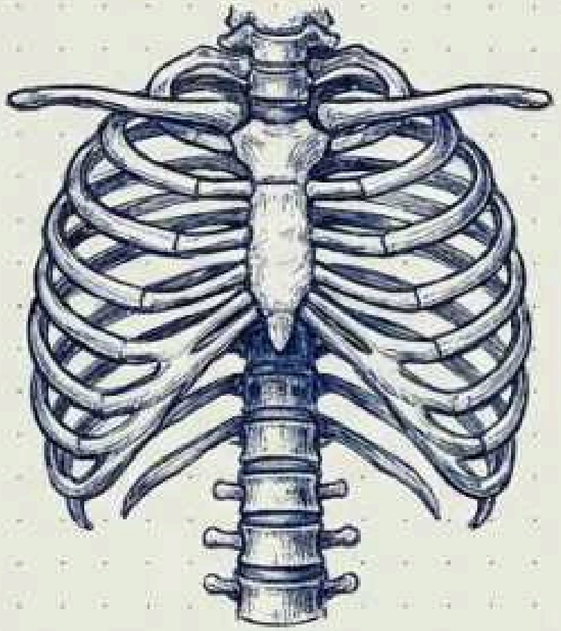
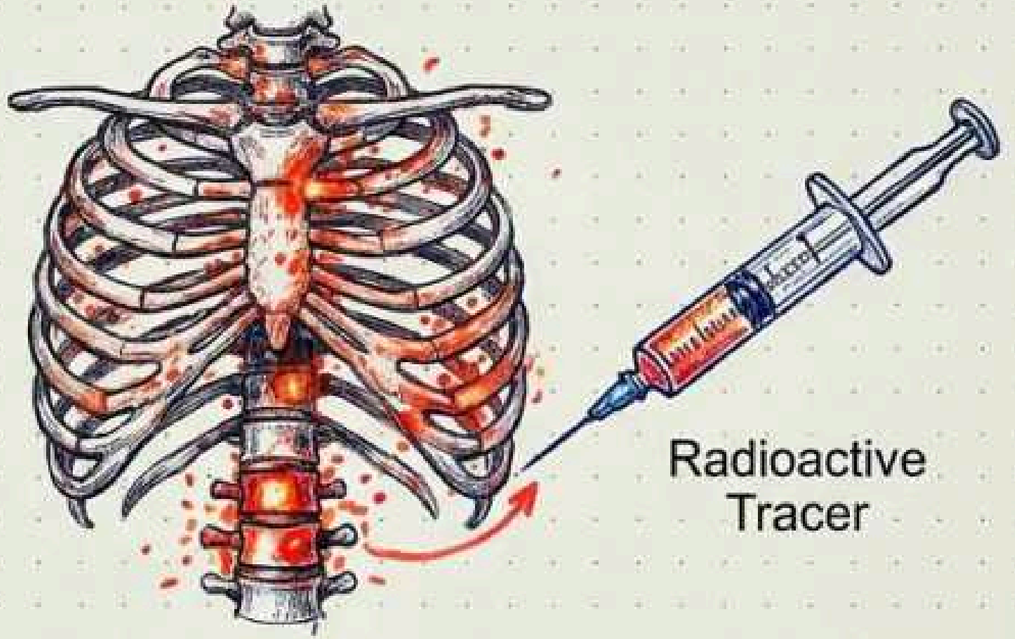
Nuclear Medicine: Function over Structure



Shows what it is (Anatomy)

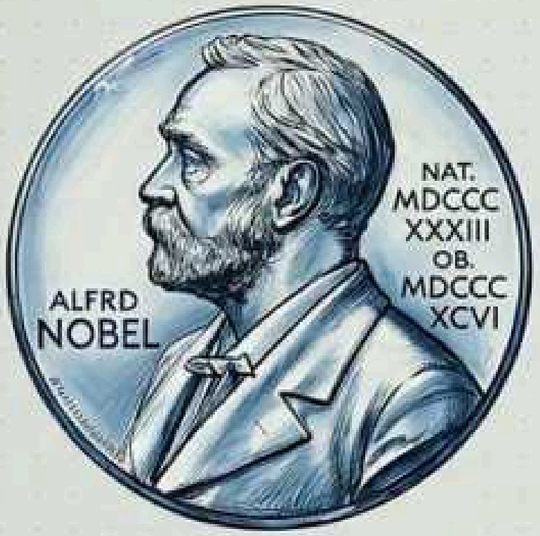


Shows what it is doing (Physiology)

Core Concept	Mechanism
A targeting substance labeled with a radioactive atom is injected into the body.	The tracer travels to specific tissues, and a specialized camera maps its location by detecting the emitted radiation.

