sck cen Academy

Lesson activity

Demonstration of half-life

Credits: The Society for Radiological Protection (https://www.srp-uk.org)

Checklist for the teacher

Target audience

Third-grade science/STEM pupils

Format of activity

Interactive class activity as part of a lesson or summary

Duration

30 minutes

Learning objectives

After completing this learning activity, the pupil will be able to:

- understand that the process of radioactive decay is random and cannot be predicted
- describe how radioactive decay follows an exponential curve.

Required equipment and space

- Cup/beaker for each group
- About 60 sweets per group
  (skittles, M&Ms or similar with a letter/sign on 1 side)
- Table for results (see appendix)
- Graph paper (to draw a graph)

Time	Teacher action	Pupil action
0 mins	Remind pupils why some isotopes are unstable. Ask pupils to consider what they think is emitted during radioactive decay. Focus their attention on how many nuclei will remain after 1 half-life, after the 2nd half-life, etc. Explain that the cup full of sweets represents a radioactive source and each sweet represents an unstable nucleus. Pupils will investigate how many unstable nuclei decay per half-life.	Divide the pupils into small groups (no more than 3).
5 mins	Explain that each group must first count the number of unstable nuclei from their cup. 	The pupils complete the 'activity' – the number of unstable nuclei they have – at time 0 on the results sheet. Pupils should shake the cup and empty the contents onto the table.
10 mins	Explain to pupils that this represents 1 half-life. Explain that the sweets that landed with a sign at the top are still radioactive, and the ones with a sign at the bottom have decayed (and are therefore safe to eat!). Ask the pupils how many nuclei they expected to expire after 1 half-life (50%).	The pupils should count and record the number of active particles on the results sheet for 1.
15 mins	Ask the pupils how the number of remaining active particles compares to the original number. Is it exactly half? Remind the pupils that radioactive decay is a probability calculation and therefore cannot be predicted – but we can make a good estimate.	The pupils continue their test by cutting out their cup of sweets: removing the expired nuclei, counting the active ones, and recording them on the results sheet. This is repeated until no active particles remain.
25 mins		The pupils should draw a graph on the graph paper. Time on the X-axis, activity on the Y-axis.
30 mins	Ask the pupils what shape this graph is. Ask the pupils what this curve tells you about radioactive decay. Explain that this is an exponential function. These demonstrations can be followed by: - a graph of a real example of radioactive decay. - using a graph to calculate activity after a certain amount of time. - examples of half-lives of different isotopes (see appendix), their uses, and the relationship between the half-life and suitability for particular applications.	

The science

The rate of radioactive decay is described by the term half-life (half-life).
Half-life refers to the time it takes for half of the nuclei to decay in a sample of radioactive isotopes.

Because the rate of radioactive decay is measurable, unstable isotopes are useful ways to determine age. This technique uses C-14 to date the age of organic materials that were once alive. This process is called carbon-dating.

Appendices

Half-life	**Activity** (number of active particles)
0	
1	
2	
3	
4	
5	

Table to be expanded as needed.

Radionuclide	**Half-life**
Carbon-14	5,730 years
Americium-241	432.6 years
Cesium-137	30 years
Tritium (H-3)	12.3 years
Krypton-85	10.7 years
Polonium-210	138 days
Phosphorus-32	14.3 days
Fluorine-18	109 minutes
Nitrogen-16	7.1 seconds

Discuss how half-life may be several thousand years, or a fraction of a second and how this usually means there is utility in a variety of applications.

Ask whether anyone knows what some radionuclides are used for.

Carbon-14

Carbon-dating given the long half-life.

Americium-241

(Used to be in) smoke detectors – several hundred years means a lifetime for your stay at home... replacing the battery is annoying enough! These have since been banned from the market because safer alternatives exist. Discuss the risks and (optical) alternatives.

Phosphorus-32

Tracer that can label amino acids and phosphoproteins. The half-life is long enough for production, use and patient outcomes to be obtained. Discuss precautions that should be taken after medical treatment. Talk about medical radioisotopes that can set off alarms at public events.