Radiation Biology (hazard and protection)

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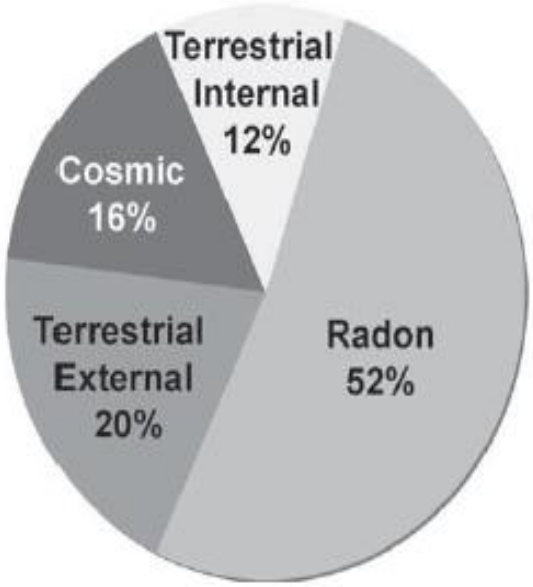
Dose units:

- **Radiation-absorbed dose (D): amount of energy absorbed from the radiation beam per unit mass of tissue. SI unit Gray, (Gy)**
- **Equivalent dose (H): This is a measure which allows the different radiobiological effectiveness (RBE) of different types of radiation to be taken into account. SI unit : Sievert (Sv)**
- **Effective dose(E): This measure allows doses from different investigations of different parts of the body to be compared. SI unit : Sievert (Sv(**

Sources of Radiation Exposure:

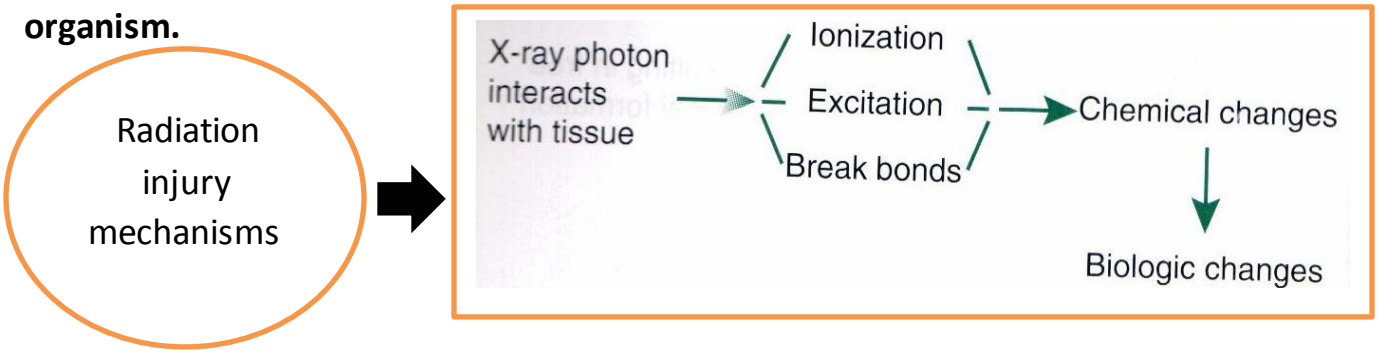
SOURCE	DOSE (μSv)
Natural	
COSMIC	0.4
TERRESTRIAL	
External	0.5
Radon	1.2
Other	0.3
TOTAL	2.4
Man-made	
MEDICAL (ESTIMATED)	
X-ray diagnosis	2
Nuclear medicine	0.5
CONSUMER PRODUCTS OTHER	0.08
OTHER	
Occupational	0.01
Fallout	0.01
Nuclear fuel cycle	<0.01
Dental radiology	≤0.01
TOTAL	2.5



