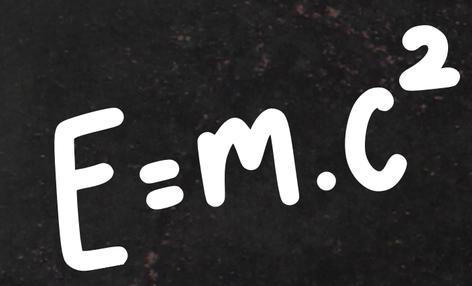
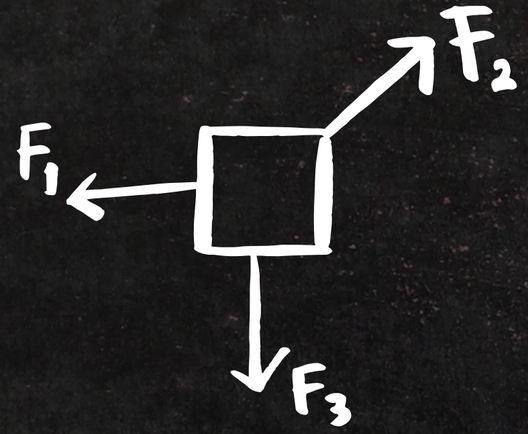
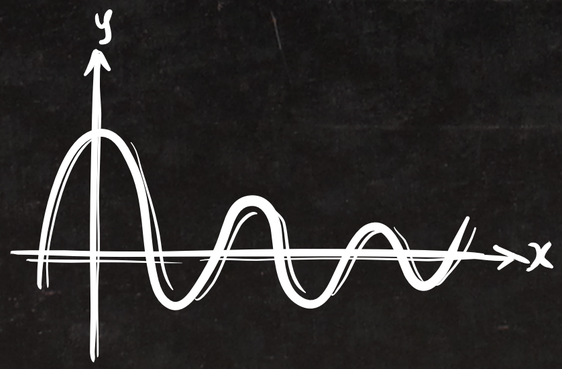
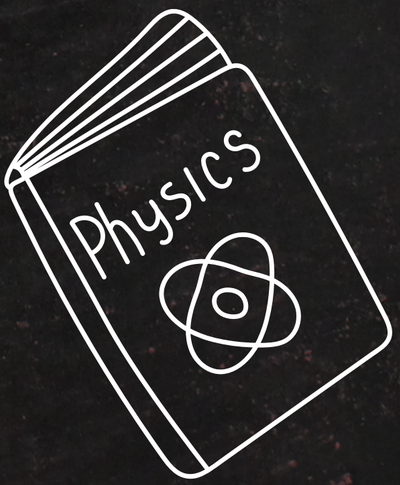




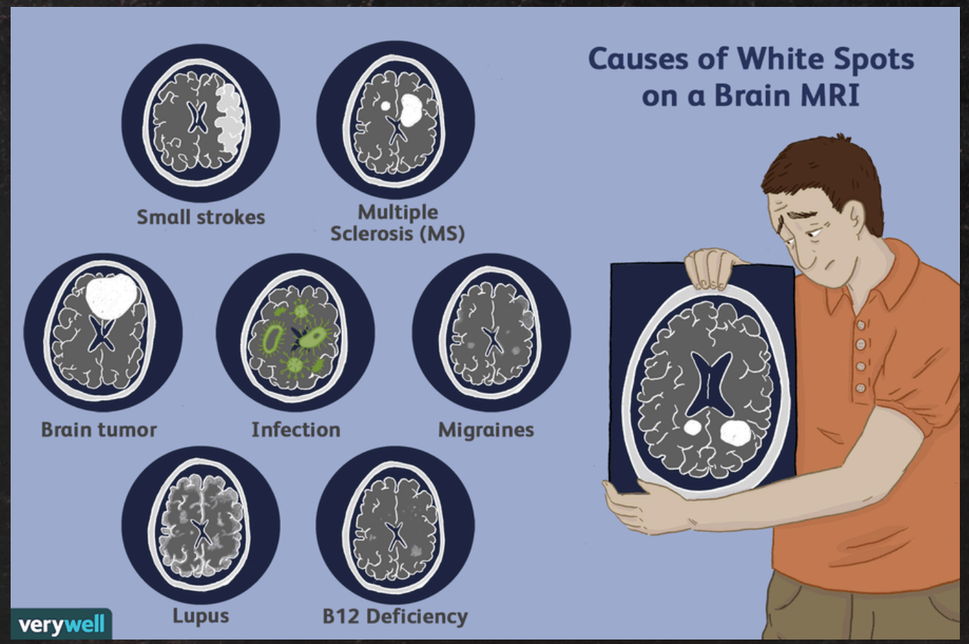
A Brief Overview of the Quantum Physics Behind Medical Tests

