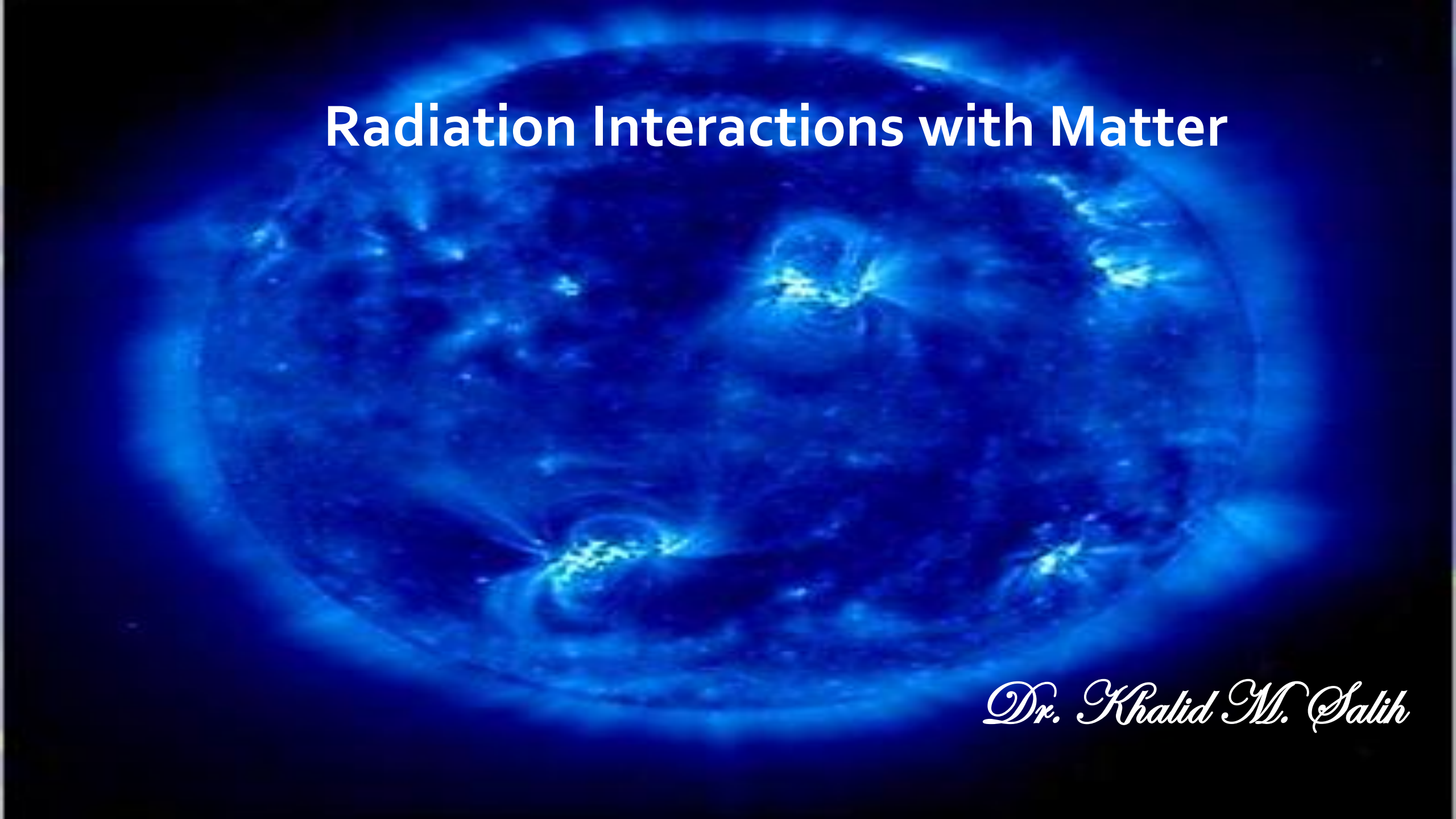
Radiation Interactions with Matter



