STEM in the lab

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BACKGROUND RADIATION

GRADE LEVELS

This activity is appropriate for students in grades 9-12.

MISSION

Use a Geiger counter to detect and measure background radiation.

VOCABULARY

GEIGER COUNTER: a device for measuring radioactivity by detecting and counting ionizing particles.

RADIATION: the emission of energy as electromagnetic waves or moving subatomic particles.

RADIOACTIVE DECAY: the changes in an atom once it has become unstable and begins to lose particles.

MATERIALS

- Geiger counter
- Table for recording data

INTRODUCTORY READING

Read this analogy to students:

Suppose someone sets up a water sprinkler and maintains a steady flow of water to the sprinkler. Counting the rate at which the sprinkler puts water on the ground by how many drops of water fall on a sheet of notebook paper in a short time will not yield the same result every time or in every location. This is because the water falls on to the ground in discrete units (drops).

Similarly, radiation (alpha and beta particles, gamma photons, etc.) strikes a given location in discrete units or amounts. If the average number of water drops falling on a piece of paper in one minute is 25 drops, you may not get exactly 25 drops in a one-minute measurement. Results ranging between 20 and 30 drops are likely, and counts as low as 15 and as high as 35 might occur, though that is less likely. This same variation in measurements may occur with radiation.

ABOUT THIS ACTIVITY

In this lesson, students will use a Geiger counter to demonstrate the above analogy. Students will also learn about background radiation and ways to eliminate background radiation. Students should also be able to answer the question: Why would we take a measurement of background radiation levels before starting a radiation experiment?

Ask Students:

Does anyone know what radiation is?

Has anyone seen radiation used before?

What is a Geiger counter?

The **nuclei** of some atoms are unstable. These are called radioactive atoms or isotopes. **Radiation** is energy emitted from radioactive atoms, either as electromagnetic waves or as particles. **Geiger counters** measure radioactive decay.

The Geiger-Muller Counter was invented in 1928 and is used to detect radioactive particles. Geiger counters register the presence of some radiation, even when not near a known radiation source. The devices measure the background radiation that is present.

Photo credit: Wikipedia

Everyone on Earth is exposed to background radiation. The amount of radiation depends on where you live. Those at lower elevations receive less radiation than those at higher elevations. The radiation in our world comes from many sources. Radon gas (produced from the decay of uranium in the soil), cosmic radiation (from outer space and the sun), terrestrial sources (in the ground and rocks), and internal sources (in our body, like potassium) are a few examples.

Ask Students:

How can we accurately measure a radioactive source? *(We need to know how much radiation is naturally present in the environment)*. The difference between the background radiation and the radiation measured near a specific object will give us the level of radiation.

Although background radiation is steady on average, you would never conclude that by listening to or watching a Geiger counter. The amount of radiation will vary, depending on the specific time which you take the measurement. Turn on a Geiger counter. Move around the room to show that there is radiation all around us. Pass out Geiger counters to students and have them complete the following activity.

DIRECTIONS

1. Explain to students a Geiger counter measures radiation by making a click each time it detects a radioactive particle. Have students measure background counts for one minute by counting the number of clicks from the Geiger counter (don't just make the measurement by reading the counts/min scale on the Geiger counter - students need to count). Have students enter the results of all the groups into the table. Remind students that we are exposed to background radiation every day. People are slightly radioactive because of the potassium-40 and carbon-14 in our bodies. Use the Geiger counter to measure a person's radioactivity. It's not very high, but it exists.

2. Analyze the group results. Do the results vary? What are the highest and lowest values? What is the range? What are some reasons for the differences? (Possible answers include inaccurate counting or timing, variations in background radiation, different Geiger counters.)

   Ask Students:

   How could they make results more accurate? *(One possible answer is to remove jewelry and repeat the measurements.)*

3. Have students run a second and third trial. This time, only enter the data for their own group in the table.

   Ask Students:

   Do the results for your lab group vary from one trial to another? If so, why?

   What is the range for your own measurements? *(At this stage, students may have discovered that the results for their own group vary slightly in each trial. Discuss this variation.)*

4. Consider the possibility that errors were made during every measurement and discuss whether this is likely.

5. Discuss the idea that the amount of background radiation present may actually be slightly different from one moment to the next — even though it has an "average" value. Refer to the water sprinkler analogy mentioned in the introduction.

6. Have each group enter the range for their own measurements in the bottom row of the table. Look at the data and ask "Were the clicks always evenly spaced? OR, did the clicks sometimes cluster together with pauses between them?" (Clicks are usually NOT evenly spaced. There are usually some clusters of clicks and some pauses.)

7. Discuss the possibility that this variation, or clustering, of clicks may impact how long a time period we use for measuring radioactivity levels. For example, using a really short time period might make measurements more prone to error than a longer time period, especially if the short period measurements were made during a pause or cluster of clicks.

8. Have students enter the data for all groups.

   Ask Students:

   Are there variations from group to group? If so, what are some possible reasons? (Variations in Geiger counters, variations due to location in the room, etc.)

   How could we determine if these differences are due to our Geiger counters being different or to differences within the room?

Final Notes:

You should realize when you begin this activity that these uncalibrated instruments are likely to give slightly different results under identical conditions and at the same time. However, it IS possible for there to be slight variations within the room. Proximity to a particular building material or exposure to some other radiation source, for example, may produce higher background readings in a specific location.)

There are several experimental approaches your students could use in resolving this issue. (You could have each group take measurements at the same location and compare them. OR, each group could move to each of the identified locations and make readings for comparison. Students may come up with other suggested solutions.)

THE SCIENCE BEHIND IT

Atoms of uranium are used in nuclear reactions. A nuclear reactor converts the heat created by nuclear fission into electricity. Fission occurs when a neutron splits a uranium atom into two smaller atoms, releasing heat and more neutrons that split more atoms, continuing a controlled chain reaction. The heat released by fission is used to create clean steam that spins a turbine to generate electricity.

FURTHER EXPLORATIONS

» Students could measure background radiation levels in other areas of the school (indoors, outdoors, on a higher floor, in the basement, etc.). Each group could prepare a table to summarize its findings and compare them to the results of other groups. They could see if there are differences between clear, sunny days and cloudy days, etc.

» Use known radioactive sources so students can experiment with different types of shielding (metal, paper, etc.)

RESOURCES

» http://www.spectrumtechniques.com/wp-content/uploads/2016/12/Spectrum-Techniques-Teachers-Guide.pdf

» https://www.nuclearscienceweek.org/for-educators/lesson-plans

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COUNT RATE

	GROUP 1	GROUP 2	GROUP 3	GROUP 4
MEASUREMENT TIME (1 minute)				
1ST TRIAL				
2ND TRIAL				
3RD TRIAL				
RANGE FOR GROUP (lowest and highest count)				
MEAN (Average)				

CLASS AVERAGE: ___________________________