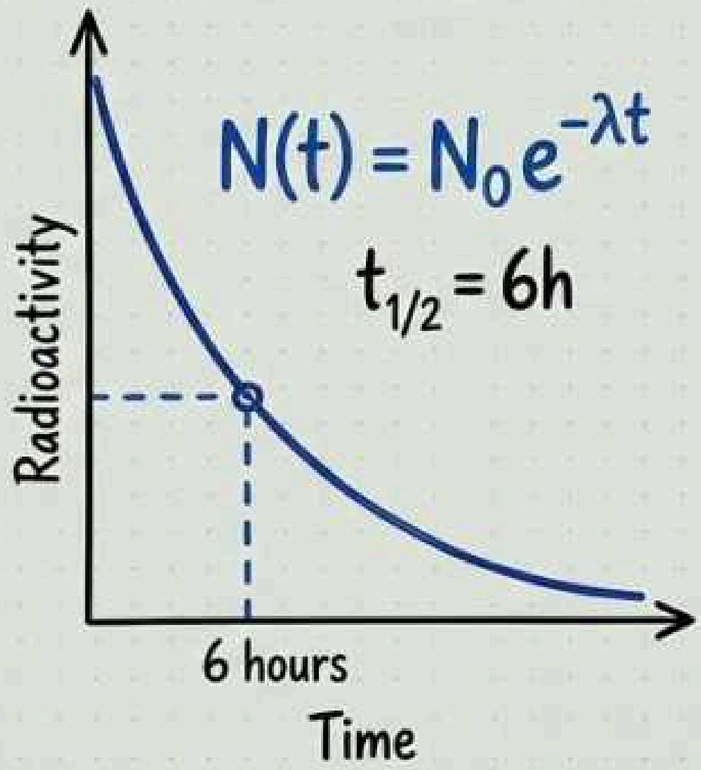
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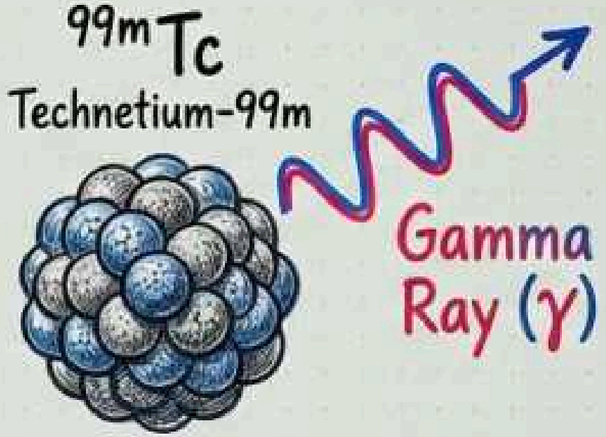
The Tracer Principle & Technetium-99m



1943: George de Hevesy

The Origin: Tracking chemical processes using radioactive atoms.





The Workhorse: Technetium-99m

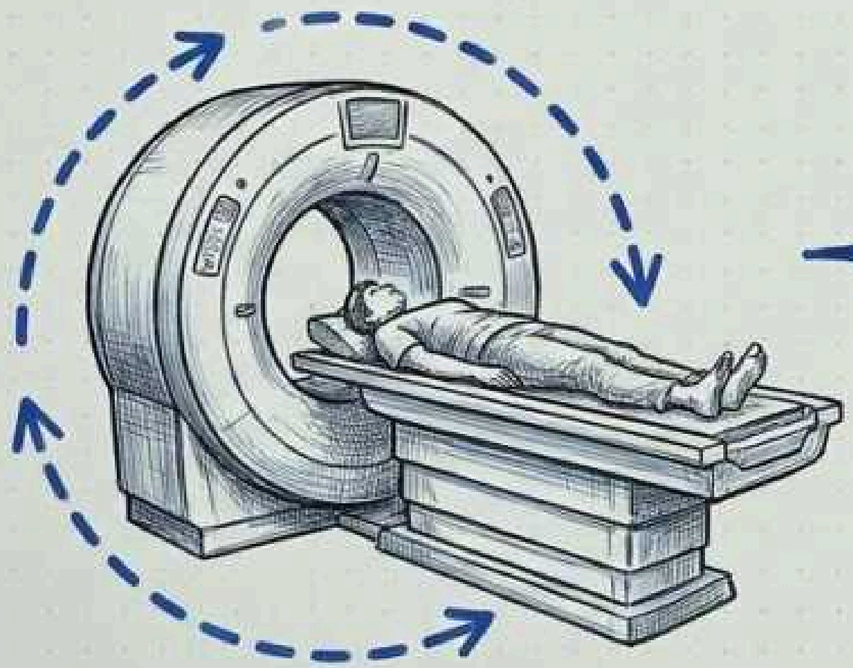
- Emits detectable gamma rays.
- 6-hour half-life: perfectly balanced to image, yet fades safely and quickly.