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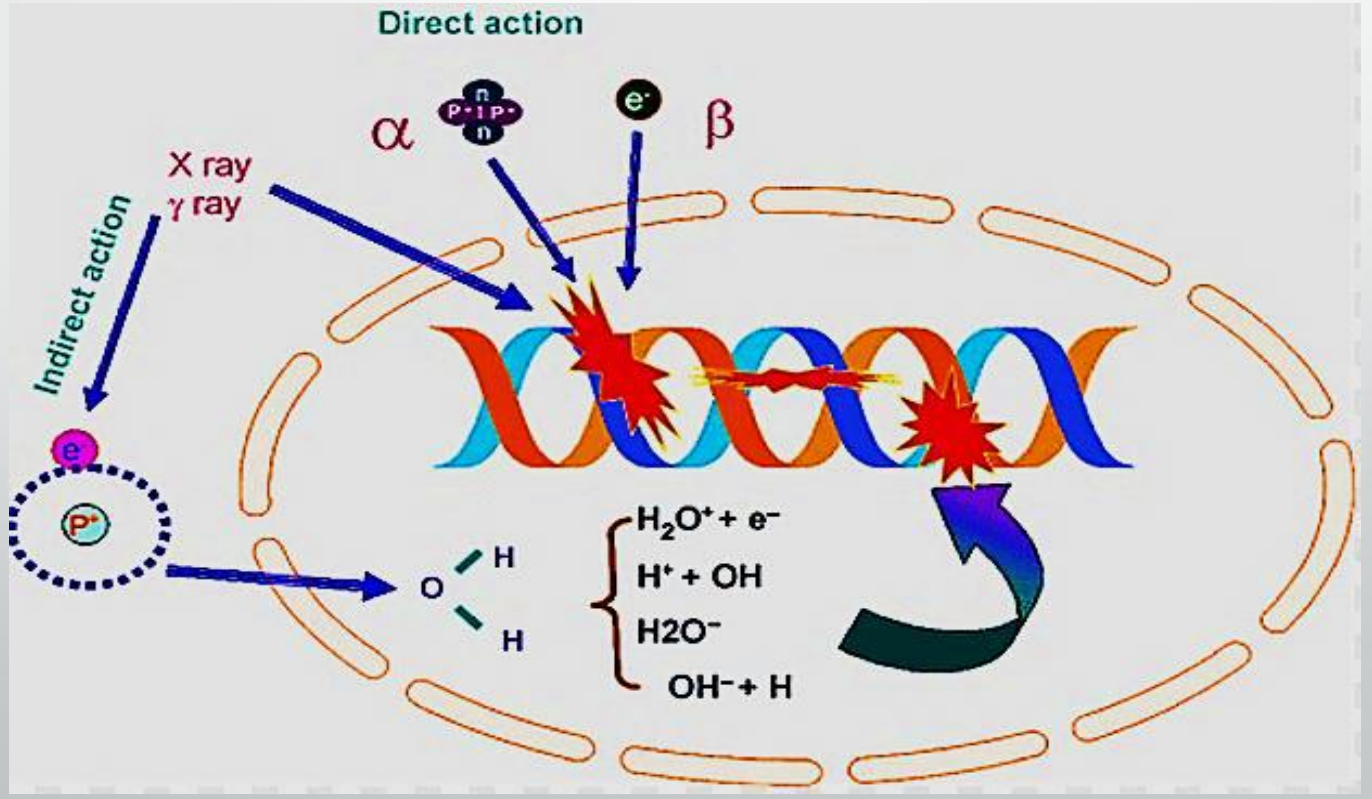
