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Nuclear Medicine (Quickstudy: Academic)

QUICK STUDY ACADEMIC OUTLINE
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Nuclear Medicine

Essentials of Radiopharmaceuticals, Radiation Safety & Detectors, Terminology, Tools, Techniques & Equipment

OVERVIEW

Scope of Practice

- Nuclear Medicine (or **NuMed**) involves the following aspects of skills, practice and technology:
 - patient care
 - radiopharmaceuticals
 - computer data acquisition & processing
 - radiopharmaceuticals
 - radioisotope therapy
 - radiation safety
 - radioisotope use
- NuMed is a **multidisciplinary field**, in which medicine is linked to:
 - chemistry
 - radiation biology
 - physics
 - computer technology
- In more advanced terms, it includes:
 - molecular nuclear medicine
 - in vivo & in vitro-chemistry
 - physiology

(NOTE: See page 6 for a **Glossary of Nuclear Medicine Terminology**)

How NuMed Works

- NuMed** has **therapeutic** and **diagnostic** components. The use of drugs called **radiopharmaceuticals** during tests for diagnosis, therapy and medical research.
- Because** all **diagnostic** and **most** **imaging** procedures are based on the **radioisotope** **receptor** **interaction** **within** **the body**, they are classified as **in vivo** **examinations**.
 - Most **NuMed** imaging procedures done for therapy are often performed within the **body** (i.e., in **radiotherapy**), and as a **closed** **cycle**.
 - However, medical research conducted using nuclear medicine is performed outside the **body** (i.e., in a **laboratory**), and as a **closed** **cycle**.
 - Most **radioisotopes** **administered** **radiopharmaceuticals** that are **injected**, **sealed** **or** **inhaled** by the **patient**.
- These **radiopharmaceuticals** are **attached** to **chemicals** that have an **affinity** for **particular** **organs**, **tissues** or **other** **areas** of **interest**.
- With the **radiopharmaceutical** **travels** **throughout** **the** **body**, the **radioisotope** **receptor** **receptor** **and** **energy** **transfer** **occurs**, and **radiopharmaceuticals** **decay** and **they** **produce** **gamma** **ray** **emissions**, which **allow** **them** **to** **be** **detected** **and** **imaged**.
- A **gamma**, or **scintillation**, **camera** is **placed** **very** **close** **to** **capture** and **translate** the **gamma** **ray** **into** **photons**. **These** **are** **then** **converted** **into** **images**.
- These **images** **are** **then** **utilized** **to** **gain** **information** **regarding** **the** **organs**, **tissues** **and** **structures** **of** **interest**.
- For **more** **than** **one** **second** **after** **an** **injection**, **more** **commonly**, **skipped** **as** **computer** **imaging**.
- For **most** **patients** **to** **study** and **identify** **a** **medical** **problem** **based** **on** **the** **organ** **or** **tissue** **function** **(physiology)**.
- Different **images** **are** **utilized** **to** **study** **different** **parts** **of** **the** **body**; in other words, the **radiopharmaceutical** **is** **chosen** **depending** **on** **the** **molecular** **composition** **target** **or** **an** **organ/tissue** **of** **interest**.
- For the **more** **extensive** **examinations**, **organs**, **tissues** or **other** **anatomical** **areas**, they **produce** **an** **image** **by** **using** **the** **total** **amount** **of** **radioactive** **material** **possible** **to** **complete** **the** **test**.
- The **purpose** **of** **the** **gamma** **camera** **is** **to** **detect** **and** **record** **the** **movement** **and** **location** **of** **radiopharmaceuticals** **in** **the** **body**.
- With the **use** **of** **other** **imaging** **modalities**, **most** **commonly**, **3D** **or** **2D** **3D** **images**, **which** **can** **display** **the** **structure** **(anatomical)** **and** **the** **function** **(metabolic, physiologic, pathologic)** **of** **the** **issue** **or** **organ** **of** **interest**.
- The **images** **taken** **by** **the** **camera** **that** **can** **be** **isolated** **and** **used** **to** **diagnose** **disorders**, **metabolic** **disorders**, **infection**, **bone** **loss**, **etc.**

BASIC NUCLEAR PHYSICS

Atoms

- The diagram at right demonstrates the basic composition of the atom, which includes the nucleus and the electrons outside in the shells that orbit the nucleus.
- The electrons have discrete energy levels, depending upon which electron they reside in (i.e., $1s, 2s, 3s, \dots$).
- Each electron has a negative charge and each electron has one unit of negative charge, the nucleus is positive and it has no charge.
- The protons and neutrons are called nucleons.
- Each nucleon has approximately 2,000 times the mass of an electron. Thus, the majority of the mass of an atom is in the nucleus.
- An atom **loses** **or** **gains** **electrons** **to** **become** **stable**, but these differences in charge (i.e., charge not being equal) can affect the characteristics and stability of the atom.
- The **proton-to-neutron ratio** in the nucleus determines the **stability** of the atom.
- In other words, if there are more protons than neutrons or more neutrons than protons—the atom becomes unstable.

