UNIT-II

NUCLEAR RADIATION AND ITS EFFECTS ON THE BODY

2.1 Radionuclides in medicine and biology

Radionuclides, or radioactive isotopes, are widely used in medicine and biology for both diagnostic and therapeutic purposes. Here's an overview of some commonly used radionuclides and their applications:

❖ **Diagnostic Applications**

a. Nuclear Medicine Imaging (Scintigraphy, PET, SPECT)

These techniques use radionuclides to visualize physiological processes.

- **Technetium-99m (Tc-99m)**
  - **Half-life:** 6 hours
  - **Applications:** Used in over 80% of nuclear medicine procedures, including bone scans, cardiac imaging (myocardial perfusion), and functional studies of the liver, lungs, and kidneys.

- **Fluorine-18 (F-18)**
  - **Half-life:** 110 minutes
  - **Applications:** Used in **Positron Emission Tomography (PET)**, particularly as **F-18 fluorodeoxyglucose (FDG)** for imaging metabolic activity in cancer, brain disorders, and heart diseases.

- **Iodine-123 (I-123)**
  - **Half-life:** 13 hours
  - **Applications:** Used for thyroid imaging and function tests.

- **Gallium-68 (Ga-68)**
  - **Half-life:** 68 minutes
  - **Applications:** PET imaging of neuroendocrine tumors using Ga-68- labeled somatostatin analogs.

- **Thallium-201 (Tl-201)**
  - **Half-life:** 73 hours

- **Applications:** Myocardial perfusion imaging to assess coronary artery disease.

❖ **Therapeutic Applications**

Radionuclides are used to treat various diseases, especially cancers.

- **Iodine-131 (I-131)**
  - **Half-life:** 8 days
  - **Applications:** Treatment of hyperthyroidism (Graves' disease) and thyroid cancer. Also used in some cases of lymphoma.
- **Yttrium-90 (Y-90)**
  - **Half-life:** 64 hours
  - **Applications:** Radioembolization therapy for liver cancer and **radioimmunotherapy** for non-Hodgkin lymphoma.
- **Lutetium-177 (Lu-177)**
  - **Half-life:** 6.7 days
  - **Applications:** Used in targeted radionuclide therapy, especially for **neuroendocrine tumors**.
- **Radium-223 (Ra-223)**
  - **Half-life:** 11.4 days
  - **Applications:** Treatment of metastatic prostate cancer to the bone.
- **Phosphorus-32 (P-32)**
  - **Half-life:** 14.3 days
  - **Applications:** Used in the treatment of **polycythemia vera** and certain bone marrow disorders.

❖ **Research and Biological Applications**

Radionuclides are also essential tools in biological research, such as tracing metabolic pathways and studying molecular interactions.

- **Carbon-14 (C-14)**
    - **Half-life:** 5,730 years
    - **Applications:** Used in **radiolabeling** organic compounds to study metabolic pathways.

- **Tritium (H-3)**
    - **Half-life:** 12.3 years
    - **Applications:** Used for **DNA labeling** and tracking the synthesis of nucleic acids and proteins.

- **Sulfur-35 (S-35)**
    - **Half-life:** 87.5 days
    - **Applications:** Labeling proteins to study **protein synthesis** and function.

- **Phosphorus-32 (P-32)**
    - **Applications:** Used in molecular biology to label **nucleotides** in DNA and RNA research.

Use of Radionuclide

- **Half-life:** Determines the duration the radionuclide remains active and is crucial for balancing diagnostic clarity with patient safety.
- **Type of Emission:**
    - **Gamma emitters** (e.g., Tc-99m, I-123) are primarily used for imaging.
    - **Beta emitters** (e.g., I-131, Y-90) are used for therapy as they cause localized tissue damage.
    - **Alpha emitters** (e.g., Ra-223) have high energy and are used for treating bone metastases.

- **Targeting Mechanisms:** Many radionuclides are attached to molecules (like antibodies or peptides) that specifically target certain tissues or tumors.