Radiobiology:

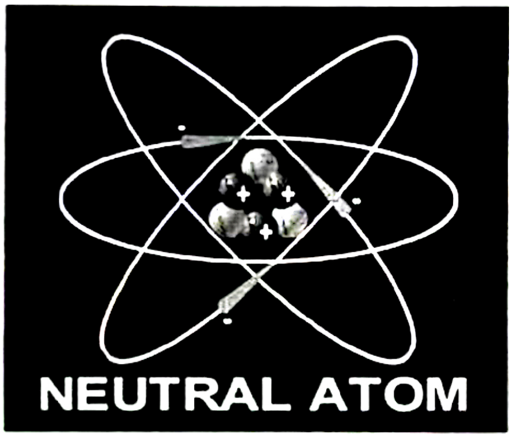
Introduction:

Scientists have studied radiation for over 100 years and a great deal of information is known about it.

Radiation is part of nature. All living creatures, from the beginning of time,have been, and are still being, exposed to radiation.

Radiation: is an energy in the form of electro-magnetic waves or particulatematter,traveling in the air.

Basic Model of a Neutral Atom:



- ·Electrons (-) orbiting nucleus of protons (+) and neutrons. Same number ofelectrons as protons; net charge =0.
- ·Atomic number(number of protons) determines element.
- ·Mass number(protons+neutrons)

Radioactivity: If a nucleus is unstable for any reason, it will emit and absorbparticles. There are many types of radiation and they are all pertinent to everydaylife and health as well as nuclear physical applications.

Types of radiation:

Different forms of radiation may be emitted from an unstable radioactivenucleus.Energy is released and a new, more stable nucleus is formed.

A-Particulate Radiation

B-Electromagnetic Radiation

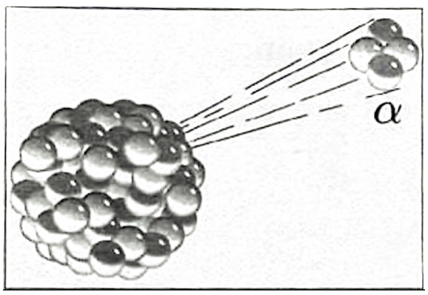
Particulate Radiation can be classified as particulate if they .are in motion andpossess sufficient kinetic energy

:Principal Types

- Alpha·
- Beta

Alpha particles: Ernest Rutherford, an English scientist, discovered alphaparticles in 1899 while working with .uranium

It consists of two neutrons and two protons bound together .to thenucleus of a Helium atom, its positively charged



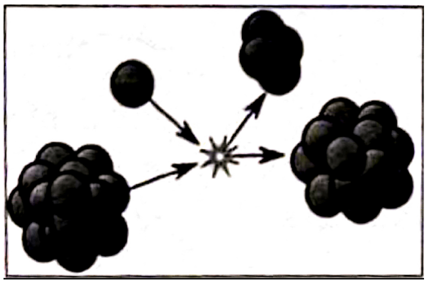
Though the least powerful of the three types of radiation,alphaparticles are none the less the most densely ionizing of the three.
That meanswhen alpha rays can cause mutations in any living tissue they come intocontact with, potentially causing unusual chemical reactions in the cell .andpossible cancer

- They are still viewed as the least dangerous form of radiation, as long as it'snot ingested or inhaled, because it can be stopped by even a thin sheet ofpaper or even .skin, meaning that it cannot enter the body very easily

- Alpha particles are most commonly used in smoke alarms

C- Beta particles:

Henri Becquerel is credited with the discovery of beta particles. In1900,he showed that beta particles were identical to electrons,which hadrecently been discovered by Joseph John Thompson.



Beta particles are high-speed charged electrons (that can be positivelyor negatively charged) emitted from the nuclei of decaying radioisotopes,itcharacterized by its high energy and .speed
The beta particles emitted are a form of ionizing radiation also .known asbeta rays

Ionizing radiation: It is a type of radiation that is able to disrupt atomsand molecules on which they pass through,giving rise to .ions and free radicals

Beta particles weigh only a small fraction of a neutron or proton. As a result,beta particles interact less readily with material than alpha particles.

Betaparticles will travel up to several meters in air, and are stopped by thin layersof metal or plastic.

Beta particles may travel 2 or 3 meters through air.Heavy

clothing,thick cardboard or one-inch thick wood will provide .protection from beta radiation

Beta radiation is more hazardous because,like alpha radiation,it cancause ionization of living cells. Unlike alpha radiation, though,betaradiation has the capacity to pass through living cells,though it can bestopped by an aluminum sheet.

A particle of beta radiation can causespontaneous mutation and cancer .when it comes into contact with DNA
Beta radiation is mainly used in industrial processes such as .paper mills andaluminum foil production

<u>D-Neutron Radiation</u>
Neutron radiation is not as readily absorbed as charged particle radiation,which makes this type highly penetrating

Neutrons are absorbed by nuclei ofatoms in a nuclear reaction. This most-often creates a secondary radiationhazard, as the absorbing nuclei transmute to the next heavier isotope, many ofwhich are unstable.

Apart from cosmic radiation, spontaneous fission is the onlynatural source of neutrons. A common source of ,neutrons is the nuclear reactor
in which the splitting of a uranium or plutonium nucleus is accompanied by theemission of neutrons. The neutrons emitted from one fission event can strike thenucleus of an adjacent atom and cause another fission event, inducing a chainreaction. The production of nuclear power is based upon this principle.

