The Discovery (1895)



Nov 1895

German physicist Wilhelm Röntgen discovers an unknown ray (X-ray) capable of penetrating solid objects and darkening photographic plates.

Hand radiogen

Wnna Bertha's human first Withmmial Rrtnst radiograph

Immediate Impact

Global adoption within months to locate bullets and set bone fractures.

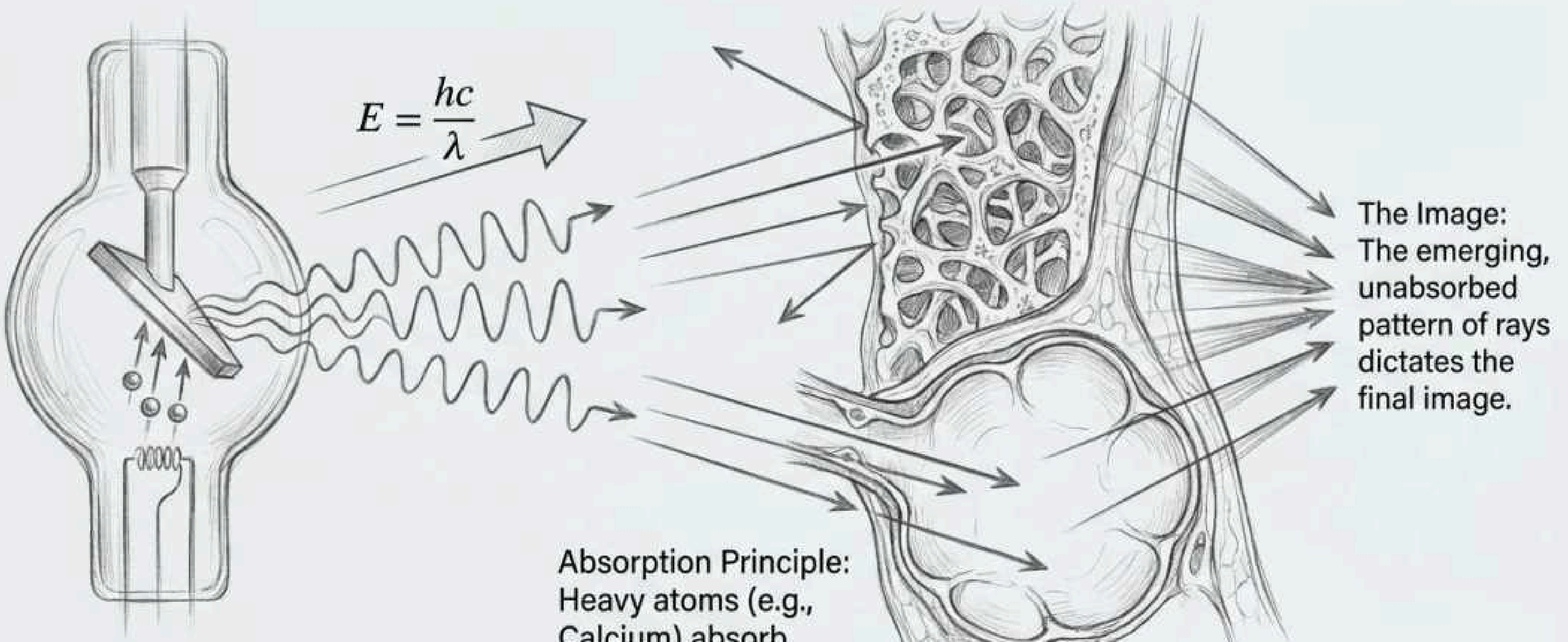
1901 Milestone

Röntgen is awarded the first Nobel Prize in Physics.

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Physics of Image Formation

¶ *1.2*



Production: Fast electrons strike a metal target to emit high-energy electromagnetic radiation.

