Types of Radiation Units & Doses

Dr. Khalid M. Salih

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).**

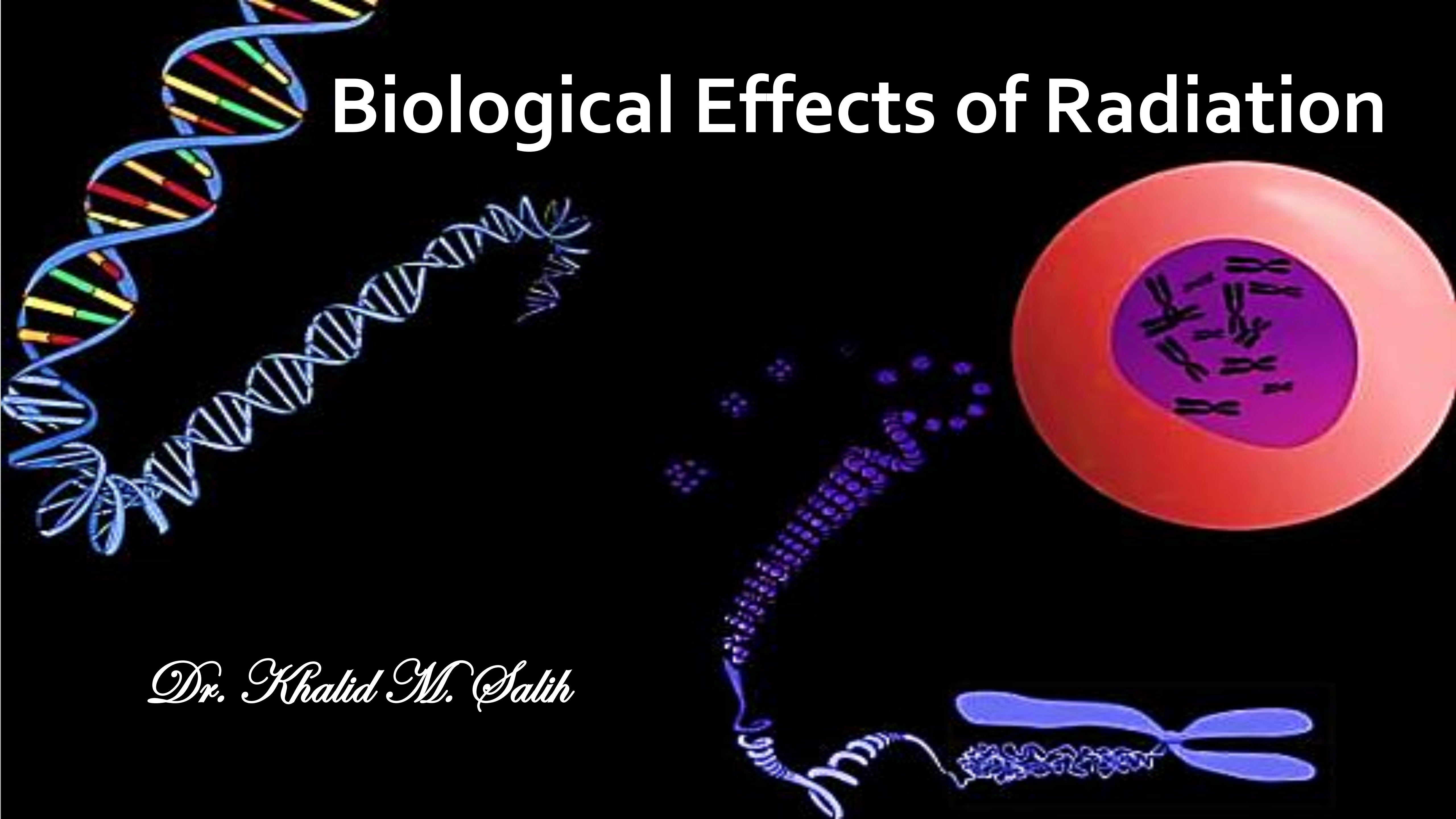
Biological effectiveness of each type of radiation depend on:

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.