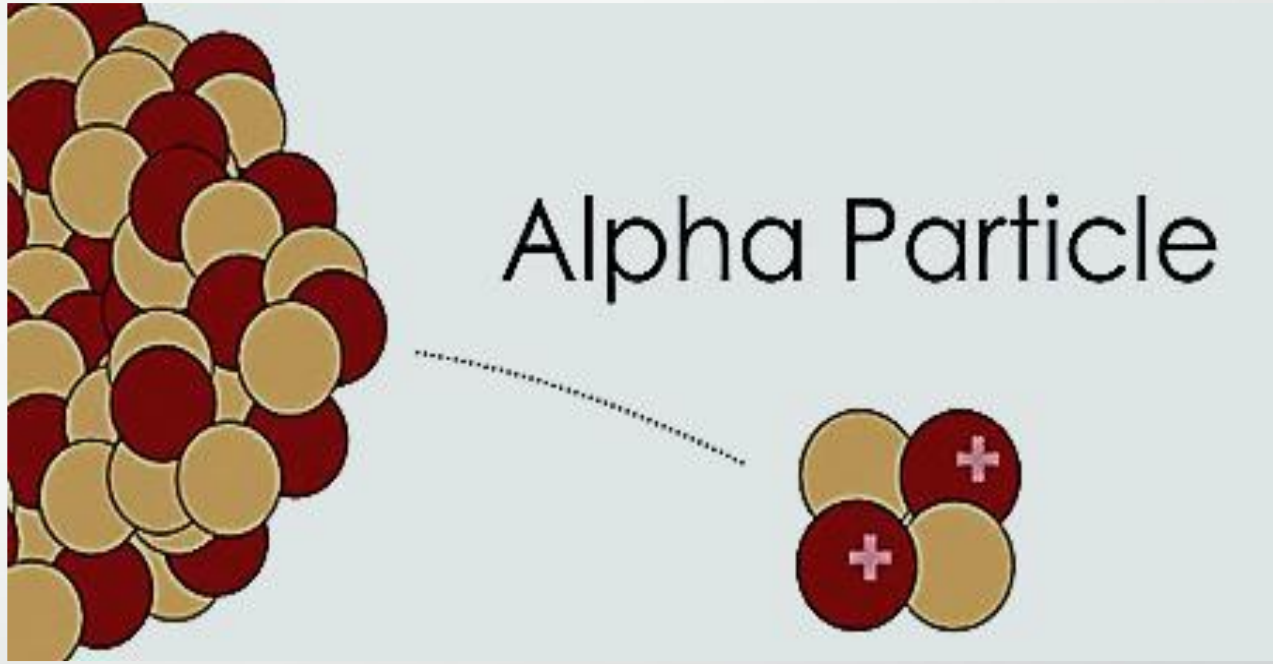
Types of Interaction

