Radiological Basics
Module Objectives

• Identify the basic components of an atom.
• Identify four basic types of ionizing radiation.
• Define ionizing radiation, radioactivity, radioactive material, and radioactive contamination.
• Distinguish between radiation exposure and radioactive contamination.
Historical Background

- In 1895, X-Rays discovered
- Stage set for the use of radiation
- Studies provide a detailed understanding of hazards and benefits of radiation
Atomic Structure

• All matter is made up of atoms
  • Protons
  • Neutrons
  • Isotopes
  • Electrons

• Not all atoms are stable

• Unstable atoms are known as radioactive atoms
Ionizing Radiation

- Non-Ionizing Radiation
  - Visible light/heat/radio waves/microwaves
  - Does not have sufficient energy to cause ionization

- Ionizing Radiation
  - Physical change in atoms by making them electrically charged—called ionization
Ionization
Four Basic Types of Ionizing Radiation

- Alpha
- Beta
- Gamma
- Neutron
Alpha Radiation
Beta Radiation
Gamma Radiation
Neutron Radiation
Radioactive Material and Radioactivity

- Radioactive material is any material that spontaneously emits ionizing radiation.
- Process of unstable atom emitting radiation is called radioactivity.
- When a radioactive atom goes through the process of radioactivity, also called radioactive decay, it will change to another type of atom.
Radioactive Material and Radioactivity

• Radioactive decay is measured in half-lives
• Half-life is the time it takes for ½ of the radioactive atoms present to decay to another form
• Half-life is unique to each radioactive isotope and can vary greatly
• Radioactive pharmaceutical products (called radiopharmaceuticals) typically have half-lives of a few hours or days
Radioactive Material and Radioactivity

- Regardless of the half-life, the radioactivity level of any given amount of radioactive material is constantly decreasing.

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Half-Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen-16</td>
<td>7 seconds</td>
</tr>
<tr>
<td>Technetium-99m</td>
<td>6 hours</td>
</tr>
<tr>
<td>Thallium-201</td>
<td>73 hours</td>
</tr>
<tr>
<td>Cobalt-60</td>
<td>5 years</td>
</tr>
<tr>
<td>Cesium-137</td>
<td>30 years</td>
</tr>
<tr>
<td>Americium-241</td>
<td>432 years</td>
</tr>
<tr>
<td>Uranium-238</td>
<td>4.5 billion years</td>
</tr>
</tbody>
</table>
Radioactive Contamination

• When radioactive **material** is where it is not wanted (e.g., on the ground, in water, or on you), we refer to it as “contamination”
Radiation Versus Contamination

- Radiation is a type of energy; contamination is material
- Exposure to radiation will not contaminate you
- Radioactive contamination emits radiation
Exposure to Radioactive Material

- At an incident scene, you may be exposed to radiation
- If the containers are intact, you should not expect unsafe exposure
- Exposure to radiation at controlled levels does not constitute a hazard
Radioactive Contamination Types

- If radioactive material is released, it is possible to become contaminated
- Contamination continues to be an exposure hazard
Radioactive Contamination Types

- Can be External or Internal

**External**
- Secondary contamination

**Internal**
- Can be difficult to remove
Avoid Radioactive Contamination

• Do not:
  • Eat
  • Drink
  • Smoke
  • Chew

• Use PPE while on the scene of an incident involving radioactive material
Radiological Units

- Traditional units of measure and International System of Units (SI) are used in measuring radiation and radioactivity

- For radiation measurement:

<table>
<thead>
<tr>
<th>Common Units</th>
<th>Exposure</th>
<th>Absorbed Dose</th>
<th>Dose Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>roentgen (R)</td>
<td>rad</td>
<td>rem</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SI Units</th>
<th>coulomb/kilogram (C/kg)</th>
<th>gray (Gy)</th>
<th>sievert (Sv)</th>
</tr>
</thead>
</table>
Radiological Units

- Radioactivity or the strength of a radioactive source is measured in:
  - Traditional units of curies (Ci)
    - 1 Ci = that quantity of radioactive material in which 37 billion atoms are transformed per second – $3.7 \times 10^{10}$ disintegrations per second (dps)
  - SI units of becquerel (Bq)
    - 1 Bq = that quantity of radioactive material in which 1 atom is transformed per second – 1 disintegrations per second
Radiological Units

- Because the unit for measuring activity is so small, prefixes are often used

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Prefix</th>
<th>Prefix Value</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>p</td>
<td>pico</td>
<td>1 trillionth, or $10^{-12}$</td>
<td>pCi = 1 trillionth of a curie</td>
</tr>
<tr>
<td>n</td>
<td>nano</td>
<td>1 billionth, or $10^{-9}$</td>
<td>nCi = 1 billionth of a curie</td>
</tr>
<tr>
<td>μ</td>
<td>micro</td>
<td>1 millionth, or $10^{-6}$</td>
<td>μCi = 1 millionth of a curie</td>
</tr>
<tr>
<td>m</td>
<td>milli</td>
<td>1 thousandth, or $10^{-3}$</td>
<td>mCi = 1 thousandth of a curie</td>
</tr>
<tr>
<td>k</td>
<td>kilo</td>
<td>1 thousand, or $10^{3}$</td>
<td>kBq = 1 thousand becquerel</td>
</tr>
<tr>
<td>M</td>
<td>mega</td>
<td>1 million, or $10^{6}$</td>
<td>MBq = 1 million becquerel</td>
</tr>
<tr>
<td>G</td>
<td>giga</td>
<td>1 billion, or $10^{9}$</td>
<td>GBq = 1 billion becquerel</td>
</tr>
<tr>
<td>T</td>
<td>tera</td>
<td>1 trillion, or $10^{12}$</td>
<td>TBq = 1 trillion becquerel</td>
</tr>
<tr>
<td>P</td>
<td>peta</td>
<td>1 quadrillion, or $10^{15}$</td>
<td>PBq = 1 quadrillion becquerel</td>
</tr>
</tbody>
</table>
Summary

Atoms are made up of protons, neutrons, and electrons.
Summary

The four basic types of ionizing radiation are alpha, beta, gamma, and neutron.
Radioactive material is any material that spontaneously emits ionizing radiation.
Summary

The process of an unstable atom emitting radiation is called radioactivity.
Summary

Radioactive material in an unwanted location is called contamination.
Summary

Radiation can pass through the body; contamination can be deposited in or on the surface of the body.
Summary

The SI unit for measuring radioactivity (activity) is the becquerel.
Radiological Basics 
Exercise
Electromagnetic radiation with no mass or charge
Made up of 2 protons and 2 neutrons
Mass of 1, neutral charge
Negative charge

Type of radiation:
- [ ] Alpha
- [x] Beta
- [ ] Gamma
- [ ] Neutron

Ideal shielding material:
- [ ] Lead
- [ ] Paper
- [x] Plastic
- [ ] Water
In the photo at right, what is the radiological hazard?

☐ Radiation
☐ Contamination
☒ Both
Questions