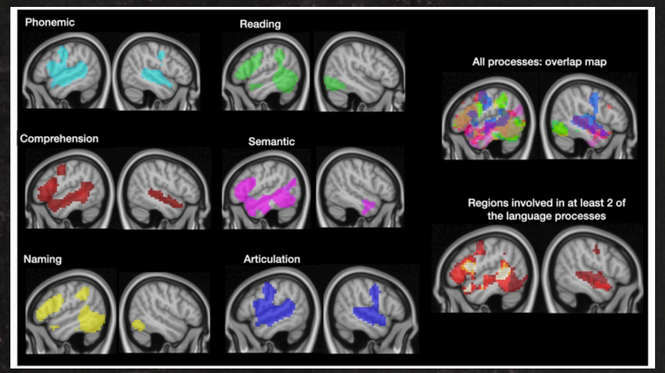


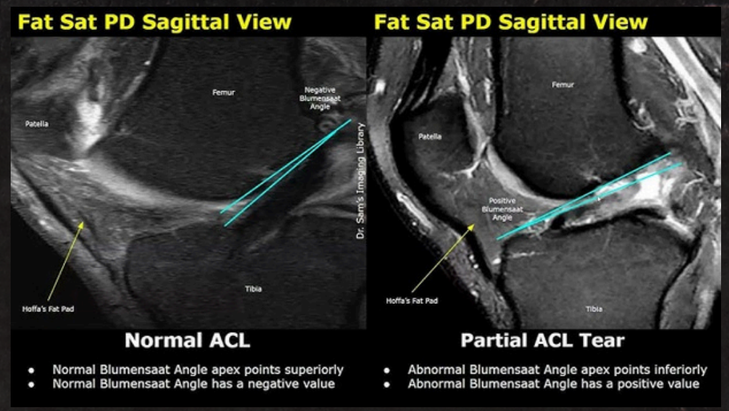


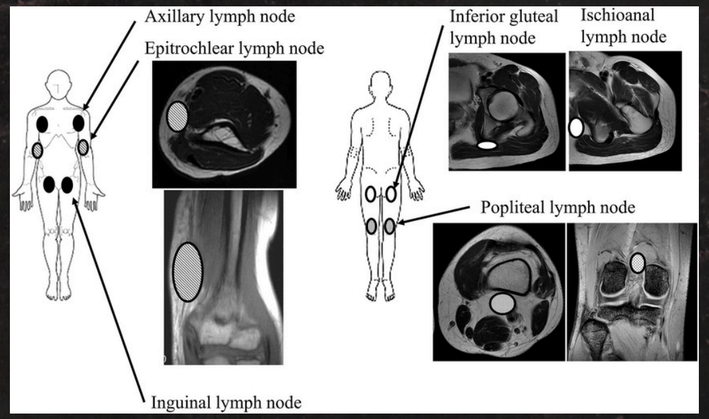
Magnetic Resonance Imaging (MRI)

- Quantum implications: Proton spin-1/2 in field B_0 (Zeeman splitting). Precession at Larmor frequency ($\omega=\gamma B_0$). Radiofrequency pulse creates transverse quantum coherency; decay via T_1 (spin-lattice) and T_2(spin-spin) relaxation.
- Types: T_1-weighted, T_2-weighted, FLAIR, DWI/ADC, fMRI
- Indications: Brain/spine (stroke, tumor, MS), ligaments/menisci, marrow/soft tissue, liver/pelvis with contrast, cardiac function/scar



