Radiation

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Non-Ionizing Radiation

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Electromagnetic Fields

Electromagnetic fields (**EMF**) radiation does not have sufficient energy to break the bonds that hold molecules in cells together, and so it does not produce ionization of matter.

Effects on the body depend on the frequency and magnitude of **EMF**.

Electromagnetic Fields

Magnetic fields can induce flows of electric current in the body.

Radiofrequency (RF) radiation is partially absorbed, penetrating a short distance into tissues, and can give rise to localized heating.

Electromagnetic Fields

Sources of exposure (occupational and environmental)

Static and extremely low-frequency fields (ELF)

- Electrical power lines
- Household electrical appliances
- Electrical transport
- Welding.


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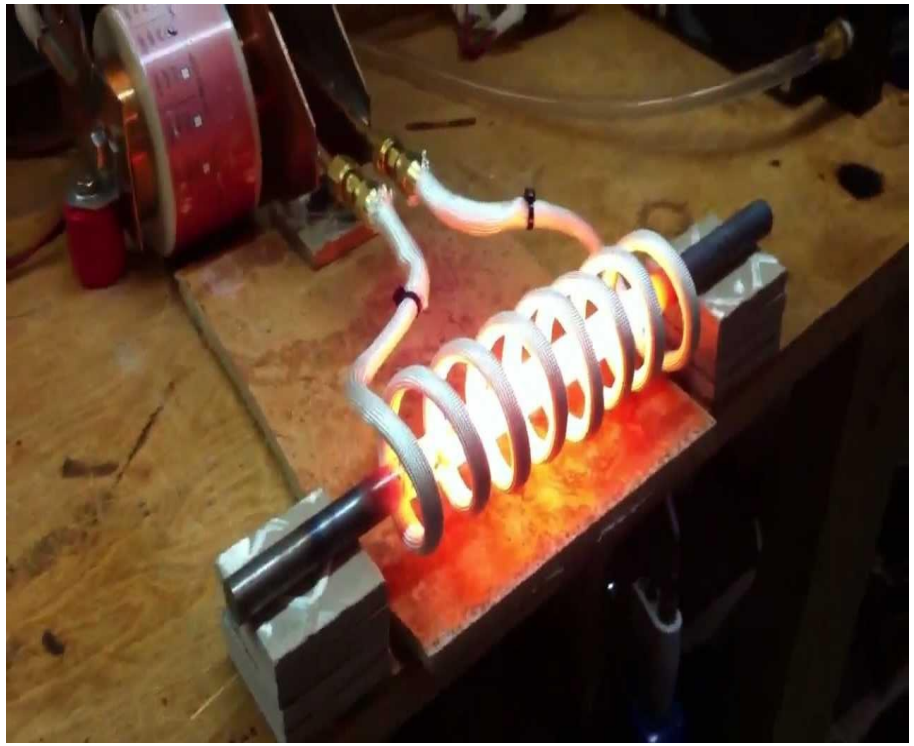
Electromagnetic Fields

High-frequency or radiofrequency fields (RF)

- Radar
- Radio and television broadcast facilities
- Mobile telephones and their base stations
- Induction heaters
- Anti-theft devices.

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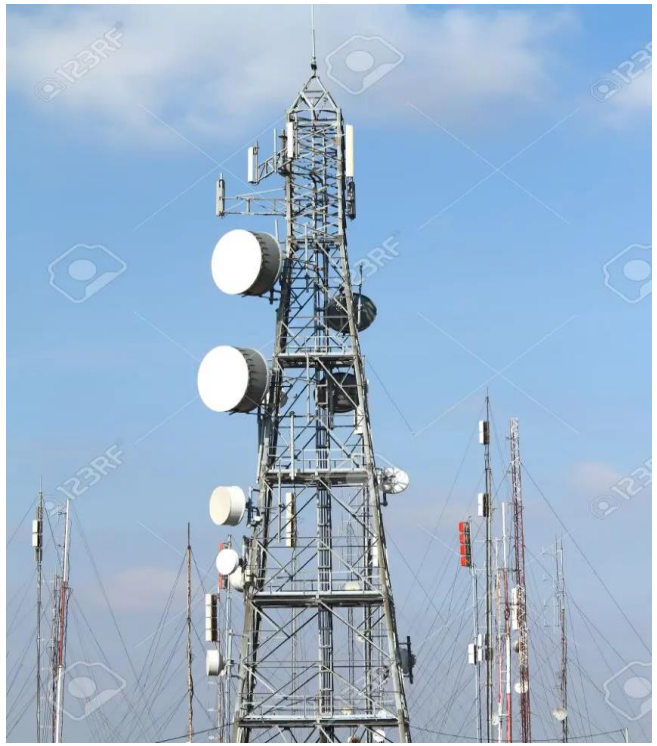


Ionizing Radiation

Prof. Ashraf Zaghloul

Radiation is energy that comes from a source and travels through space or a material medium at the speed of light.

