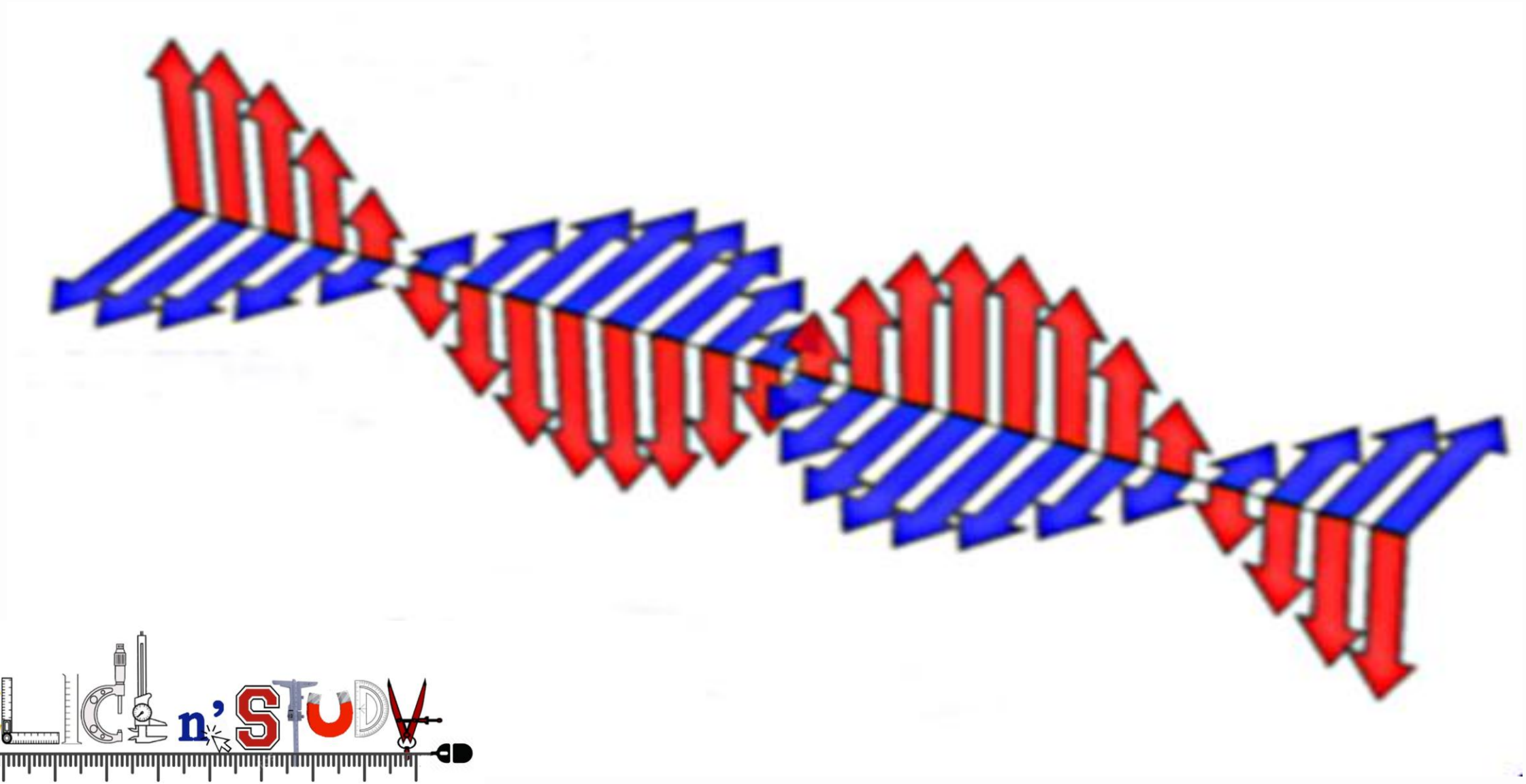
Electromagnetic Waves



Electromagnetic Waves

- Electromagnetic waves are propagated by electric field(E) and a magnetic field(B) which are oscillating at right angles to each other.