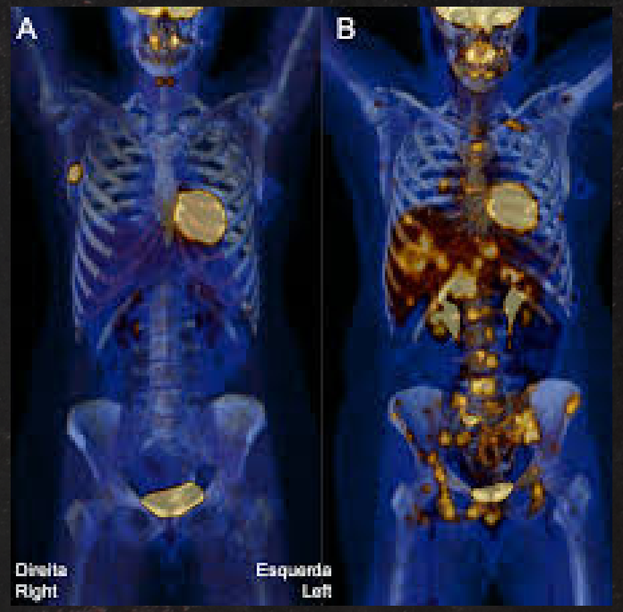


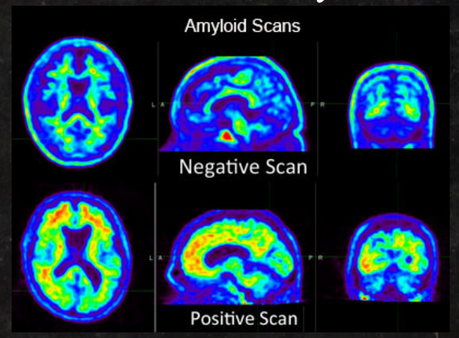


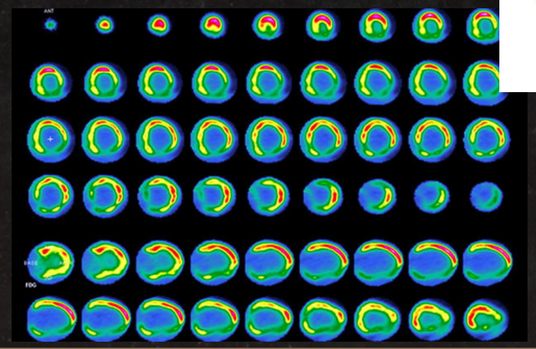


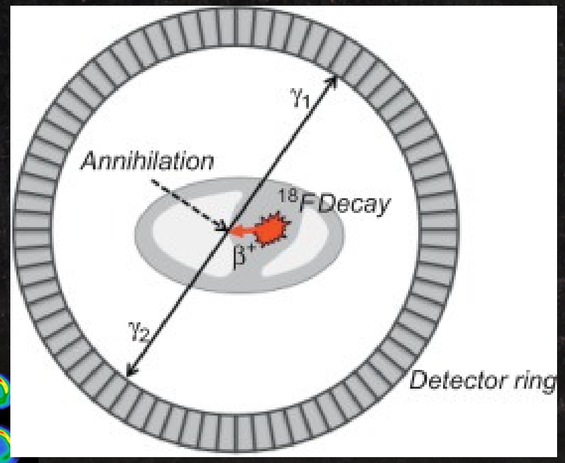
Positron Emission Tomography (PET)

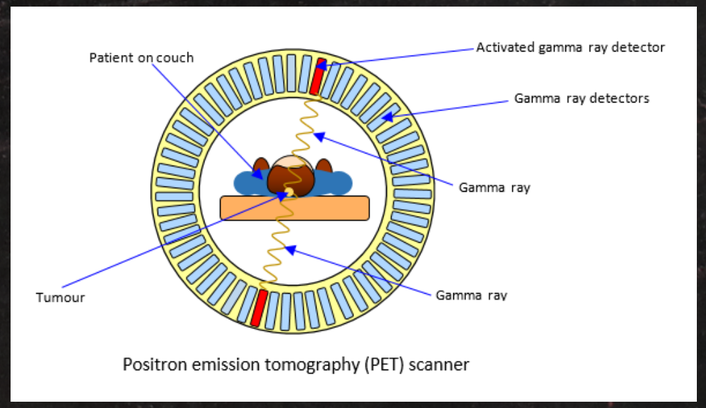
- Measures: Metabolic or receptor activity using radiotracers (commonly F-FDG for glucose uptake). Often used with CT or MRI.
- Quantum Implications: uses positron-electron annihilation to image biological process
- How it works: FDG is phosphorylated and trapped as FDG-6-P--hypermetabolic tissue glows (glucose gets trapped there).
- Indications: Oncology (staging, recurrency, therapy response), neuro (epilepsy focus, dementia patterns), cardiac viability





