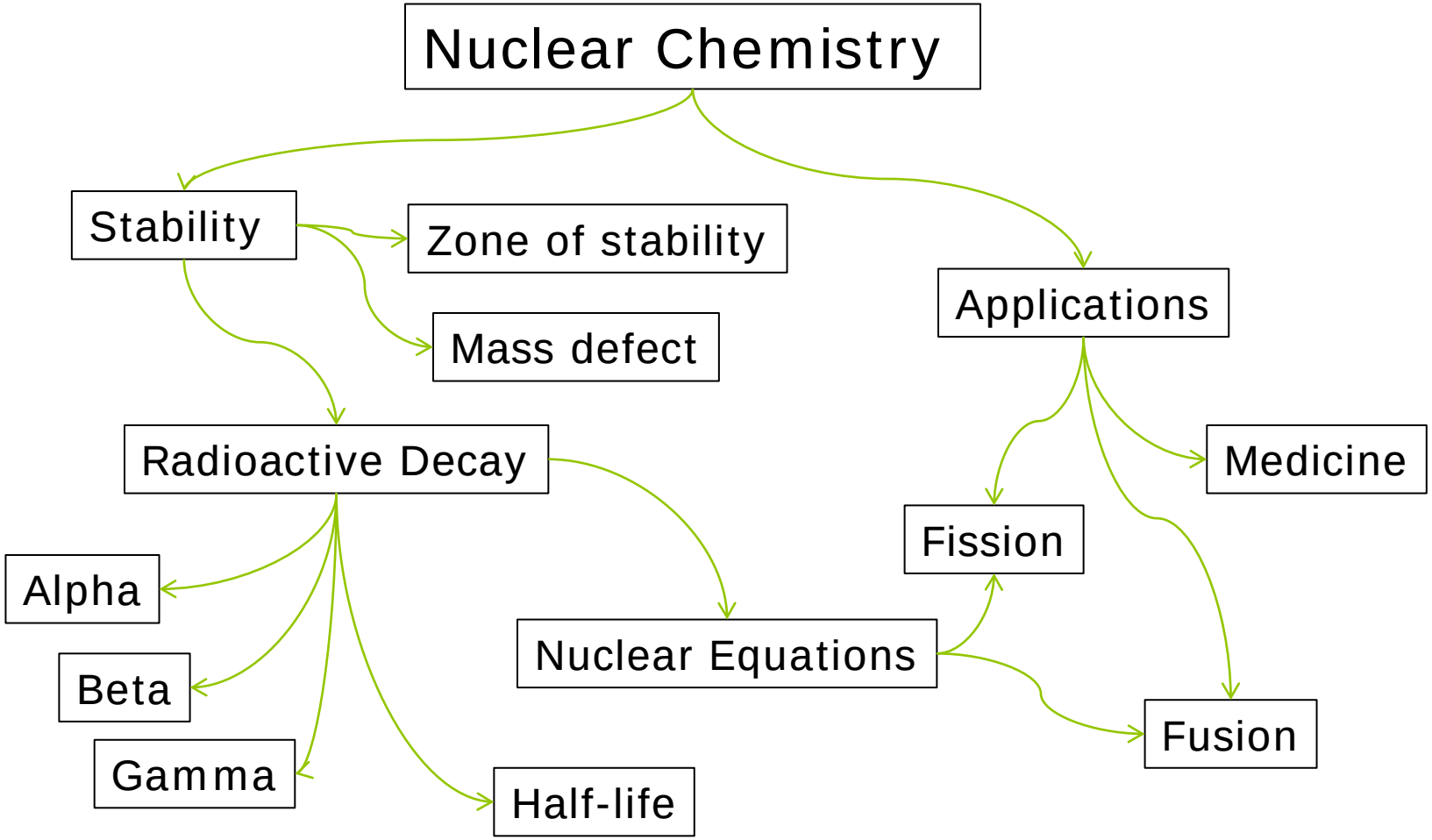
Nuclear Chemistry

Bromfield Honors Chemistry

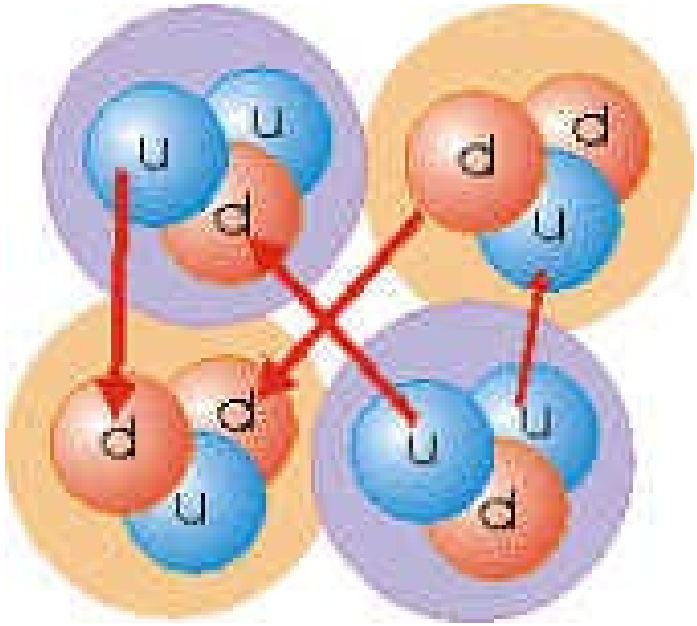

Nuclear Chemistry
Stability
Zone of stability
Mass defect
Radioactive Decay
Alpha
Beta
Gamma
Half-life
Nuclear Equations
Applications
Medicine
Fission
Fusion

