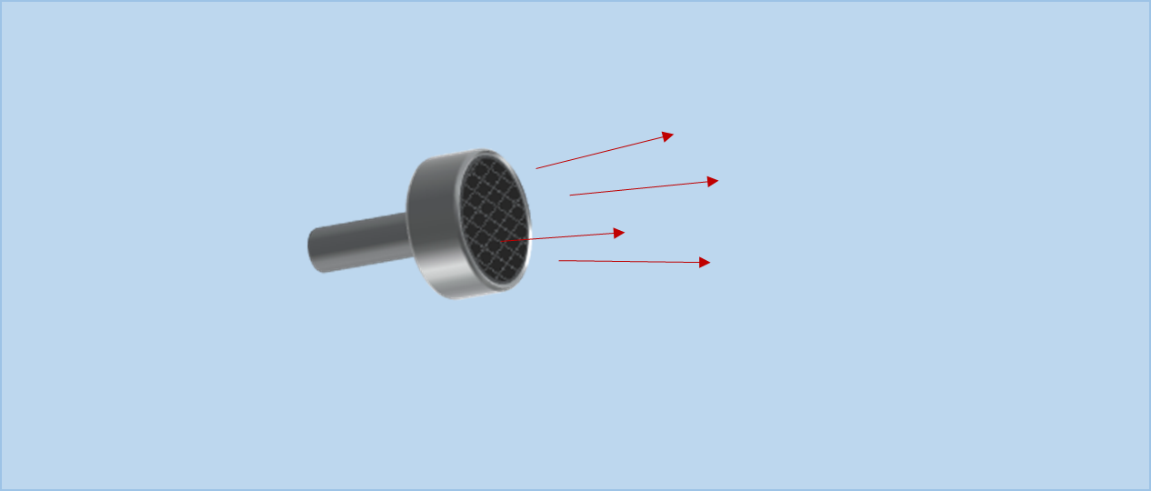
**Striking gold**

The most powerful microscopes **cannot** see atoms.

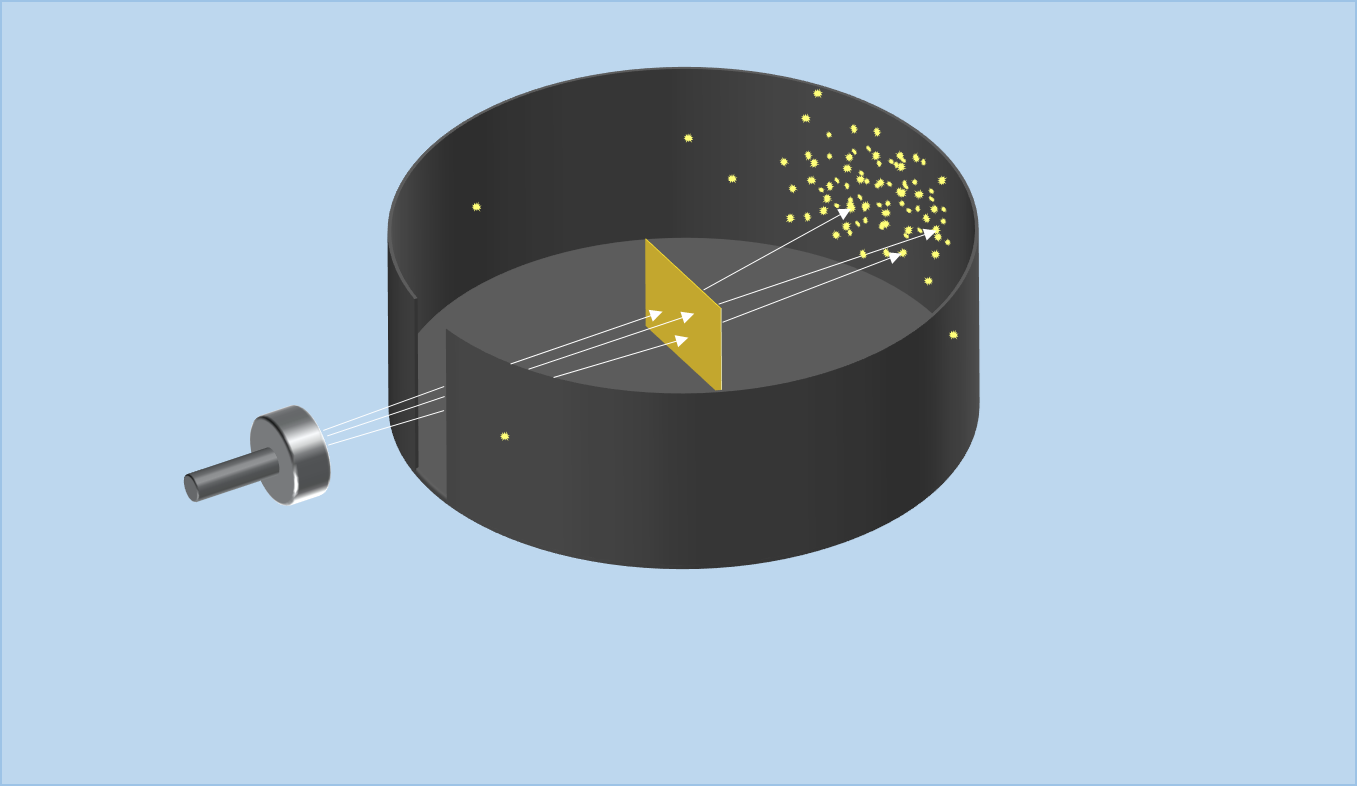
Ernest Rutherford used alpha particles to find out more about atoms.