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Gamma Cameras & SPECT Imaging

SPECT: Single Photon Emission Computed Tomography

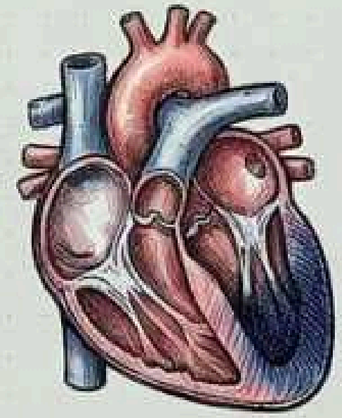
Rotating cameras capture 3D functional cross-sections of the body.





Bone Scans

Detects bone rebuilding: Cancer spread, stress fractures, infection.



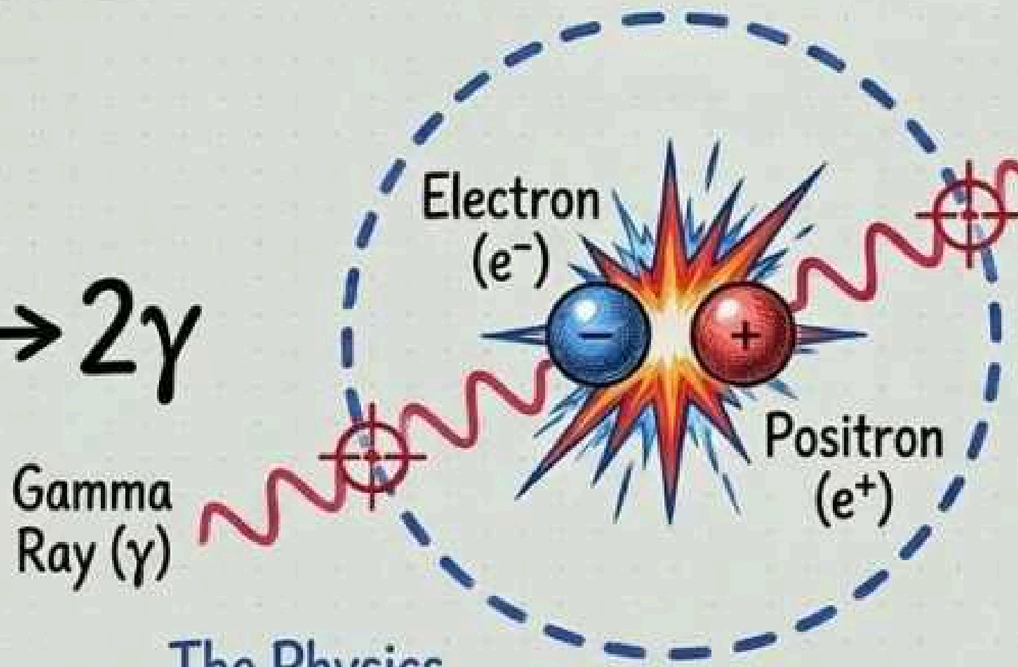
Myocardial Perfusion

Reveals areas receiving too little blood during stress.

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PET Mechanics: Positron Annihilation

$$e^+ + e^- \rightarrow 2\gamma$$



$$E=mc^2$$

PET

Positron Emission Tomography.

The Physics

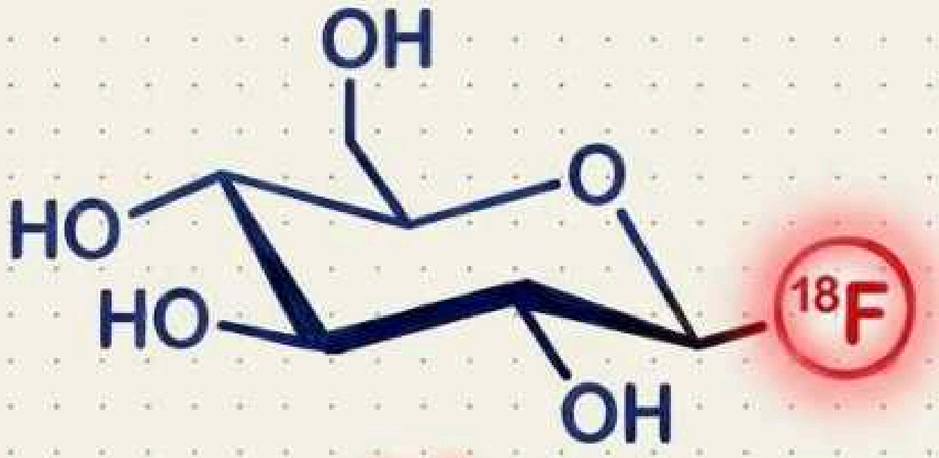
Tracers emit positrons (antimatter). Annihilation with an electron produces opposite-traveling gamma rays.