Everyday radiation

- Video clip: Everyday radiation
- Video clip: Radon

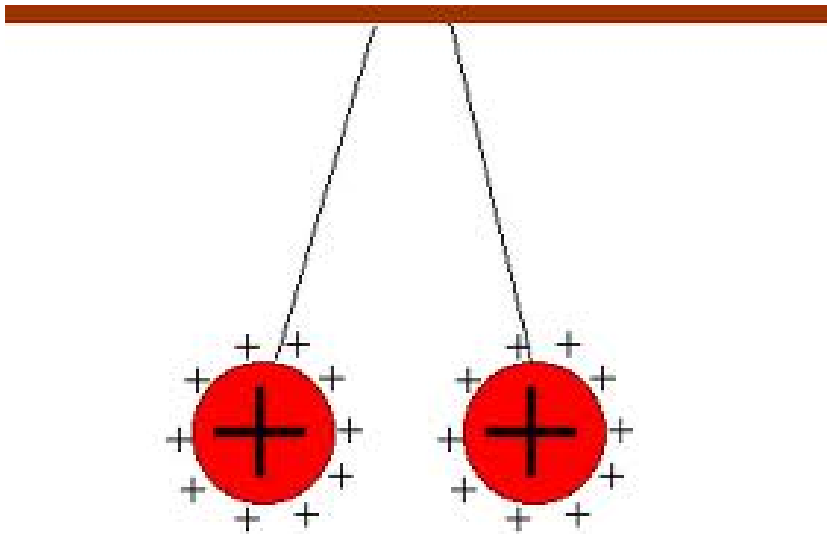
Two main forces in nucleus

- Strong nuclear force—all nuclear particles attract each other



Two main forces in nucleus

- Electric forces—protons repulse each other
  - Like charges repel

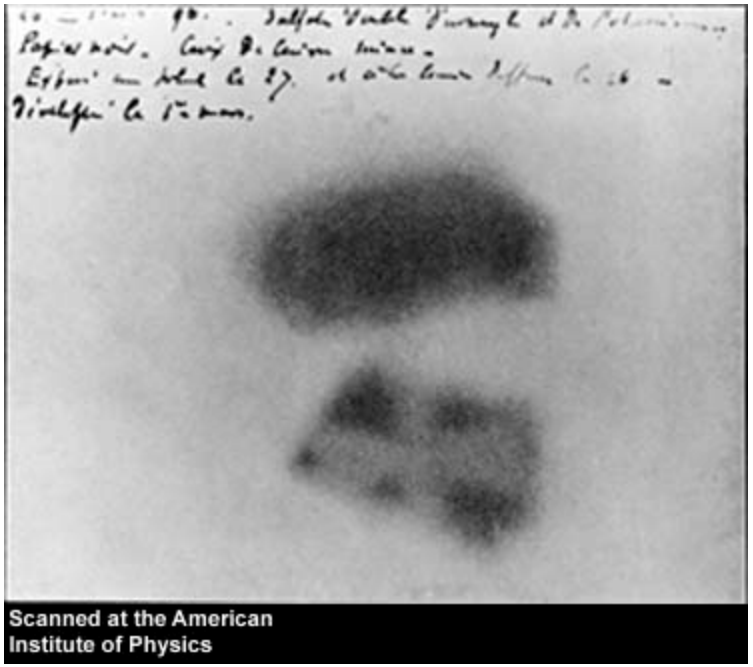


Key Scientists