This energy has an electric field and a magnetic field associated with it, and has wave-like properties.

Radiation energy is able to penetrate various materials

Natural radiation is everywhere (ubiquitous) واسع الانتشار in our environment.

Radiation comes from space (i.e., cosmic rays) and from naturally occurring radioactive materials contained in the earth and in living things.

Sources and levels of ionizing radiation in the environment:

Ionizing radiation arise either from natural or artificial sources:

A- Natural sources include three main sources:

Cosmic rays **أشعة كونية** which arise in outer space and its intensity varies with altitude.

Terrestrial radiation **أشعة أرضية** which emanates from radium, uranium and thorium in the earth's crust which also varies markedly from one geographical region to another.

Radon exposure in indoor airs which affect the bronchial epithelium.

Internal radiation which is emitted by potassium 40 (k-40) and other naturally occurring radionuclides normally present in the body.

B- Artificial sources include:

X-ray diagnosis , nuclear medicine , consumer products e.g. (color TV, smoke detectors), atomic weapons.

High risk occupational groups are:

Radiologists, uranium miners, nuclear power plant operations.

Source	Exposure (U.S. Average)
External Background Radiation	0.54 mSv y^{-1}
Natural K-40 and Other Radioactivity in Body	0.29 mSv y^{-1}
Air Travel Round Trip (NY-LA)	0.05 mSv
Chest X-Ray Effective Dose	0.10 mSv per film
Radon in the Home	2.28 mSv y^{-1}
Man-Made (medical x rays, etc.)	3.14 mSv y^{-1}

Occupations at Risk

The maximum exposure limit for occupationally exposed worker is 50 mSv (5rem) in any given year

1 Rontgen = amount of X-ray that produces one electrostatic unit of charge in one cubic centimeter under standard condition of temperature and pressure.

Exposure of the skin to one Rontgen X-ray typically deposits a dose slightly <(1 rad) in underlying epidermis.

