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Review Article

A ray of black on cells: A short review on radiation biology

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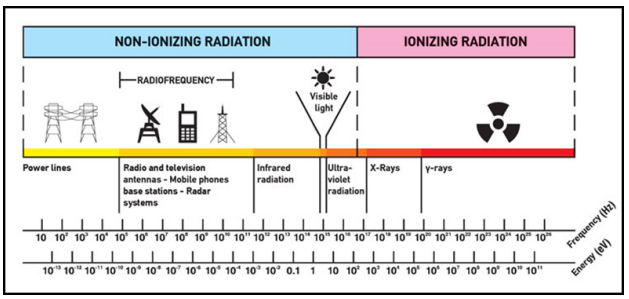
ABSTRACT

Atom is the fundamental unit of elements. The nature of radiation is the transmission of energy through space & matter. The interaction between radiation & matter occurs at 10^{-13} seconds after exposure & may persists for seconds, hours, decades & possibly even generations. X-Ray are forms of electromagnetic waves, which are useful in various imaging modalities for diagnosis & treatment planning of diseases. This review " A ray of black on cells: a short review on radiation biology" intends to focus on effects of radiation on living systems.

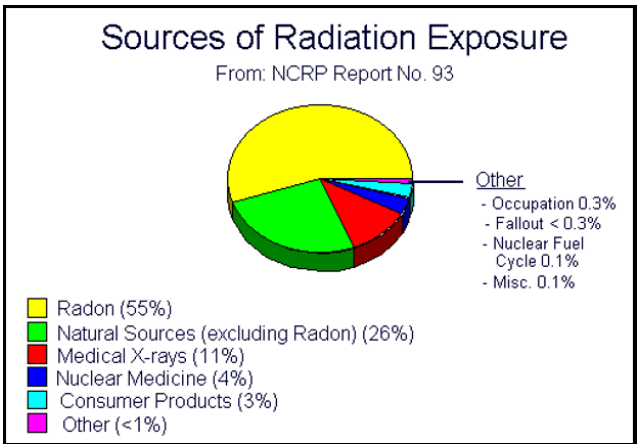
1. Introduction

1. When X rays interact with human body there are various changes that take place in the body.



2. Total Radiation

1. How are tissues affected by x-rays



3. Effects in atoms and molecules

1. Excitation: If the energy of excitation is too large, it may produce a break in the molecular bond and disrupt the molecule
2. Ionization: An ionized becomes more chemically reactive as it attempts to find an electron to find the missing one

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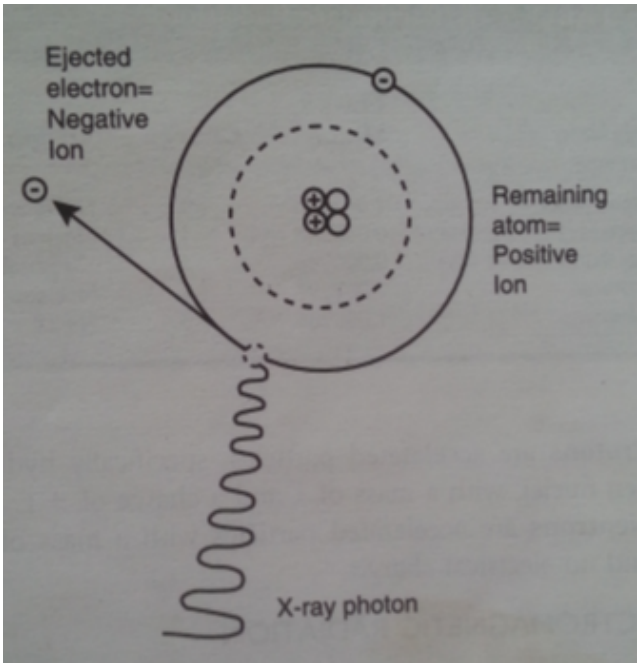
3. Breaking of molecular bonds: If enough molecules are damaged, there is a loss of cell function, disruption of internal organelles, or even death of the cell. [1–4]



1. Chemical effects of radiation
2. Radiolysis of water

3.1. *Ionization of water photoelectron/photon - ion pair*

1. Positive water molecule

$$Phaton + H_2O \rightarrow e^- + H_2O^+$$
$$Photoelectron\ e^- + H_2O \rightarrow 2e^- + H_2O^+$$