- Henri Becquerel
  - Discovered uranium radiation

Key Scientists

- Henri Becquerel
  - X ray emission by uranium compounds
  - SI unit for radioactivity is called the Becquerel

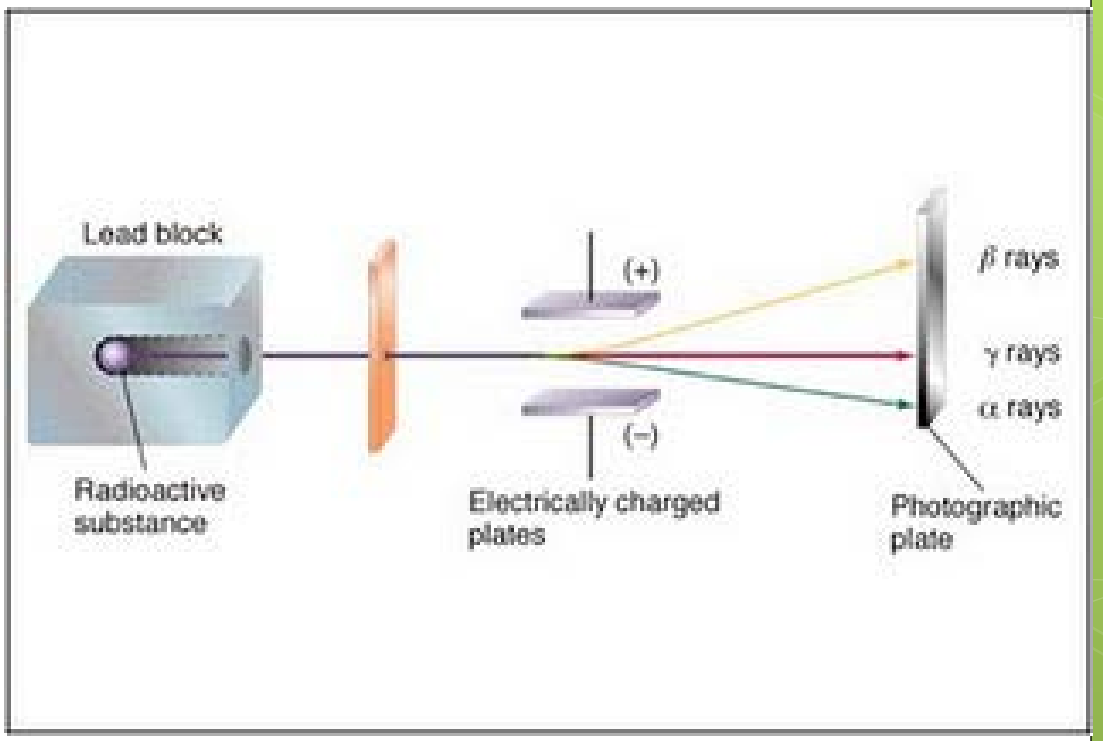


Key Scientists

- Marie and Pierre Curie
  - Radioactivity is an inherent feature of the structure of these atoms
  - Discovered radium, polonium

