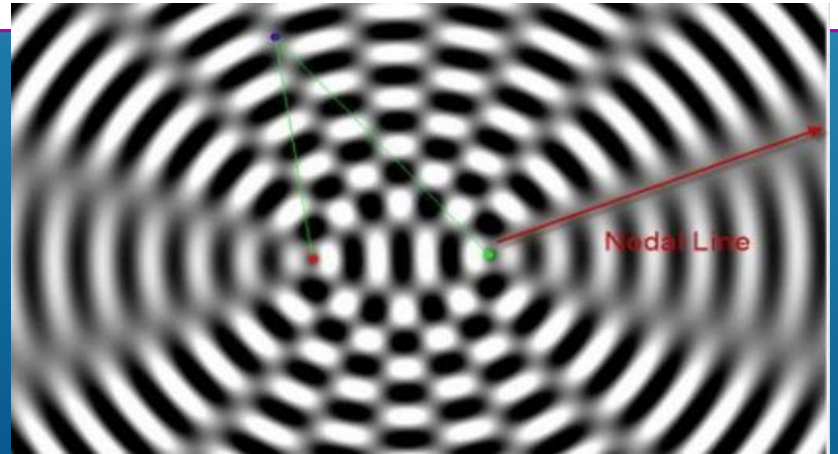


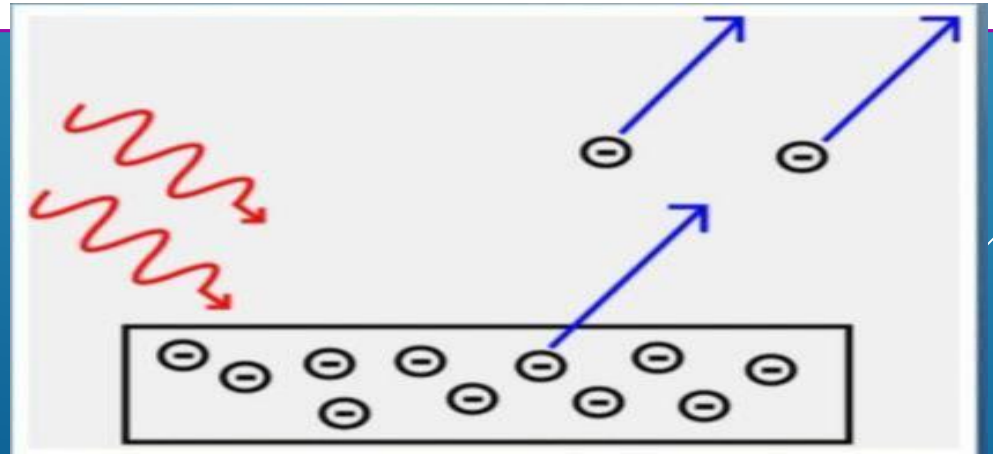
Properties of Electromagnetic radiation

- A small and somewhat variable window of frequencies is sensed by the eyes of various organisms; this is what we call the visible spectrum, or light.
- EM radiation carries energy and momentum that may be imparted to matter with which it interacts.
- Electromagnetic waves are transverse waves.
- Electromagnetic waves travel at the speed of light $c = 2.998 \times 10^{10}$

EMR WAVE-PARTICLE DUALITY

- **EM radiation exhibits both wave properties and particle properties at the same time (wave-particle duality).**
- **both wave and particle characteristics have been confirmed in a large number of experiments.**
- **In the wave aspect, the electromagnetic can exhibit interference and diffraction patterns similar to waves.**
- **In the particle aspect, particles have well-defined positions and momenta, behaving as discrete entities.**
- **Wave characteristic** **Particle characteristics**





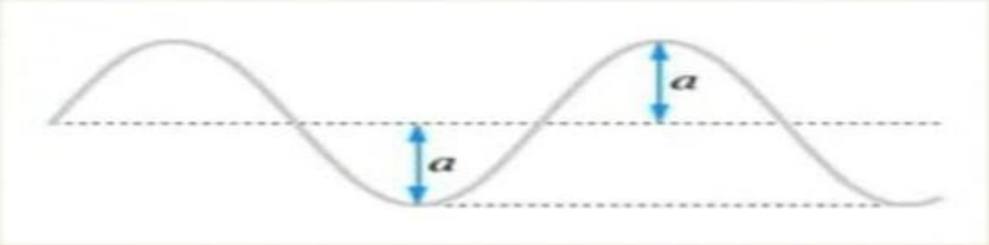
The Parameters That Characterize A Wave "Amplitude Wavelength , Wavenumber And Frequency

- **Amplitude (a): It is a measurement of the maximum vertical value of a single cycle.**