The Advantage

Detecting both rays simultaneously (coincidence detection) pinpoints the event, yielding sharper, quantitative images.

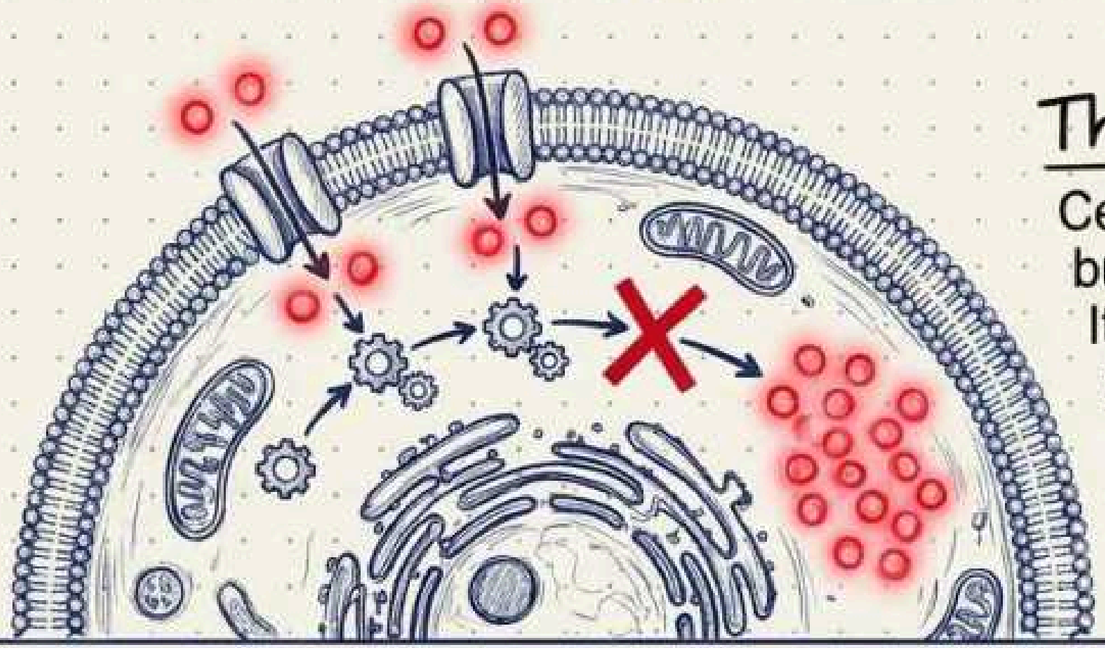
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FDG: Mapping Glucose Consumption



The Tracer: FDG

A glucose analog labeled with radioactive fluorine.