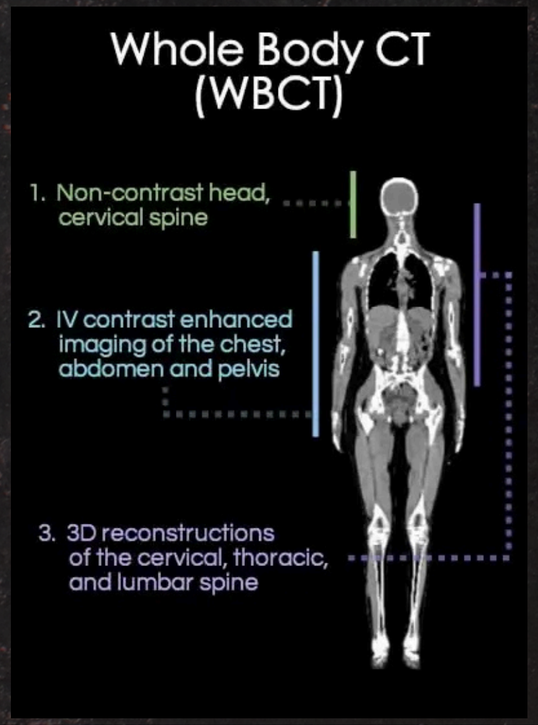


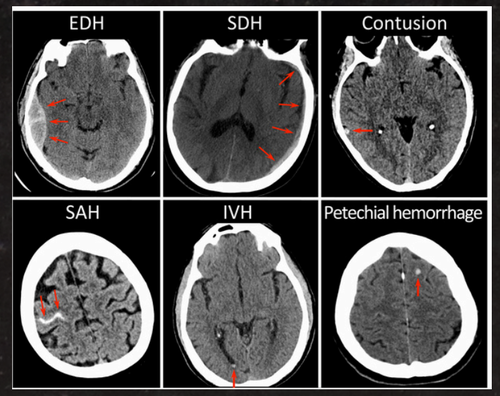


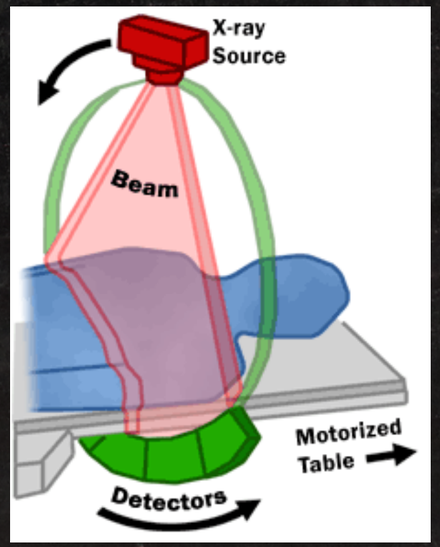


Computed Tomography (CT) Scan

- Measures: X-ray attenuation (Hounsfield Units) for soft-tissue contrast
- Quantum Implications: Utilizes X-rays made by bremsstrahlung and characteristic lines, then absorbed and scattered via photoelectric effect and Compton scattering
- Indications: Trauma and acute bleed, lung disease and PE, abdominal emergencies, complex fractures
- hundreds-thousands of projections around patient, computer resonstructed into cross-sectional 3D slices (& 3D volumes)