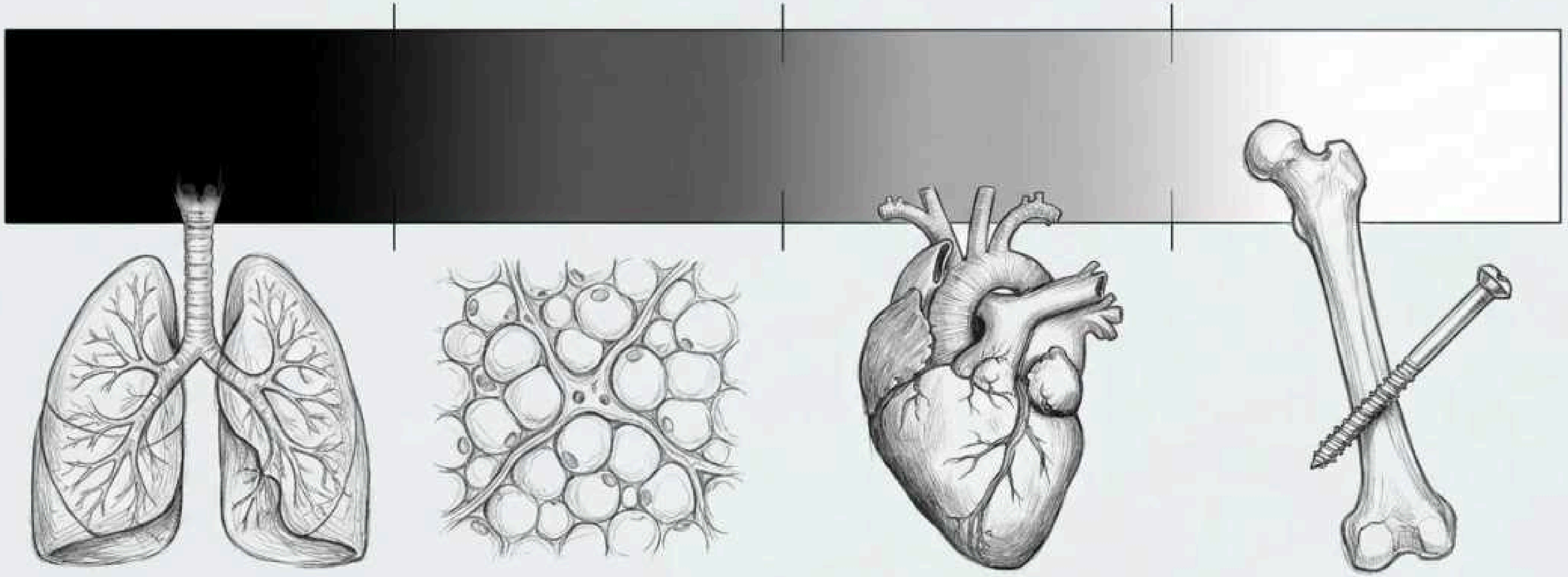
Absorption Principle: Heavy atoms (e.g., Calcium) absorb radiation heavily; air absorbs very little.

The Image: The emerging, unabsorbed pattern of rays dictates the final image.

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The Four Basic Densities

¶ 1.3



Air | Fat | Soft Tissue / Fluid | Bone / Metal

Diagnostic Key: Disease alters this established baseline (e.g., fluid filling normally black lungs in pneumonia).

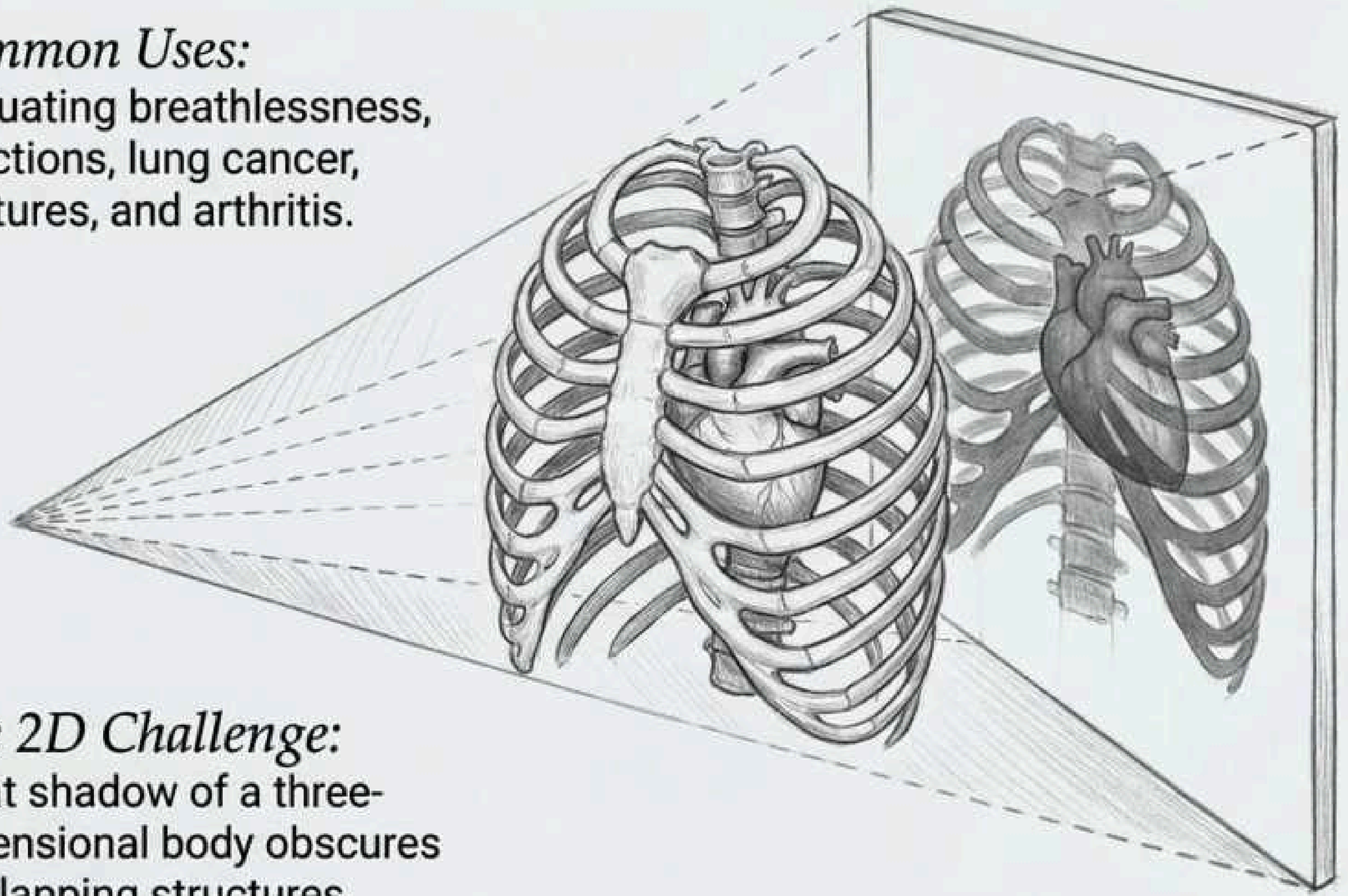
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Plain Radiographs: The Workhorse