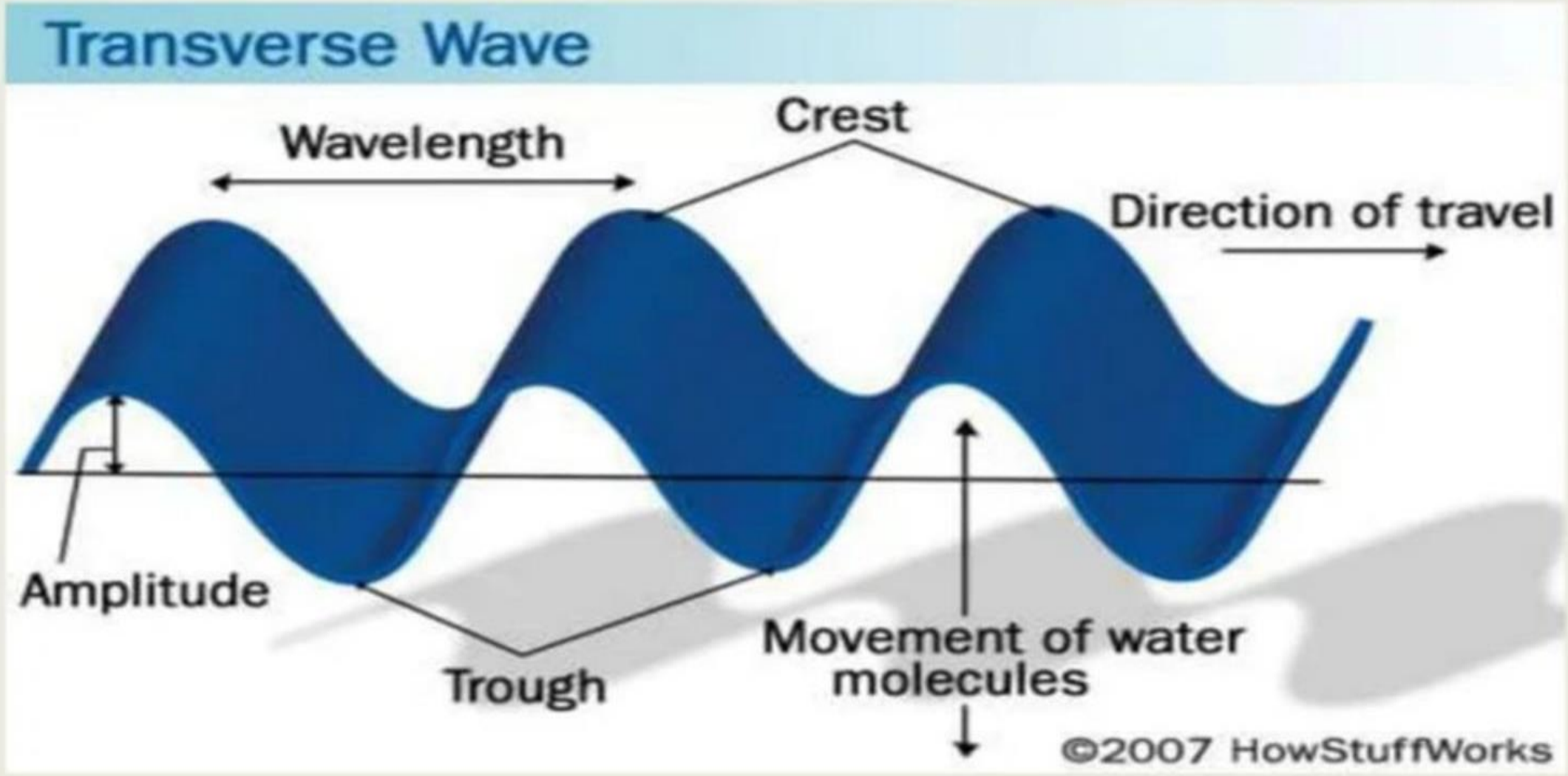
Wavelength: It is the distance between the two adjacent crests (C-C) or troughs (T-T) in a particular wave and denoted by λ (lambda). It can be expressed in Angstrom/in millimicrons (mμ).

$1\ Å = 10^{-8}\ cm;\quad 1\ m\mu = 10^{-7}\ cm$

- Crests: it is point on a wave with the greatest positive value or upward displacement in a cycle
- Trough: is inverse of crest



Electromagnetic Waves



Wave number: It is defined as the total number of waves which can pass through a space of one cm. It is the reciprocal of wavelength and is expressed in cm^{-1}.

$$\bar{\nu} = \frac{1}{\text{wave length}}$$

If the wavelength of a light is known, the corresponding wave number can be calculated. For example, if the wavelength of a radiation is 2.5 μ, then the corresponding wave number can be calculated as follows;

$\lambda = 2.5\ \mu = 2.5 \times 10^{-4}$ cm

Thus, Wave number, $\bar{\nu} = \frac{1}{\lambda \text{ in cm}} = \frac{1}{2.5 \times 10^{-4}}$

$= 4000\ cm^{-1}$

An important aspect of the nature of light is frequency.

Frequency: It is defined as the number of waves which can pass through a point in one second. It is expressed as v is cycles/sec or in Hertz (Hz) where 1 Hz = 1 cycle sec^{-1}

Frequency is inversely proportional to the wavelength, thus greater the wavelength, smaller is the frequency.

$$\text{Frequency} \propto \frac{1}{\text{Wavelength}}$$

$$\text{Frequency, } \nu = \frac{c}{\lambda}$$

Frequency continued.....

The wavelength of the visible light is 3800 -7600 Å, calculate the corresponding frequency range.

a) $\lambda = 3800$ Å

$= 3800 \times 10^{-8}$ cm

Thus,

$$\nu = \frac{c}{\lambda}$$

$$= \frac{2.998 \times 10^{10}\ cm\ sec^{-1}}{3800 \times 10^{-8}\ cm}$$

$$= 7.88 \times 10^{14}\ sec^{-1}$$

$$= 7.88 \times 10^{14}\ Hz$$

b) For $\lambda = 7600$ Å, do it by yourself