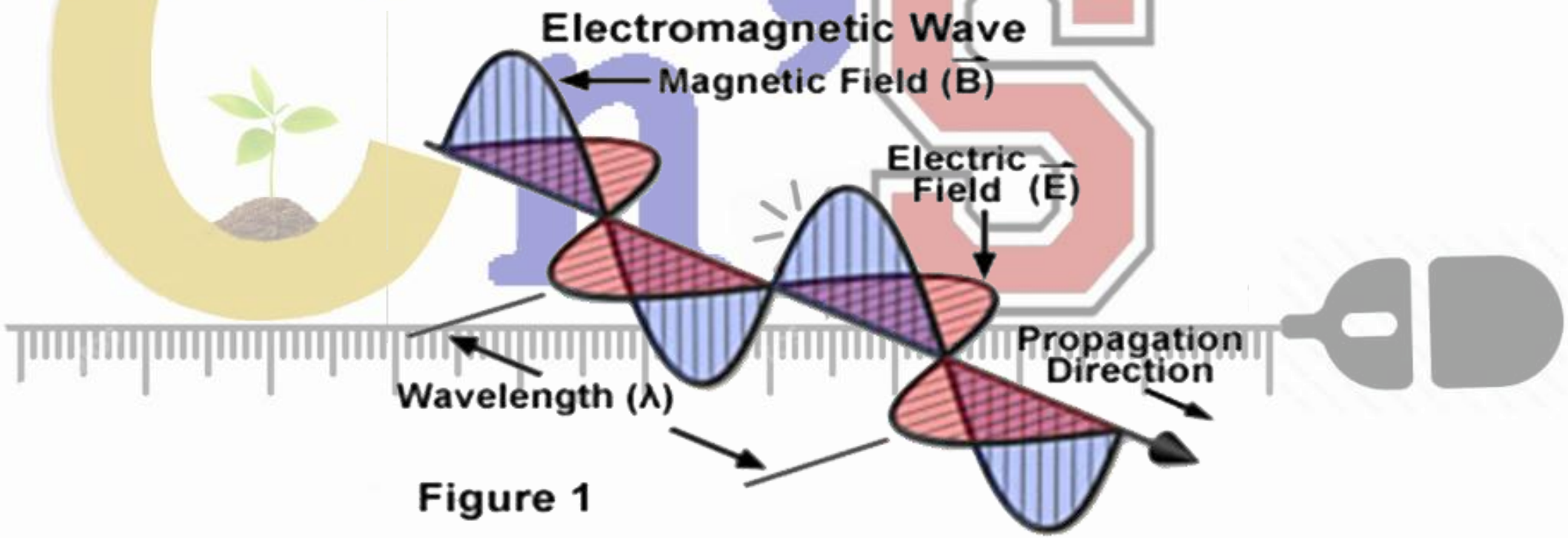
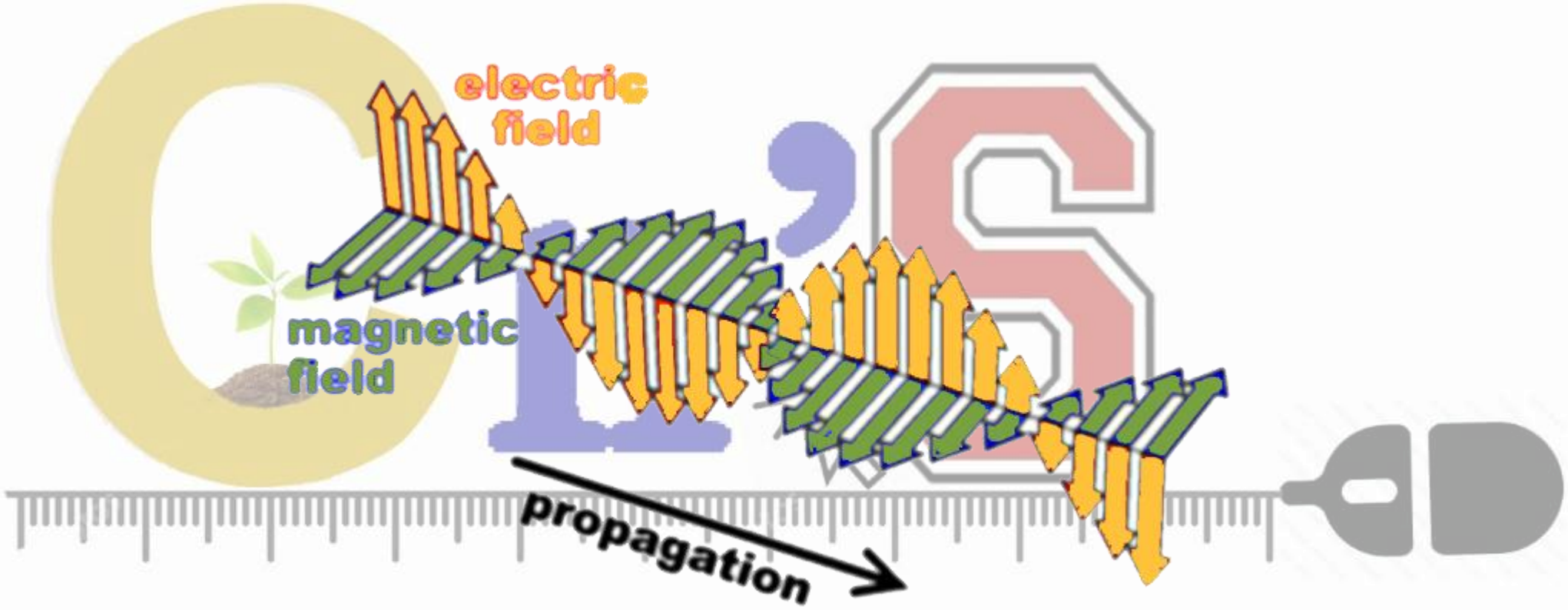