¶ *1.4*

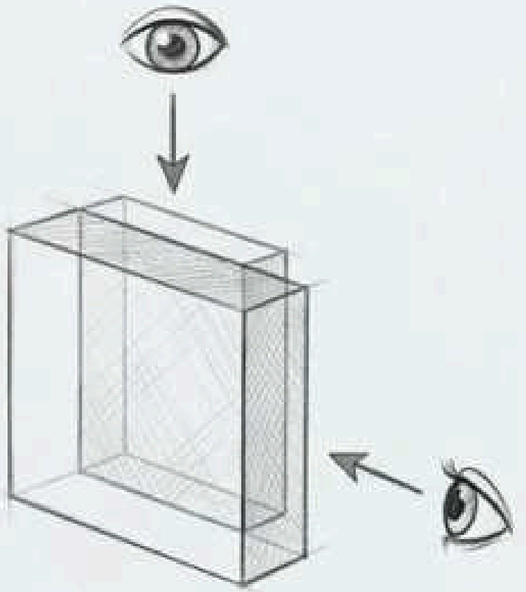
Common Uses:

Evaluating breathlessness, infections, lung cancer, fractures, and arthritis.



The 2D Challenge:

A flat shadow of a three-dimensional body obscures overlapping structures.



The Solution:

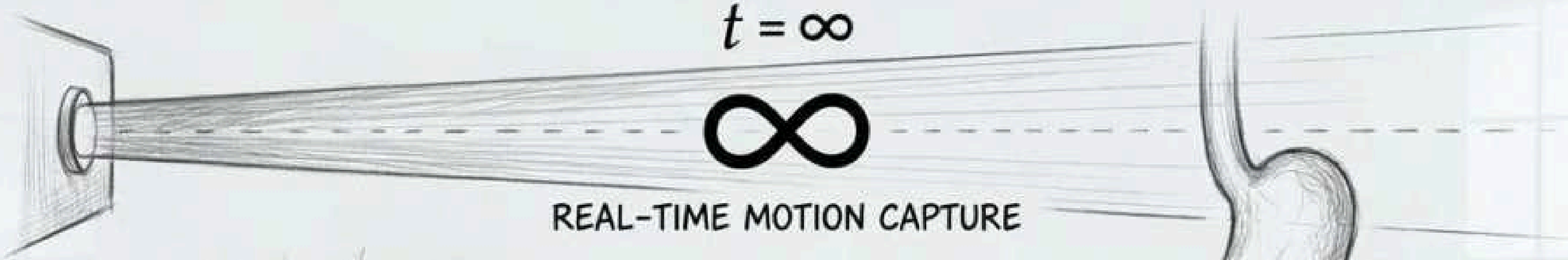
Always capture two orthogonal views (at right angles).

