Health Physics Society
Specialists in Radiation Safety

Introduction to Radiation and Radiation Detection
Background Radiation

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Radioactive nuclei emit radiation. This radiation cannot be sensed by the human body; the ears can't hear it, the eyes can't see it, the nose can't smell it, and the skin can't feel it. Therefore, to measure, or sense, radiation, some kind of detector is needed. The purpose of this activity is to become familiar with a radiation detector.

Your teacher will demonstrate how to turn on the radiation detector and how to take one-minute counts. Each count (or click if you have the sound turned on) represents some kind of radiation that leaves energy in the detector Geiger tube.

1. Turn on your detector and set it to take a one-minute count. What do you observe?

2. Take ten successive one-minute counts and record the data below. Find the average. Record your one-minute counts below.

_________ _________ _________ _________ __________

_________ _________ _________ _________ __________

Average: ___________counts per minute (cpm)

Range: Lowest value: _________ Highest value: __________

3. Compare your average with the averages of other groups in the class. Are they about the same or do they differ significantly?

4. Where do you think this radiation is coming from?

5. Hold a packet of table salt (sodium chloride; NaCl) on the detector, right on the exposed end of the Geiger tube. Take a one-minute count. Record the count below. Then do the same for a packet of "no-salt" (potassium chloride; KCl). Then explain what you observed.

Counts: NaCl: _________cpm KCl: ___________cpm

6. Several objects are on a table. Use your detector to determine which ones are radioactive. On the chart below, indicate which ones are radioactive. Some objects may emit some radiation, but not enough to give counts significantly above background; for those record "maybe" for its radioactivity. After you have made your determinations, your teacher will tell you what radioactive material is emitting the radiation.

	Radioactive?			Material
Object	Yes	No	Maybe	(from teacher)
__________________	___	___	___	_________________
__________________	___	___	___	_________________
__________________	___	___	___	_________________
__________________	___	___	___	_________________
__________________	___	___	___	_________________
__________________	___	___	___	_________________
__________________	___	___	___	_________________
__________________	___	___	___	_________________
__________________	___	___	___	_________________

Teacher Notes

Materials:

Digital radiation detector (Radalert or Vernier DRM-BTD), one for each group of students.

For exercise 6, you will need an assortment of radioactive and non-radioactive materials. Below is a list of items that exist, but you probably will not be able to get many of them. Those scientists who have these items generally take years to gather their collection.

Several "no-salt" (KCl) salt packets. These can be obtained from restaurant supply houses, or talk to owners of a local restaurant to see if they have any and be willing to give you a few. Or, purchase a container of "no-salt" salt and make small packets, about 1 inch square. The **potassium** is radioactive.

Radioactive gas lantern mantles. (Make sure they are radioactive; Coleman mantles are nonradioactive.) These contain **thorium**, which is radioactive.

Radioactive rocks. Examples are autunite (**uranium**) and tyuyamunite (**uranium**), thorite (**thorium**), carnotite (**uranium**), uranite (**uranium**), metatorbernite (**uranium**), and uranophane (**uranium**). These are not available from science supply companies, so try to obtain some from friends who are rock collectors, or check the Internet.

Fiesta ware. The radioactive ones are red-orange, but they must be old. Newer versions are not radioactive. These may be found at flea markets or antique stores. These contain **uranium** in the red-orange glaze.

Old "glow-in-the-dark" watches and military instrument dials. These have **radium** on the dials to make them glow. Newer "glow-in-the-dark" watches contain tritium, but tritium emits a very low-energy beta particle that doesn't get through the watch crystal.

Thoriated tungsten welding rods. You can get these at a welding supply company, but they are expensive. These contain **thorium**.

Fertilizer high in potassium (potash). Local garden store. Potash is the last of the three numbers on fertilizer. Try to get something with at least an 8. For example, some vegetable fertilizer is 5-10-10. This contains **potassium**. The activity may not be strong, so the count rate above background will be small.

Vaseline and depression glass. This is a yellow or yellow-green colored glass in various shapes. It can be found at flea markets and antique stores. It contains some **uranium**. Its activity may be small.

Assortment of nonradioactive materials. Nonradioactive lantern mantles (Coleman), nonradioactive rocks ("ordinary" rocks like limestone, sandstone, marble, etc.), new "glow-in-the-dark" watch, etc.

Teacher's instructions:
First explain the operation of the detector. Go over the various switches; audio is fun, but after a while it can be annoying, so let the students turn the audio on for a while, have a bit of fun, then turn it off.

Students should work in groups of 3 to 6 so they can discuss answers among themselves.

The students don't really need to know about the exact operation of the detector. However, if someone asks, you can say that the Geiger tube is filled with a gas and when radiation interacts with the gas, it knocks out electrons from the atoms in the gas. A voltage (about 700 volts) is applied to a wire in the center of the tube, creating a large positive charge on the wire. When the radiation knocks electrons loose, these electrons are attracted to the center wire, causing an electrical current, which results in a "count" and/or a click.

Emphasize that the end cover is delicate (therefore covered with a protective screen), so they should not poke any sharp objects in it. Breaking the end cover will ruin the detector.

Answers for the activities:

1. The students should observe that the detector produces counts. They may venture to say the radiation is coming from space or some other source. It is not important what they conjecture about the source, just that they say radiation is present, even when they are supposedly not near any radioactivity.

2. Typically, the background count is from 10 to 15 cpm.

3. Most groups will get averages close to each other, but it is possible for one to differ by 2–3 cpm from most of the class. Also, the range can vary from about 3 cpm to 20 cpm. This is a good time to talk about averages and statistics. Radiation produced from any source is random, so the number detected in one minute is also random. Depending on the age and background of the class, you can talk about the Gaussian (or normal, or bell-shaped) curve. Advanced classes could generate hundreds of one-minute counts (easier if the detector is connected to a computer) and generate a Gaussian curve.

4. Now the students need to discuss the possible sources of the radiation. They are three: cosmic radiation from the sun and outer space, radiation from the earth (from radioactivity in the soil and rocks, and maybe in the building materials), and radiation from our own bodies. This last source is mostly from potassium, which will be investigated in the next activity.

5. Most potassium is stable, but a small fraction is radioactive. This small fraction has a very long half-life (millions of years), so its activity is constant. A small packet of "no-salt" salt (i.e., KCl) has enough activity to produce a measurable count over background, generally about 10 cpm above background. The difference should be measurable, but if not, have the students repeat the experiment.

6. The students should find the objects that are radioactive. The radiation from the potash fertilizer and the Vaseline glass may be weak, so those may be "maybe" on the students' lists. For these, you may want to suggest that the students place the detector close to the object, hold it there, and take several one-minute counts to get an average. The average may be a few cpm above background. When the students are finished, inform the students what radioactive element is in each radioactive object.