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Nuclear diagnostics and Magnetic Resonance Imaging

Week 1; Lecture 2; Section 1: Radionuclides for nuclear medicine

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Section 1

Radionuclides for nuclear medicine

A practical matter . . .

A "Goldilocks" problem:

- Lifetime: neither:
  Too long—too small a fraction of decays used for imaging;
  Too short—too small a fraction delivered for imaging
- Practical lifetimes for imaging: minutes (seconds) to days
  - Longer-lived isotopes have applications in therapy
- Decay products 'sufficiently' penetrating:
  - Imaging requires external detection of radiation
- Radiation must emerge from the body:
  - Without leaving an unacceptably large dose . . . and . . .
  - With properties that make it easy to detect . . . and . . .
  - Pointing back to the origin of the radiation

Desirable properties of radioisotopes

- α-emitters are not suitable for imaging;
  Range too small, deposit too much dose
- γ-emitters: γ energy in range $50 < E_\gamma < 600\,\text{keV}$;
  Low-energy photons have large interaction probability so unlikely to leave body, simply deposit dose
- Beta emitters: e^- absorbed or lose energy and scatter, not used for imaging;
  If absorbed, e^- simply deposits dose, reducing rate that could be detected.
  Energy loss and scattering of high-energy e^- destroys pointing accuracy and make e^- hard to detect.
- e^+ emitters exploited in positron-emission tomography;
  Signal (back-to-back photons) from e^+e^- annihilation.

Radiopharmaceuticals – examples

Nuclide	Compound	Measurement	Example of clinical use
^{99m}Tc	^{99m}Tc-methylene diphosphonate (MDP)	Bone metabolism	Metastatic spread of cancer
^{99m}Tc	Sestamibi, Tetrofosmin	Myocardial perfusion	Coronary artery disease
^{99m}Tc	MAG3, DTPA	Renal function	Kidney disease
^{99m}Tc	HMPAO, EDC	Cerebral blood flow	Neurologic disorders
^{131}I	Sodium Iodide	Thyroid function	Thyroid disease
^{67}Ga	Gallium citrate	Sequestered in tumours	Tumour localization
^{111}In	Labelled white blood cells	Sites of infection	Detecting inflammation
^{18}F	Fluorodeoxyglucose	Glucose metabolism	Cancer, neurological disorders and myocardial diseases
^{13}N	Ammonia	Myocardial perfusion	Coronary artery disease

Summary of section 1

Nuclear decay processes exploited in nuclear medicine:

- γ emitters; $50 < E_\gamma < 600\,\text{keV}$;
- e^+ emitters

Lifetimes . . . "from minutes to days"