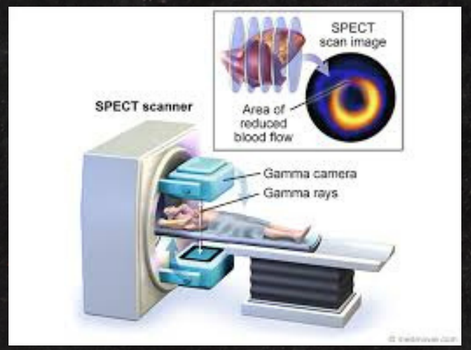


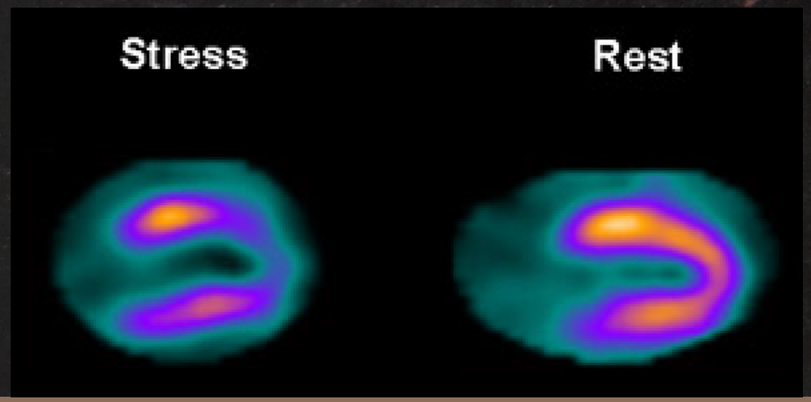


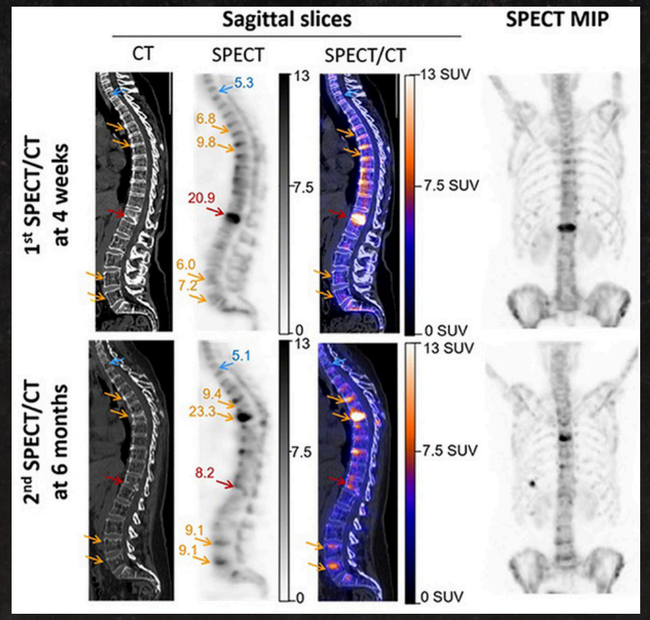


Single-Photon Emission Computed Tomography (SPECT)

- Quantum implications: Gamma emission from nuclear isomers is quantized; photons selected by collimators; detection via photoelectric effect in scintillators/PMTs or semiconductors
- Indications: Myocardial perfusion stress/rest, bone metatasis, thyroid update, and some brain perfusion