The Mechanism

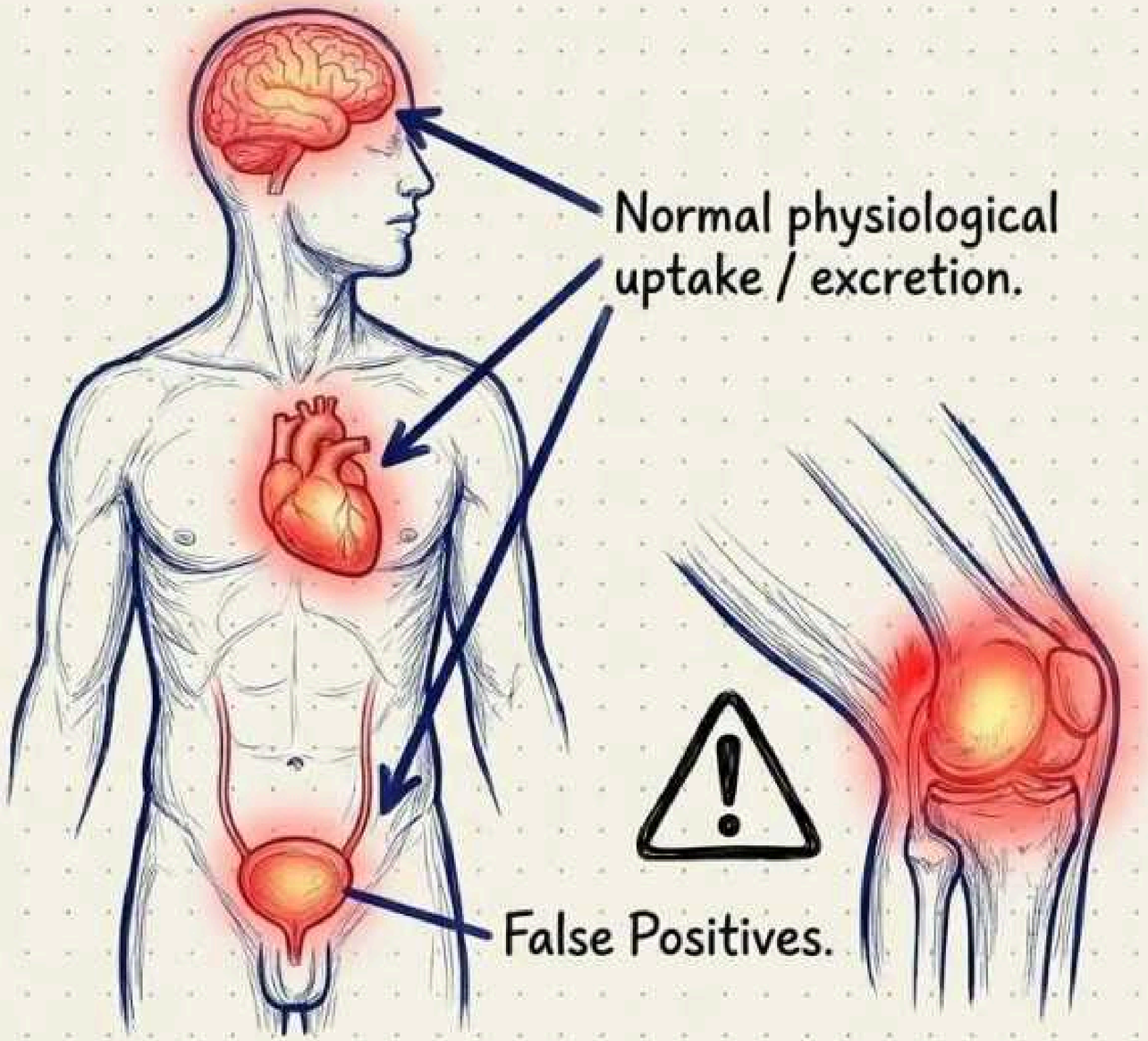
Cells absorb it like glucose but cannot metabolize it. It accumulates in direct proportion to glucose consumption.

Oncology Uses

Because many cancers consume glucose rapidly, they appear as bright spots. Used to diagnose, stage, judge treatment response, and plan radiotherapy.

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The Limits of FDG: Interpreting with Care



The Rule

FDG uptake maps metabolism, which is NOT specific to cancer.

Confounders

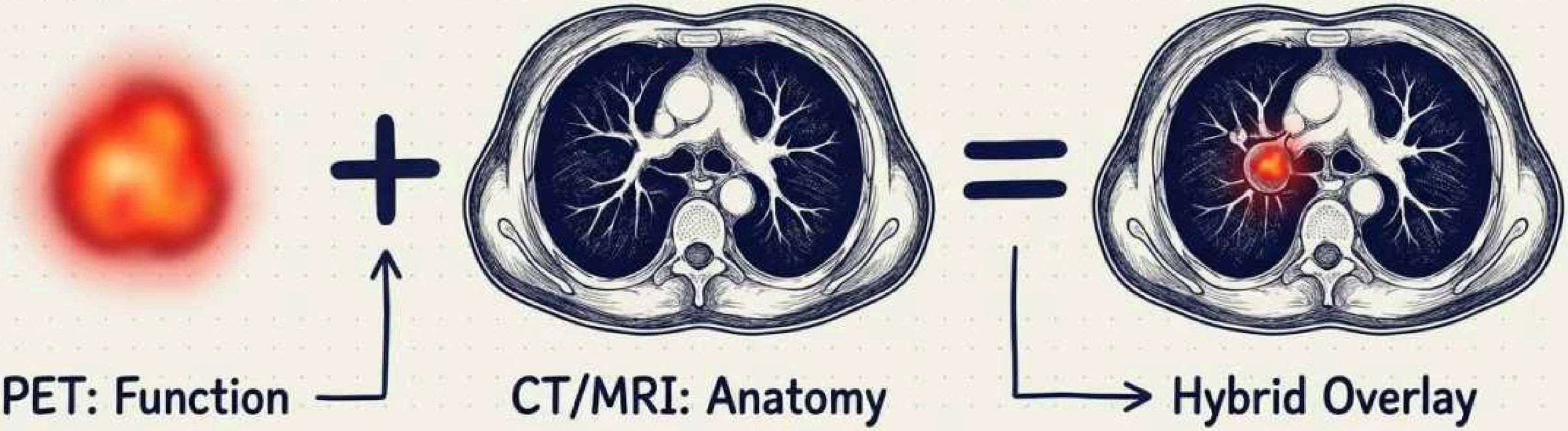
Inflammation and infection also consume glucose rapidly, visually mimicking tumors.