There are **2** types of radiation energy

Non-ionizing radiation

Ionizing radiation

Non-ionizing Radiation

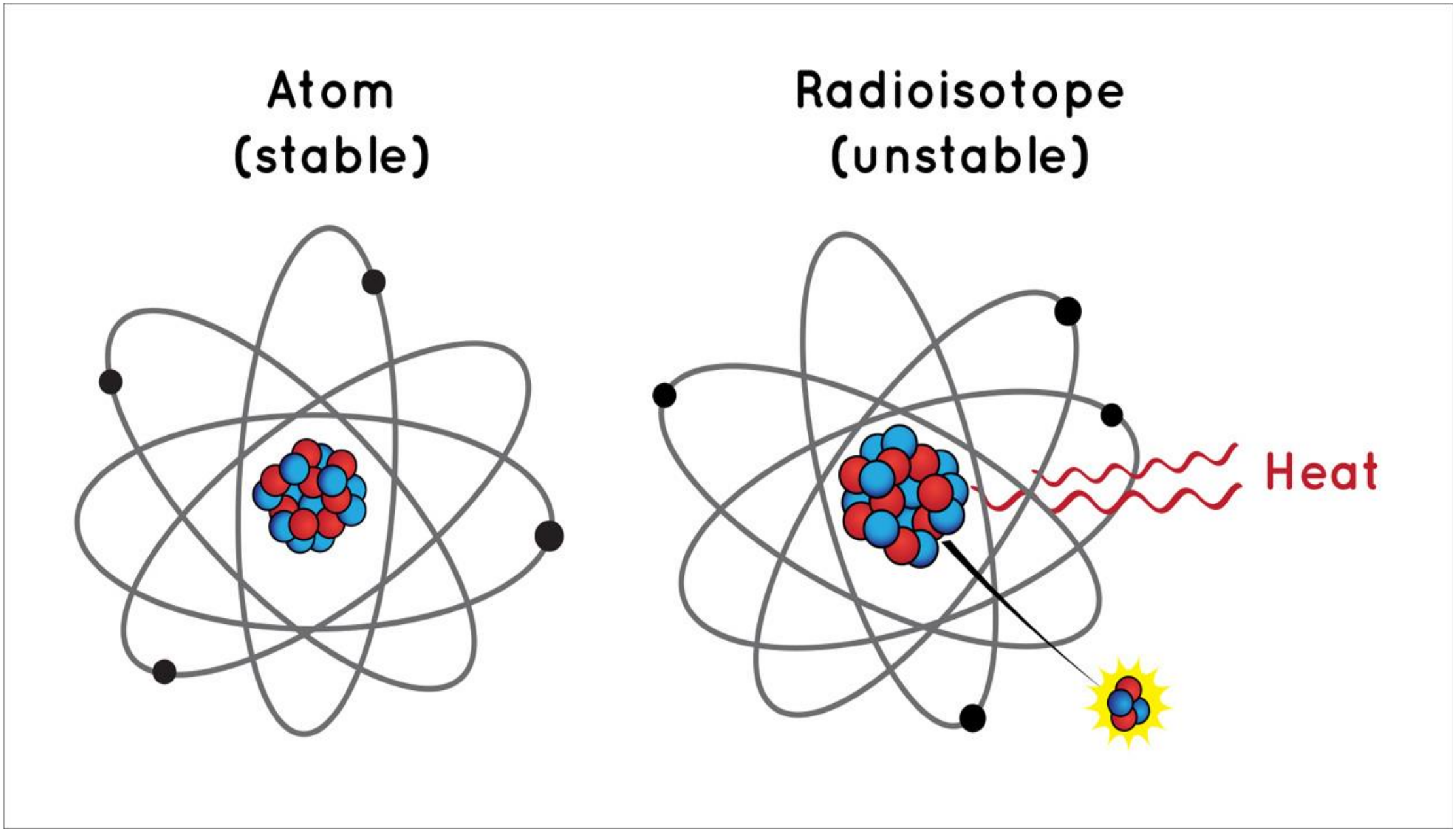
Light, radio, and microwaves are types of non-ionizing radiation

Ionizing Radiation

Any source which can produce charged particles (ions).

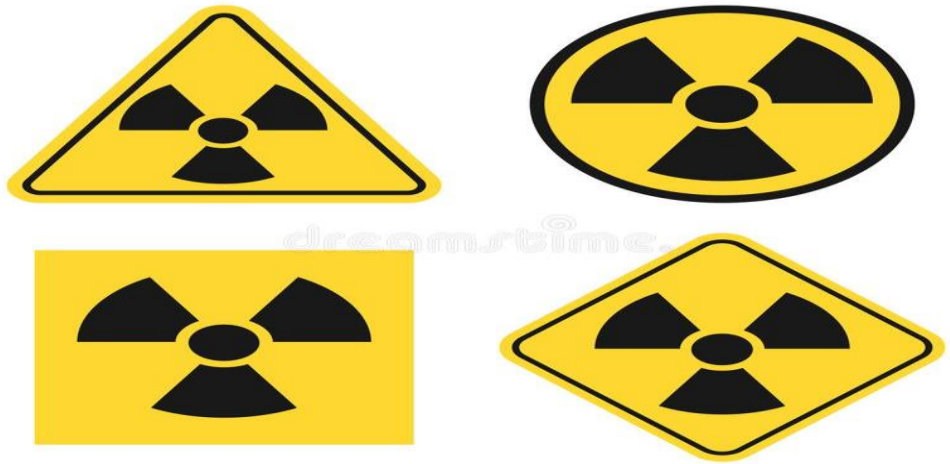
Ionizing radiation is produced by **unstable atoms**.

Unstable atoms differ from stable atoms because unstable atoms have an **excess of energy or mass or both**. Radiation can also be produced by high-voltage devices (e.g., x-ray machines).


Atom
(stable)
Radioisotope
(unstable)
Heat

Atoms with unstable nuclei are said to be radioactive.

In order to reach stability, these atoms give off, or emit, the excess energy or mass. **These emissions are called radiation**.

