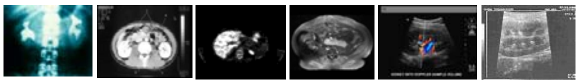
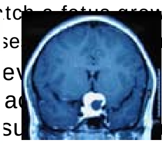


Medical Imaging:
A Look inside

Medical Imaging

- Allows physicians to see what had previously been unseeable: internal organs and tissues, bones, a beating heart, etc.
- Allows physicians to:
  - detect brain tumors early
  - monitor patient's treatment
  - watch a fetus grow


se ri
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su d nd
functions to simulate pathology

Medical Imaging

- Visible Human Project™
  - National Library of Medicine

http://www.nlm.nih.gov/research/visible/visible_human.html

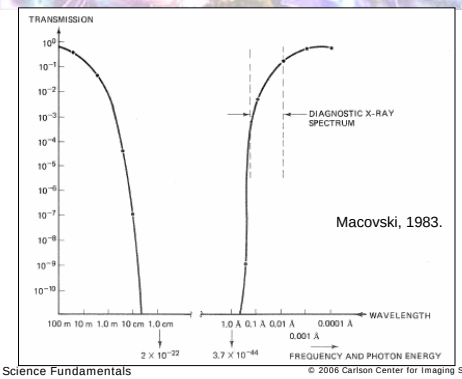
Medical Imaging

Simulated colonoscopy, plastic pipe with polyps
(Visualization Laboratory SUNY Stony Brook)

What Photons to Use?

- Tissues and organs made up of primarily water, bone, and gases
- Assess the entire electromagnetic spectrum to find region(s) where outer body is "partially transparent" so that inner structures can be seen
- Two decisive parameters:
  - **Resolution**
    - determined by wavelength, shorter λ ⇒ better resolution
  - **Attenuation**

Transmission of Body



Macovski, 1983.

Use “X Rays”

- Short wavelengths:

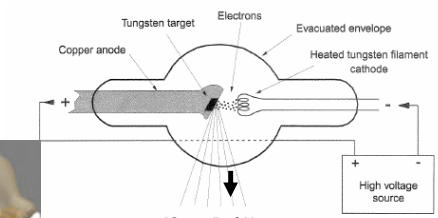
  $0.1 \text{ nm} \lesssim \lambda \lesssim 10 \text{ nm}$

⇒ High energies via:

$$E = h\nu = hc/\lambda$$

- Can penetrate tissue, but still absorbed by bone

Source of X rays



“Spray” of X rays

Bushberg, 1994

www.mcw.edu/medphys/learning

Sensors/Detectors of X rays

- Photographic Film
- Film + Scintillator
- Digital detector

X-Ray Film

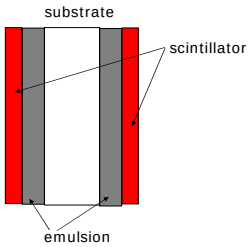
- THICK emulson coated on both sides of transparent substrate (e.g., mylar)
  - made thick to increase absorption of X rays

Scintillator

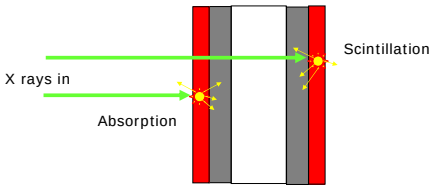
- Often Cesium Iodide (CsI)
- Absorbs high-energy X rays and produces a “shower” of lower-energy photons
  - UV or visible
- Lower-energy photons are measured by light sensors
  - Silver-Halide emulsion
  - Electronic sensor