Radioisotopes

- An **unstable** **atom** is **called** a **radioisotope**.
- Radioisotopes can decay by alpha, beta or gamma emissions.
- Alpha decay is a **nuclear** **process** **involving** **the** **removal** **of** **two** **protons** **and** **two** **neutrons** **from** **the** **nucleus** **in** **order** **to** **give** **up** **its** **excess** **energy**.
- This emission process will continue until the number of neutrons and the number of protons in the nucleus is **equal**.
- Alpha decay is **highly** **inelastic** **instability** in the form of **radioactivity**, which has been defined as a spontaneous release of energy of radioactive particles from the nucleus of atoms.
- Every radioisotope (also referred to as an **isotope**) has a distinct pattern for emitting ground state.
- Ex: $^{198}_{\Lambda} \text{Au}$ undergoes alpha decay by emitting beta particles and gamma rays.
- Radon-222 has an abundance of positive undergo decay by the process of positive emission or electron capture.

Positron Decay

- When a **positron** is **emitted** **to** **a** **neutron** and the **positive** **charge** is **spotted** **on** **a** **neutron**, **positive** **charge** **emission** **or** **beta** **decay**.
- As the **beta** **particle**, **is** **emitted** **in** **the** **opposite** **direction**, and the **charge** **is** **split** **between** **the** **particles**.
- Now, the **initial** **particle** **is** **neutral**, **has** **no** **charge** **and** **has** **become** **a** **neutron**.

Electron Capture

- An **electron** **from** **an** **electron** **shell** **in** **close** **proximity** **to** **the** **nucleus** **and** **is** **captured** **by** **a** **proton**.
- It **then** **combines** **with** **the** **proton**, **which** **gives** **a** **neutron** (i.e., the $-1e$ **charge** **of** **the** **electron** **cancel** **each** **other** **out**, **leaving** **a** **neutral** **particle**).
- Subsequent **characteristics** **radiations** **are** **emitted** **as** **the** **outer** **electrons** **move** **into** **the** **vacant** **shell**.
- Both of these decay processes—positron decay and electron capture—cause the **number** **of** **protons** **in** **the** **nucleus** **to** **increase** **by** **one** **and** **increase** **the** **number** **of** **neutrons** **by** **one**.
- Ex: $^{131}_{\Lambda} \text{I}$ undergoes electron capture.

Beta Decay

- Commonly, radioisotopes with an abundance of neutrons undergo decay by the process of **beta** **emission**, which results from converting a **neutron** **to** **a** **proton**.
- beta decay process requires the **neutron** **particle** **to** **spit** **a** **-1e** **charge** **particle** **(beta)**, thus leaving the **neutron** **particle** **with** **a** **+1e** **charge** **particle** **(proton)**, which decreases the **number** **of** **neutrons** **in** **the** **nucleus** **by** **one** **and** **increases** **the** **number** **of** **protons** **by** **one**.

Alpha Decay

- Alpha decay in radioisotopes having a large and unstable mass.
- They contain a positive charge of $2+$ and an atomic mass of ≈ 8 .

Gamma Emission

- It is **the** **emission** **of** **an** **excited** **nucleus** **to** **return** **to** **an** **excited** **state** **and** **return** **to** **the** **ground** **state**.
- When an **excited** **nucleus** **releases** **the** **gamma** **ray**, the **nucleus** **then** **releases** **its** **excess** **energy** **of** **an** **heat**.

The Tech Knows

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Synopsis

Nuclear medicine, an exciting but complex medical field, predominates the world of healthcare technology. Let our comprehensive 3-panel (6-page) guide make it all clear! All key aspects of nuclear medicine, from basic nuclear physics to diagnostic testing procedures, are covered in-depth, with up-to-date information that is enhanced by useful charts and tables. Each section features "The Tech Knows" - summary of critical points, set off graphically for easy reference.

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Really great study guide.

This is a nice quick reference with very general information.

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