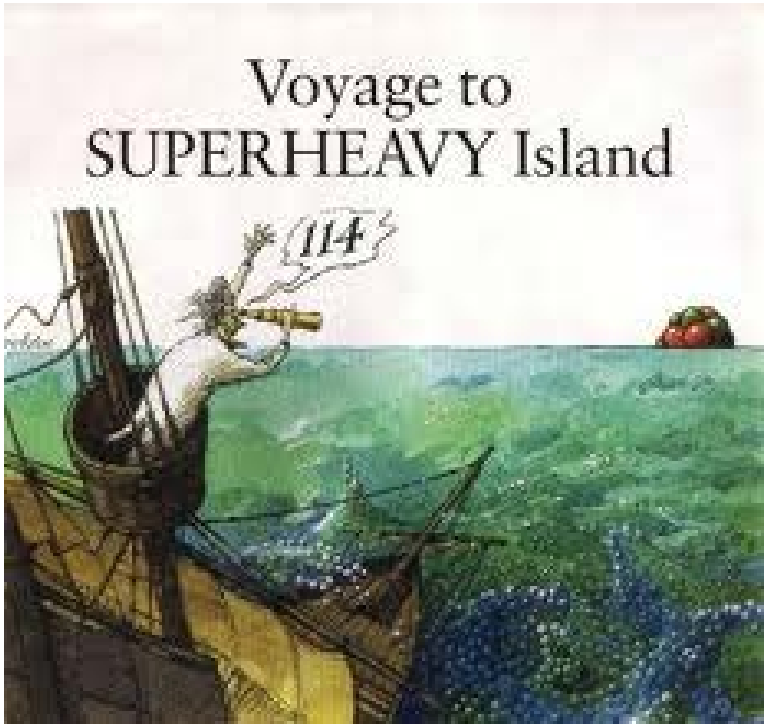
Key Scientists

- Ernest Rutherford
  - Discovered radon
  - Alpha “rays”
    - Helium ions
  - Beta “rays”
    - Identified as electrons



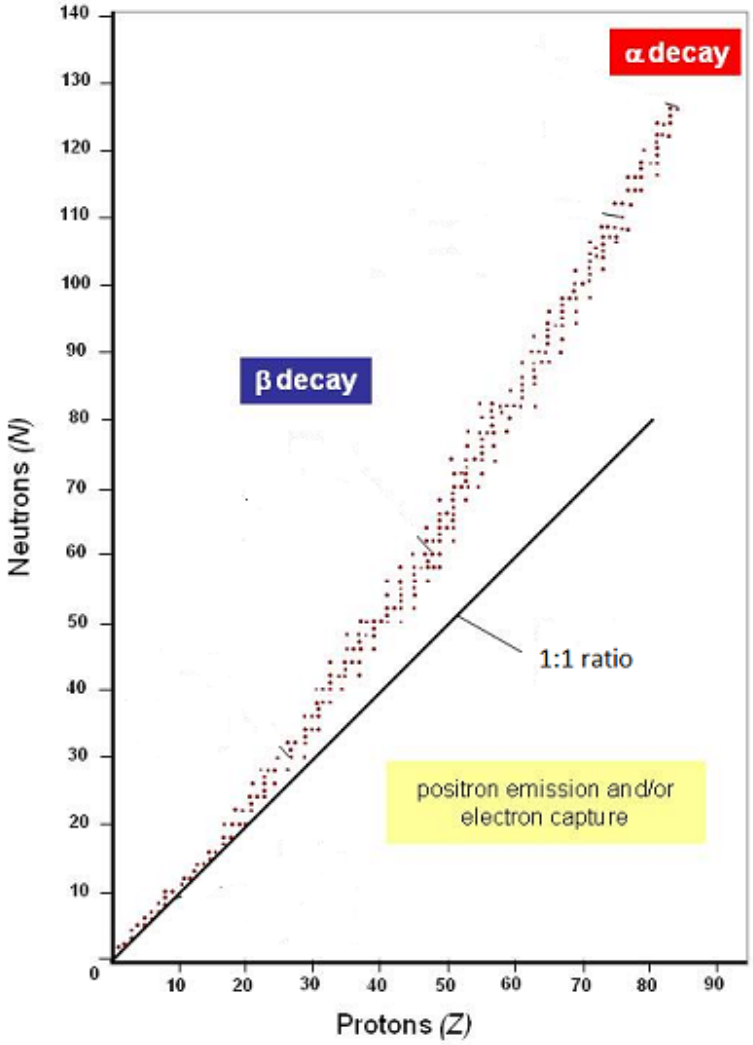
What determines stability?

