UNIT-II

NUCLEAR RADIATION AND ITS EFFECTS ON THE BODY

2.4 RADIATION CARCINOGENESIS

Radiation carcinogenesis refers to the process by which exposure to ionizing radiation leads to the development of cancer. Ionizing radiation, which includes X-rays, gamma rays, and particles like alpha and beta particles, has enough energy to remove tightly bound electrons from atoms, creating ions. This can cause direct damage to DNA or generate reactive oxygen species (ROS) that indirectly damage cellular components.

Mechanisms of Radiation Carcinogenesis:

1. **DNA Damage:**
   - **Direct Damage:** Ionizing radiation can break DNA strands, leading to mutations if not properly repaired.
   - **Indirect Damage:** Radiation interacts with water molecules in cells to produce ROS, which then damage DNA, proteins, and lipids.
2. **Chromosomal Aberrations:**
   - Radiation can cause chromosomal translocations, deletions, and duplications, potentially activating oncogenes or inactivating tumor suppressor genes.
3. **Genomic Instability:**
   - Radiation can induce persistent changes in the genome, leading to increased mutation rates in subsequent cell generations.
4. **Bystander Effect:**
   - Cells not directly hit by radiation may still exhibit damage due to signals from nearby irradiated cells.
5. **Microenvironmental Changes:**
   - Radiation may alter the tissue microenvironment, promoting inflammation, which can support tumor development and progression.

Factors Influencing Radiation Carcinogenesis:

- **Type and Energy of Radiation:** High-LET (Linear Energy Transfer) radiation (e.g., alpha particles) causes more complex DNA damage than low-LET radiation (e.g., X-rays).
- **Dose and Dose Rate:** Higher doses and faster delivery increase risk. However, even low doses over time can pose a risk.
- **Tissue Sensitivity:** Some tissues (like bone marrow and thyroid) are more sensitive to radiation-induced carcinogenesis.
- **Age and Gender:** Younger individuals are generally more sensitive, and some cancers show gender-specific sensitivity.
- **Genetic Susceptibility:** Variations in DNA repair genes can affect individual susceptibility to radiation-induced cancer.

Cancers Associated with Radiation Exposure:

- **Leukemia** (especially acute myeloid leukemia)
- **Thyroid cancer** (notably after childhood exposure)

- **Breast cancer**
- **Lung cancer (particularly from radon exposure)**
- **Skin cancer** (especially basal cell carcinoma)
- **Bone cancer** (historically seen in radium dial painters)

Examples of Radiation Carcinogenesis in History:

1. **Hiroshima and Nagasaki Survivors:** Increased rates of leukemia and solid tumors observed among atomic bomb survivors.
2. **Chernobyl Disaster:** Surge in thyroid cancers, particularly in children exposed to radioactive iodine.
3. **Medical Radiation:** Increased cancer risks linked to high doses of diagnostic imaging or radiation therapy.
4. **Radon Exposure in Miners:** Elevated lung cancer risks in miners exposed to radon gas.

Prevention and Risk Mitigation:

- **Radiation Protection Standards:** Using shielding, minimizing exposure time, and maximizing distance from radiation sources.
- **Monitoring and Regulations:** Occupational exposure limits and public health guidelines for environmental radiation.
- **Medical Imaging Justification:** Ensuring medical imaging is only used when necessary and using the lowest effective dose.