Neutrons are able to penetrate tissues and organs of the human body when theradiation source is outside the body. Neutrons can also be hazardous if neutron-emitting nuclear substances are deposited inside the body. Neutron radiation isbest shielded or absorbed by materials that contain hydrogen atoms, such asparaffin wax and plastics.

B- Electromagnetic radiation:

Electromagnetic energy is the term given to energy traveling across emptyspace and used to describe all the different kinds of energies released into spaceby stars such as the Sun. All forms of electromagnetic radiation (which includesradio waves, light, cosmic rays, etc.) moves through empty space with the samevelocity and not significantly less in air.

These kinds of energies include:
- Radio Waves
- TV waves
- ·Radar waves

- ·Heat (infrared radiation)
- Light
- ·Ultraviolet Light(This is what causes Sunburns)
- ·X-rays(emitted by X-ray tubes)
- ·Short waves
- ·Microwaves,like in a microwave oven

- ·Gamma rays(Y)

- They are weightless packets of energy called photons,which have thesmallest wavelengths and but have much higher energy of any otherwave in the electromagnetic spectrum. Unlike alpha and betaparticles, which have both energy and mass,

- gamma rays are pure energy which are often emitted along with alphaor beta particles during radioactive decay and in nuclear explosions.
- Gamma rays are a radiation hazard for قال the entire body. They can easilypenetrate barriers, such as skin and clothing that can stop alpha andbeta particles.
- Gamma rays have so much penetrating power that several inches of adense material like lead or even a few feet of concrete may berequired to stop them. Gamma rays can pass completely through thehuman body easily;as they pass through,

- Gamma rays are the most useful type of radiation because they cankill off living cells easily, without lingering there. They are thereforeoften used to fight cancer and to sterilize food,and kinds of medical equipment that would either melt or become compromised bybleaches and other disinfectants.

- X-rays

- X-rays are similar to gamma rays in that they arephotons of pureenergy.
- X-rays and gamma rays have the same basic properties but come fromdifferent parts of the atom. X-rays are emitted from processes outsidethe nucleus, but gamma rays originate inside the nucleus. They alsoare generally lower in energy and,therefore,less penetrating thangamma rays but have higher

energy than ultraviolet waves. As the wavelengths of light decrease,they increase in energy. We usuallytalk about X-rays in terms of their energy rather than wavelength.Thisis partially because X-rays have very small wavelengths. It is alsobecause

- X-ray light tends to act more like a particle than a wave.

- X-rays can be produced naturally or artificially by machines using electricity.

- Ultraviolet
- The dividing line between ionizing and non-ionizing radiation in the electromagnetic
- spectrum falls in the ultraviolet portion of the spectrum and while most UVis classified as non-ionizing radiation, the shorter wavelengths from about150 nm (UV-C) are ionizing. UV-C from the sun is nearly all absorbed bythe ozone layer.

Properties Considered When Ionizing Radiation Measured

Ionizing radiation is measured in terms of:

- the strength or radioactivity of the radiation source
- the energy of the radiation
- the level of radiation in the environment, and
- the radiation dose or the amount of radiation energy absorbed by the human body.

From the point of view of the occupational exposure, the radiation dose is the most important measure. The risk of radiation-induced diseases depends on the total radiation dose that a person receives over time.

Radiologic Units

There are five units accustomed for measure radiation:

The Rontgen(R or r)

Is the unit of dose of electromagnetic radiation exposure or intensity. It isequal to the radiation intensity that will create 2.08x10° ion pairs in a cubiccentimeter of air that is:
$1R = 2.08x10^9$ion pairs/cm3

The official definition, however, is in terms of electric charge per unit mass of air:
1R=2.58x104C/kg

The charge refers to the electrons liberated by ionization. The output of x-raymachines is specified in roentgens or sometimes millroentgens (mR).The roentgenapplies only to x-rays and gamma rays and their interactions with air.

Rad

The radiation-absorbed dose (rad) is the amount of energy (from any type ofionizing radiation) deposited in any medium through which they pass (e.g.,water,tissue,air).

Biologic effects usually are related to the radiation absorbed dose,and thereforethe rad is the unit most often used when describing the radiation quantity receivedby a patient or an .experimental animal
An absorbed dose of 1 rad means that 1 gram of material absorbed 100 ergs ofenergy (a small but measurable amount) .as a result of exposure to radiation
1Rad=100 ergs/g

Rem

The rem(Roentgen equivalent man) is the traditional unit of dose equivalent(DE) or occupational exposure. It is used to express the quantity of radiationreceived by radiation

workers. Some types of radiation produce more damage thanx-rays.
The rem accounts for these differences in biologic effectiveness. This isparticularly important to persons working near nuclear reactors or .particle accelerator

Curie
Curie (Ci) the original unit used to express the decay rate of a sample of radioactive material. The curie is equal to that quantity of radioactive material (notthe radiation emitted by that material) in which the number of atoms decaying .persecond is equal to 37 billion (3.7x101°)

The curie is the basic unit of radioactivity used in the system of radiation units in the United States, referred to as "traditional" units. Becquerel(Bq)or Curie(Ci) is a measure .of the rate(not energy) of radiation emission from a source

Electron Volt
Electron Volt(eV) is the amount of energy by the charge of a single electron moved across an electric potential .difference of one volt

Table 1.3: The special quantities of radiologic radiation radiation science and their-associatedspecial units

Quantity	Customary unit		SI unit	
	Name	Symbol	Name	Symbol
Exposure	Roentgen	R	Coulomb per kilogram	C/kg
Absorbed dose	rad	rad	gray	Gy
Dose equivalent	rem	rem	Seivert	Sv
Radioactivity	Curie	Ci	Becquerel	Bq