- **Direct interaction:** ***particulate radiation*** (α, and β particles) are directly ionizing and disrupt the atomic structure of absorbing matter.
- **Indirect interaction:** ***electromagnetic radiation*** (X, and γ rays) produce secondary electrons (charged particles) after energy absorption in matter.

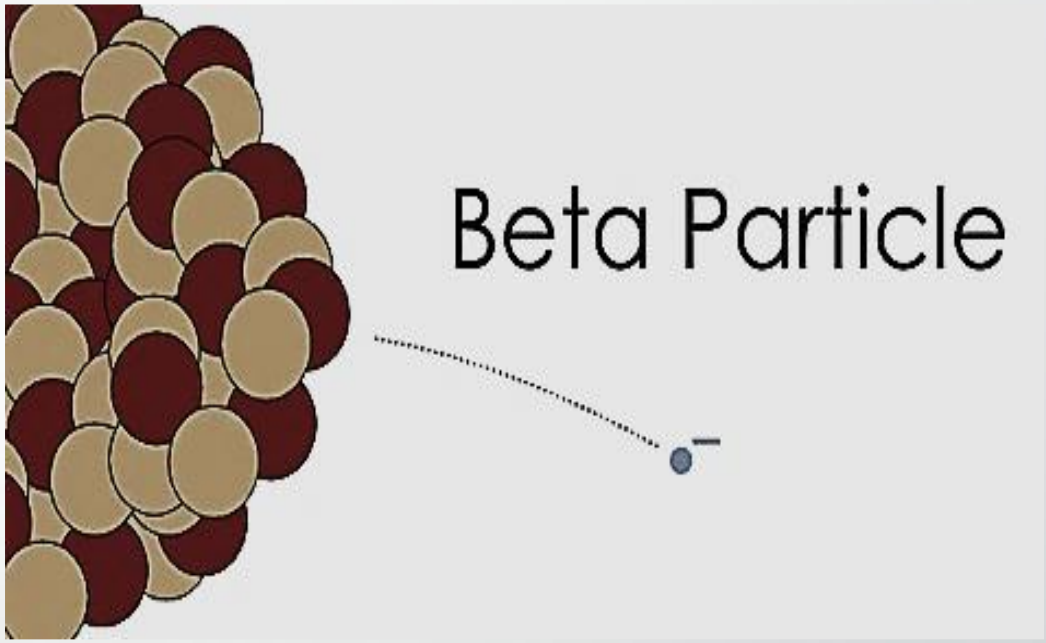


Alpha (α) particles

- Positively charged
- Higher mass particles (2P + 2 N)
- Lower velocity
- Highly ionizing
- Quickly losing their energy
- Weakly penetrate in body tissue
- Stopped and fully absorbed by low density material with a thickness of few millimeters such as paper, and clothes.

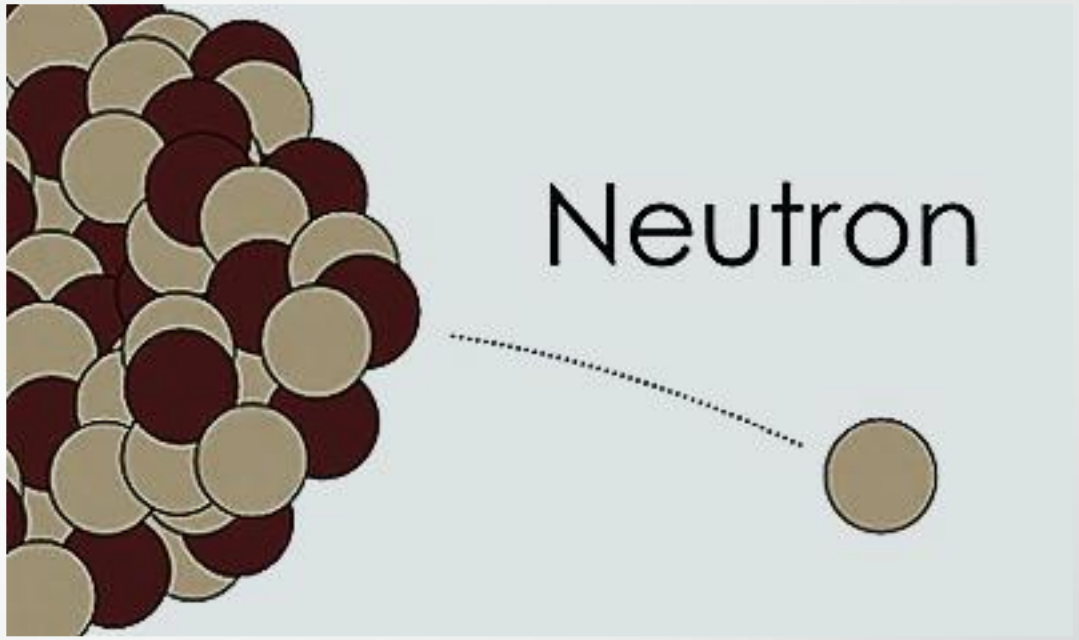


Beta (β) particles



- Lower mass with a single negative charge
- Less energetic
- Higher velocity than alpha particles
- Penetrate tissues to a greater depth (skin)
- Stopped by plastic material (few centimeters) or metal material (few millimeters).