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Fluoroscopy & Contrast

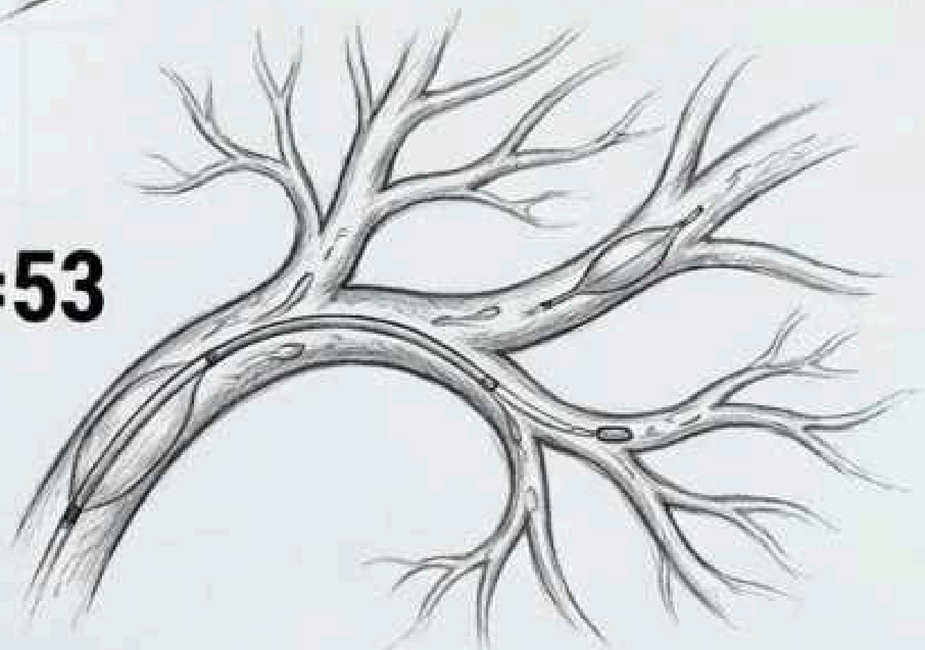
¶ 1.5

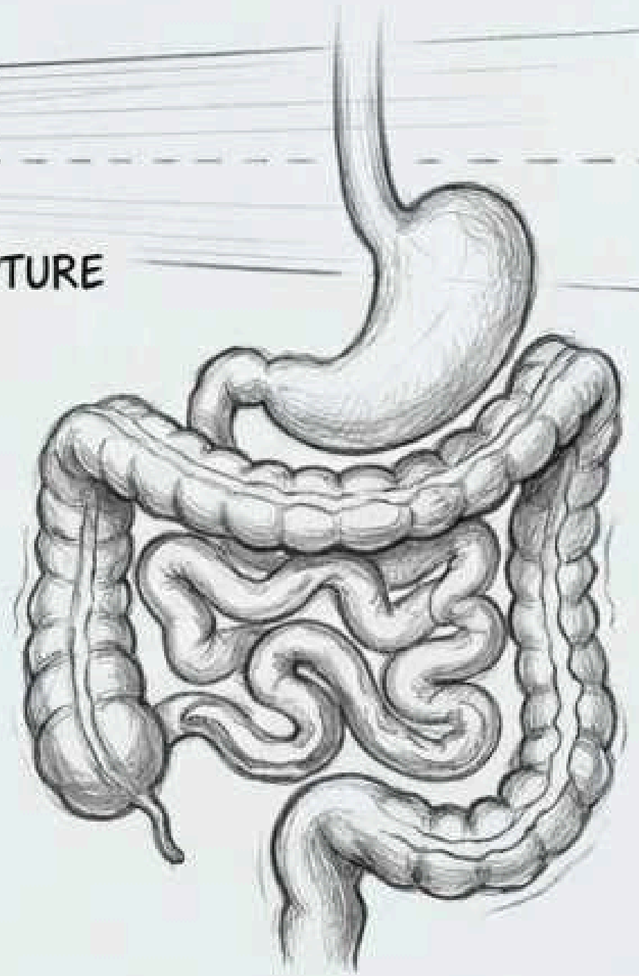
$t = \infty$



REAL-TIME MOTION CAPTURE

I, Z=53





Ba, Z=56

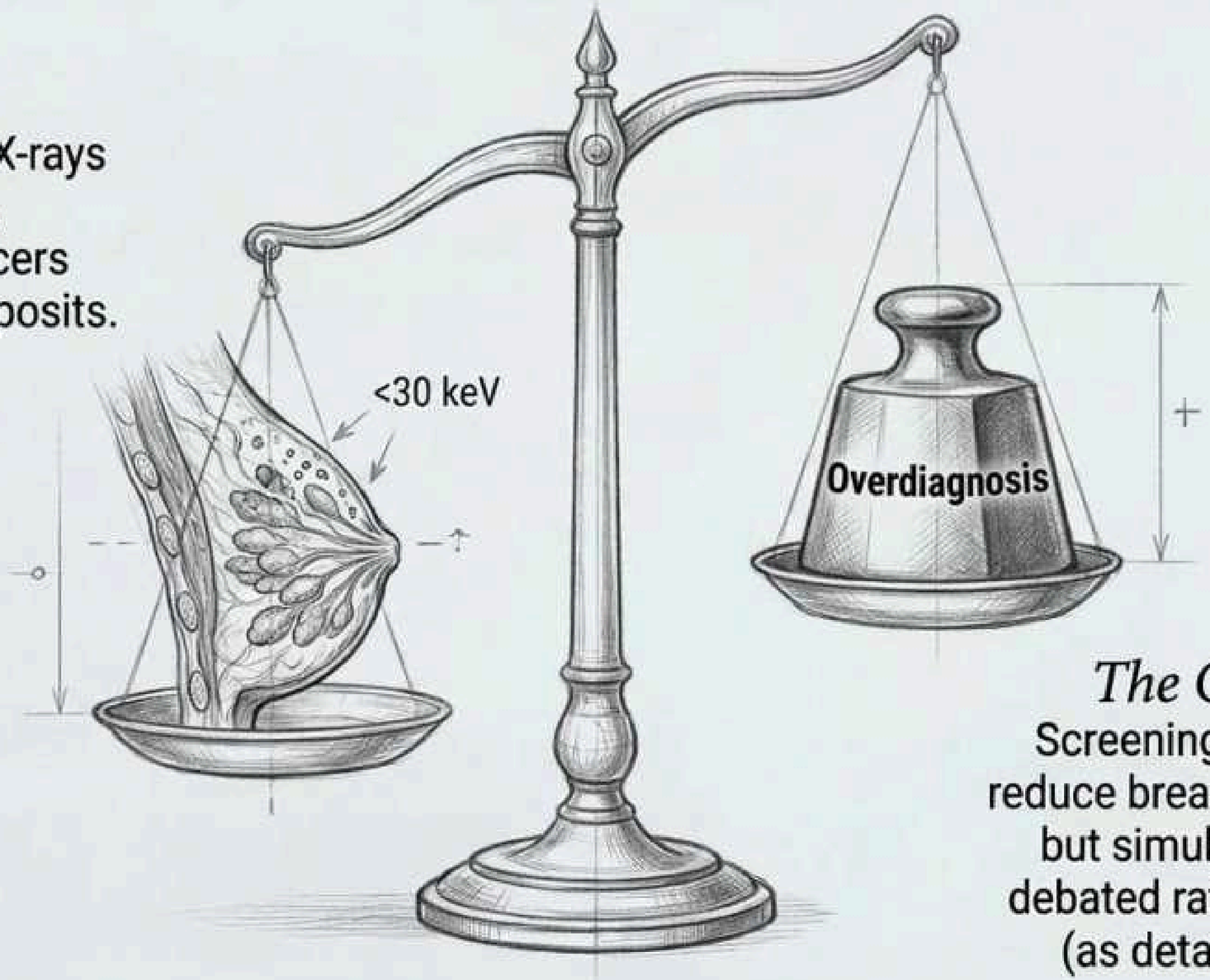
Mechanism: Uses a continuous X-ray beam to produce moving images in real-time.
Clinical Applications: Watching swallowing, guiding vascular catheters, placing orthopedic pins.
Contrast Agents: High-absorbency substances (Iodine, Barium) introduced to outline the gut and blood vessels.

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Mammography: Balancing Outcomes

¶ 1.6

Detection:
Utilizes low-energy X-rays to image the breast, targeting small cancers and tiny calcium deposits.