2. Formation of Hydroxyl free radical

$$OH^0 + OH^0 \rightarrow H_2O_2$$
$$H^0 + 0_2 \rightarrow HO_2^0$$

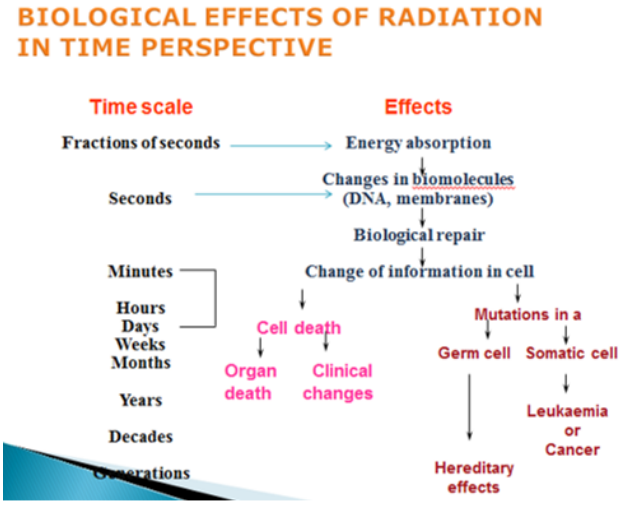
4. Time scale of radiation damage

4.1. *Latent period*

The time interval between irradiation and development of the observed biological effect is known as latent period. [5]

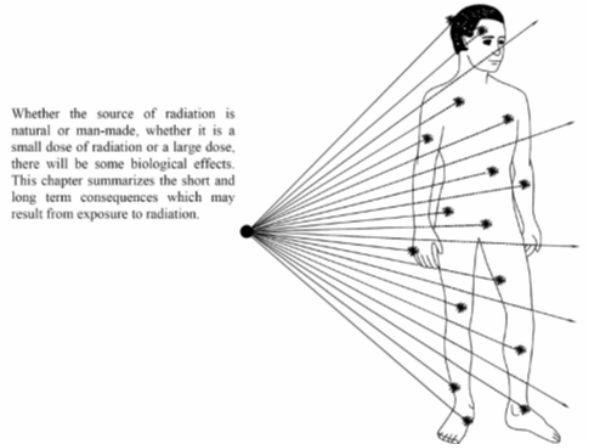
4.2. *Accumulative effects of radiation*

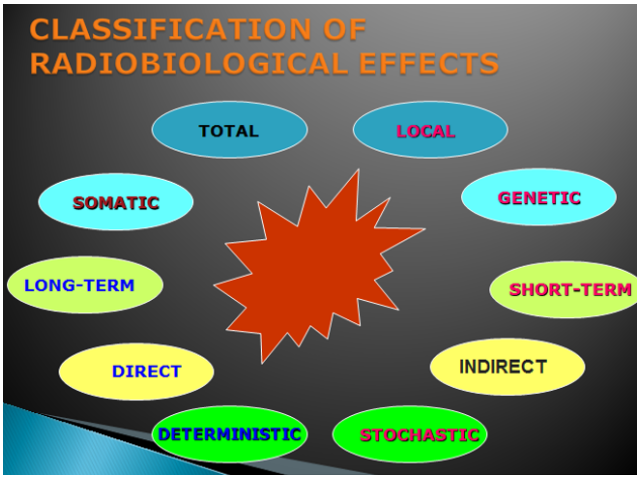
Each succeeding radiation exposure is assumed to add a small increment to the radiation damage.

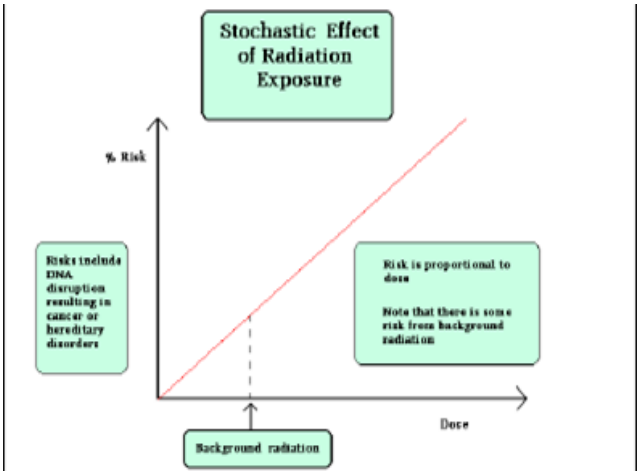


4.3. *Dosimetry*

1. Equivalent dose(HT): The equivalent dose is used to compare the biological effects of different types of radiation to a tissue or organ. HT =Σ WR *DT
2. Effective dose(E : Is used to estimate the risk in humans E= Σ WT *HT
3. Radioactivity(A : Describes the decay rate of a sample of radioactive material.
4. Classification of radiobiological effects