Figure 1

EMW is a Transverse Wave –i.e. Light



Electromagnetic Waves

- The ratio between the amplitudes of these oscillations is equal to the velocity of the wave. = where C is velocity of electromagnetic wave.
- Velocity of electromagnetic waves in a vaccum is 3.0×10^8 m/s-1
- A medium is not required for the propagation of electromagnetic waves.
- The velocity of electromagnetic waves will reduce when propagated through a medium.

- Experiments show that the electric field is responsible for many functions of electromagnetic waves. (Exposure to photographic films, Fluorescence etc.). Hence the plane of vibration of electromagnetic waves is accepted as the plane of vibration of electric field.(E)
- Electromagnetic waves are transverse waves since they can be confined to one plane(can be polarized) under experimental conditions.
- Vibrations can occur in all the planes according to the method of generation of electromagnetic waves.
- Plane polarized waves could be obtained by filtering through a plane polarizing filter or by using a transmitting antenna.

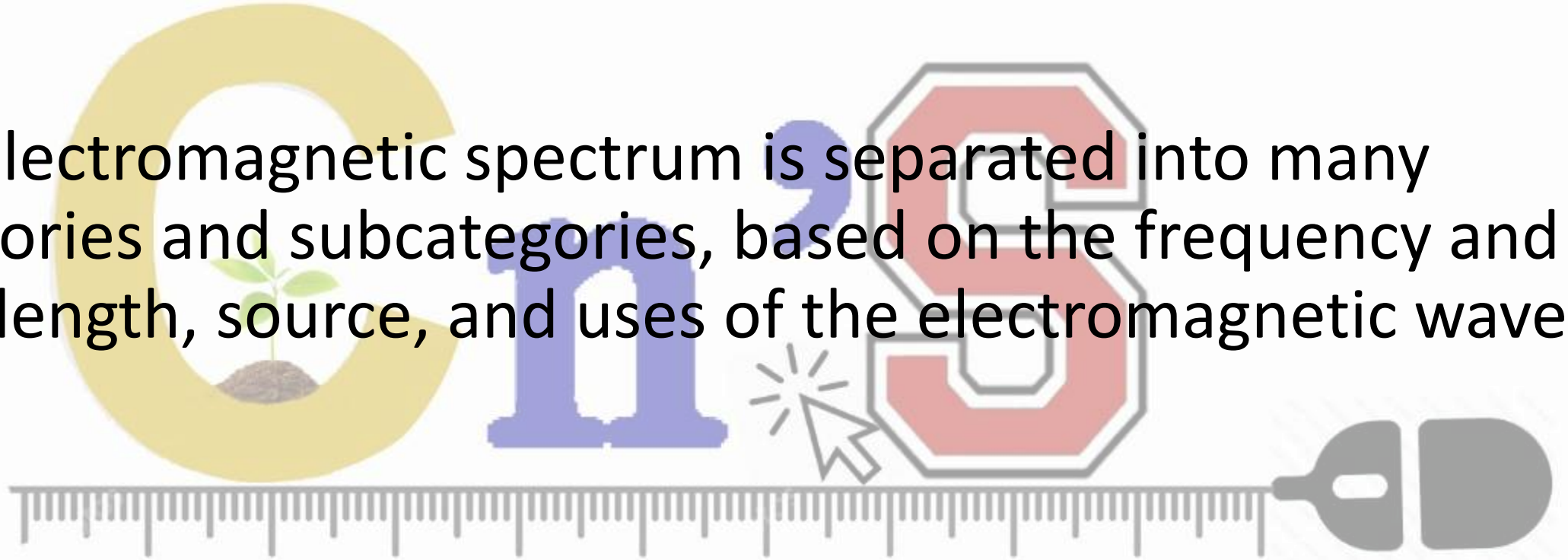
EM Wave Characteristics:

- James Clerk Maxwell, a 19th-century physicist, developed a theory that explained the relationship between electricity and magnetism and correctly predicted that the speed of electromagnetic waves is 3.0×10^8 m/s in a vacuum.
- "c" is the symbol for the speed of light in a vacuum.
- The relationship between the speed of propagation, wavelength, and frequency for any EM wave is given by **$c=f\lambda$**

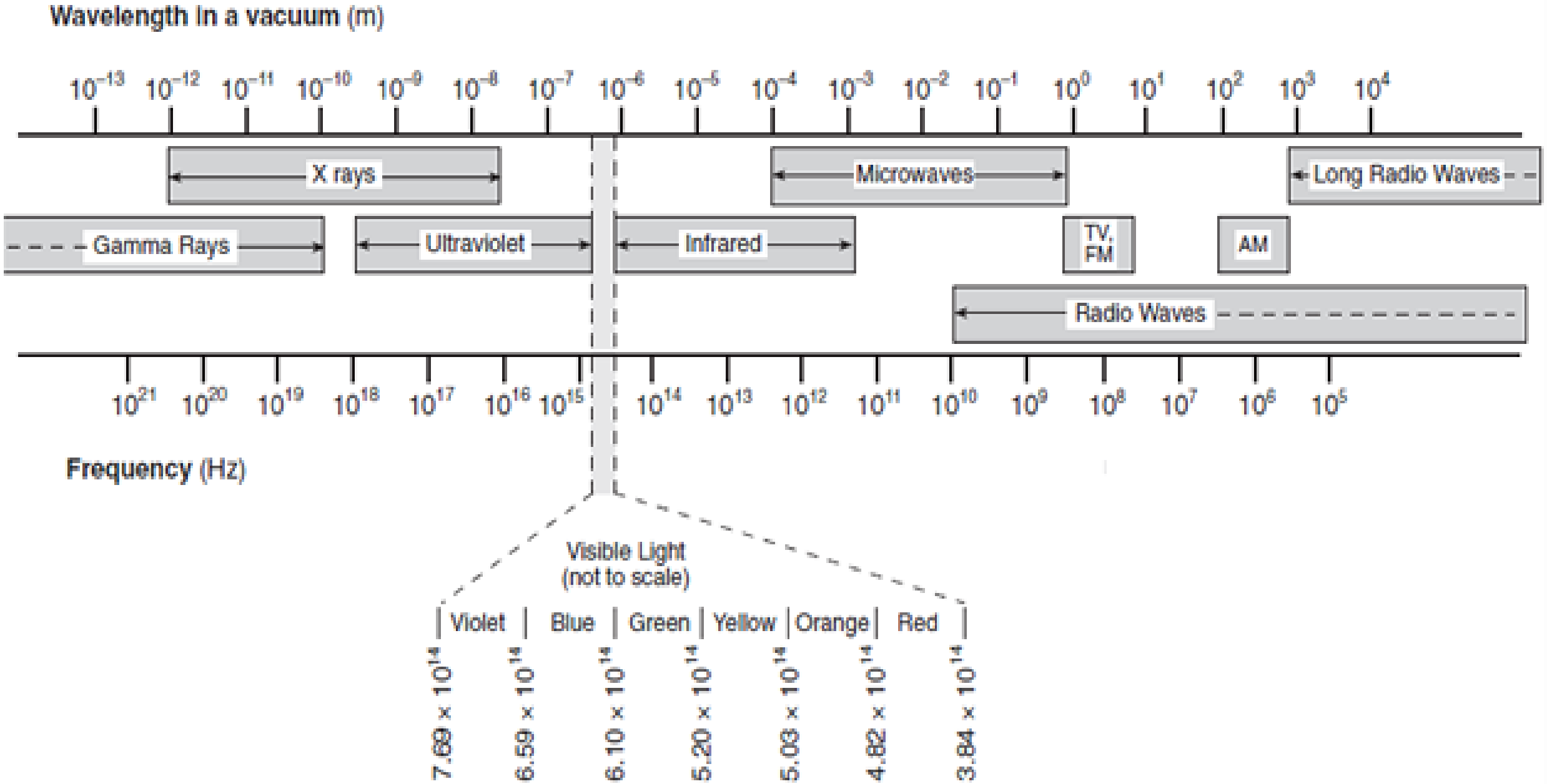
James Clerk Maxwell
(1831–1879)

The EM Spectrum

- The electromagnetic spectrum is separated into many categories and subcategories, based on the frequency and wavelength, source, and uses of the electromagnetic waves.