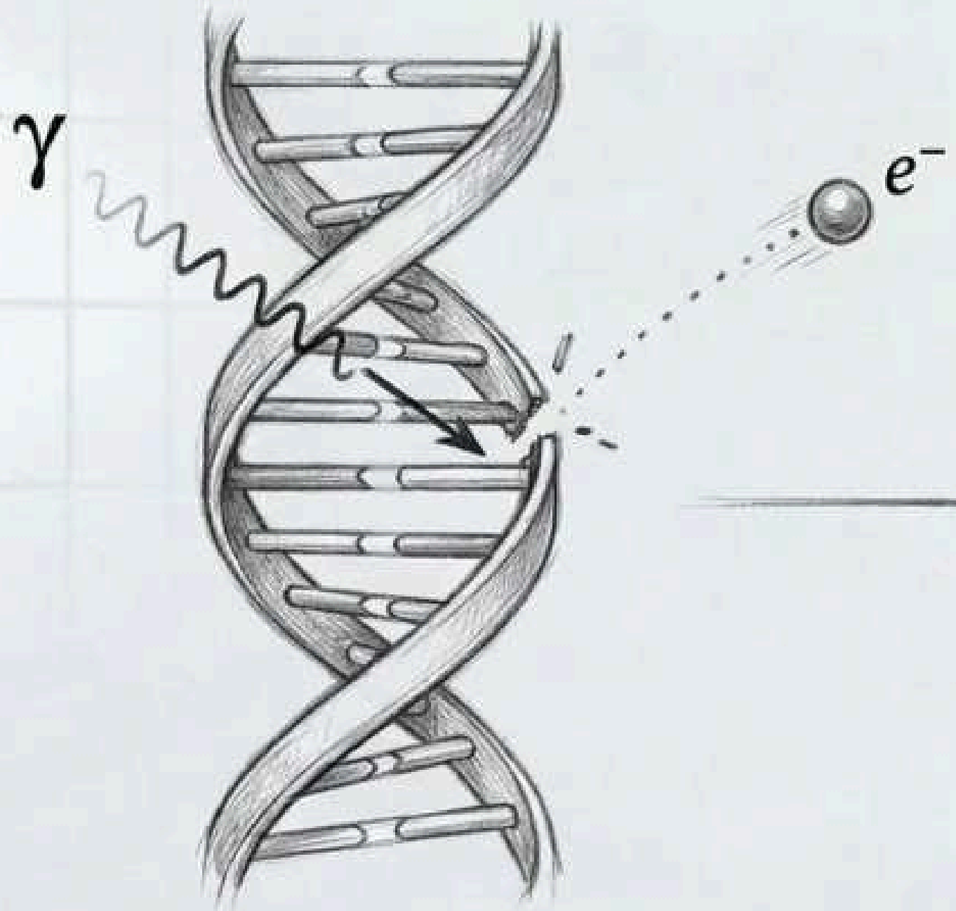


The Clinical Debate:
Screening programs actively reduce breast cancer mortality, but simultaneously lead to a debated rate of overdiagnosis (as detailed in MED 515 B).

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Ionising Radiation Biology

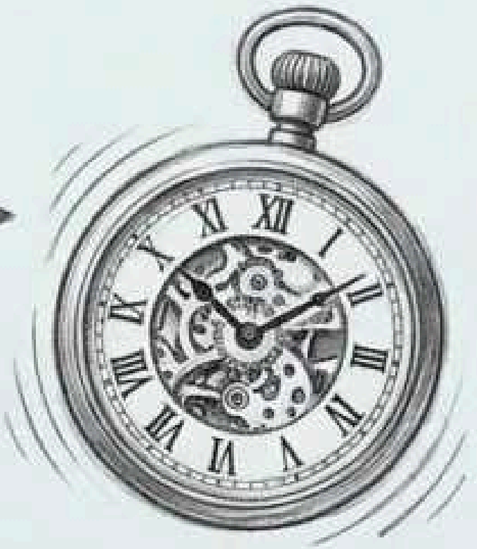
¶ *1.7*



Mechanism: X-rays carry sufficient energy to knock electrons from atoms, resulting in DNA damage.



High Dose Consequences:
Acute burns and radiation sickness (experienced by unprotected early workers).

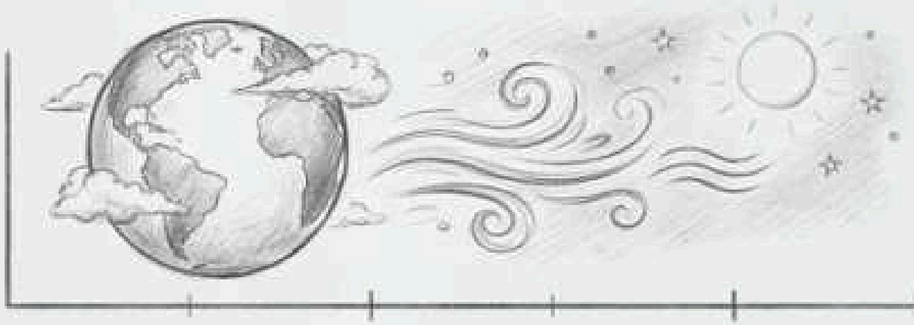


Diagnostic Dose Risks:
A very small increase in the long-term risk of developing cancer.

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Quantifying Dose Equivalents

1 mSv = Millisievert



Background: Ground, air, and space exposure = 2–3 mSv/year.



Chest X-Ray: ~0.1 mSv = equivalent to a few days of background radiation.



Abdomen CT: ~10 mSv = equivalent to several years of background radiation.

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Principles of Radiation Protection

¶ 1.9



Justification: Every exposure must **demonstrably** do **more good** than **harm**.

Dose Limits: Strict thresholds apply to workers and the public.



Optimisation (ALARA): Doses must be As Low As Reasonably Achievable.

$$\lim_{dose \to min}$$

Vulnerability: Children require particular care due to higher radiation sensitivity and more remaining years for potential cancer development.