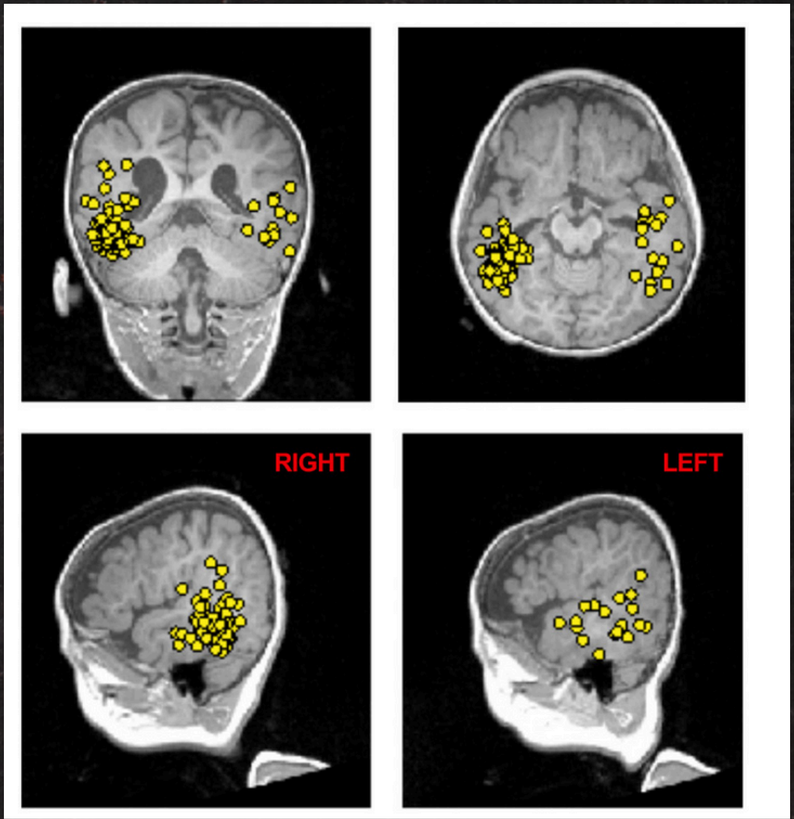


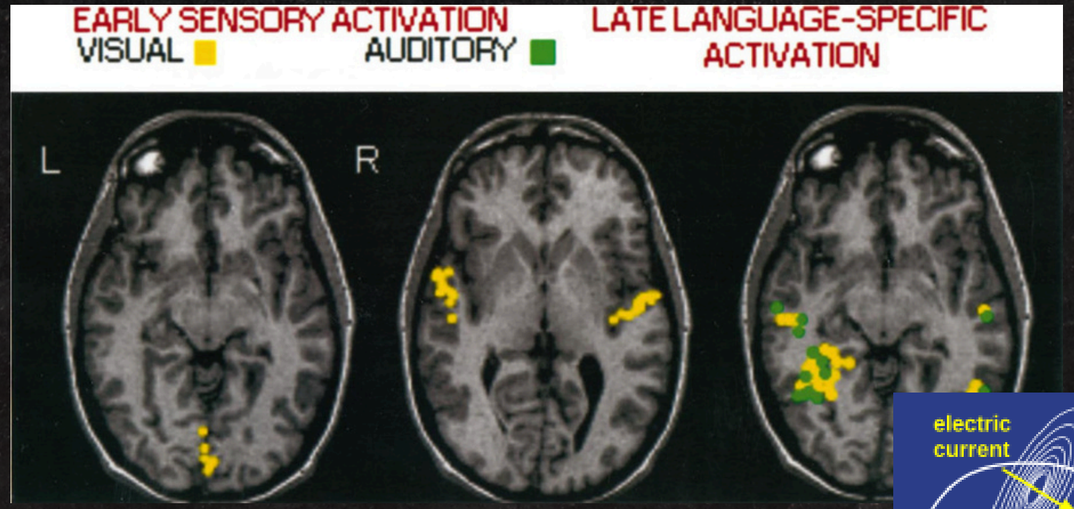


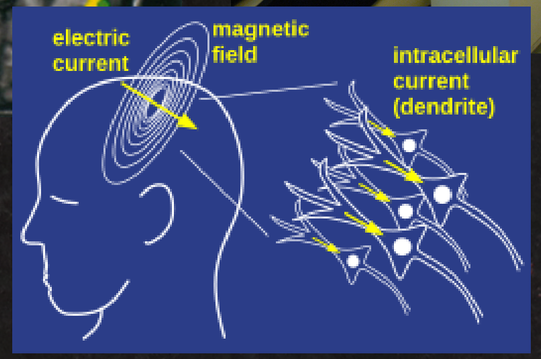


Magnetoencephalography (MEG)

- Measures: brain function
- Quantum implications: SQUIDs use superconductivity and Josephson interference → magnetic flux quantized → measurable voltage
- Indications: Epilepsy presurgical mapping, language/sensory/motor lozalization