The EM Spectrum:



Types of EM Waves

- **Radio Waves** – The lowest frequency electromagnetic waves. Radio Waves are produced by currents in wires and are further sub-divided into additional types based on their applications.

- **Radio waves**, are the result of charges accelerating through conduction wires. They are used in radio and television communication systems.

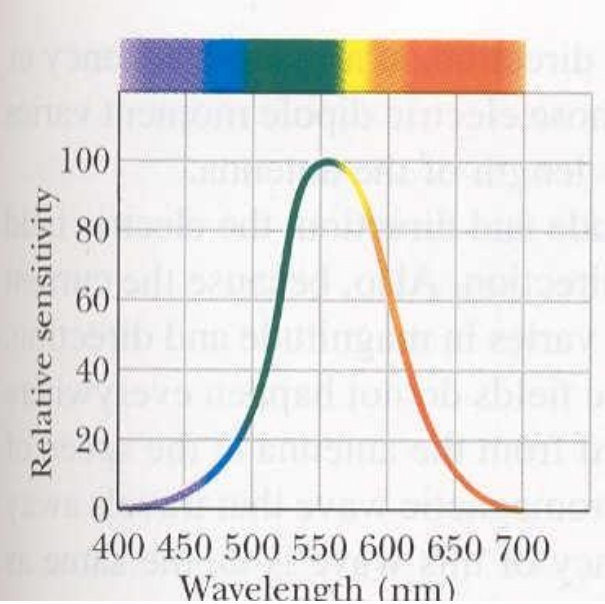
- **Microwaves** – Microwaves are produced by accelerating electrons. Microwave ovens are an interesting domestic application.Microwave ovens use the microwaves to induce an alternating electric field in the oven. Some molecules in the food (mostly water) are polarized and absorb the energy by constantly reorienting themselves to the alternating electric field.
- **Microwaves**, have wavelengths ranging between about 1 mm and 30 cm, and are generated by electronic devices. They are well suited for the radar systems used in aircraft navigation.

- **Infrared Radiation** – Produced by thermal motion and the associated motion of atoms and molecules.
- **Infrared waves** (sometimes called heat waves), produced by hot bodies and molecules, have wavelengths ranging from about 1 mm to the longest wavelength of visible light, 700 nm. They are readily absorbed by most materials. The infrared energy absorbed by a substance appears as heat. This is because the energy agitates the atoms of the object, increasing their vibrational or translational motion, and the result is a temperature rise. Physical therapy and infrared photography are some practical applications.

- **Ultraviolet Radiation** – Produced by electron transitions in atoms and molecules. Ultraviolet Radiation is above the frequency detectable by the human eye. Exposure to UV Radiation increases the chances of skin cancer. **Ultraviolet light** (UV) covers wavelengths ranging from about 400 nm to 0.6 nm. The Sun is an important source of ultraviolet light (which is the main cause of suntans). Most of the ultraviolet light from the Sun is absorbed by atoms in the upper atmosphere, or stratosphere. This is fortunate, because UV light in large quantities has harmful effects on humans. One important constituent of the stratosphere is ozone from reactions of oxygen with ultraviolet radiation. Most UV Radiation is absorbed by Ozone (O3) . This ozone shield converts lethal high-energy ultraviolet radiation to heat, which warms the stratosphere.

Visible Light

Visible light, the most familiar form of electromagnetic waves, may be defined as the part of the spectrum that is detected by a human eye. Light is produced by the rearrangement of electrons/ transitions in atoms and molecules. The wavelength of visible light are classified as colors ranging from violet, 400 nm, to red, 700 nm. The eye's sensitivity is a function of wavelength and is greatest at a wavelength of about 560 nm (yellow-green).



- **X-rays** – Produced in high-voltage discharges. Exposure to X-rays increases the chances cancer and genetic defects, but can penetrate the body deeper than just the skin. X-ray images can travel through the body and produce their images based on the density of what they pass through.
- **X-rays** are electromagnetic waves with wavelengths from about 10 nm to 0.1 pm. The most common source of x-rays is the acceleration of high-energy electrons bombarding a metal target. X-rays are used as a diagnostic tool in medicine and as a treatment for certain forms of cancer. Because x-rays damage or destroy living tissues and organisms, care must be taken to avoid unnecessary exposure and overexposure.

- **Gamma Rays** – Produced from the nucleus of an atom. The nuclear processes can range from all types of decay to nuclear reactions. Gamma rays can penetrate the body like X-rays, but are more energetic and much more hazardous.
- Gamma rays are emitted by radioactive nuclei. They are highly penetrating and cause serious damage when absorbed by living tissues. Those working near such radiation must be protected by garments containing heavily absorbing materials, such as layers of lead.