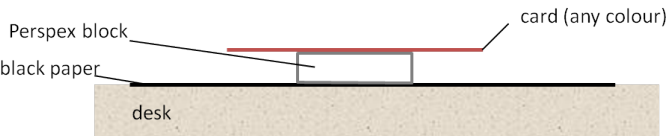




## The Mysterious Atom

<i>What's the mystery?</i>	What is inside an atom, and how can we find out? Our ideas of atomic structure have changed over time as scientists have made observations and hypotheses, tested their ideas and come to conclusions. This process is still happening at CERN as particle physicists continue to unravel our understanding of the mysterious atom.
<i>Domain(s)</i>	Physics
<i>Subdomain keywords</i>	Particle physics, atomic structure, hypothesis
<i>Age group</i>	11-16
<i>Expected time for the mystery</i>	Approx. Time for teacher preparation - 1 hour Approx. Time in classroom - one 50 min lesson
<i>Safety/Supervision</i>	None  Disclaimer: The authors of this teaching material shall not be held responsible for any injury or damage to persons or properties that might occur in their use.
<i>Preparation &amp; List of Materials</i>	<p><b>Before the lesson:</b> For the Engage: A mystery box or tube needs to be prepared. You can make one or several depending on time and budget. The simplest idea is a sealed box with an unknown object inside. A few can be made which can be passed around the class. See the resources section for more information.</p> <p>For the Explore: On a desk place a sheet of black sugar paper - as large as possible. On top place a perspex block (e.g. the type used for optics experiments) and secure to the paper with blu-tack so it does not move. Place more blu-tack on top of the block and stick an A4 sheet of card on top of this so the block is hidden.</p>

	 <p>Set up one set of this equipment for each small group of students (each should have a different shaped perspex block if possible). Each group will also need some marbles/ball bearings of different sizes, a small dish of talcum powder and a piece of chalk.</p>
<i>Learning objectives</i>	Students will : Describe how scientists propose theories about the atom using the processes of observe, hypothesise, test, and conclude.
<i>Authors</i>	Gemma Young and John Walker - Sheffield Hallam University

THE MYSTERIOUS ATOM is an activity developed by the TEMI project ([www.teachingmysteries.eu](http://www.teachingmysteries.eu)) in collaboration with CERN education.



## Guidance notes for teachers

This classroom tested teaching plan uses the four innovations of the TEMI project as detailed in the Teaching the TEMI way book (TTTW). You should read this companion book to help get the most from your teaching.

The TEMI techniques used in this teaching plan uses 1) productive science mysteries (TTTW section 1) 2) The 5E model for engaged learning (TTTW section 2) 3) the use of presentation skills (showmanship) to engage your students (TTTW section 3) and 4) the apprenticeship model for learning through GRR, graduated release of responsibility (TTTW section 4). You might also wish to use the hypothesiser lifeline sheet which is available on TEMI website to let you students document their ideas and discoveries as they work.

### *Engage: Capture student's attention*

Let the students investigate the mystery box/tube (but they must not open them!). In doing this they will start to use the process of observing, hypothesising, testing and concluding as they try and work out what is inside the box or how the tube works.

Then show the class a picture of a the Dalton model of the atom, also called the 'billiard ball' model. Explain that scientists wondered - what is inside an atom? How can we work this out without looking inside one? Remind them that we cannot see atoms with optical devices to discern their presence or individual properties. Draw an analogy between the mystery box/tube and the atom, and hence make a link to making and testing hypotheses.

### *Explore: Collect data from experiments*

Divide the class up into small groups. Each group uses the equipment set up in advance (Perspex block hidden under a piece of card). They place the marbles into talcum powder and then roll them under the card. They should observe the paths the marbles take and develop hypotheses about the nature of the block which can be further tested. They make repeated observations in order to reach conclusions about their block.

### *Explain: What's the science behind the mystery?*

Students present their conclusions and evidence. Reveal each block to allow them to assess their success. Discuss what they concluded about the block, what they could not conclude and why. They may also have ideas for further tests.

Show the class an animation of Rutherford's famous gold foil experiment. A suitable example is described in the Resources section below, although you may have to explain some of the information further depending on the age of your students. Explain that Rutherford was testing the theory that the atom was made up of mainly positive charge with evenly distributed electrons (the 'plum pudding' model). His prediction based on this was that positive charges will go straight through the atoms in the gold foil. However, in his test this did not happen so he modified the model to be consistent with his results.

Discuss with the class how his experiment was similar to the activity that they have just done.

### *Extend: What other related areas can be explored?*

Explain that even though we have discovered a lot about the atom and subatomic particles, we still do not know everything. Introduce CERN as a place where scientists are continuing to unravel the mysteries. Information and a short video can be found at CERN's website. Tell the class that one thing that they hope to find is evidence that particles of dark matter exist.

### *Evaluate: Check the level of student scientific understanding*

Give the class a simple explanation of what dark matter is (see 1:40 - 3:00 of the video in the Resources section below). This can be shown, or a transcript read out. Ask the students to listen and write down where scientists are: observing, hypothesising, testing, concluding.