Alpha particles shoot out of some radioactive materials.

* Alpha particles have a positive electric charge.
* Alpha particles are too small to see with a microscope.
* Radioactive material is inside a holder to protect the person using it.

He shot alpha particles at atoms in gold foil.



**1.** A radioactive material

**2.** shoots out

alpha particles

**3.** at gold foil.

**4.** The surrounding screen is fluorescent

*There are about 2000 layers of atoms in the gold foil.*

*Most alpha particles go straight through all of them.*

**5.** and a dot of light appears each time an alpha particle hits it.

**6.** Most alpha particles go straight through.

About one in every thousand bounces backwards.

Some students are talking about Rutherford’s scattering experiment.

They are thinking about what it tells us about atoms.

**Josh:** Alpha particles are smaller than an atom.

**Keira:** Most of an atom is empty space.

**Mohammed:** The diameter of a nucleus is a lot smaller than the diameter of an atom.

**Libby:** Most of the mass of an atom is in its nucleus.

**Nicole:** Pictures of atoms in textbooks are not drawn to scale.

**To answer**

1. Who is right about what atoms are like?
   * *Explain your answer.*
2. Who is wrong about what atoms are like?
   * *What would you say to help them understand?*

|  |  |
| --- | --- |
| Cards for  **Striking gold** | **Josh:** Alpha particles are smaller than an atom. |
| **Keira:** Most of an atom is empty space. | **Libby:** Most of the mass of an atom is in its nucleus. |
| **Mohammed:** The diameter of a nucleus is a lot smaller than the diameter of an atom. | **Nicole:** Pictures of atoms in textbooks are not drawn to scale. |

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| Cards for  **Striking gold** | **Josh:** Alpha particles are smaller than an atom. |
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*Physics > Big idea PMA: Matter > Topic PMA5: Nuclear physics > Key concept PMA5.1: Atomic nuclei*

|  |
| --- |
| **Response activity** |
| **Striking gold** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | There is a fixed number of positively charged protons in the nucleus of each atom of an element, but the number of neutrons can vary to make isotopes that are either stable or unstable. |
| Observable learning outcome: | Describe the structure and scale of an atom. |
| Activity type: | Talking heads |
| Key words: | Atom, nucleus, electron, proton, neutron, positive charge, negative charge |

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

* Diagnostic question: Building blocks

**What does the research say?**

Research into students’ mental models of atoms (Harrison and Treagust, 1996) produced some unexpected responses during student interviews, most notably that the majority of respondents thought that atoms are visible under a powerful microscope. This has implications on students understanding that atomic structure is a model and not a representation of reality. If students believe that scientists have seen atoms then, the researchers suggest, students may be more likely to consider a model to be a realistic representation of the structure of an atom.

Another, much less frequent but surprising response, was that small, but significant, numbers of students thought that an atom was alive. This appeared to arise due to a confusion that atoms behaved like biological cells (possibly due to the presence of something called a nucleus in both).

In Harrison and Treagust’s study (1996), the large majority of students (age 13-16, n=42) pictured electrons much closer to a nucleus than in a real atom. They found students’ ideas of scale were usually similar to the (necessarily) out of scale illustrations of atoms drawn in text books.

**Ways to use this activity**

This task is intended for discussion in pairs or small groups. It can be done as a pencil and paper exercise or projected onto a screen.

Students should read the statements and follow the instructions on either the worksheet or the PowerPoint. Listening in to the conversations of each group will often give you insights into how your students are thinking. Each member of a group should be able to report back to the class.

Feedback from each group can be used, with careful teacher questioning, to bring out a clear description or explanation of the science.

*Differentiation*

The quality of the discussions can be improved with a careful selection of groups; or by allocating specific roles to students in each group. For example, you may choose to select a student with strong prior knowledge as the scribe, and forbid them from contributing any of their own answers. They may question the others and only write down what they have been told. This strategy encourages contributions from more members of each group.

NB in any class, small group discussions typically improve over time and a persistence with this strategy is often very successful in the medium to long term.

**Expected answers**

All of the statements are right.

1. The findings that most alpha particles can pass through many layers of atoms suggests they are much smaller than the atoms in order to fit.
2. Most of an atom must be empty space, because most of the alpha particles go straight on and pass through without hitting anything.
3. Alpha particles that hit the nucleus can bounce backwards, which shows the nucleus has much more mass than an alpha particle (and isn’t just pushed forward with the alpha particle).
4. If most of the nucleus is empty space, the nucleus must be very small in comparison to the whole atom.
5. If pictures of atoms in text books were drawn to scale, the electrons would not fit on a page. If the nucleus was drawn with a diameter of 0.5 cm, the picture of the atom drawn to scale would be about 50 m across.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

Harrison, A. G. and Treagust, D. F. (1996). Secondary students' mental models of atoms and moelcules: Implications for teaching chemistry. *Science Education,* 80(5)**,** 509-534.