X-Ray Imaging
Medical Imaging

• Primary purpose is to identify pathologic conditions.
• Requires recognition of normal anatomy.
List of diagnostic imaging studies

- Plain x-rays
- CT scan
- MRI
- Nuclear imaging/PET
- Ultrasound
- Mammography
- Angiography
- Fluoroscopy
What are x-rays?

- No mass
- No charge
- Energy
X-rays

wavelength (nm)
Basic x-ray physics

- X-rays: a form of electromagnetic energy
- Travel at the speed of light
- Electromagnetic spectrum
  - Gamma Rays
  - Visible light
  - Microwaves
  - Radio waves
  - X-rays
  - Infrared light
  - Radar
Three things can happen

• X-rays can:
  – **Pass** all the way **through** the body
  – Be deflected or **scattered**
  – Be **absorbed**

*Where on this image have x-rays passed through the body to the greatest degree?*
X-rays Passing Through Tissue

- Depends on the energy of the x-ray and the atomic number of the tissue
- Higher energy x-ray - more likely to pass through
- Higher atomic number - more likely to absorb the x-ray
X-rays

• X-rays are produced when electrons are accelerated and collide with a target
  – Bremsstrahlung x-rays
  – Characteristic x-rays

• X-rays are sometimes characterized by the generating voltage
  – 0.1-20 kV    soft x-rays
  – 20-120 kV    diagnostic x-rays
  – 120-300 kV   orthovoltage x-rays
  – 300 kV – 1 MV intermediate energy x-rays
  – > 1MV        megavoltage x-rays
Bremmstrahlung

- Bremmstrahlung x-rays occur when electrons are (de)accelerated in the Coulomb field of a nucleus.
Characteristic x-rays

- After excitation, ions with a vacancy in their inner shell can de-excite
  - Radiatively through x-ray fluorescence
  - Non-radiatively through the emission of Auger electrons
Characteristic X-rays

- Thus an x-ray spectrum will also show characteristic x-rays arising from L to K and M to K transitions after ionization of a K electron
  - Usually transitions to higher shells absorbed by the filtration or are not x-rays
X-ray Tube

• X-ray tubes
X-ray Tube

• More detail