Activity 3: Penetrating Powers of Ionizing Radiation

Objectives

Students will:

- Predict whether each type of ionizing radiation has the ability to penetrate, or pass through, our skin and body.
- Demonstrate the penetrating powers of ionizing radiation.
- Consider how we are exposed to radiation and how we can limit our exposure.
- Differentiate between radiation exposure and radiation contamination.

Next Generation Science Standards

The concepts in this activity can be used to support the following science standard:

- PS4. Waves and Electromagnetic Radiation.

Materials and Resources

- *Radiation Exposure: Teacher Background Information*.
- *Vocabulary Materials.*
- *Penetrating Powers of Ionizing Radiation Worksheet* demonstration materials:
  - Cardboard box (for a class demonstration or one box per group) with several holes in one side or a side covered with plastic mesh (from a hobby or hardware store); the holes/mesh size should be relative to the "beta particle" representations.
  - Light objects to represent beta particles (e.g., a ping pong ball or small beads if using mesh). Some, but not all, of the objects should be able to fit through the cardboard or mesh holes. Mark objects with a negative symbol (–) to represent the negative charge of a beta particle if possible.
  - Larger beads or objects (e.g., a baseball or larger beads) to represent alpha particles. The objects should be heavier than the "beta particles" and not fit through the cardboard or mesh holes. Mark objects with a positive symbol (+) to represent the positive charge of an alpha particle if possible.
  - Flashlight to represent x-rays and gamma rays.
- *Penetrating Powers of Ionizing Radiation Worksheet* (one per student, pair or group) and *Penetrating Powers of Ionizing Radiation Teacher Answer Key*.
- *Penetrating Powers of Ionizing Radiation Image*.

Time

45-60 minutes.

Vocabulary

- Alpha particles
- Beta particles
- Direct exposure
- Exposure pathways
- Gamma rays
- Ingestion
- Inhalation
- Ionizing radiation
- Radiation
- Radiation exposure
- Radiation protection
- Radioactive contamination
- X-rays

Directions

1. Start with a vocabulary activity if students are not familiar with radiation and the terms used in this activity, or provide students with the terms and definitions. NOTE: When defining alpha particles, beta particles, gamma rays and x-rays, do not include the penetrating powers and how they can be stopped.

2. Distribute the *Penetrating Powers of Ionizing Radiation Worksheet* to students. Direct students to read and complete the first question.

3. Discuss students' predictions and reasons for their predictions.

4. Explain that the students are going to help you demonstrate the penetrating powers of radiation, or the ability of radiation to pass through our skin and body.

5. Show students the alpha particle, beta particle, x-ray and gamma ray representations (see Materials and Resources for appropriate objects).

6. Ask for several student volunteers if conducting a class demonstration, or provide direction to students if having them conduct the demonstration in groups.
   - Explain that the cardboard box or mesh represents our skin.
   - Have at least two students try to toss the alpha particles (larger object like baseball or large beads) through the cardboard holes or pour them over the mesh. If tossing the alpha particles, direct at least one student to toss the alpha particle lightly so that it falls short of the cardboard box.
   - Ask students to think about what they saw and hypothesize why this occurred and how this relates to exposure to alpha particles. **Alpha particles are heavy and may lack the energy to reach you and penetrate the outer dead layer of skin.**
   - Have several students try to toss beta particles (smaller object like ping pong ball or small beads) through the cardboard holes or pour beta particles through the mesh. Some should make it through and some not. Ask students to hypothesize what occurred and how this relates to exposure to beta particles. **The speed of individual beta particles depends on how much energy they have, and varies over a wide range. Some beta particles may have enough energy to penetrate our skin while others may not.**
     NOTE: Alpha and beta particles may not have enough energy to penetrate skin or clothing, but if inhaled or ingested, alpha and beta particles can transfer large amounts of energy to surrounding tissue and damage cells. Radiation exposure can serve as a benefit; for example, in controlled situations when it is used to diagnose and treat diseases. In uncontrolled situations, like high radon levels in a home, radiation can pose health risks and concerns.
   - Ask a student to (or you) shine the x-ray and gamma ray representation through the cardboard or mesh. Be sure to turn the box so it's facing the students and they can see the light shining through the holes/mesh or open the back side of the box so they can see the light shining through. Make sure the light is not directed toward another person. Ask students to hypothesize what occurred and how this relates to exposure to x-rays and gamma rays. X-rays and gamma rays are the most energetic. They can penetrate and pass through many kinds of materials, including our bodies.