Blind Spots

The brain, heart, and urinary tract naturally glow, which can obscure adjacent abnormalities. Interpretation requires careful comparison with other findings.

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Hybrid Imaging: Function + Anatomy



- **The Breakthrough:** Introduced around 2000, combining PET with CT (or MRI) in a single scanner transformed the field.
- **The Synergy:** PET reveals WHERE the activity is; CT/MRI reveals EXACTLY WHICH STRUCTURE it is in.
- **Clinical Impact:** This synergistic approach is the undisputed standard in modern cancer care.

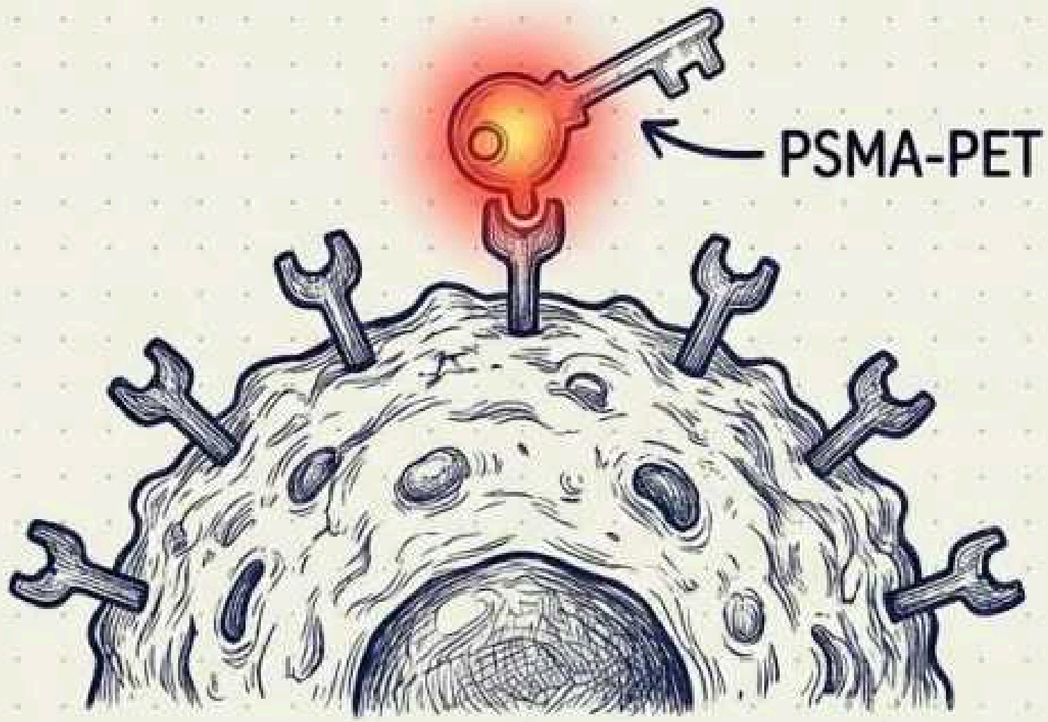
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Next-Gen Tracers: Molecular Specificity

¶ 5.8

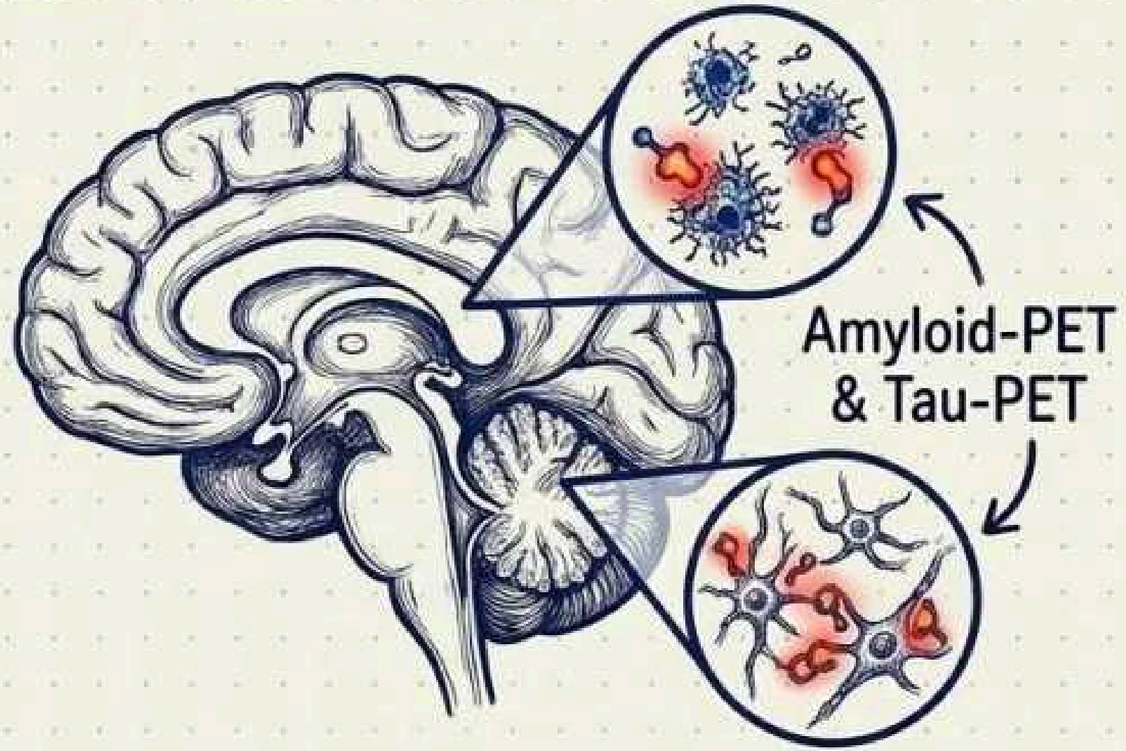
Moving beyond glucose to target exact molecular signatures.