- Balance between strong force and electric force



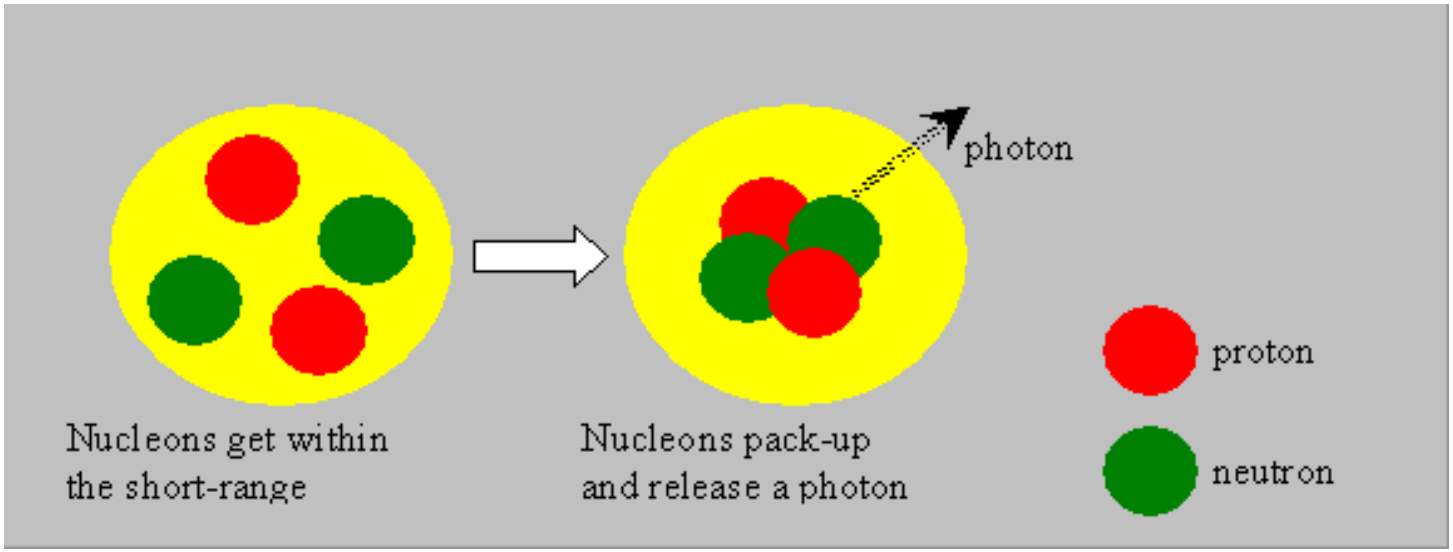
What determines stability?

- Neutron:proton ratio in nucleus
  - Most stable between 1:1 and 1.5:1



What determines stability?

- Binding energy
  - Energy released when a nucleus is formed from nucleons



Unstable Nuclei

- Most atoms have stable nuclei.
- All elements with atomic number ≥84 are unstable.
- Unstable nuclei (i.e., “radioactive” nuclei) undergo spontaneous change, giving off energy or particles when they change.