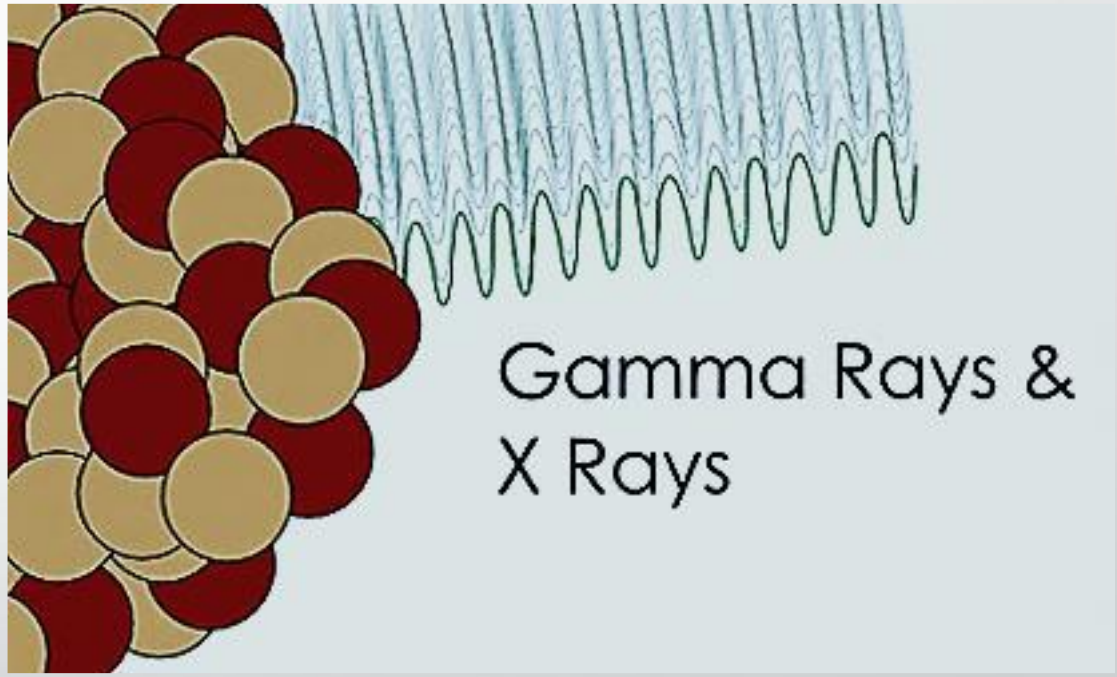
Neutrons



- Uncharged (neutral)
- More penetrated than charged particles
- Produce ionizing of matter indirectly via secondary events.
- Travel great distances in air (100s to even 1000s meters), and several meters in solid matters
- Stopped only with hydrogen rich shielding such as concrete or water.

Electromagnetic radiation (X, and γ rays)

- Gamma ray originate from nucleus
- X-ray originate from electron cloud of atom.
- Both are photons (massless & uncharged)
- Progress at the speed of light
- Deeply penetrate further than alpha & beta
- Stopped by dense metal, concrete, or earth.
- Indirectly ionizing



Sources of Radiation

A. Natural Sources

1. *Cosmic radiation*
2. *Terrestrial radiation*
3. *Internal Source*

B. Man - made Sources

1. *Public exposure*
2. *Occupational exposure*

Natural Source: *Cosmic radiation*

- Charged particles from the sun and stars interact with the earth's atmosphere and magnetic field to produce a shower of cosmic radiation consists of ***positively charged particles***, as well as ***gamma radiation***.
- The exposure of an individual to cosmic rays is greater at higher elevations than at sea level because at higher elevations the amount of atmosphere shielding decreases and thus the dose of cosmic rays increases.