Biological Effects of Radiation



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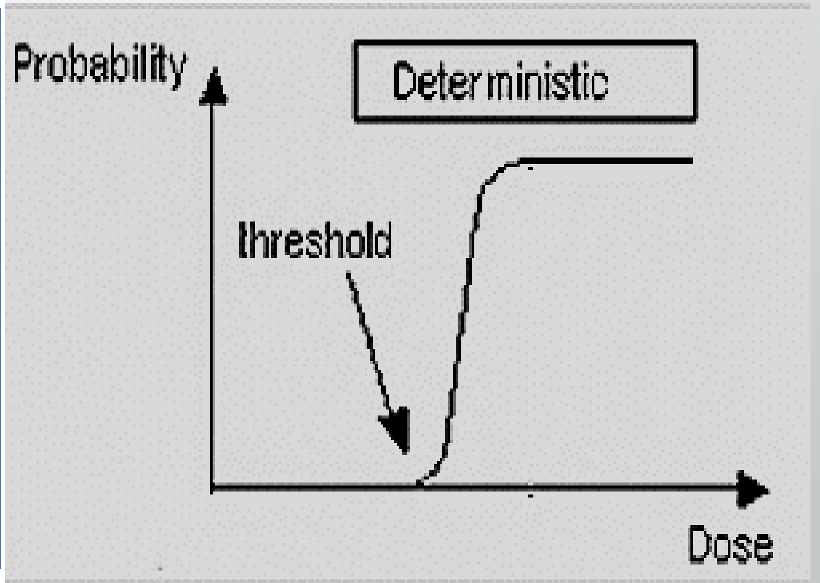
Biological Effects of Radiation

1. Deterministic effect

- ***Probability*** of this effects is not proportional to absorbed dose
- This effect has a ***threshold***, below which the effect will not occur.
- ***Severity*** of this effect is directly proportional to absorbed dose
- This effect of radiation can cause cataract, hair loss, infertility.

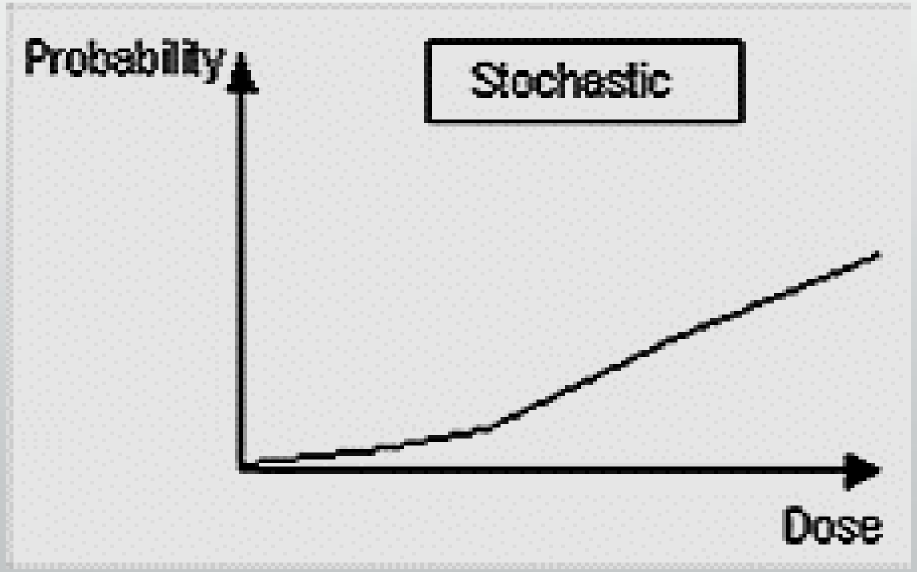
Organs	Effects	Threshold (mSv)	
		Acute dose (single)	Chronic dose (multiple /year
Testis	Permanent infertility	> 3500	>2000
Ovary	Permanent infertility	>2500	>200
Eye	Cataract	>5000	>150



