RADIOBIOLOGY

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FINAL YEAR BDS

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- It is the study of effects of radiation on living systems.
- Radiation acts on living systems through direct and indirect effects
- When the energy of a photon or secondary electron ionizes biologic macromolecules, the effect is termed direct.
- The photon may be absorbed by water in an organism, ionizing the water molecules. The resulting ions form free radicals (radiolysis of water) that in turn interact with and produce changes in the biologic molecules. This series of events is termed indirect.

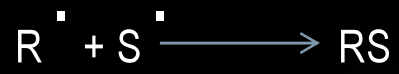
DIRECT EFFECT

- Free radical production:

- Free radical fates

Dissociation:

Cross-linking:



INDIRECT EFFECTS

- $RH + OH^{\cdot} \longrightarrow R^{\cdot} + H_20$

- $RH + H^{\cdot} \longrightarrow R^{\cdot} + H_2$

- The interaction of hydrogen and hydroxyl free radicals with organic molecules can result in the formation of organic free radicals. About two thirds of radiation-induced biologic damage results from indirect effects

CHANGES IN DEOXYRIBONUCLEIC ACIDS

- Radiation produces a number of different types of alterations in DNA, including the following:

- **BREAKAGE OF ONE OR BOTH DNA STRANDS**
- **CROSS-LINKING OF DNA STRANDS WITHIN THE HELIX, TO OTHER DNA STRANDS, OR TO PROTEINS**
- **CHANGE OR LOSS OF A BASE**
- **DISRUPTION OF HYDROGEN BONDS BETWEEN DNA STRANDS**

DETERMINISTIC & STOCHASTIC EFFECTS

- Radiation injury to organisms results from killing of large no.of cells is deteministic effect.
- Sublethal damage to individual cells that results in cancer formation / heritable mutation is stochastic effect

DETERMINISTIC EFFECTS ON INTRACELLULAR STRUCTURES

- **NUCLEUS**

Nucleus is more radiosensitive (in terms of lethality)than the cytoplasm.

- **CHROMOSOME ABERRATIONS**

Chromosomes serve as useful markers for radiation injury. The type of damage that maybe observed depends on the stage of the cell in the cell cycle at the time of irradiation.

CHROMATID ABERRATION: If radiation exposure occurs after DNA synthesis ,only one arm of affected chromosome is broken .

CHROMOSOME ABERRATION: If radiation induced breakdown occurs before the DNA has replicated , damage manifest as break in both arms .