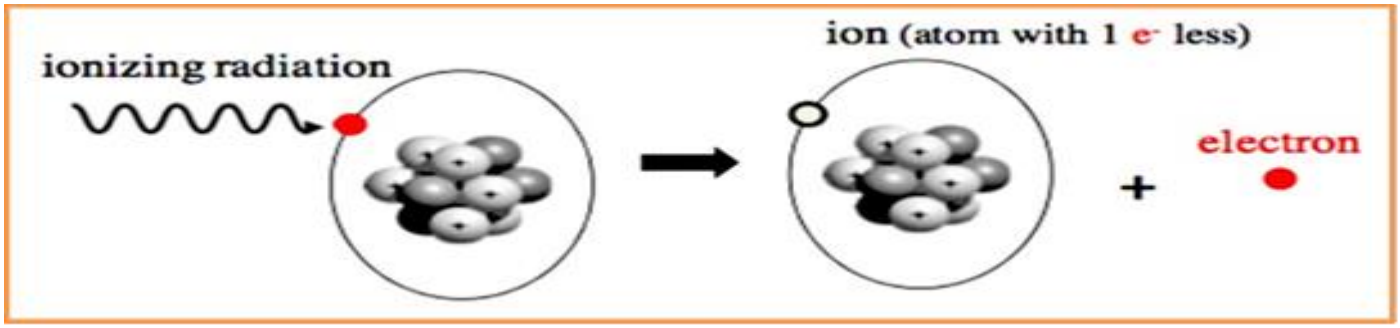
Radiobiology:

Is the study of the effects of ionizing radiation on living systems. The initial interaction between ionizing radiation and matter occurs at the level of the electron within the first 10-13 second after exposure. These changes result in modification of

biologic molecules within the ensuing seconds to hours. In turn, the molecular changes may lead to alterations in cells and organisms that persist for hours, decades, and possibly even generations. They may result in injury or death of the cell or organism.



Ionizing radiation:-radiation that is capable of producing ions by adding or removing an electron to an atom.

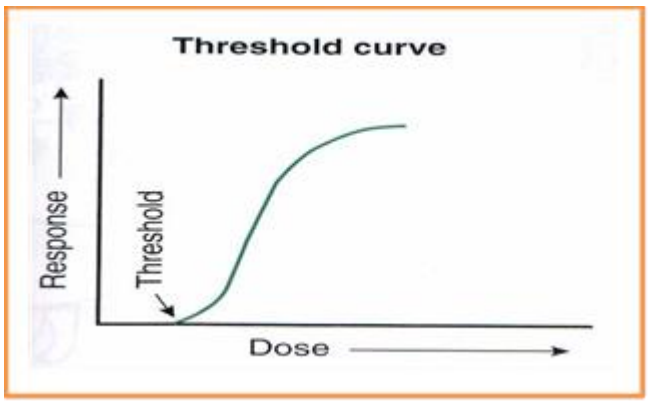


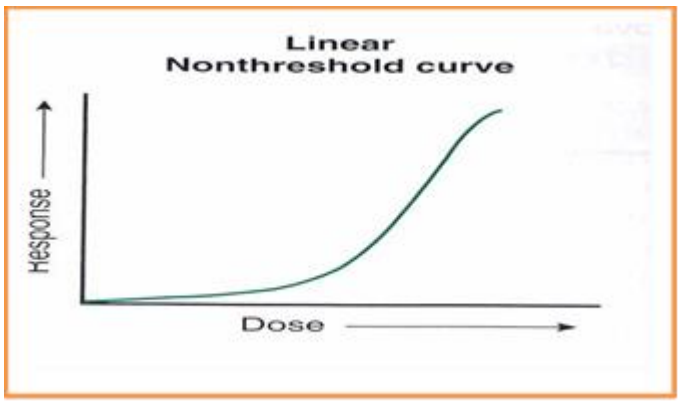
<u>Biologic effects of ionizing radiation may be divided into two broad categories</u>: Deterministic effects and stochastic effects. Deterministic effects are those effects in which the severity of response is proportional to the dose. These effects occur in all people when the dose is large enough. Deterministic effects have a dose threshold below which the response is not seen. Examples of deterministic effects include oral changes after radiation therapy and radiation sickness after whole-body irradiation.