Biological Effects of Radiation

2. Stochastic effect

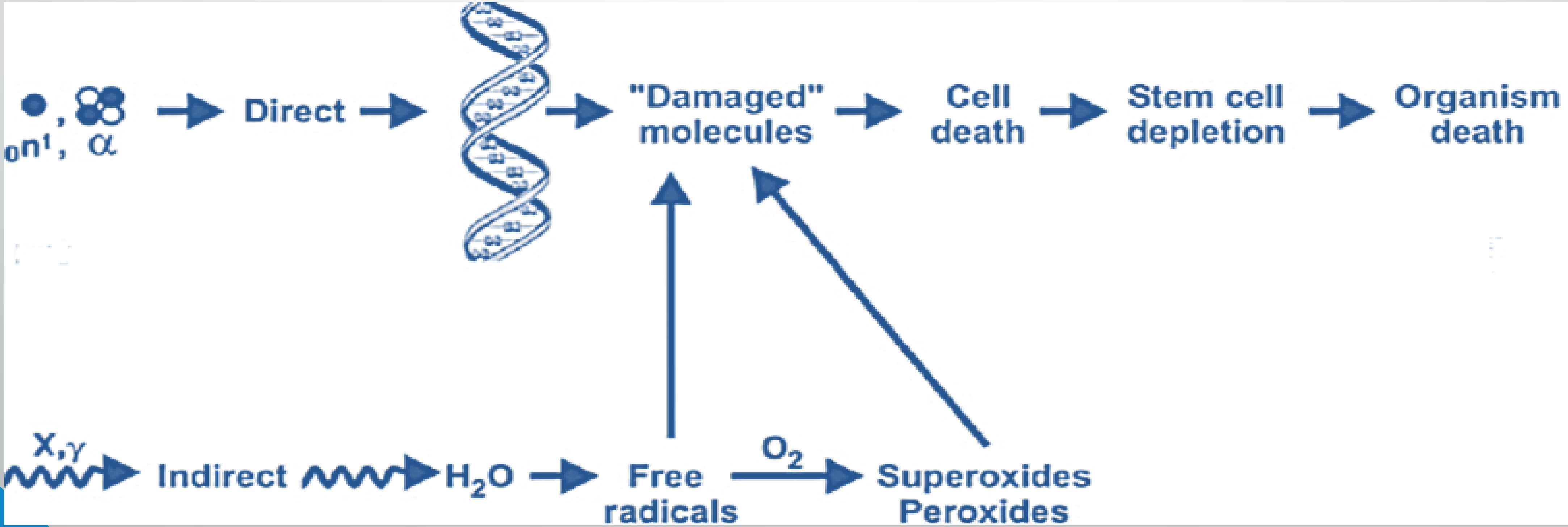
- ***Probability*** of this effect is directly proportional to absorbed dose.
- There is no ***threshold***, so any dose may or may not produce this effect
- ***Severity*** of this effect is independent on the absorbed dose.
- Stochastic effect of radiation can cause cancers or genetic modifications.