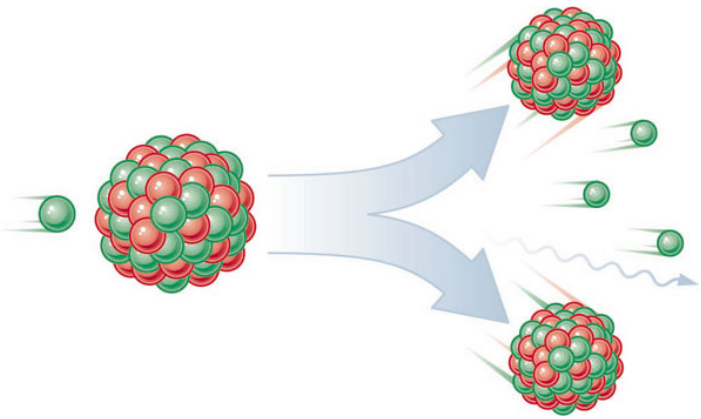
Nuclear Reactions

- 3 basic types
- Transmutation
  - nucleus of one element is transformed into nucleus of different element
    - Aka radioactive decay or nuclear decay
    - Nuclear reactions affect the nucleus of an atom

$$ {}^{9}_{4}Be + {}^{4}_{2}\mathrm{He} \rightarrow {}^{12}_{6}C + {}^{1}_{0}n $$

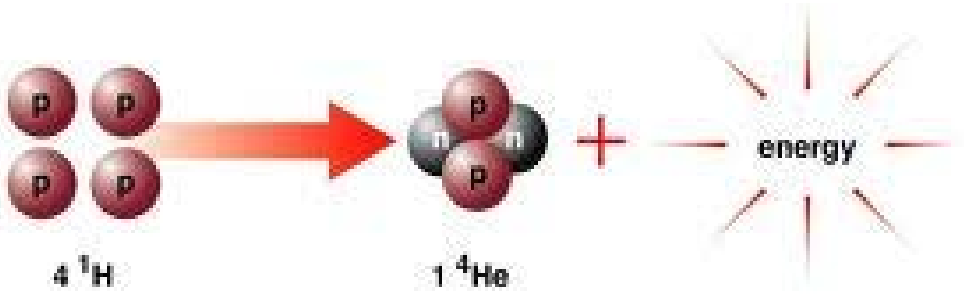
Fission

- A very heavy nucleus splits into two smaller nuclei



Fusion

- Two nuclei with small masses combine to form heaver, more stable nuclei



Particles in Nuclear Decay

- 3 main types
  - Alpha particles
    - 2 protons, 2 neutrons—a helium nucleus
    - +2 nuclear charge

$${}_{2}^{4}\alpha$$

  - Cannot penetrate skin; dangerous if ingested
  - Can be stopped by a piece of paper

$${}_{2}^{4}He$$

Nuclear Particles, cont.