Natural Source: *Terrestrial radiation*

- Ground, rocks, building materials and drinking water contained many radioactive materials such as ***radium***, ***uranium*** and ***thorium*** which are ingested with food and water.
- ***Radon gas*** is originated from the decay of natural uranium in soil, and when it is inhaled by human emits ***alpha radiation*** that cause ***lung cancer***.
- The dose from terrestrial sources also varies in different parts of the world according to the concentrations of uranium and thorium in their soil.

Natural Source: *Internal radiation*

- We have various radioactive isotopes inside our bodies from birth such as:

  1. potassium-40

  2. tritium (3H)

  3. carbon-14

  4. lead-210

- The variation in dose from one person to another is not as great as the variation in dose from cosmic and terrestrial sources.

Man - made Source: *Public exposure*

The majority of people may exposed to radiation for one or several times during their life from the following sources:

a) Medical X-ray for diagnosis (chest X-ray)

b) Nuclear medicine for therapy (iodine -131, Technetium - 99, Cobalt-60, and Cesium-137)

c) Consumer products (tobacco, fuels (gas, coal), ophthalmic glass, televisions, airport X-ray systems, smoke detectors, building & road construction materials, etc.).

d) Residual fallout from nuclear weapons testing, shipment, and accidents.

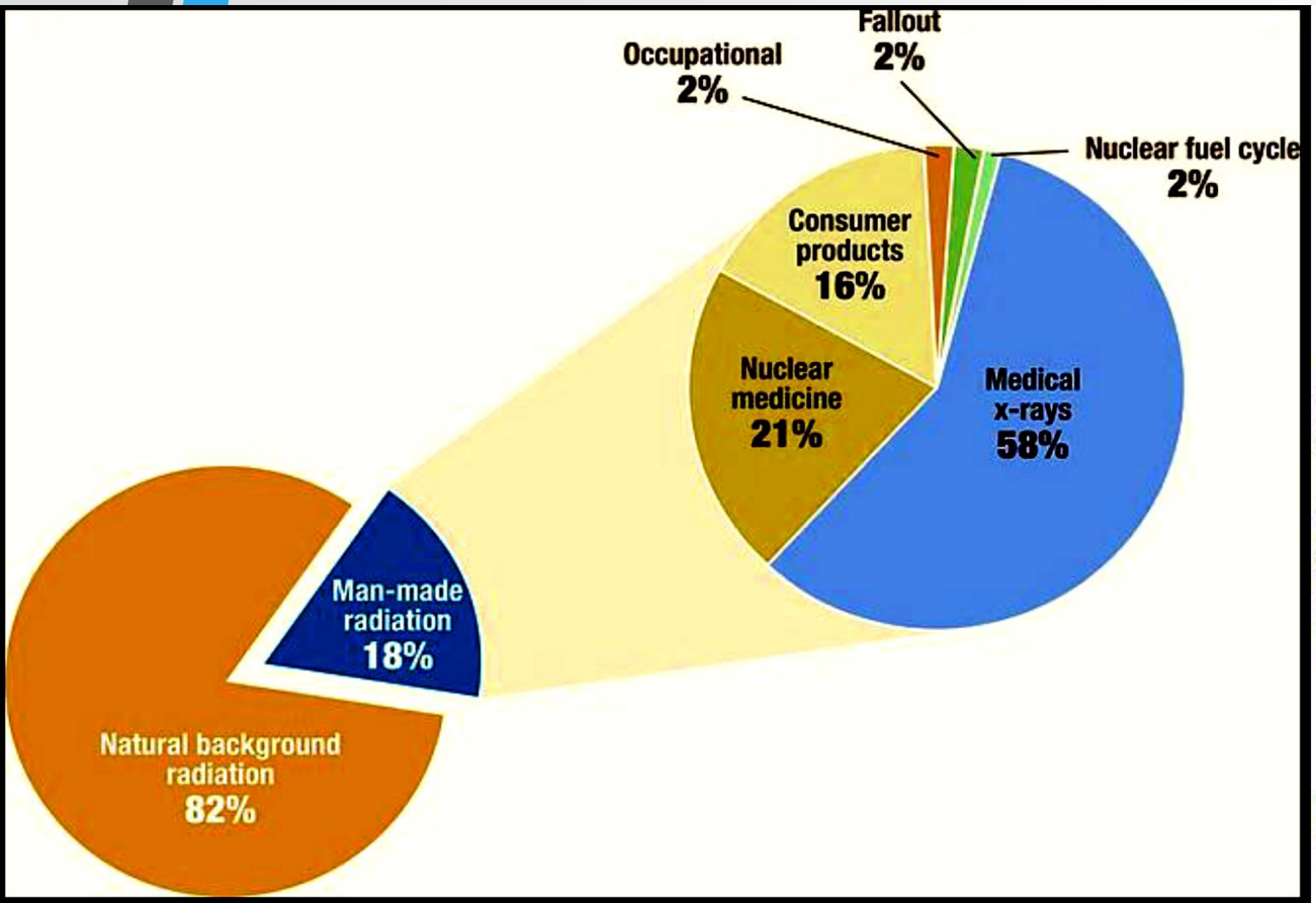
Man - made Source: *Occupational exposure*