Table 4.1 Summary of the main *acute effects* following large whole-body doses of radiation

Dose	Whole-body effect
0.25 Sv	Nill
0.25–1.0 Sv	Slight blood changes, e.g. decrease in white blood cell count
1–2 Sv	Vomiting in 3 hours, fatigue, loss of appetite, blood changes Recovery in a few weeks
2–6 Sv	Vomiting in 2 hours, severe blood changes, loss of hair within 2 weeks Recovery in 1 month to year for 70%
6–10 Sv	Vomiting in 1 hour, intestinal damage, severe blood changes Death in 2 weeks for 80–100%
>10 Sv	Brain damage, coma, death

By contrast, stochastic effects are those for which the probability of occurrence of the change, rather than its severity, is dose dependent. Stochastic effects are all-or-none: a person either has or does not have the condition. For example, radiation-induced cancer is a stochastic effect because greater exposure of person or population to radiation increases the probability of cancer but not its severity. Stochastic effects are believed not to have dose thresholds.





<u>Theories of radiation injury:</u>

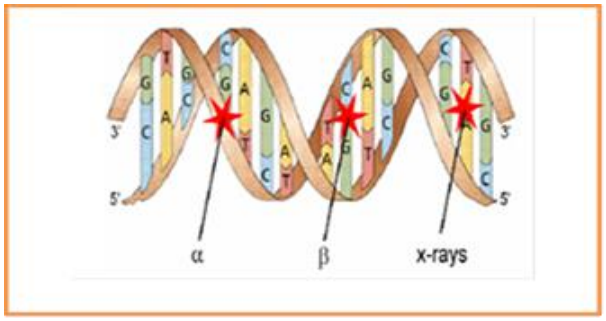
A-Direct effect: can effect on cell itself by breaking the strand of DNA and cause formation of new cell which nonfunctional.

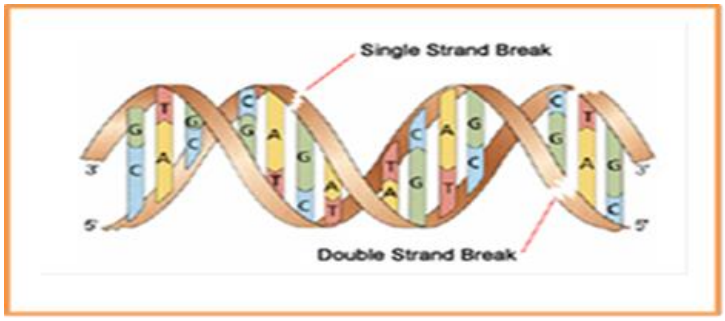
1. Change or loss of a base

٢- .Disruption of hydrogen bonds between DNA strands

٣- .Breakage of one or both DNA strands

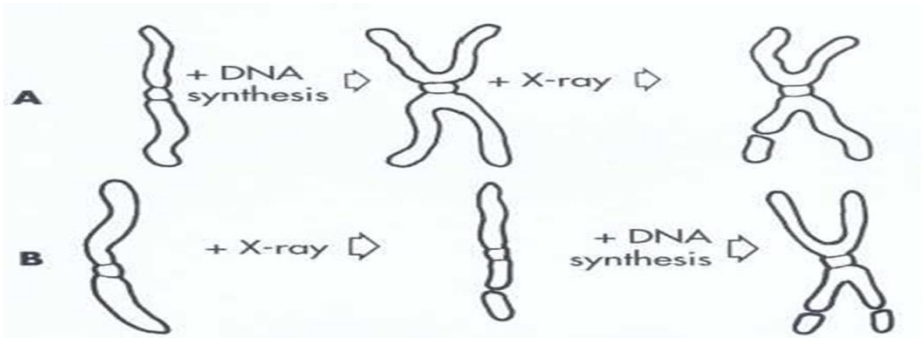
٤- .Cross-linking of DNA strands within the helix, to other DNA strands, or to proteins.





