CLASSIFICATION OF RADIATION

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Outline

- **Classification of radiation**
- Particulate Radiation
- Ionizing and non-ionizing radiation
- **Electromagnetic radiation** (velocity and amplitude, frequency and wavelength)

- Alpha and Beta particles, and gamma radiation
- Decay model.

Objectives of 3rd week lecture

The student should be able to do the followings;

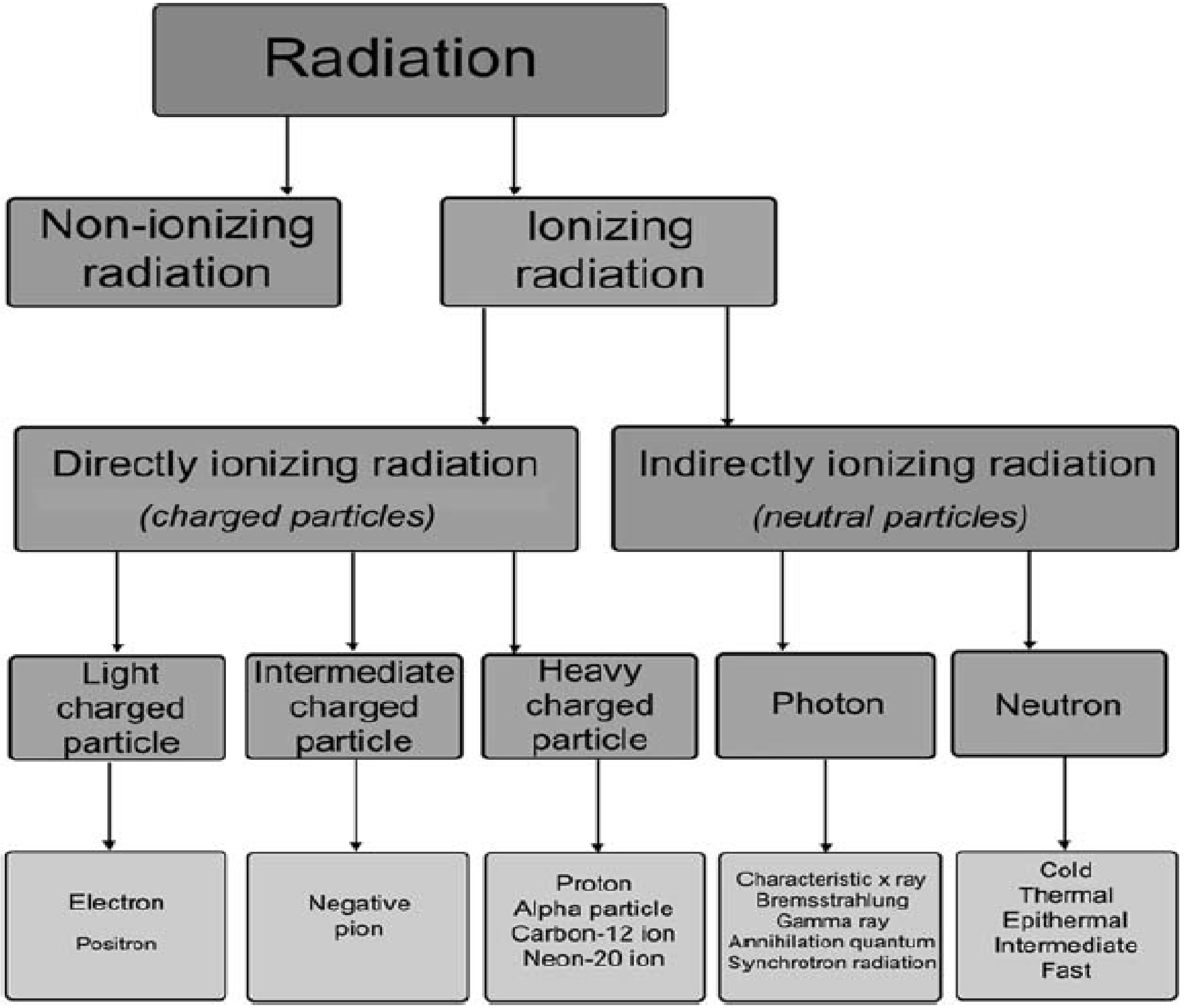
- Classify radiation
- Explain the Particulate Radiation
- Differentiate between Ionizing and non-ionizing radiation
- Explain the Electromagnetic radiation (velocity and amplitude, frequency and wavelength)
- Differentiate between Alpha, Beta particles, and gamma radiation
- Explain the decay model.