Beta particles

- An electron emitted from the nucleus
- -1 charge

$${}^{0}_{-1}\beta$$

- Fast moving, can penetrate into skin
- Can be stopped by lead or glass

$${}^{0}_{0}\gamma$$

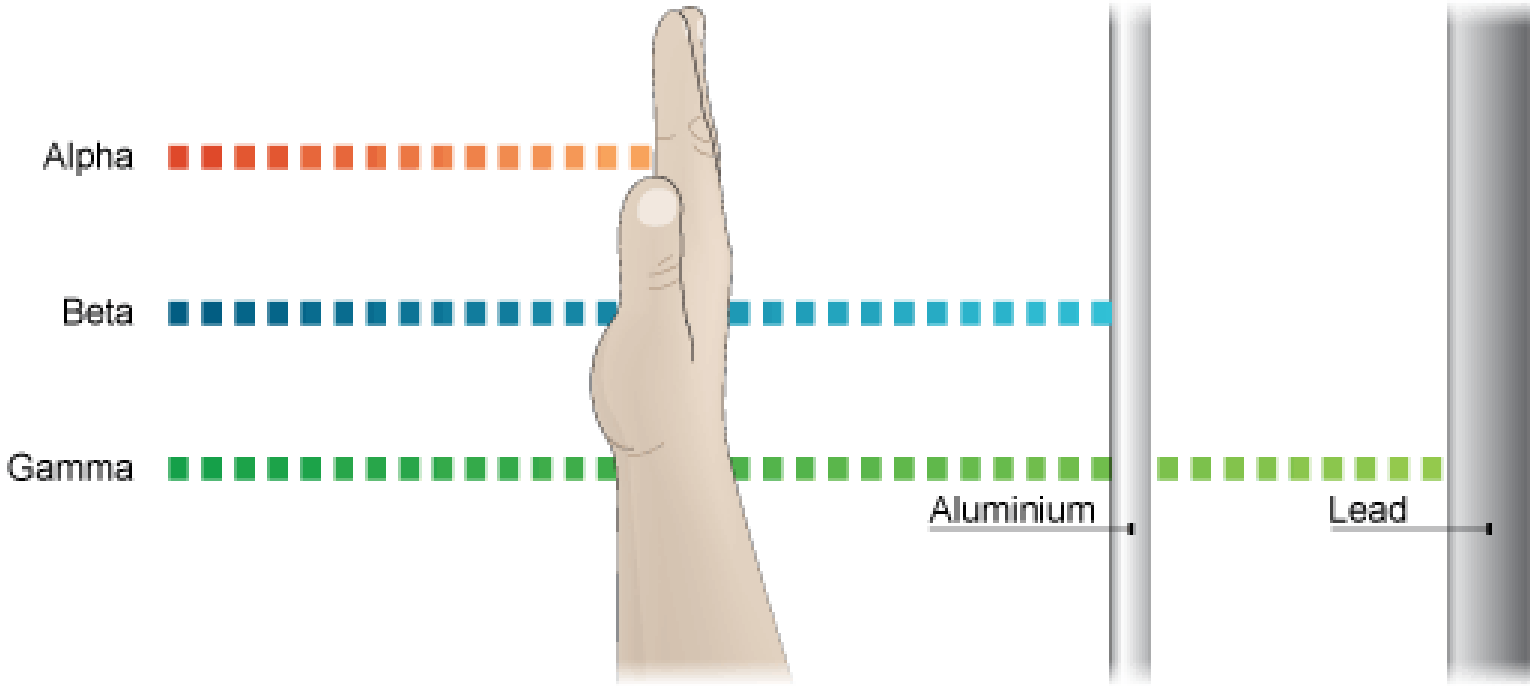
Nuclear Particles, cont.

Gamma rays

- High energy electromagnetic waves emitted from nucleus
- No mass, no charge
- Very penetrating; may not be stopped by several feet of concrete