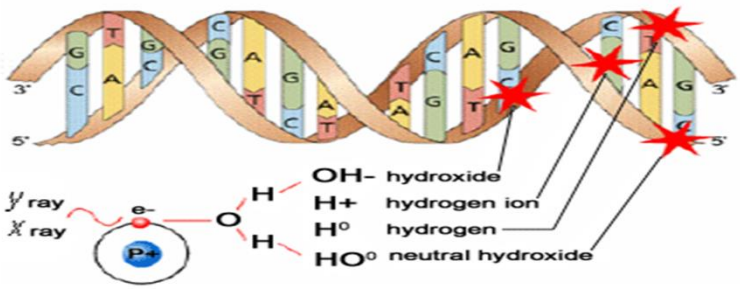
<u>Chromosome aberrations</u>. A, I irradiation of the cell after DNA synthesis results in a single-arm chromatid aberration.

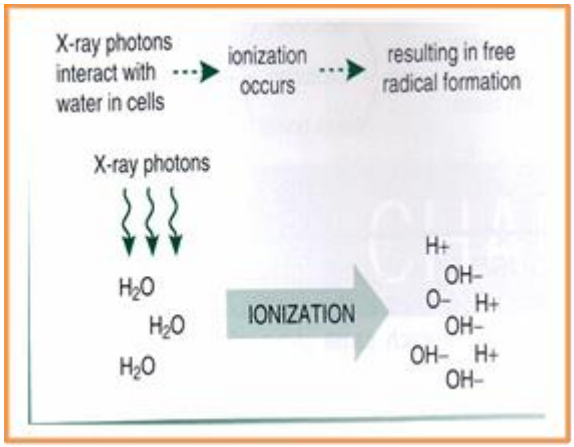
B, Irradiation before DNA synthesis results in a double-arm aberration.

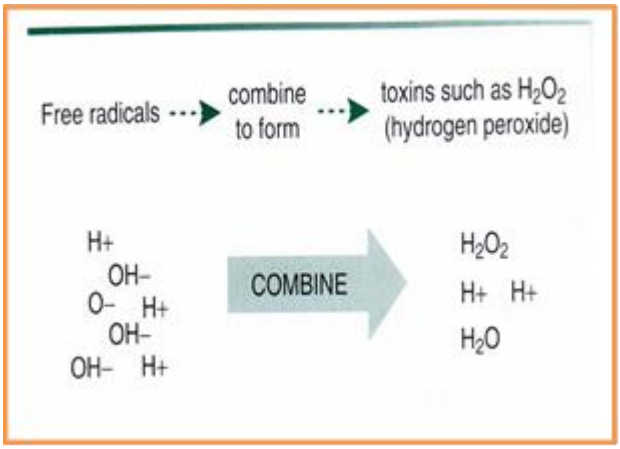


B-Indirect effect: Because water is the predominant molecule in biologic systems (about 70% by weight), it frequently participates in the interactions between x-ray photons and the biologic molecules of an organism. About two thirds of radiation induced biologic damage results from indirect effects. The interaction of hydrogen and hydroxyl free radicals with organic molecules can result in the formation of organic free radicals. Such reactions may involve the removal of hydrogen:

The OH' free radical is more important in causing such damage.







Sequence of radiation injury-:

- **Latent period: it is period of time starting from the exposure of x-ray till the appearance of its signs and symptoms.**
- **Period of injury: cellular injuries may result e.g. cell death, chromosomes breaking and abnormal mitotic activity.**
- **Recovery period: not all cellular radiation injuries are permanent ,cellular damage is followed by repair. Most of the damage caused by low level radiation is repaired within the cells of the body.**

Radiation Effects

-Short-term effects: are associated with large amounts of radiation absorbed in short time minutes,days,or weeks. e.g(atomic bomb).Acute radiation syndrome(ARS)

-Long-term effects: are associated with small amounts of radiation absorbed repeatedly over a long period after years, decades or generation.(cancer and genetic defects).

- Somatic effects: are seen in the person irradiated that produces changes in somatic cells.(cancer, leukemia and cataracts).

- Genetic effects:-are not seen on person irradiated, but are passed on to future generations. Affect health of the offspring, not repaired.(mutation).