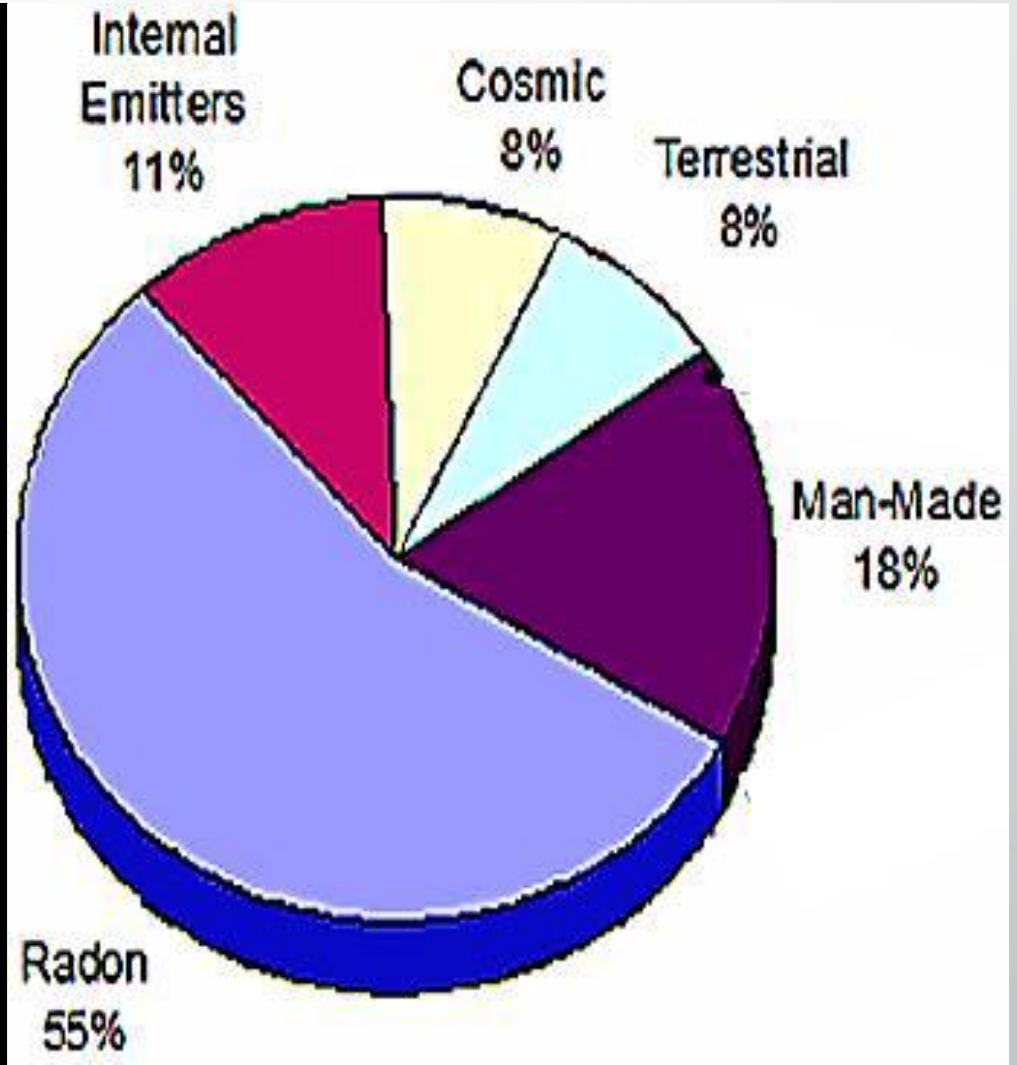
- Some workers are exposed to artificial sources of radiation commonly used in the manufacturing and service industries such as:

  1. ***Nuclear fuel cycle at a nuclear plant***
  2. ***X-ray machines***
  3. ***Radiography***

The average annual radiation dose from:

- **Natural sources** (*Radon, Internal, Terrestrial, Cosmic*) **(82%)**
- **Man-made** (*Medical X-ray, Nuclear Medicine, Consumer Products*) **(18%)**





Types of Radiation Units & Doses

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Types of Radiation Units

1. Measurement of Decay Rate

- The amount of radioactive material in a given object contains unstable atoms which are continuously decaying, so the more unstable atoms, the greater the decay rate. This rate of decay is measured by two units:

  a) Curie (Ci) is a unit used to measure a radioactivity and related to the decay rate (disintegration rate), so One curie = 2,200,000,000,000 **d**isintegrations **p**er **m**inute **(2.2 x 10^{12} dpm).** This means that every minute, 2.2 x **10^{12}** atoms decay and give off radiation.

  b) Becquerel (Bq) is a unit also used to measure a radioactivity and one Becquerel is that quantity of a radioactive material that will have **60 dpm**. As a result, there are **3.7 x 10^{10}** Bq in one curie.

Types of Radiation Units

2. Measurement of Exposure Dose

Roentgen (R) measure of how many ion pairs are formed in a given volume of air when it is exposed to radiation only to gamma and x-rays.

3. Measurement of Absorbed Dose

a) **Rad** (**R**adiation **a**bsorbed **d**ose) measure energy absorbed from any type of radiation, but it does not describe biological effects of different radiations.

b) **Gray (Gy)** is a standard international (SI) unit also used to measure absorbed dose, and each **1 Gray = 100 rads**.

Types of Radiation Units

4. Measurement of Equivalent Dose

- It is the quantity of radiation dose that is relative to the harm or risk caused by a given dose of radiation when compared to any other doses of radiation of any type. ***Equivalent dose = absorbed dose x quality factor*** **(Q)**

  a) Roentgen **e**quivalent **m**an **(rem)** (1 rem = 1000 mrem).

  b) Sievert (Sv) is standard international (SI) unit also used to measure equivalent dose, and each **1 Sievert = 100 rem**.

Types of Radiation Doses

Dose: The amount of radiation you receive and measured by **(mrem).**

Dose Rate* (*intensity): how fast you receive the dose and measured by **(mrem/hr).**

Biological effectiveness of each type of radiation depend on:

1. **Type of radiation**
2. **Type of tissue**
3. **Period of time exposure**

Types of Radiation Doses

1. ***Equivalent dose*** compare biological effectiveness of different types of radiation on the same tissue (absorbed dose quality factor of radiation type) (rem or Sievert).
2. ***Effective dose*** estimate risk of radiation in humans (sum of equivalent doses to each organ and tissue factor) (Sievert - Sv)
3. ***Collective dose*** is dose received per person X number of persons exposed per year.
4. ***Chronic dose*** is a radiation dose received over a long period of time.
5. ***Acute dose*** is a radiation dose received over a short period of time.


THANK YOU