Mechanisms of Damage

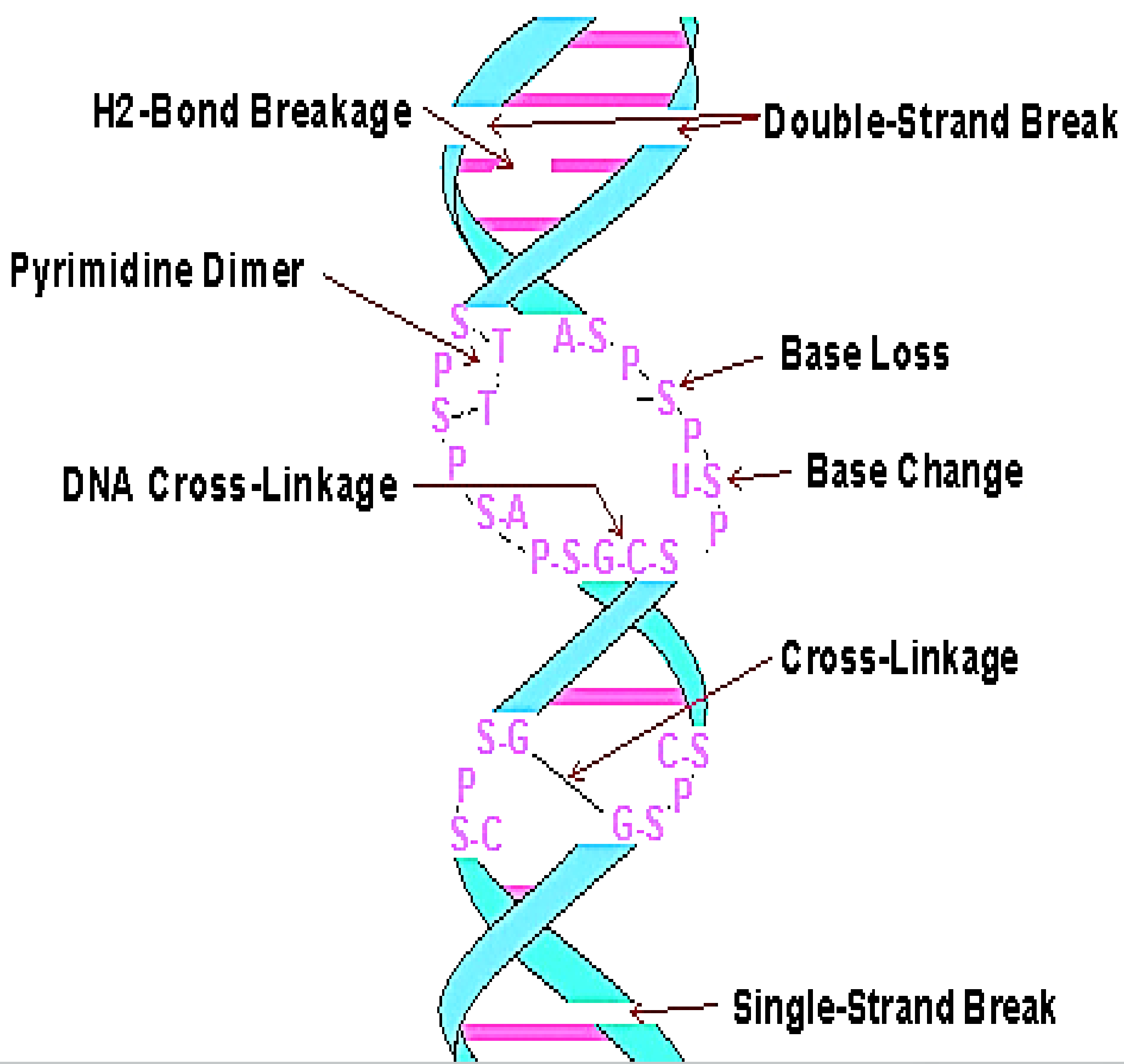
1. **Direct mechanism:** Radiation directly hit atoms of macromolecules (DNA, RNA, proteins, lipids & carbohydrates)

2. **Indirect mechanism:** Radiation hit water to form ***free radicals*** in a process called ***radiolysis*** which can contribute to the destruction of the cell.