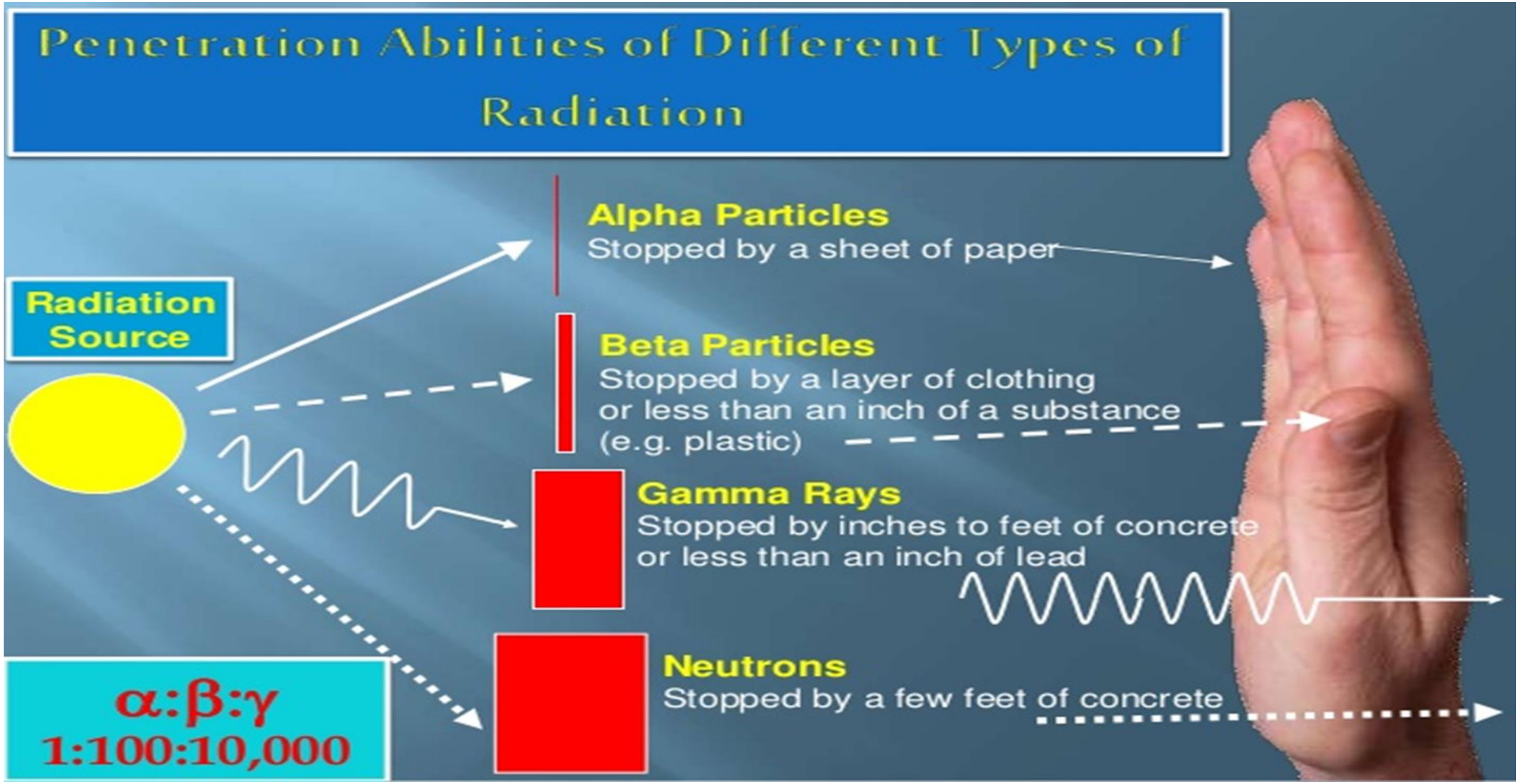


Ionizing radiation consist of two types:

Electromagnetic radiation (e.g. X-rays & gamma rays). They possess no mass, no charge and are characterized by extremely short wave length and high energy & frequency).

The particulate radiations: consist of electrons, protons, neutrons, alpha particles, Beta particles, heavy charged ions and other atomic particles varying in nature and charge:

- alpha particles possess low penetration power and high ionizing power
- Beta particles, neutrons, protons, and electrons have great penetration and ionizing power.


