**Half-life of pizza**



Some students are using a pizza to explain radioactive half-life.

* They cut the pizza in half and eat one half.
* Next, they cut the remaining piece in half and eat one half.
* They repeat this several more times.

**To answer**

1. State three ways in which this is a **good model** for explaining half-life.

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**2.** State three ways in which this is **not an accurate model** for explaining half-life.

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**3.** Describe how the model could be improved to explain half-life.

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*Physics > Big idea PMA: Matter > Topic PMA5: Nuclear physics > Key concept PMA5.4: Radioactive half-life*

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| **Response activity** |
| **Half-life of pizza** |

**Overview**

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| Learning focus: | Radioactive half-life is the predicted time it takes for half of a large sample of radioactive nuclei to decay randomly. |
| Observable learning outcome: | Describe the decay of a radioactive material.  Describe patterns in the random nature of radioactive decay and interpret radioactive half-life graphs.  Make calculations using values of half-life. |
| Activity type: | Critiquing a representation |
| Key words: | Radioactive half-life, radioactive atoms, radioactive material, radioactive decay |

This activity can help develop students’ understanding by addressing the sticking-points revealed by the following diagnostic questions:

* Diagnostic question: Radioactive material
* Diagnostic question: Radioactive half-life
* Diagnostic question: Radioactive half-life graph
* Diagnostic question: Predicting radioactivity
* Diagnostic question: Carbon dating

**What does the research say?**

Misunderstandings that may stem from a thinking that ‘only clearly determined events can lead to predictable outcomes’ are:

* a radioactive material will be safe and no longer radioactive after one half-life (Lijnse et al., 1990);
* *all* the radioactive atoms will have decayed after one half-life (or after *two* half-lives); and
* half-life is a special time before which, or at which, a particular nucleus decays (Hull and Hopf, 2020).

In each of these examples, students appear to have used the idea that ‘half-life’ is predictable, to develop a misunderstanding that the decay of particular radioactive atoms is also predictable. The last example additionally shows how some students (about a third of a sample of 55 students age 13-14) ascribe the predictive nature of a whole sample to a single radioactive nucleus (Hull and Hopf, 2020). In fact, an individual radioactive nucleus does not have a half-life and its decay is random. Half-life is instead, a *good predictor* of the time it takes for half of a sample of *very many* radioactive nuclei to decay.

Another misunderstanding students have is that atoms disappear during radioactive decay (Prather, 2005). Prather (2005) found that the majority (59%) of (n=258) undergraduate students believed that the mass or volume of a radioactive substance would reduce by half during one half-life. Expressed differently, this means that a radioactive object disappears as it decays. This misunderstanding is likely to stem from the fact that is not clear to a lot of students that radioactive materials contain both stable and unstable atoms.

**Ways to use this activity**

Students should complete this activity in pairs or small groups, and the focus should be on the discussions. It is through the discussions that students can check their understanding and rehearse their explanations.

Philosophically science can be said to be a description of the ‘best model’ we have for the world. In this activity students should identify ways in which this particular model is a good representation of the real world, and ways in which it is not.

Students should work together to answer the questions on either the worksheet or the PowerPoint. Giving each group one worksheet to complete between them is helpful for encouraging discussion, but each member should be able to report back to the class. Listening in to the conversations of each group will often give you insights into how your students are thinking.

Ending with the students completing the worksheet or questions from the PowerPoint individually, might help them to consolidate their learning.

*Differentiation*

You may choose to use simplified worksheets for some students, for example with gaps to fill in so they can focus on the science. In some situations, it may be more appropriate for a teaching assistant to read and/or scribe for one or two students.

**Expected answers**

**1. Why this is a good model for explaining half-life:**

The remaining portion of the pizza is the same as the proportion of radioactive nuclei that have not undergone radioactive decay.

The portion of the pizza that is eaten represents the proportion of radioactive nuclei that have undergone radioactive decay.

The pizza that has been eaten has not disappeared, it has changed into chewed up food.

If the time taken for students to cut and eat the pizza each time is always the same, then each repeat represents one half-life.

**2. Why this is not an accurate model for explaining half-life:**

When radioactive atoms decay, the (often new types of) atoms that remain have not moved out of the radioactive material.

Radioactive atoms decay randomly throughout a radioactive material and not all those in one half at a time.

The size and mass of the radioactive material remains (almost exactly) the same during the time the radioactive atoms are decaying.

The time it takes for each half to be eaten, and to decay, is likely to get less and less as more of the pizza is eaten.

**3. To improve the model:**

Each portion of the pizza could be replaced by an equal sized portion of a different type of pizza. This represents how the ‘radioactive atoms’ are replaced by different, more stable atoms (for alpha and beta decay).

Rather than half of the whole pizza being replaced, half of each quarter could be replaced and so on. This better represents how radioactive atoms decay randomly throughout the whole pizza.

A timer could be used to time each cutting and halving of the ‘radioactive atoms’ in the pizza, so that the time for them to half is always the same (one half-life).

Different types of pizza could be used, each one with a different length of half-life.

Some garlic bread could be placed on one side to represent background radiation.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG) with the original image of a pizza by petrovhey from Pixabay.

**References**

Hull, M. M. and Hopf, M. (2020). Student Understanding of Emergent Aspects of Radioactivity. *International Journal of Physics and Chemistry Education,* 12(2).

Lijnse, P. L., et al. (1990). Pupils' and mass-media ideas about radioactivity. *International Journal of Science Education,* 12.1.

Prather, E. (2005). Students' beliefs about the role of atoms in radioactive decay and half-life. *Journal of Geoscience Education,* 53(4)**,** 345-354.