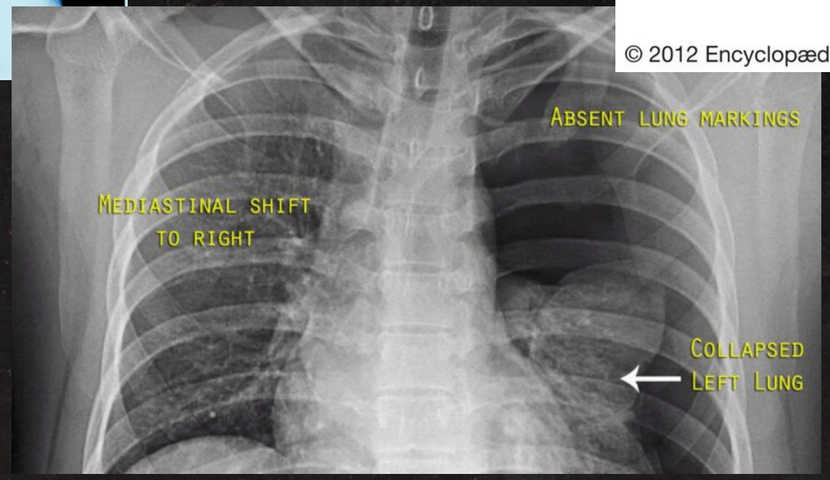


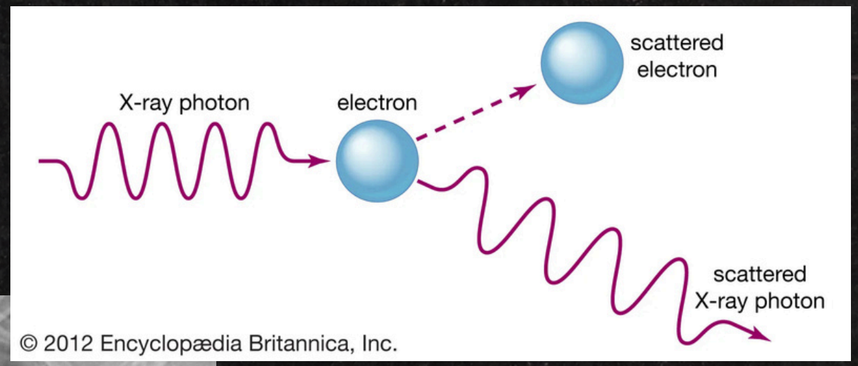


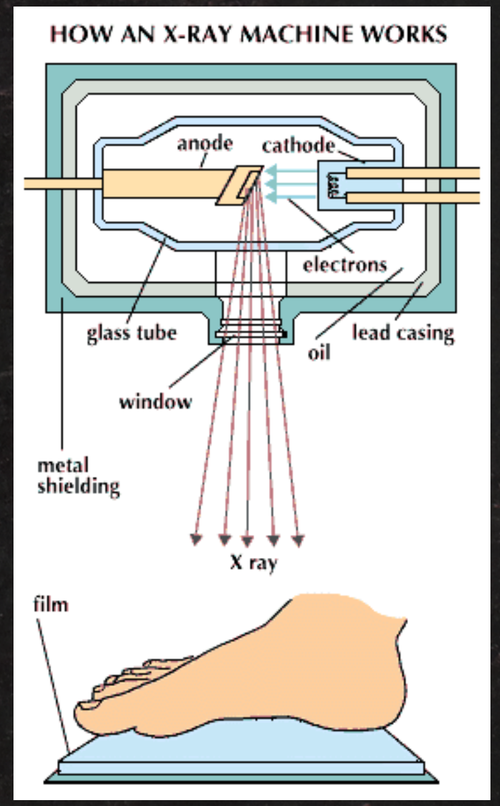


X-ray radiography

- Measures: X-ray attenuation (Hounsfield Units) for NOT soft tissue contrast
- Quantum Implications: Utilizes X-rays made by bremsstrahlung and characteristic lines, then absorbed and scattered via photoelectric effect and Compton scattering
- Indications: bone, chest lines/tubes, pneumothroax, quick checks
- one (or a few) 2D projectionS) of X-ray attenuation through body







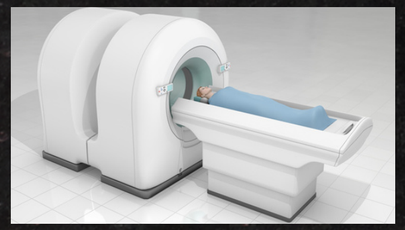
Quick Summary

CT

Fast 3D anatomy; best for blood, bone, lung, stones, trauma, PE. Uses ionizing radiation; often iodine contrast

MRI

Best soft-tissue contrast; brain/spine/joints /liver/pelvis; no ionizing radiation; slower



PET

Metabolism/receptors (whole-body oncology, neuro, inflammation); commonly paired with CT/MRI; ionizing radiation

SPECT

Perfusion/turnover (cardiac, bone, thyroid); broader tracer menu, lower resolution than PET; ionizing radiation

MEG

Millisecond-scale brain mapping (epilepsy); detector physics is quantum; no radiation

X-ray

Quick 2D snapshot (chest, fractures, devices); lowest dose; superposition limits soft-tissue detail

why radiation doses matter? how do doctors regulate it?