Classification of Radiation

1- ***Non-ionizing radiation*** all types of electromagnetic radiation that cannot ionize matter because it does not carry enough energy to ionize atoms.

2- ***Ionizing radiation*** can ionize matter either directly or indirectly because its energy exceeds the ionization potential of atoms and molecules of the absorber.

Notice: Ionization is the physical or chemical process of converting neutral atoms or molecules into charged particles, known as ions, by gaining or losing electron.



Particulate Radiation/ Alpha Particles

- **Radiation** is the transfer of energy.
- **Particulate ionizing radiation**: electrons, protons, and even rare nuclear fragments are in motion and possess sufficient kinetic energy. At rest, they cannot cause ionization.

- There are two main types of particulate radiation: **alpha particles** and **beta particles**. Both are associated with radioactive decay.
- **Alpha particle** is equivalent to a helium nucleus. It contains two protons and two neutrons. Its mass is approximately 4 amu, and it carries two units of positive electric charge.
- Compared with an electron, the alpha particle is large and exerts great electrostatic force.
- Alpha particles are emitted only from the nuclei of heavy elements. Light elements cannot emit alpha particles because they do not have enough excess mass (excess energy).

Particulate Radiation/ Alpha Particles

- After being emitted from a radioactive atom, the **alpha particle** travels with high velocity through matter.
  - Because of its great mass and charge, however, it easily transfers this kinetic energy to orbital electrons of other atoms.
  - The average alpha particle possesses 4 to 7 MeV of kinetic energy and ionizes approximately 40,000 atoms for every centimeter of travel through air, so, the energy of an alpha particle is quickly lost, and It has a very short range in matter.
  - In air, **alpha particles** can travel approximately **5 cm**; in soft tissue, the range may be less than **100 μm.**
  - alpha radiation from an external source is nearly harmless because the radiation energy is deposited in the superficial layers of the skin.

Particulate Radiation/ Beta Particles

- Beta particles differ from alpha particles in terms of mass and charge.
- They are light particles with an atomic mass number of 0 and carry one unit of negative or positive charge.
- The only difference between electrons and negative beta particles is their origin.
- Beta particles originate in the nuclei of radioactive atoms and electrons exist in shells outside the nuclei of all atoms.
- Positive beta particles are positrons. They have the same mass as electrons and are antimatter.
- A beta particle is an electron emitted from the nucleus of a radioactive atom.
- After being emitted from a radioisotope, beta particles traverse air, ionizing several hundred atoms per centimeter.
- The beta particle range is longer than that for the alpha particle. Depending on its energy, a beta particle may traverse 10 to 100 cm of air and approximately 1 to 2 cm of soft tissue.

Electromagnetic Radiation

- X-rays and gamma rays are forms of electromagnetic ionizing radiation.
- X-rays and gamma rays are often called **photons**.
- Photons have no mass and no charge. They travel at the speed of light ($c = 3 \times 10^8$ m/s) and are considered energy disturbances in space.
- The difference between x-rays and gamma rays is their origin. Gamma rays are emitted from the nucleus of a radioisotope and are usually associated with alpha or beta emission. X-rays are produced outside the nucleus in the electron shells.
- Gamma rays come from the nucleus. X-rays come from the electron cloud.
- The ionization rate in air of approximately 100 ion pairs/cm, about equal to that for beta particles. But x-rays and gamma rays have an unlimited range in matter.
- Photon radiation loses intensity with distance but theoretically never reaches zero.