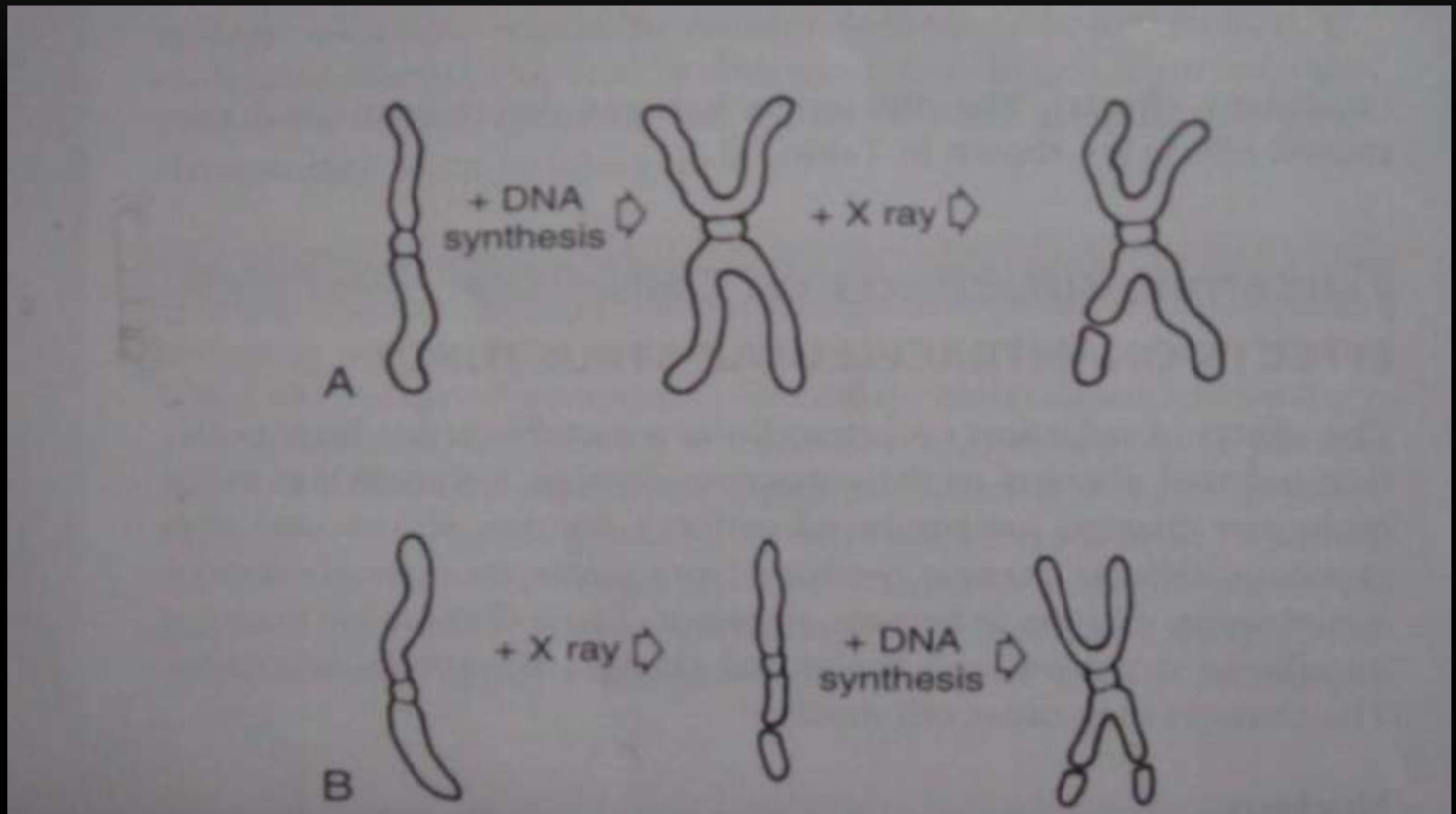
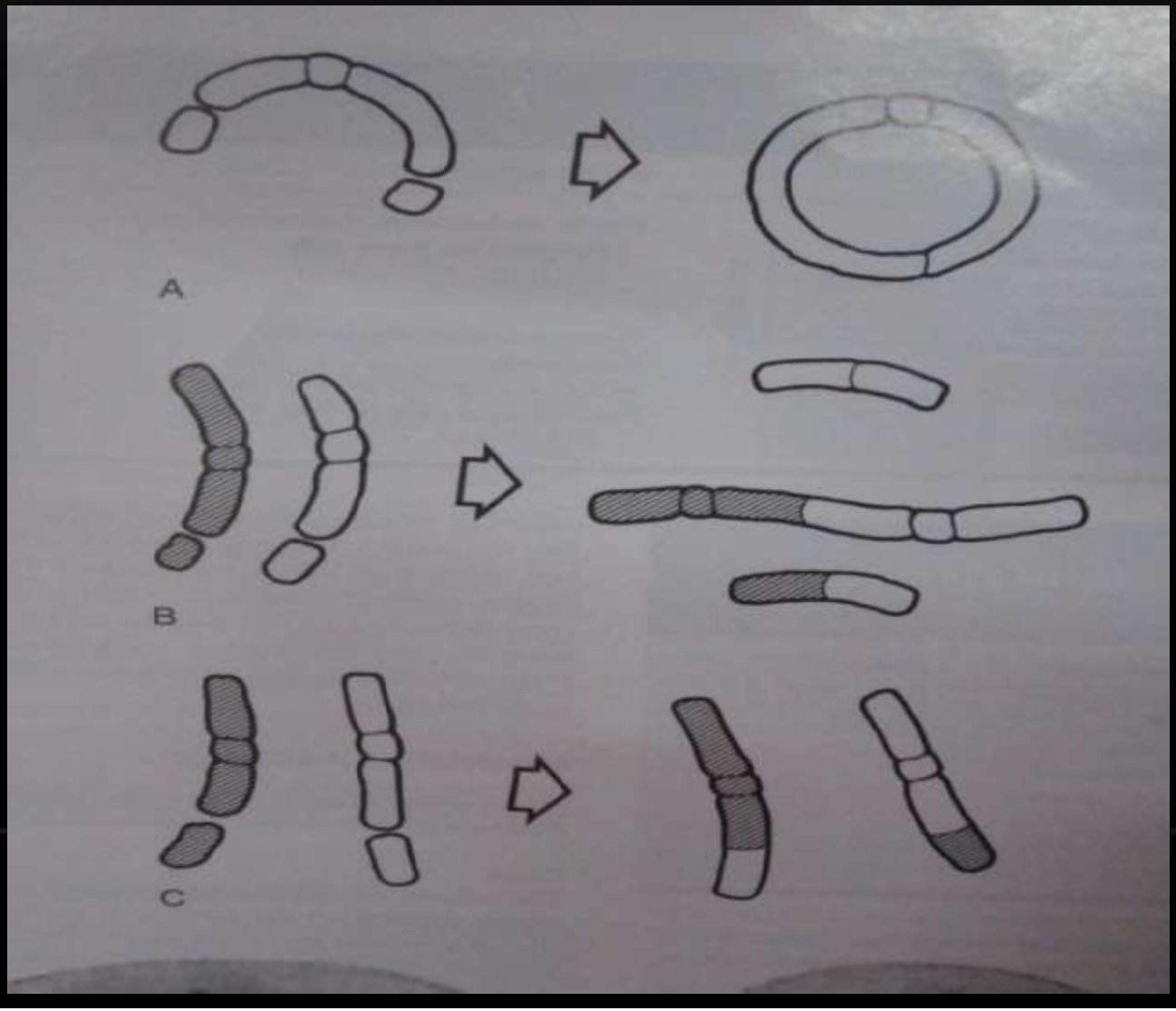