Oncology (Prostate Cancer)



Binds to specific proteins on prostate cancer cells, detecting micro-metastases far more sensitively than older diagnostic tests.

Neurology (Alzheimer's Disease)



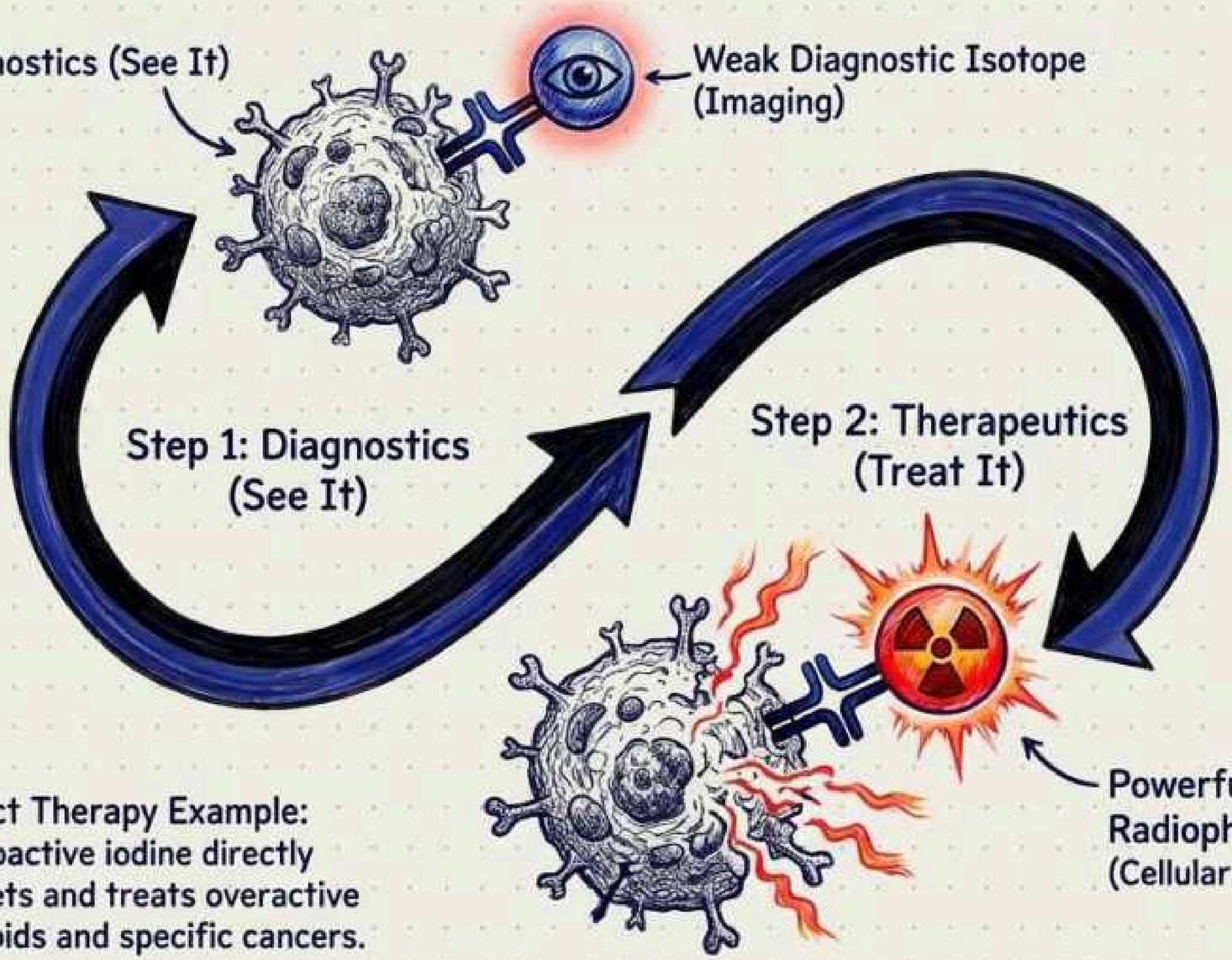
Visualizes distinct Alzheimer's pathologies directly in the brain, vastly improving both clinical diagnosis and research.