Penetration Abilities of Different Types of Radiation
Radiation Source
Alpha Particles
Stopped by a sheet of paper
Beta Particles
Stopped by a layer of clothing
or less than an inch of a substance
(e.g. plastic)
Gamma Rays
Stopped by inches to feet of concrete
or less than an inch of lead
Neutrons
Stopped by a few feet of concrete
α:β:γ
1:100:10,000

Within the body, the distribution and retention of each internally deposited radionuclide is governed by both its physical decay (its **physical half life**), which vary from seconds to years, and its biological removal (its **biological half life**).

Radiation injuries include 2 types:

Stochastic injuries which is assumed to lack dose threshold (e.g. mutagenic and carcinogenic injuries or effects), which are viewed as a probabilistic effects that can result from radiation induced changes in single cell within affected organs.

Non-stochastic injuries which cause acute and chronic tissue reactions that result from the killing of large numbers of cells in affected organs (e.g. erythema of skin, depression of blood count, oligospermia, cataract of the lens). **Dose related**.

Tissues with the most rapid cellular turnover are the most radiosensitive

(e.g. reproductive, hematopoietic, gastro-intestinal tissues)

Acute effect of ionizing irradiation:

Generalized effect due to brief but heavy exposure of all or part of the body (acute radiation syndrome).

Localized effect:

- Effect at cellular level (**gene mutation**, chromosome aberrations and cytotoxic effect)
- Effect on tissues or organs, particular relevance to occupational or accidental irradiation (e.g. **skin**, **blood forming tissues**, **reproductive organs**, **gastrointestinal tract** and **eye lens**).

Symptoms & prognosis depend on the degree of exposure & the equivalent absorbed dose

Localized effects:

1)Effects at cellular levels:

Gene mutation: Radiation may alter DNA sequence within the cell even in a single gene and irreversibly alter or kill the cell.

Mutagenic effects of radiation have not yet been documented in germ cells but well demonstrated in somatic cells.

Chromosomal aberration (structure or number): two event chromosome aberration of lymphocytes resulting from interference of radiation with either chromosomal segregation during their cell division or by causing chromosomal breaking.

Cytotoxic effects: high dose of radiation may be able to kill any cell but a small dose can render most human cells incapable of proliferating.

2)Effects on tissues & organs relevant to occupational exposure:

Effects on skin:

- The earliest reaction is **erythema**.

Erythema become evident with 2 hours after rapid exposure.

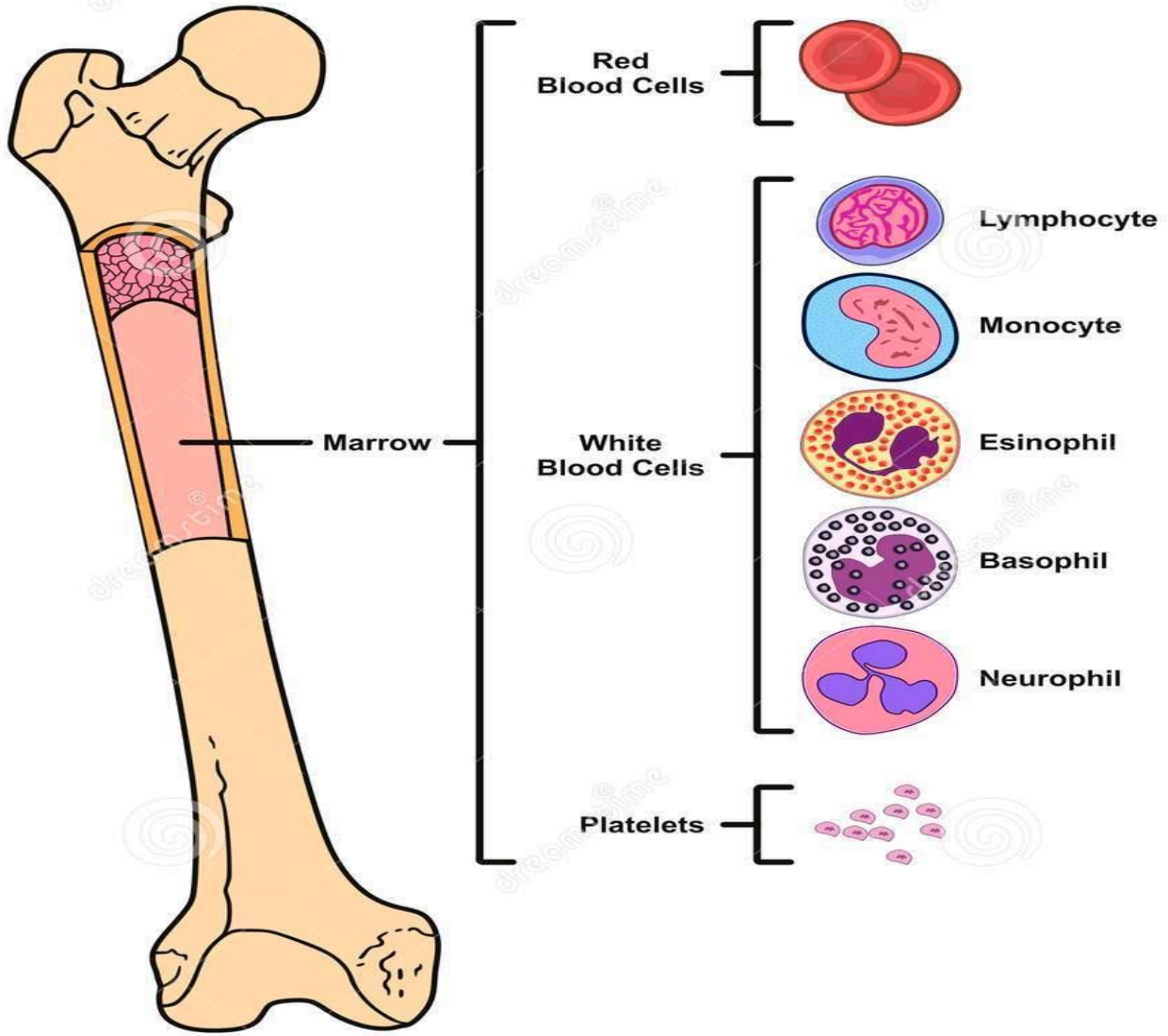
Also the skin may become dry, smooth shiny, thin, sensitive and pruritic, and there are signs of telangiectasia, atrophy and diffuse pigmentation. The nails may appear white and striated.