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Pregnancy Considerations

¶ 1.10

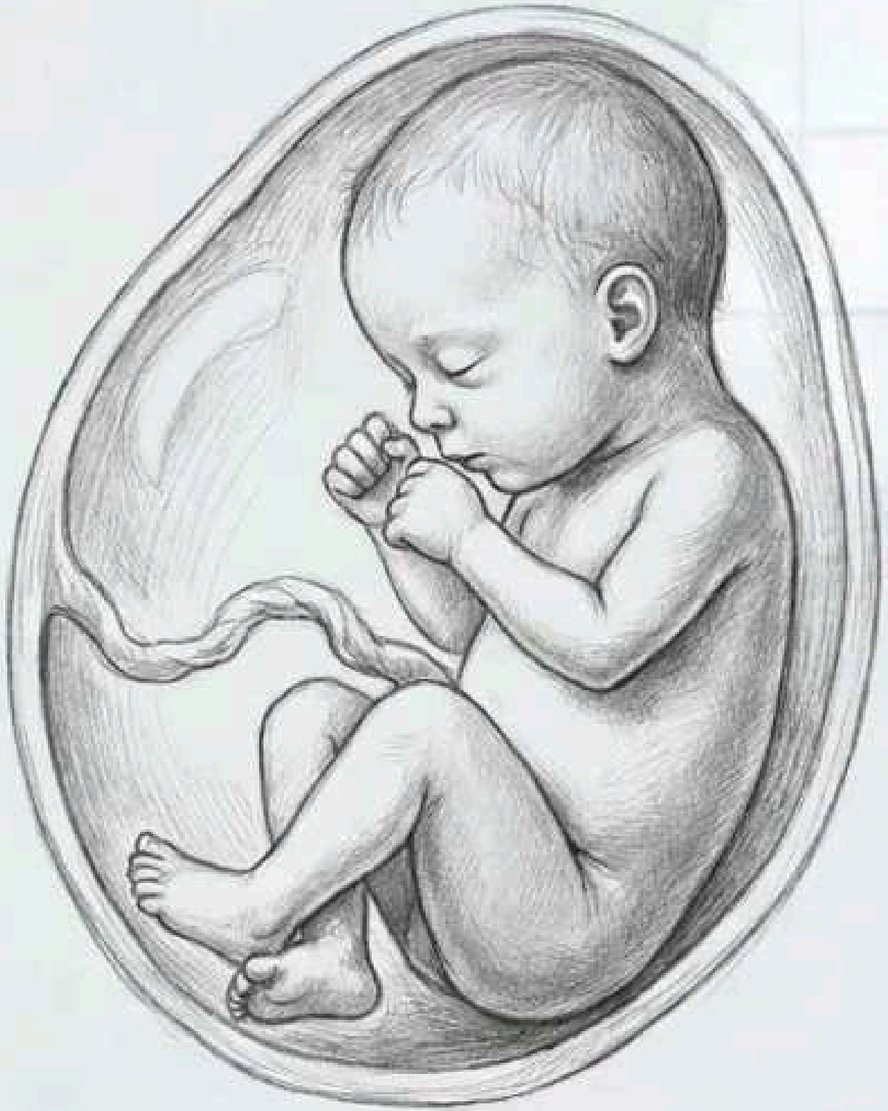
Step 1: Is the patient potentially pregnant? (Mandatory screening before abdominal/pelvic imaging).

↓

Step 2: Fact Check. Doses from most diagnostic tests remain far below the threshold known to harm a fetus.