Electromagnetic Radiation

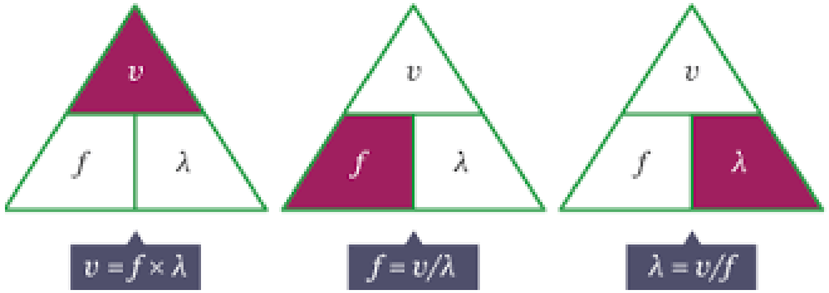
- Particulate radiation has a range in matter, and that range depends on the particle's energy.
- In nuclear medicine, beta and gamma radiation are most important. In radiography, only x-rays are important.
- The penetrability and low ionization rate of x-rays make them particularly useful for medical imaging

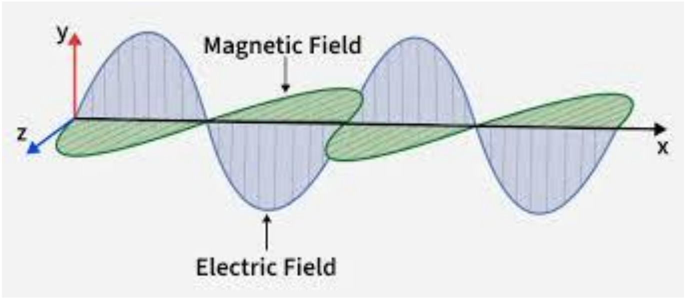
		APPROXIMATE RANGE		
Type of Radiation	**Approximate Energy**	**In Air**	**In Soft Tissue**	**Origin**
PARTICULATE				
Alpha particles	4–7 MeV	1–10 cm	≤0.1 mm	Heavy radioactive nuclei
Beta particles	0–7 MeV	0–10 m	0–2 cm	Radioactive nuclei
ELECTROMAGNETIC				
X-rays	0–25 MeV	0–100 m	0–30 cm	Electron cloud
Gamma rays	0–5 MeV	0–100 m	0–30 cm	Radioactive nuclei

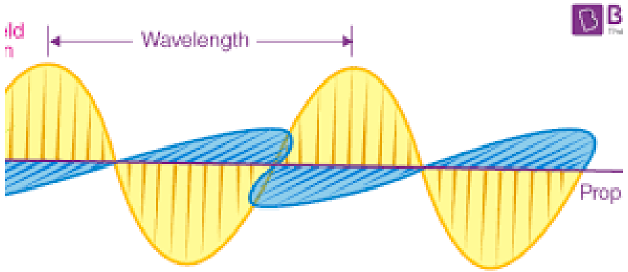
Electromagnetic Radiation / examples

- Find the wavelength of electromagnetic radiation with 100 Hz frequency.

- Find the frequency of electromagnetic radiation if its wavelength is 2 m.

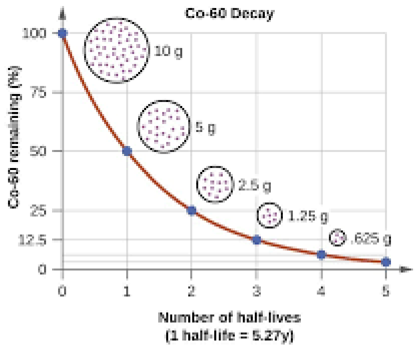






The radiation decay model

- The radiation decay model (or radioactive decay law) describes how an unstable isotope decreases in quantity over time by emitting radiation, following an exponential process.
- Activity (A): The number of decays per second, measured in Becquerels (Bq). Activity also follows the exponential decay law: $A(t) = A_0 \times e^{-\lambda . t}$
- Half-Life ($t_{1/2}$): The time required for half of the radioactive atoms in a sample to decay.
- Example: a sample of 256 radioactive atoms, find the remaining after 5 half lives (5 $t_{1/2}$).



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