X-Ray Film + Scintillator

- “Sandwich” of X-ray film and scintillators on both sides

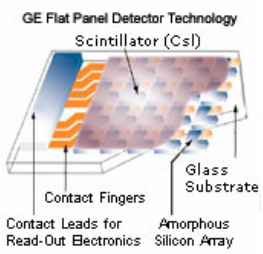


X-Ray Film + Scintillator



Digital X-Ray Detector

- Single-piece amorphous silicon flat panel with cesium iodide scintillator



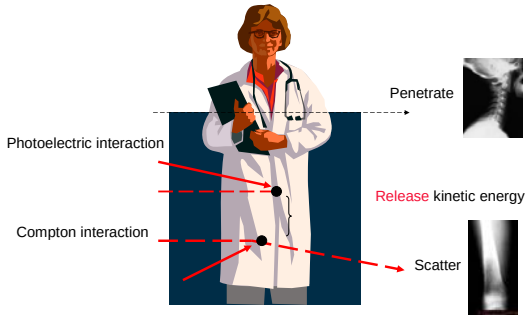
http://www.gehealthcare.com/usen/xr/radio/products/digital_xray/products/digdetector.html

Specifications, Kodak Digital X-ray Detector

Characteristic	Value
Pixel pitch	143 µm
Effective active area	429 x 429 mm
Image Matrix size	3000 x 3000 pixels
Optical fill factor	~ 68%
Geometrical fill factor	100%
CsI:Tl Absorption layer	500 µm
ADC	14 bits
Sampling rate	2 MSPS

- "pitch" = distance between pixel centers
- 14 bits ⇒ 2^{14} = 16384 gray values

Interactions of X rays with Tissue



2D projection of a 3D structure.

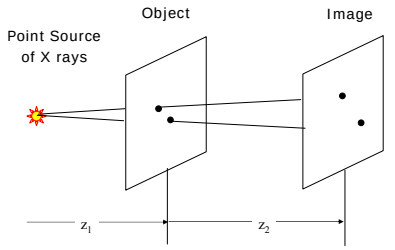
Sources of Tissue Attenuation

- Photoelectric Interaction:

  $E = h\nu$

- Compton Interaction
  - biggest source of attenuation
  - collision of X-ray photon and free electron
  - must include special relativity in calculation of energy

Magnification with Point X-ray Source



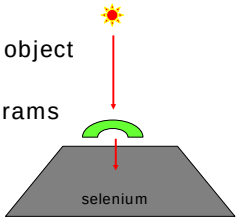
$$M_t = +\frac{z_2}{z_1}$$

Absorbed Dose:

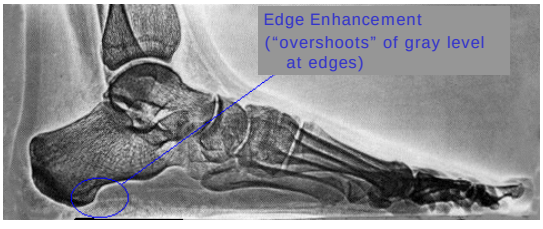
- Once measured in “Roentgen Equivalent Man” = “REM”
  - Approximate dose from any radiation corresponding to exposure to one roentgen
- One roentgen = Unit of exposure measuring ionizing ability of X rays
  - produces one electric charge per million cubic meters of air at STP
- Absorbed X rays “deposit” energy in cells
  - May cause damage/mutations

Xeroradiography

- Use Selenium photoconductor as sensor
- Image created in same way as laser printer
  - charged toner + fuser
- More output at edges of object
  - “built-in” edge enhancer
- Often used for mammograms

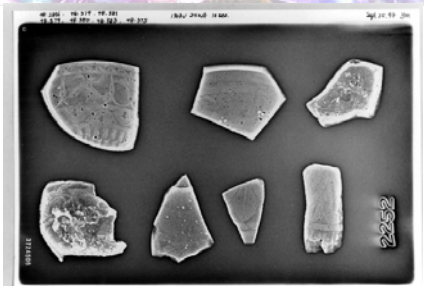


Edge Enhancement in Xeroradiography



http://www.footsupports.com/pages/Heel/foot_xxr.gif

Useful for Other Objects



http://aic.stanford.edu/jaic/img/jaic39-02-001-ch1fg4.jpg

used to examine archeological artifacts, pioneered by Dr. Robert Johnston, RIT

Xeroradiography

- made of wax
- nails inside

http://americanhistory.si.edu/vidal/religion.htm