↓

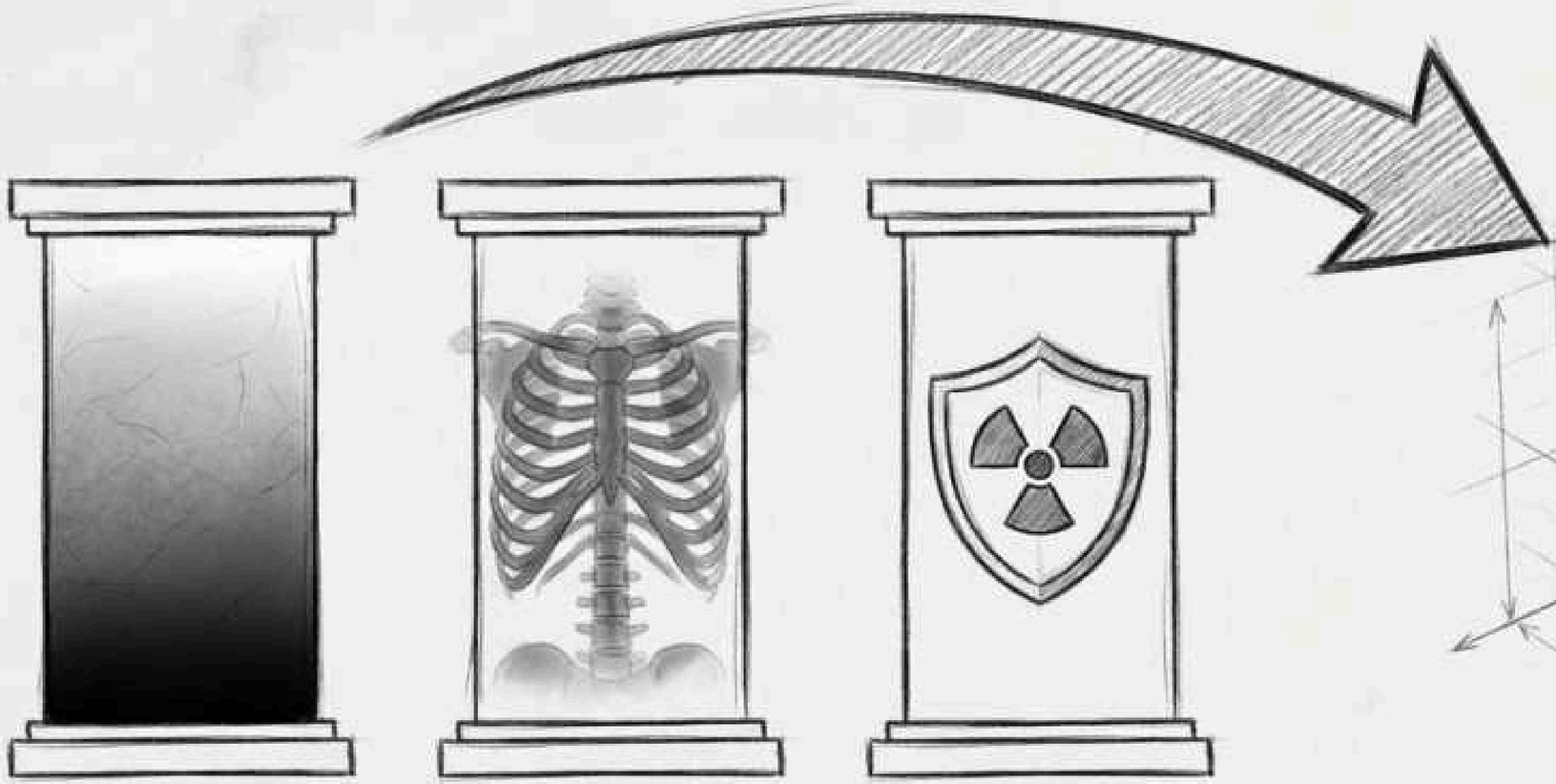
Step 3: Clinical Rule. Necessary imaging must NOT be withheld when the mother's health depends on it.



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Summary & The Leap to 3D

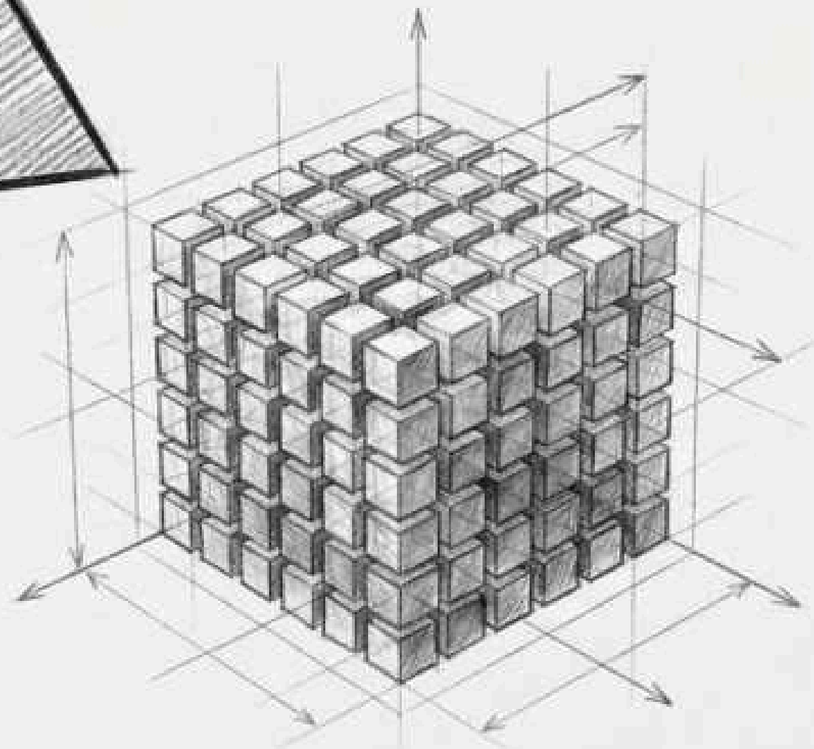
¶ 1.11



Pillar 1: X-rays uniquely reveal differences in tissue density.

Pillar 2: Plain radiographs remain the enduring workhorse of medical imaging.

Pillar 3: Radiation risk is strictly managed by justification and keeping doses low.



Next Lecture:

Computed Tomography
(Building 3D pictures from 2D X-rays)

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