4.4. *Deterministic effect*

1. Response is proportional to the dose
2. Cell death
3. Threshold
4. Eg. effect on oral cavity

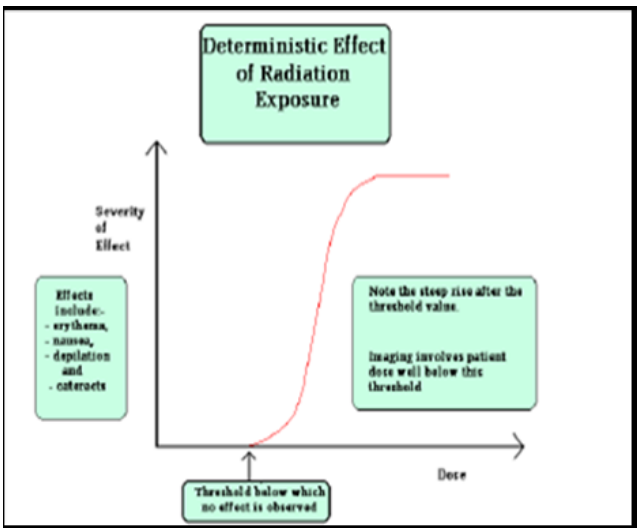


Fig. 1:

4.5. ***Stochasatic effect***

1. Probability of the response the dose
2. All or none
3. No threshold
4. Eg. Radiation induced cancer

4.6. *Radiation affects life in two ways*

1. Direct effect
2. Indirect effect

4.6.1. *Direct effect*

Photon or 2^{*} electron hit bio-molecule-ionization

1. Free radical production

$RH + X - ray \rightarrow R^{0} + H^{+} + e$

2. Free radical fates

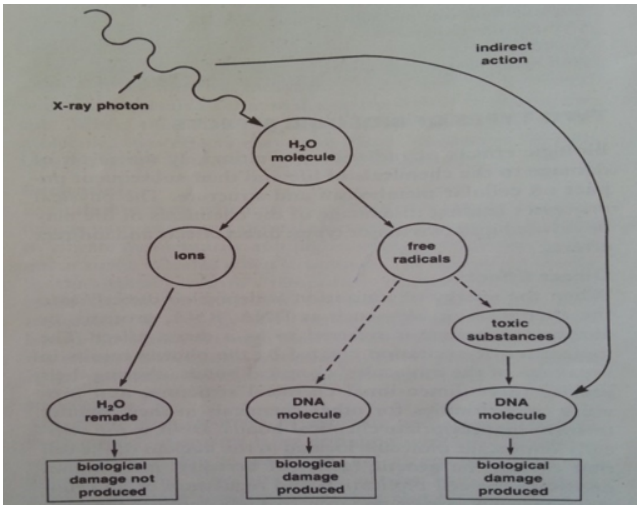
- Dissociation

$R^{0} \rightarrow x + Y$

- Cross linking

$R^{0} + S^{0} \rightarrow RS$

4.7. *Indirect effect*



4.8. Displaced electron reacts with water molecule

Negative water molecule

$$e_- + H_2O \rightarrow H_2O^-$$

Unstable and dissociate into

1. Hydroxyl ion and
2. Hydrogen free radical

$$H_2O^- \rightarrow OH^- + H^0$$

4.9. Effects on biological molecules

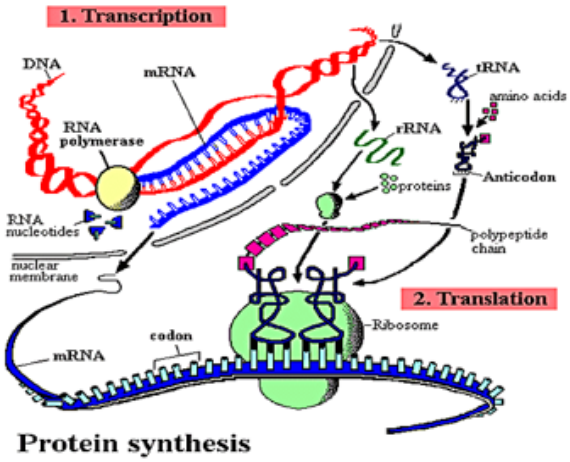
1. Effects on nucleic acids
2. Effects on proteins
3. Effects on cell kinetics

4.10. Effects on nucleic ACIDS

1. Breakage of 1 or both DNA strands.
2. Cross linking of DNA strands with the helix, or to other DNA strands
3. Change or loss of base.
4. Disruption of Hydrogen bonds between DNA strands

4.11. Effect on proteins

1. Affects the secondary and tertiary structure
2. Affects side chains, hydrogen and sulfide bonds
3. Inter and intra molecular connection
4. Amplification of effect by influencing enzymes
5. Less significant than DNA damage



