

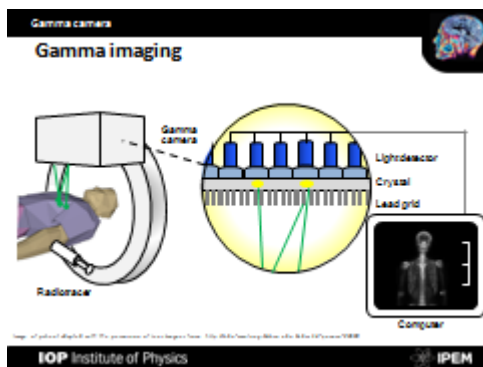
Curriculum links:

- Types of radiation
- Half-life

Introduction

Gamma cameras image the radiation from a tracer introduced into the patient's body. The most commonly used tracer is technetium-99m, a metastable nuclear isomer chosen for its relatively long half-life of six hours and its ability to be incorporated into a variety of molecules in order to target different systems within the body. As it travels through the body and emits radiation the tracer's progress is tracked by a crystal that scintillates in response to gamma-rays. The crystal is mounted in front of an array of light sensors that convert the resulting flash of light into an electrical signal. Gamma cameras differ from X-ray imaging techniques in one very important respect; rather than anatomy and structure, gamma cameras map the function and processes of the body.

Lesson notes



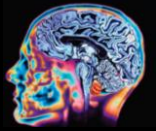
Gamma imaging

Gamma imaging carried out by injecting patient with a tracer that emits gamma rays.

- **CLICK:** *injection of radiotracer into patient, emission and detection of gamma ray*

Gamma cameras are made of a crystal (sodium iodide) which produces a burst of light when gamma rays hit it. Light is picked up by detectors (photomultiplier tubes) located behind the crystal. Electrical output from detectors is fed to computer to produce image.

Lead grid (collimator) only allows gamma cameras aligned with the 'holes' to hit crystal - allowing a "sharper" image to be obtained.



Gamma camera

Radioactive decay

Type	Symbol	Composition	Stopped by
Alpha	α	Helium nucleus	A few cm of air
Beta	β	electron	A few mm of aluminium
Gamma	γ	A high energy photon	Thick lead

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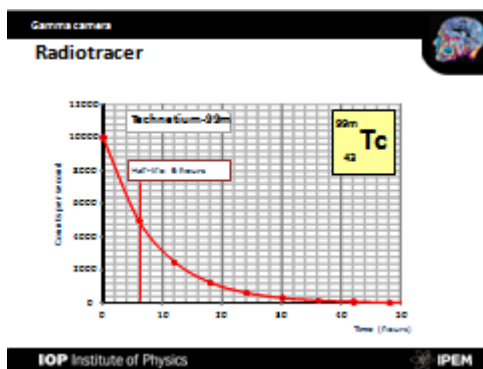
Radioactive decay

Gamma rays are produced by unstable nuclei when protons and neutrons re-range to a more stable configuration. Gamma decay usually follows an alpha or beta decay and does not change element.

- **CLICK:** *beta decay of molybdenum-99 to technetium-99m followed by gamma decay to technetium-99.*

Unlike alpha and beta radiation, gamma rays

- are electromagnetic waves
- can pass through body (so can be used for medical imaging).



Radiotracer

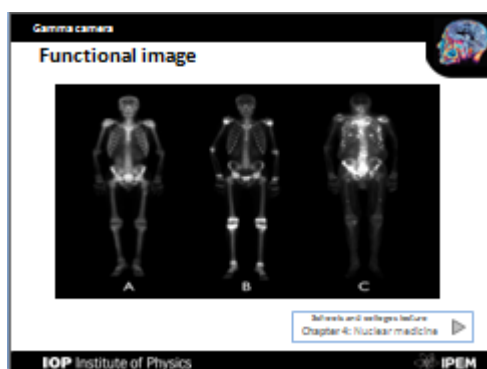
Technetium preferred because of its half-life of six hours. Half-life is time taken for count-rate/number of (parent) unstable nuclei to reach half their initial value.

Half-life of a few hours is long enough to allow

- radiotracer to get to organ
- build an image

Half-life of a few hours short enough to

- keep total patient radiation exposure low
- ensure that the patient does not remain radioactive once they return home



Functional image

Unlike techniques such as X-ray imaging, gamma cameras produce a **functional** (rather than anatomical) image.

Bone growth (for example) can be imaged by attaching technetium-99m to a molecule that is preferentially taken up by skeletal system.

- **Activity:** *Can you identify healthy teenager, healthy adult and cancer patient?*

Image A: healthy adult. Image B: healthy teenager (as indicated by greater growth at end of bones). Image C: cancer patient (as indicated by random growth).

- **Chapter 4:** *launch chapter 4 of Schools Lecture on nuclear medicine*

Note: in chapter 4 of the Schools Lecture Michael Wilson mistakenly states that the Alexander Litvinenko was poisoned with Radium; he was in fact poisoned with Polonium-210.



Worksheet mark-scheme

1.

(a) (alpha) cannot pass through body

OR

increases patient dose without contributing to image

✓

(b) Iodine-123

✓

(c) *One example of why half-life should not be longer than a several hours:*

Keep patient exposure low/so that patient does not remain radioactive when they return home

One example of why half-life should not be shorter than a several hours:

Radiotracer needs to be prepared/takes time to travel to organ/needs to last long enough to build image.

✓

2.

(a) time taken (for count-rate/activity/number of unstable nuclei) to halve

✓

(b) *Evidence of attempted half-life calculation*

✓

15 (mg)

✓

3.

(a) An electron (emitted from nucleus)

[Accept: positron]

✓

(b) 57 (neutrons)

✓

(c) *Equation copied correctly and number 43 added*

✓

TOTAL: 10 Marks