Cellular damage of radiation

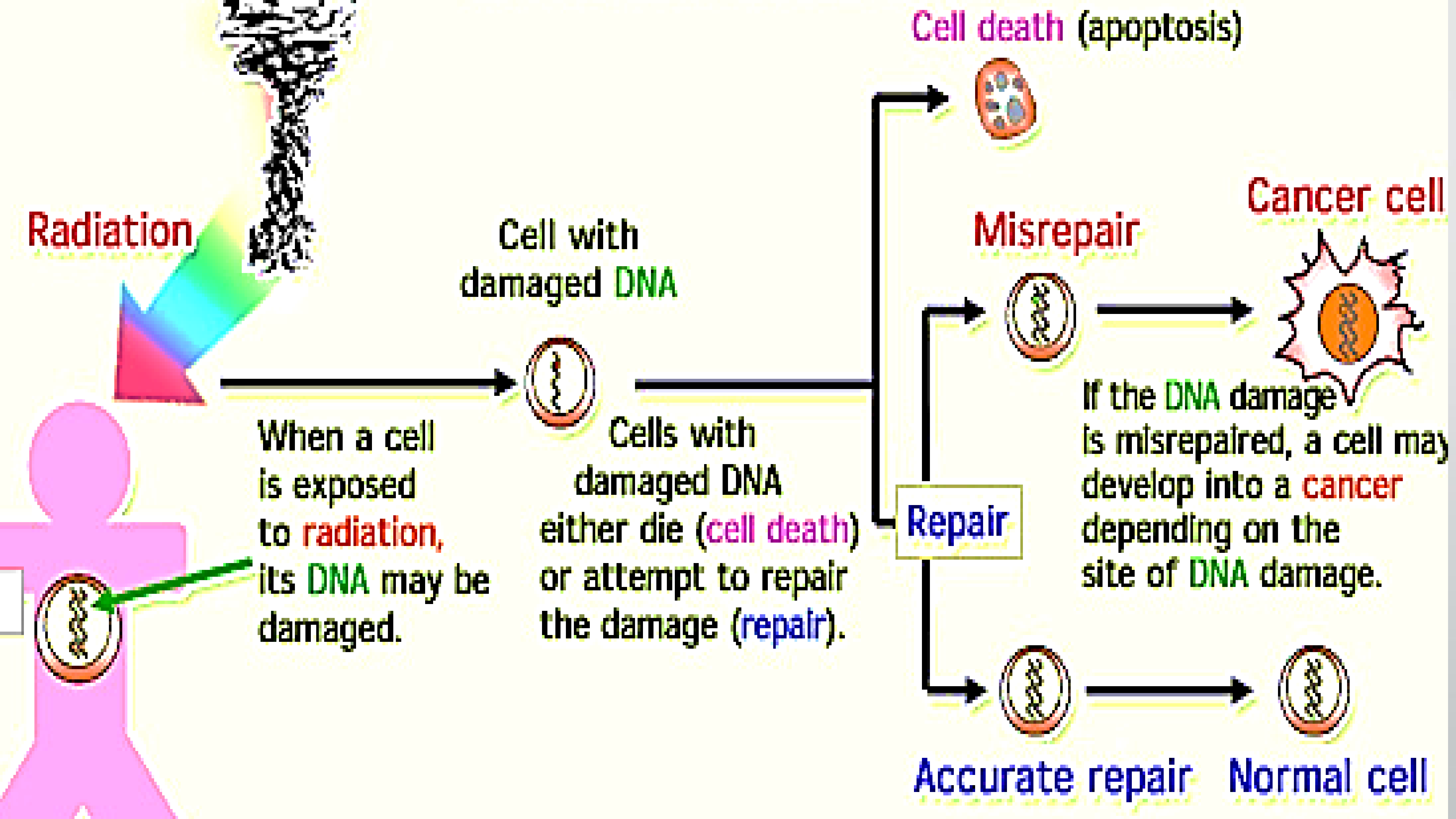
Transfer radiation energy to atoms and molecules in the cellular structure (DNA) lead to ***genomic instability*** due to:



- within seconds (physical & biochemical effects)
- within few minutes (**Cell death or Cell repair)**
- **Within** hours-days-weeks or months (clinical symptoms):

a) **Somatic damages** arise from genomic instability in somatic cells of irradiated person either appear **early** after exposure (hair loss, infertility), or appear **late** after exposure (cataract & cancer)

b) **Genetic damages** arise from genomic instability in germ cells of irradiated parents and seen in their **offspring** as genetic malformations.