Effects on blood forming organs:

- **Hematopoietic cells** are highly sensitive to radiation and undergo degenerative changes within minutes after a dose of one SV.

Similarly **lymphocytes** are highly radiosensitive and a dose of 1 - 6 SV whole body irradiation suffices to cause prompt lymphopenia with profound depression in the immune response.

Bone Marrow & Blood Cells



Effects on gastro intestinal tract:

When a large part of the small intestine is exposed to dose > 10 SV, fulminant dysentery like reaction is produced due to ulceration of intestinal mucosa which may cause death from days to 2 weeks after exposure.

Effects on Reproductive organs:

- **Immature spermatogonia and oocytes** are highly radiosensitive and a small dose (0.15 SV) suffices to depress sperm count temporarily.

- **Permanent sterility** may result from a dose in excess of 4SV.

Effects on Lens of the eyes:

Posterior sub capsular opacity can be detected microscopically after a dose of 1SV a single brief exposure. But the threshold for a vision, impairing cataract is estimated to vary from about 2 - 4 SV.

The carcinogenic effects of radiation:

leukemia, cancer of the breast and cancer of the thyroid.

The scarring effects in other tissues:

High dose of radiation exposure can lead to endarteritis obliterans, intestinal stenosis, pulmonary fibrosis and cataract.

Maximum permissible doses for occupational exposures are:

For protection against stochastic effect:

Annual (effective dose) 50 mSv.

For protection against non stochastic effects in individual organs:

Annual effective dose for lens of the eye 150 mSv.

Annual effective dose for all other organs 500 mSv.

In case of radiation accidents the following measures should be taken:

- Clinical evaluation of workers including injuries other than radiation (e.g. burns, smoke inhalation or trauma).

- Person who handles the worker should wear protective gloves or clothes.

- The contaminated victim should be isolated and decontaminated by carefully rinsed with water and the rinsed water isolated as radioactive waste.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If radioactivity are inhaled, oral and nasal cavities should be rinsed with water (avoid swallowing any).

- Management of the victim should be followed and treated according to the degree of exposure as a case of acute whole body irradiation.

Good recording for signs and symptoms and environmental measures.

Doses involved in medicine and dentistry must be limited as possible this can be achieved by:

- Limiting number of radiographs / patient.
- Limiting size of the field exposed.
- Limiting of use of fluoroscopy as possible.
- Shielding tissues outside the field especially fetus & gonads.