$$^{0}_{0}\gamma$$

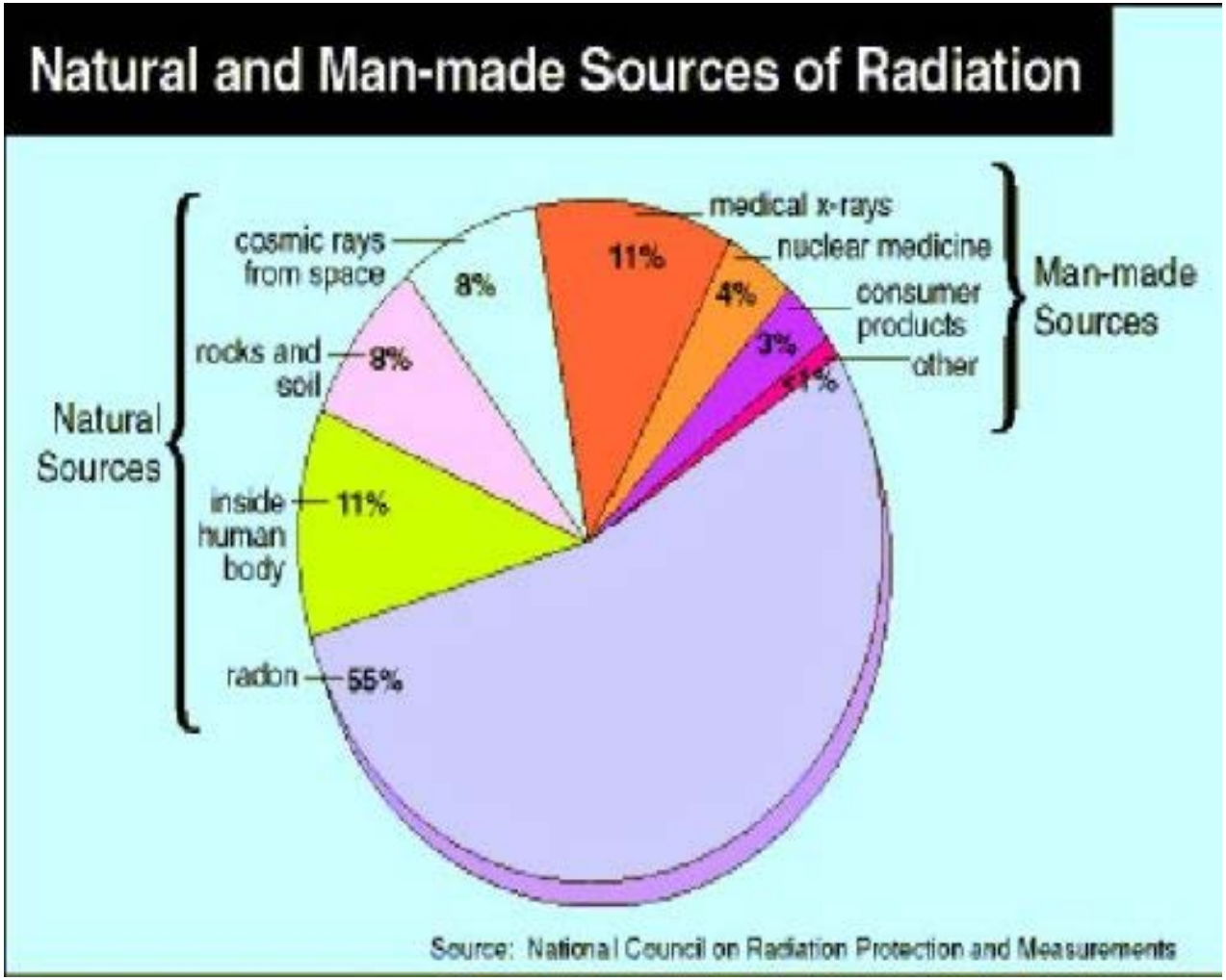
Penetrating Power



More Nuclear Particles

- Positrons
  - Mass of electron, positive charge $_{+1}^{0}\beta$
- Neutrons
  - 1 amu, no charge $_{0}^{1}n$
- Protons
  - 1 amu, +1 charge $_{1}^{1}p$

Sources of Exposure



What Happens When Radiation Impacts Human Body?

Exposure (rem)	Health Effect	Time to Onset (without treatment)
5-10	Changes in blood chemistry	Within hours
50	Nausea	Within hours
55	Fatigue	Within hours
70	Vomiting	Within hours
75	Hair loss	2-3 weeks
90	Diarrhoea	
100	Haemorrhage	
400	Possible death	Within 2 months
1,000	Destruction of intestinal lining internal bleeding and death	1-2 weeks
2,000	Damage to central nervous system loss of consciousness; and death	Minutes Hours to days

Source: US EPA

Videos

- Nuclear Reactor Meltdown
- Nuclear Blast Footage
- Plutonium

Balancing Nuclear Equations

- Both mass and charge must be conserved.
  - Sum of masses must be the same on both sides of arrow.
  - Sum of charges must be the same on both sides of arrow.
- Deduce the identity of the missing chemical species in the reaction.

Balancing a Nuclear Reaction

- Uranium-238 spontaneously decays by emitting an alpha particle.

$$^{238}_{92}U \rightarrow {}^{4}_{2}\alpha + ?$$

- Find mass of unknown
- Find atomic number of unknown
- Find symbol of unknown

$$? = {}^{234}_{90}Th$$