### *Showmanship: tips on how to teach and present this mystery*

The Engage part of the lesson is the place for showmanship. Present the boxes or tubes as mysterious objects that contain hidden secrets. Your presentation should encourage the students to explore them. Present the atom in the same way so students see it a mysterious puzzle to be solved. You can discuss how scientists are driven because of their curiosity of the world and their need to find out how things work.

### *GRR: Teaching Skills using Gradual Release of Responsibility*

**Demonstrated Enquiry (Level 0):** During the Explain section of the lesson the teacher uses Rutherford's gold foil experiment to show how a scientist carried out an experiment to test a theory and how the unexpected results led to the proposal of a new one. Through discussion, students can see links with this and what they did in both the Engage and Explore activities.

**Structured Enquiry (Level 1):** This takes place during the Evaluate. Students apply their understanding to a new context: the search for dark matter. They listen to an account of how scientists proposed the existence of dark matter and write down where they are observing, hypothesising, testing and concluding.

**Solving the Mystery:** In the Engage and Explore students experience directly how to use the processes of observe, hypothesise, test and conclude. This is informal in the Engage and more structured in the Explore to allow them to develop their awareness of this method. In the Explain, Extend and Evaluate they see how this is used by scientists to explore subatomic particles.

### *Resources*

#### **Science museum mystery boxes**

You can create a version of these for the Engage activity. Instructions can be found by going to [www.sciencemuseum.org.uk](http://www.sciencemuseum.org.uk) and searching for 'mystery boxes'. Download the pdf 'Make you own mystery boxes'.

#### **Mystery tube**

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Various online videos are available which show you how to make these. They range from quick and cheap to more elaborate versions.

**Rutherford's experiment**

Go to [www.learnerstv.com](http://www.learnerstv.com) and search for 'Rutherford's experiment'.

**Information about CERN**

Go to [home.web.cern.ch/about](http://home.web.cern.ch/about) and watch the video 'CERN in 3 minutes'.

**Dark matter video**

Go to [www.ed.ted.com](http://www.ed.ted.com) and search for 'James Gillies'.

**THE STUDENT WORKSHEET CAN BE COPIED AND USED IN THE CLASSROOM**  
Note that in some cases, answers to earlier questions may be found later in the student worksheet.



## The Mysterious Atom

We have always wondered what makes up matter. The ancient Greeks proposed that everything was made up of tiny particles called atoms. Much later we discovered that atoms were made up of smaller, sub-atomic particles such as the proton. But, just how do scientists know this about objects that are too small to be seen? And, do we now know everything there is about atoms?

### Engage What's interesting?

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| <b>Task 1</b> | Investigate the mysterious object.<br>What do you observe? Can you use your observations to come to any conclusions? |
| <b>Task 2</b> | How is the mystery object like an atom?  |

### Explore What's happening?

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| <b>Task 1</b> | Work in a small group. Underneath the piece of card is a hidden object. Your task is to work out what you can about the object <b>without looking under the card</b> . Take a ball and roll it in talcum powder. Roll the ball under the card and observe its path. You should see the path in talcum powder but use the piece of chalk to make it clearer. |
|               | Discuss in your group:  |
| <b>Task 2</b> | <b>Observe:</b> What did you see happen?<br><b>Explain:</b> What is your <b>hypothesis</b> (idea) about the object?<br><b>Test:</b> Plan where to roll the ball this time. If your hypothesis is correct, what do you predict will happen?  |
| <b>Task 3</b> | Roll the ball how you planned.  |
| <b>Task 4</b> | <b>Conclude:</b> What did you find out in your test? Can you conclude that your idea about the object is correct or wrong?  |
| <b>Task 5</b> | If you cannot work out anything about the object from your test you need to repeat this procedure many times until you are confident in your conclusion.  |
| <b>Task 6</b> | Discuss in your group: What can you conclude about the object? What can't you conclude? Can you propose any further tests which will help you? (Apart   |

from looking!)

### *Explain What's causing it?*

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| <b>Task 1</b> | Learn about how a scientist called Rutherford carried out an experiment to test a theory of the structure of the atom.   |
| <b>Task 2</b> | Use what your teacher tells you to answer the following: <ul style="list-style-type: none"><li>• What was the theory he was testing?</li><li>• Describe his <b>test</b>. What did he expect to see happen (his <b>prediction</b>)</li><li>• What did he <b>observe</b>?</li><li>• What was his <b>conclusion</b>? How did he modify the model of the atom based on this?</li></ul> |
| <b>Task 3</b> | How was Rutherford's gold foil experiment similar to the activity you have just done?  |

### *Extend What's similar?*

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| <b>Task</b> | Learn about the work going on at CERN.<br>What are some of the things scientists there are trying to work out? |
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### *Evaluate What's my understanding?*

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| <b>Task</b> | One thing that scientists are hoping to discover is evidence for the existence of dark matter.<br>Find out about how scientists proposed the theory of dark matter.<br><b>Observe:</b> What did scientists see?<br><b>Explain:</b> What was their <b>hypothesis</b> (idea)?<br><b>Test:</b> What experiment did they do?<br><b>Conclude:</b> What did they find out? |
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