FIG. **2-2** Chromosome aberrations. **A,** Irradiation of the cell after DNA synthesis results in a single-arm (chromatid) aberration. **B,** Irradiation before DNA synthesis results in a double-arm (chromosome)

Several common forms of chromosome aberrations resulting from incorrect repair



RADIATION EFFECTS AT THE TISSUE AND ORGAN LEVEL

- The radiosensitivity of a tissue or organ is measured by its response to irradiation
- **SHORT-TERM EFFECTS**

If continuously proliferating tissues (e.g., bone marrow, oral mucous membranes) are irradiated with a moderate dose, cells are lost primarily by mitosis linked death.

Tissues composed of cells that rarely or never divide (e.g., muscle) demonstrate little or no radiation induced hypoplasia over the short term.

- **LONG-TERM EFFECTS**

The long-term deterministic effects of radiation on tissues and organs depend primarily on the extent of damage to the fine vasculature. Damage to capillaries leads to narrowing & eventual obliteration of vascular lumens .

This impairs transport of oxygen,nutrients &waste products and result in death of all cell types dependent on this vascular supply.

MODIFYING FACTORS

- **DOSE :** The severity of deterministic damage seen in irradiated tissues or organs depends on the amount of radiation received**.**
- **DOSE RATE :** When organisms are exposed at lower dose rates, a greater opportunity exists for repair of damage, thereby resulting in less net damage.
- **OXYGEN :** The radio resistance of many biologic systems increases by a factor of 2 or 3 when irradiation is conducted with reduced oxygen
- **LINEAR ENERGY TRANSFER :** In general, the dose required to produce a certain biologic effect is reduced as the linear energy transfer (LET) of the radiation is increased.

RADIATION EFFECT ON ORAL TISSUES

- **ORAL MUCOUS MEMBRANE**
- The oral mucous membrane contains a basal layer composed rapidly dividing radiosensitive stem cells .
- Near the end of the second week of therapy, as some of these cells die, the mucous membranes begin to show areas of redness and inflammation (mucositis).
- As the therapy continues, the irradiated mucous membrane begins to break down,with the formation of a white to yellow pseudomembrane (the desquamated epithelial layer) .
- At the end of therapy the mucositis is usually most severe, discomfort is at a maximum, and food intake is difficult. Good oral hygiene minimizes infection.
- Topical anesthetics may be required at mealtimes. Secondary yeast infection by Candida albicans is a common complication and may require treatment .


Source: TUSDM

TASTE BUDS

- Taste buds are sensitive to radiation. Doses in the therapeutic range cause extensive degeneration of the normal histologic architecture of taste buds.
- Patient often notice a loss of taste acuity during the second or third week of radiotherapy.
- Bitter and acid flavors are more severely affected when the posterior two thirds of the tongue is irradiated, and salt and sweet when the anterior third of the tongue is irradiated.
- Taste acuity usually decreases by a. factor of 1,000 to 10,000 during the course of radiotherapy. Alterations in the saliva may account partly for this reduction, which may proceed to a state of virtual insensitivity,
- It is reversible & recovery to near normal levels some 60 to 120 days after irradiation.

SALIVARY GLANDS

- The parenchymal component of the salivary glands is rather radiosensitive (parotid glands more so than submandibular or sublingual glands). A marked and progressive loss of salivary secretion is usually seen in the first few weeks after initiation of radiotherapy.
- Saliva that is secreted usually has a pH value 1 unit below normal.
- It initiate decalcification of normal enamel, In addition, the buffering capacity of saliva falls.
- If some portions of the major salivary glands have been spared,dryness of the mouth usually subsides in 6 to 12 months because of compensatory hypertrophy of residual salivary gland tissue. Reduced salivary flow that persists beyond a year is unlikely to show significant recovery

TEETH

- Irradiation of teeth with therapeutic doses during their development severely retards their growth.
- Irradiation after calcification has begun may inhibit cellular differentiation ,causing malformations and arresting general growth.
- Children receiving radiation therapy to the jaws may show defects in the permanent dentition such as retarded root development, dwarfed teeth, or failure to form one or more teeth.
- Adult teeth are very resistant to the direct effects of radiation exposure.
- Radiation has no discernible effect on the crystalline structure of enamel, dentin, or cementum, and radiation does not increase their solubility.

RADIATION CARIES

- Occur in individuals who receive a course of radio therapy that includes exposure of the salivary glands.
- Clinically, three types of radiation caries exist. The most common is widespread superficial lesions attacking buccal, occlusal, incisal, and palatal surfaces.
- Another type involves primarily the cementum and dentin in the cervical region. These lesions may progress around the teeth circumferentially and result in loss of the crown.
- A final type appears as a dark pigmentation of the entire crown. The incisal edges may be markedly worn.
- The best method of reducing radiation caries is daily application for 5 minutes of a viscous topical 1 % neutral sodium fluoride gel in custom-made applicator trays.

Fig. 40

Fig. 41

Fig. 42