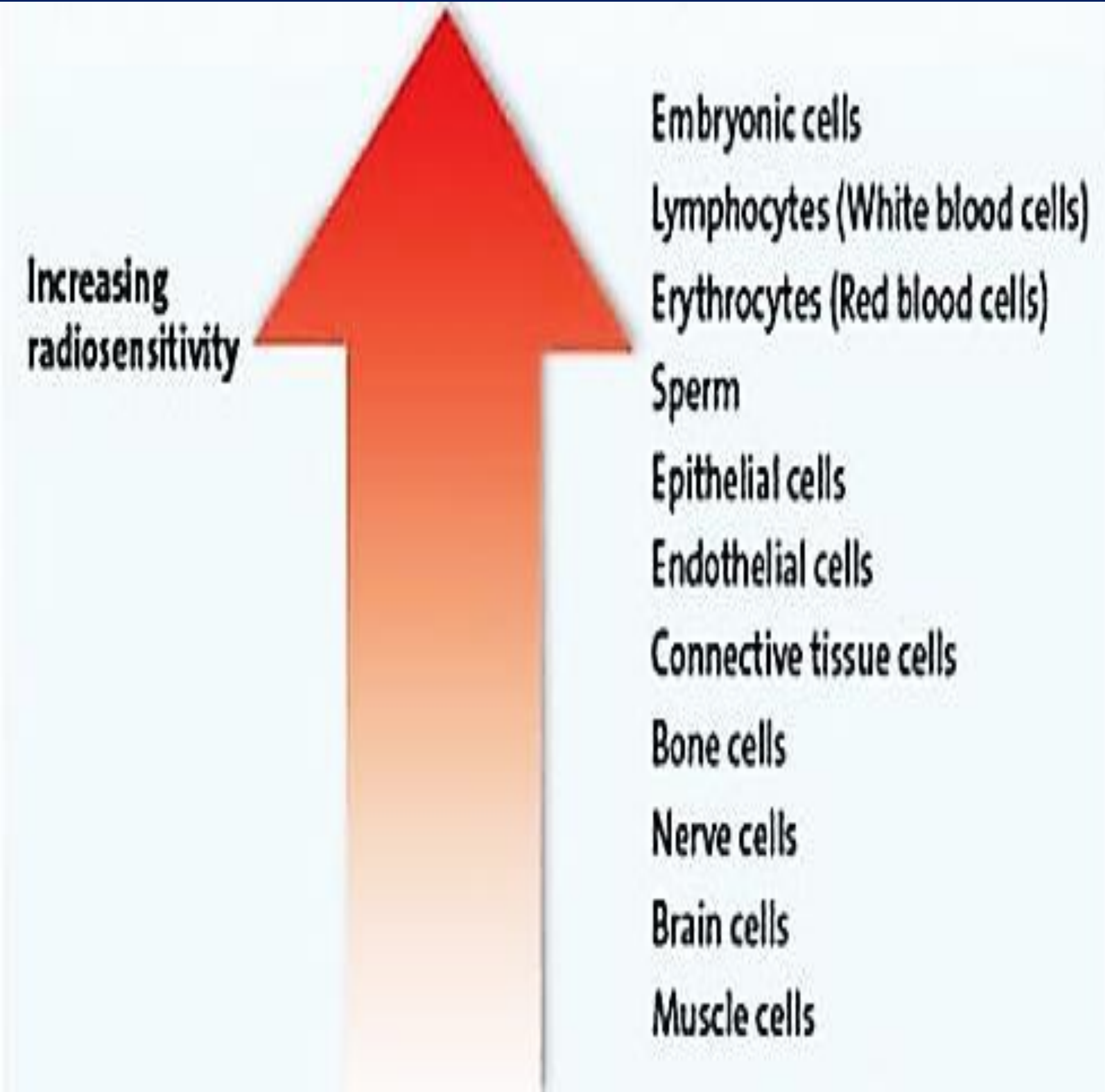

Cell death (apoptosis)
Radiation
Cell with
damaged DNA
Misrepair
Cancer cell
When a cell
is exposed
to radiation,
its DNA may be
damaged.
Cells with
damaged DNA
either die (cell death)
or attempt to repair
the damage (repair).
Repair
If the DNA damage
is misrepaired, a cell may
develop into a cancer
depending on the
site of DNA damage.
Accurate repair
Normal cell

Determinants of Radiation Effects

1. Type of radiation
2. The radiation dose
3. The dose rate of radiation
4. Species Sensitivity (*$LD_{50/30}$*)

Organism	LD_{50} (rad)	Organism	LD_{50} (rad)
Dogs, pigs	300	Cattle, rats, horses	630
Goats	350	Rabbits	800
MAN	400	Chickens	1000
Mice, monkeys	450	Insects	5000
Sheep	540	Turtles	15000
Fish	550	Bacteria/viruses	100000

Determinants of Radiation Effects



5. Cell Sensitivity *(Bergonie & Tribondeau Law)*

Radio-sensitivity of a tissue is *directly* proportional to the ***rate of proliferation*** of its cells, and *inversely* proportional to the degree of ***cell differentiation***.

Determinants of Radiation Effects

6. Part of the body exposed

Extremities (hands or feet) are able to receive a greater amount of radiation with less resulting damage than blood forming tissues found in the bone marrow.

7. Age of individual

As a person ages, cell division slows and body is less sensitive to effects of radiation.

8. Area exposed

The larger the area exposed, the greater the overall damage. Therefore, radiation therapy doses should be delivered to very limited areas (to tumor sites) rather than whole-body irradiation of the same dose.

THANK YOU