Objectives

- Discuss the difference between ionizing and non-ionizing radiation.
- Describe radioactive decay.
- Discuss the different types of ionizing radiation.
Radiation in Pop Culture

Different Types of Radiation

Ionizing Radiation

- Damages DNA.
- Produces free radicals by damaging water molecules.

Damaging molecules in the body:
- DNA
- Cells
- Tissue
- Organ
- Organism death
Cell Sensitivity

**High**
- Embryos!!!
- Blood-forming organs (numbers).
- Cancer cells / tumors.
- GI tract.
- Skin (including hair follicles).
- Muscles.

**Low**
- Central nervous system.
What is an Atom Composed Of?

Why do Certain Atoms Emit Radiation and are Radioactive?
Activity

- A measure of the amount of radioactive material
- Measured by the number of radioactive disintegrations per second
  - 1 Bequerel = 1 disintegration / sec
- Not related to mass or volume

*1 Curie = 37 billion disintegrations / sec

Radiation Measurement Units

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<thead>
<tr>
<th>S.I.</th>
<th>Formula</th>
<th>USA</th>
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<tbody>
<tr>
<td>1 Becquerel (Bq) =</td>
<td>$\frac{1}{37}$ billion x Curie (Ci)</td>
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<tr>
<td>1 Gray (Gy) =</td>
<td>100 x</td>
<td>RAD</td>
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<tr>
<td>1 Sievert (Sv) =</td>
<td>100 x</td>
<td>REM</td>
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Difference Between RAD and REM - Gray and Sievert

- RAD and Gray (Gy) express the amount of energy deposited per gram of tissue or material.
- REM and Sievert (Sv) express the health effect from the radiation deposited in a specific organ by a specific type of radiation.
- For gamma rays $1 \text{ Gy} = 1 \text{ Sv}$
Physical Half Life

- Time required for activity to be reduced by ½
- Specific to each radionuclide
  - I-131 = 8 day
  - Cs-134 = 2 yr
  - Cs-137 = 30 yr

Biological and Effective Half-Life

- Biological: time required for body to eliminate ½ of a particular element
- Effective: combined effect of radioactive decay and physical elimination
- Effective half-life is ALWAYS less than physical or biological half-life

ALARA

- “As Low As Reasonably Achievable”
- Work activities in radiation areas must be carefully planned to minimize radiation doses to workers
- Dose to general public kept low
- Control of releases of radioactive materials to the environment
How do Nuclear Reactors Work?

Nuclear Fission

Neutrons split U-235 atoms, releasing heat and fission products.

Neutron "poisons" absorb neutrons to control chain reaction.

Pressurized Water Reactor
Boiling Water Reactor

Defense in Depth -- Barriers

Decay Heat

- β decay of fission products
- Heat must be removed to prevent fuel damage
Decay Heat
- $\beta$ decay of fission products
- Heat must be removed to prevent fuel damage
- Chemical reaction releases H$_2$ gas at ~1,200 °C

Loss of Cooling Water
- Rupture of fuel cladding (small release)
  - krypton, xenon, iodine
- Zirconium oxide (H$_2$ and more heat)
- Melting of control rods (BWR)
- Melting of fuel (larger release)
  - iodine, cesium, strontium, etc.
- Liquification and relocation of fuel

Any Questions?
Summary Points

- Ionizing radiation damages cells and DNA.
- Ionizing radiation includes alpha particles, beta particles, gamma rays and neutrons.
- People are exposed to background radiation at all times.
- NPP accidents usually involve loss of coolant mechanisms.