RADIATION EFFECTS ON EMBRYOS AND FETUSES

The most sensitive period for inducing developmental abnormalities is during the period of organogenesis, between 18 and 45 days of gestation. These effects are deterministic in nature. Embryos and fetuses are considerably more radiosensitive than adults because most embryonic cells are relatively undifferentiated and rapidly mitotic. Prenatal irradiation may lead to death or specific developmental abnormalities depending on the stage of development at the time of irradiation. The fetus of a patient exposed to dental radiography receives less than0.25 uGy from a full-mouth examination when a leaded apron is used. Exposures during the first few days after conception are thought to cause undetectable death of the concepts.

The most common abnormality children exposed early in gestation was reduced growth and reduced head circumference (microcephaly), often associated with mental retardation. Other abnormalities included small birth size, cataracts, genital and skeletal malformations, and microphthalmia. The period of maximal sensitivity of the brain is 8 to 15 weeks post conception.

The cells are more sensate to x-ray if:-

1-have high mitotic division. Undergoing many division over time.e.g small lymphocytes

2-have high mitotic futures.

3-Not well differentiated, Immature cells or not highly s specialized e.g immature reproductive cells,younge bone cells.

TABLE 2-1
Relative Radiosensitivity of Various Organs

HIGH	INTERMEDIATE	LOW
Lymphoid organs	Fine vasculature	Optic lens
Bone marrow	Growing cartilage	Mature erythrocytes
Testes	Growing bone	Muscle cells
Intestines	Salivary glands	Neurons
Mucous membranes	Lungs	
	Kidney	
	Liver	

Protection of patient:

1-Use of high speed film lead to less exposure time.

2-Filtration.

3-Proper collimation.

4-Proper cone alignment to avoid repeating.

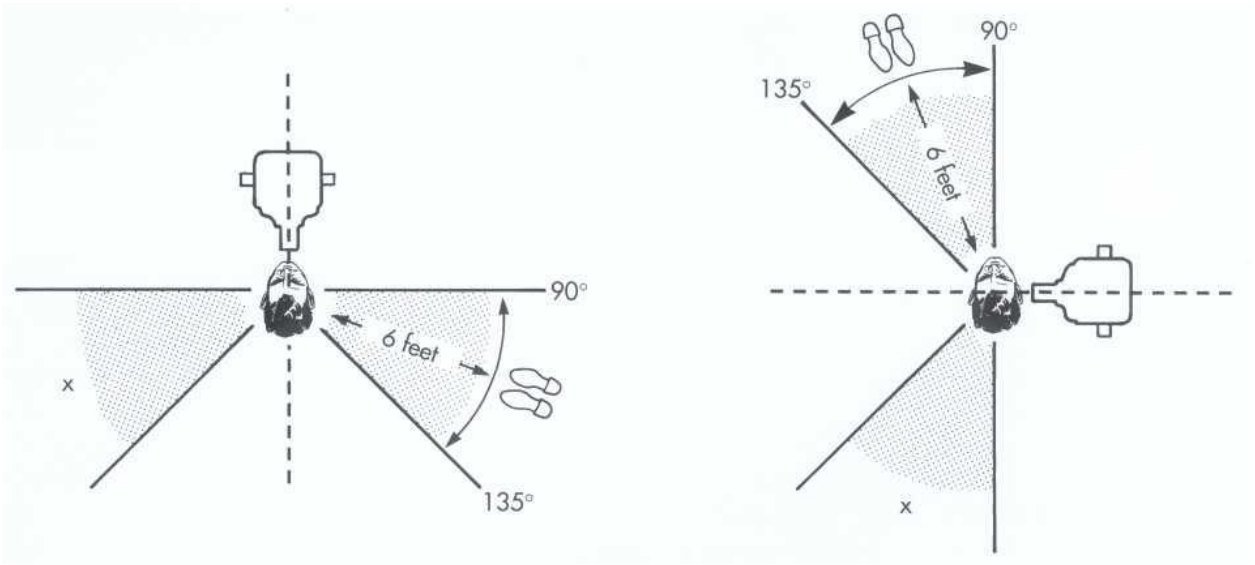
5-Use of lead apron in child and pregnant.

6-Increased object-skin distance lead to decrease in tissue exposure to radiation.

7-Proper KV,and MA.

Protection of operator:

FIG.



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