Protein synthesis

4.12. Radiation effect on cell kinetics

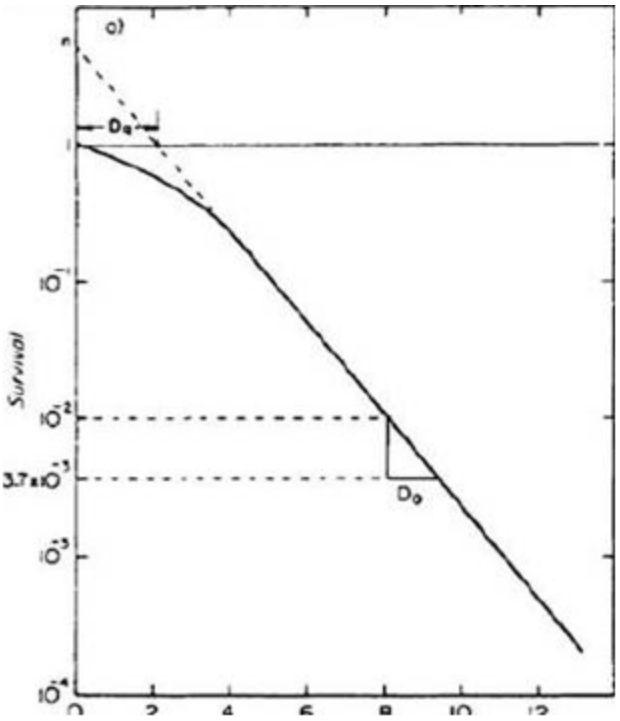
4.13. Effect on high mitotic index population

1. Decrease in tissue size
2. Cell cycle delay
3. Cell death

4.14. Bystander effect

Cells that are damaged by radiation, release into immediate environment their products causing cell aberrations, mutations, carcinogenesis

4.15. Survival curve



1. They are used to study the response of replicating cells exposed in culture to radiation
2. MODIFYING FACTORS

HOST FACTORS	RADIATION FACTORS
1.Species of animal	1.Local area vs whole body exposure
2.Intrinsic resistance	2.Linear energy of transfer(LET)
3.Type and sensitivity of tissue	3.Penetrating ability of radiation
4.Rate of cell division	4.Total dose
5.Sensitivity of cell to radiation	5.Acute vs chronic exposure
6.Phase of cell cycle	6.Oxygen
7.Ability to repair damage	7.Dose and dose rate effectiveness factor
8.Age,sex,ethnicity	

4.16. Radiation sensitivity and cell type (Bergoni and Tribondeau 1960

1. Different cells react to radiation in different ways
2. Most sensitive:

- High mitotic index cells
- Most primitive in differentiation
- Undergo many future mitosis

5. Casarett's classification of tissue radiosensitivity

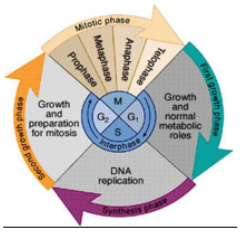
CELL TYPE	PROPERTY	EXAMPLES	SENSITIVITY
I . Vegetative intermitotic cells	Divide regularly no differentiation	Erythroblasts Interstitial crypt cells Germinal cells of epidermis ,oral mucosal cells	HIGH
II .Differentiating intermitotic cells	Divide regularly some differentiation between division	Myelocytes Spermatocytes Oocytes	
CONNECTIVE TISSUE CELLS			
III. Reverting post-mitotic cells	Do not divide regularly variably differentiated	Liver, acinar and ductal cells of salivary glands &pancreas	
IV. Fixed post-mitotic cells	Do not divide regularly Highly differentiated	Nerve cells, muscle cells, squamous epithelial cells	LOW

5.1. Effects on organs

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	

- Stage of cell cycle
- Type of damage –stage of cell in cell cycle at the time of irradiation



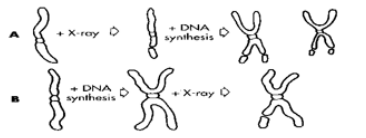


FIG. 2-2 *Chromosome aberrations.* **A,** Irradiation of the cell after DNA synthesis results in a single-arm chromatid aberration. **B,** Irradiation before DNA synthesis results in a double-arm aberration.

- Total vs Whole body exposure
- Refers to area of body exposed
- Extensive radiation injury > damage that occurs in blood-forming tissues
- Linear energy transfer

The rate at which energy is transferred from ionizing radiation to soft tissue, expressed in terms of kiloelectron volts per micrometer (keV/μm) of track length in soft tissue. The LET of diagnostic x-rays is about 3 keV/μm,[6,7]

6. Mosby's Medical Dictionary, 8th edition. © 2009, Elsevier

- High LET –double strand breakage

eg: alpha particles

- Low LET –single strand breakage

eg; X- ray

7. Conflicts of Interest

All contributing authors declare no conflicts of interest.

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