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Theranostics: See It, Treat It

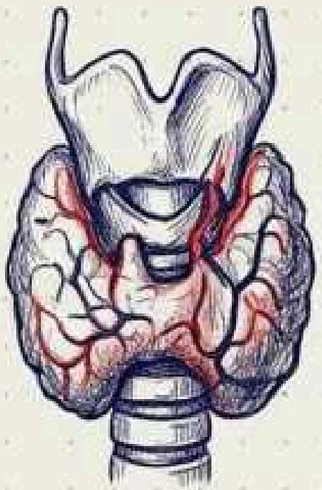
Step 1: Diagnostics (See It)

Weak Diagnostic Isotope (Imaging)



The Theranostic Cycle Pair a targeted diagnostic imaging tracer with a localized radioactive payload to deliver precision cellular radiation to the exact same sites.

Powerful Radiopharmaceutical Payload (Cellular Destruction)

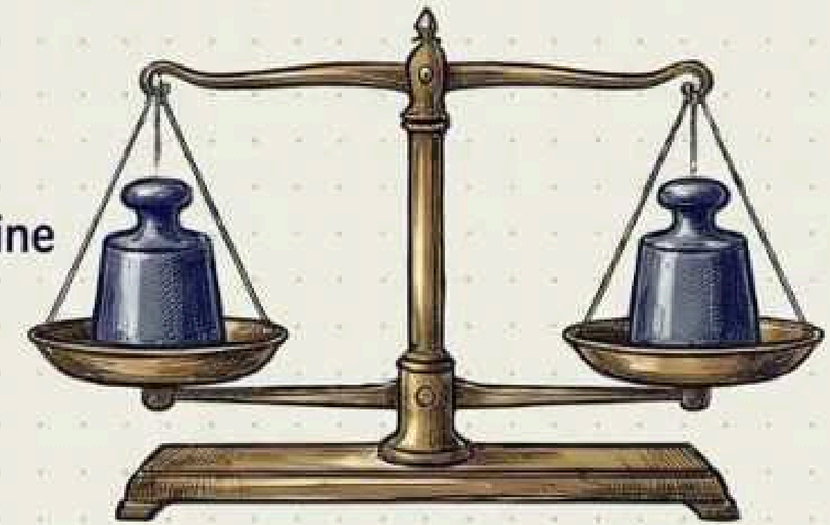


Direct Therapy Example: Radioactive iodine directly targets and treats overactive thyroids and specific cancers.

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Radiation Safety in Nuclear Medicine

¶ 5.10



Relative Exposure: Patient exposure is generally comparable to standard CT scans.

$$D(t) = D_0\left(\frac{1}{2}\right)^{t/h}$$



Short-Lived Risk: Tracers have short half-lives. Safety protocols may require temporary distancing from young children and pregnant women until the tracer fully decays.

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Summary & Looking Ahead

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Tracers map function

Hybrid scanners pair function + anatomy

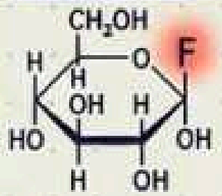


Nuclear Medicine

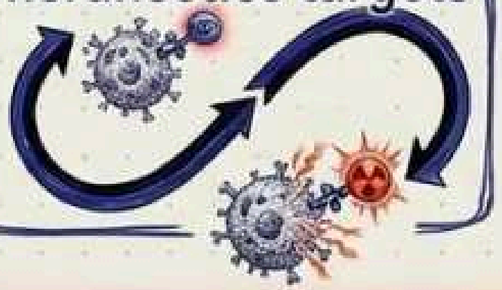
Visualizes the unseen physiology of the body.

PET/FDG tracks glucose





Theranostics targets



Evolving to highly specific molecular targeting.

Coming Next:
Imaging-Guided Treatment, Artificial Intelligence, and Wise Use.

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