7. Direct students to answer the remaining questions on the *Penetrating Powers of Ionizing Radiation Worksheet*.

8. Discuss students' responses using the *Penetrating Powers of Ionizing Radiation* ***Teacher Answer Key***. You can also share the *Penetrating Powers of Ionizing Radiation Image* while reviewing students' answers and the correct responses.

9. Conclude by having students share (verbally or in writing) at least one thing they have learned and how the activity changed their perceptions about radiation.

10. Optional activity or extension: Direct students to research radioactive elements and determine their penetrating power and how the penetrating power might serve as a risk or a benefit. A potential resource - Radionuclides: http://www2.epa.gov/radiation/radionuclides

Penetrating Powers of Ionizing Radiation Worksheet

Name: _____ Date: _____

Radiation is energy that can come from unstable (radioactive) atoms or be produced by machines. Radiation travels from its source in the form of energy waves or energized particles. The major types of ionizing radiation include:

- Alpha particles: Relatively heavy, high-energy particles.
- Beta particles: Small, fast-moving particles that vary in energy and penetrating power.
- Gamma rays: High-energy electromagnetic radiation that can travel at the speed of light and can cover hundreds to thousands of meters in air before spending their energy.
- X-rays: High-energy electromagnetic radiation that is generally lower in energy and, therefore, less penetrating than gamma rays.

1. Hypothesize whether each has the ability to penetrate (pass through) your skin and body.
   Alpha particles: _____
   Beta particles: _____
   Gamma rays: _____
   X-rays: _____

2. Did the demonstration confirm your predications above? Explain.
   _____
   _____
   _____

3. How might people be exposed to ionizing radiation?
   _____
   _____
   _____

4. How can people prevent or reduce their exposure to ionizing radiation?
   _____
   _____
   _____

5. What is the difference between radiation exposure and radiation contamination?
   _____
   _____
   _____

Penetrating Powers of Ionizing Radiation Teacher Answer Key

1. Hypothesize whether each has the ability to penetrate (pass through) your skin and body.

   Alpha particles: **Alpha particles cannot penetrate most matter. A piece of paper or the dead outer layers of skin is sufficient to stop alpha particles.**

   Beta particles: **Beta particles are capable of penetrating the skin and causing radiation damage, such as skin burns. They can be stopped by a layer or two of clothing or by a few millimeters of a substance such as aluminum.**

   Gamma rays: **Gamma rays are very penetrating. Several feet of concrete or a few inches of lead may be required to stop gamma rays.**

   X-rays: **X-rays are generally lower in energy (less penetrating) than gamma rays. Most diagnostic medical x-rays are stopped by a few millimeters of lead.**

2. Did the demonstration confirm your predications above? Explain.
   Answers will vary.

3. How might people be exposed to ionizing radiation?
   Exposure may occur from man-made sources like abandoned mines, mills, nuclear test sites or radioactive waste sites; contaminated water sources and building materials from these sites; and radioactive materials that are not disposed of properly. Exposure may also occur from natural (background) radiation sources like the sun, the atmosphere and the soil.

4. How can people prevent or reduce their exposure to ionizing radiation?
   The main radiation protection concepts are time (reducing time near a source), distance (increasing our distance from a source) and shielding (placing a barrier between us and the radiation source). It's also important to have homes and water supplies tested for radiation contamination and fixed if any problems are identified.

5. What is the difference between radiation exposure and radioactive contamination?
   Radiation exposure occurs when a person is near a radiation source. Though the radiation penetrates the body, it does not remain on the skin or in the body. Receiving an x-ray is an example of radiation exposure.

   Radioactive contamination occurs when radioactive materials are deposited on or get in objects (building materials or surfaces), people, or the environment (air, water, soil, animals and plants). For example, if radioactive dust, powder, or liquid lands on us or our clothing, or if it gets in and remains inside our body, we are contaminated.

Penetrating Powers of Ionizing Radiation Image