# TEACHING ABOUT SCIENCE

# F THE PURPOSES OF SCIENTIFIC RESEARCH

This is a lesson aimed at helping students to develop their understanding of the purposes of scientific research.

## Teachers' notes

downloaded from www.nuffieldfoundation.org/aboutscience

## Resources for students and teachers (separate download)

download from www.nuffieldfoundation.org/aboutscience
contains

OHT F0.1 Aims of the lesson
OHT F4.1 Purposes of scientific research
Cards F1–8 Research projects: summaries

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# TEACHING ABOUT SCIENCE

# F THE PURPOSES OF SCIENTIFIC RESEARCH

# TEACHERS' NOTES

## FOCUS

In this activity, students are presented with a number of descriptions of recent scientific investigations with the aim of showing that:

• scientific investigations are done to address a variety of purposes;

• some investigations are about testing ideas, rather than describing what happens;

• a considerable amount of research is about developing new experimental procedures or applications of scientific research; such work draws upon existing theoretical ideas in science.

It is hoped that the activity will enable students to identify a broader range of purposes for scientific investigations in response to general questions about the purposes of scientific investigation. Students should also be able to illustrate their answers with examples from contemporary scientific research presented through the teaching activity.

## RATIONALE

Scientific investigations can take a variety of forms. The method of investigation most commonly presented to students in school science is the process of fair testing. Questions are identified, and experiments are set up in the laboratory. Key variables are controlled.

However it is not possible to investigate many questions in this way. In astrophysics, for example, it is neither possible nor appropriate to set up an experiment in the laboratory, let alone make it a fair test. The questions investigated by astrophysicists such as Stephen Hawking often derive from complex mathematical models, and investigative methods involve gathering evidence that the predictions generated from models are correct. Chemists working in research and development do not generally improve their approaches to industrial synthesis as a result of fair tests. In many cases, the primary motives for work being carried out are economic or environmental. In fields such as epidemiology, the purpose of investigation is to identify and provide evidence for

links between variables such as the use of a particular combination of drugs to treat a condition, and a potential side effect of those drugs. However, it is neither ethical nor feasible for epidemiologists to set up fair tests to investigate possible links between drug use and side effects.

The purpose of this activity is to broaden A-level students' understanding of the various purposes for investigations in science, and the variety of methods by which professional scientists carry out their investigations. There is evidence that A-level science students tend to think about scientific investigation as a process of careful description, failing to recognise that investigations sometimes involve the testing of ideas. For example, students will often fail to make links between the data that they collect during practical work, and the ideas that form the basis of the practical work. For such students, collecting a 'good' set of data is an end in itself. The need to explain the data in terms of scientific ideas is not recognised.

To address these issues, students are asked to respond to descriptions of recent pieces of research, which have a variety of purposes. In each case they are asked to identify the key purpose of the research. Students then draw upon all of the examples to identify a range of purposes for scientific investigation.

## TEACHING METHODS

The activity involves paired discussion by the students followed by feedback to the group and a summary by the teacher that focuses on the aims of the tasks.

In pilot studies the teaching was most effective when the discussion between teacher and class related clearly to the aims of the task and challenged inappropriate or unhelpful responses from students. This could be done in a way that does not undermine their confidence but supports them in recognising a more effective way of thinking. It is not appropriate in this activity to accept all answers from the students as equally valid.

## AS/A2 LINKS

Teaching about the ways in which scientists work feature in the QCA A/AS-level subject criteria.

'AS and A-level specifications in BIOLOGY should encourage students to:
• develop an understanding of scientific methods.'

'AS and A-level specifications in CHEMISTRY should encourage students to:
• develop an understanding of the link between theory and experiment;
• appreciate the contributions of chemistry to society and the responsible us of scientific knowledge and evidence.'

'AS and A-level specifications in PHYSICS should encourage students to:
• recognise the importance of physics as a human endeavour which interacts with social, philosophical, economic and industrial matters.'

## KEY SKILLS

The activity gives students the opportunity to gain competence in the following key skill areas:

Communication Level 3

C3.1a Contribute to a group discussion about a complex subject.

Portfolio evidence of this could be in the form of a note from an assessor (the teacher) who has observed the discussion and noted how the requirements of the unit have been met, or an audio/video tape of the discussion.

# TEACHING SEQUENCE

## Introduction (brief)

**Resources** OHT F0.1 'Aims of the lesson'

**Points to raise** This lesson will be rather different from previous lessons (no writing and lots of discussion). Students should think and talk!

Students are being given the opportunity to step back and consider 'What is this thing called science?' In particular the lesson will consider 'What are the purposes of scientific research?'. This links to other areas of A-level science courses.

Students will be expected to get involved in paired discussion and feed back their ideas to the whole class (link to key skills).

## Activity F1 (10 minutes)

**Resources** Large pieces of paper and marker pens

| **Aim** |
|---|
| **F1.1** This activity is designed to enable the students to establish their own ideas about the purposes of scientific research. |

| **Instructions / Task** | **Commentary** |
|---|---|
| Students work in pairs to produce a poster/diagram/chart to give as many reasons as they can for why scientists do experiments. | Students should be made aware that the main purpose of the poster is to communicate ideas, rather than to be displayed. It doesn't have to be fantastically presented! |

## Activity F2 (10 minutes)

**Resources** Cards 1–8 'Research projects: summaries'

| **Aim** |
|---|
| **F2.1** At the end of these activities students should recognise that there are different purposes for scientific investigations. |

| **Instructions / Task** | **Commentary** |
|---|---|
| Each pair of students is given 3 or 4 of the cards to read through carefully.<br><br>Students should be prepared to feed back a summary of the research and its purpose to the rest of the group. | Students should not try to understand the research project in detail, but to identify the purpose of the research. |

## Activity F3 (10 minutes)

**Resources** blank OHT or board

**Aim**
**F3.1** At the end of this activity students should recognise that some investigations are about testing ideas, rather than describing what happens.

| Instructions / Task | Commentary |
|---|---|
| Each student or pair of students is asked to describe briefly the purpose of the research on one of the cards. All cards should be referred to.<br><br>The teacher summarises the purposes given by students on an OHT or board, as concisely as possible. The teacher should give a brief review of the conclusions reached by each group, focusing on the teaching aim of this activity.<br><br>It may be preferable to introduce OHT F4.1 at the end of this activity to provide a more concise and complete list if the one generated from student feedback is weak. | In taking feedback here the teacher should:<br><br>• focus on any comments that describe testing of ideas rather than making observations;<br><br>• filter out inappropriate or misunderstood ideas.<br>There are two possible routes to follow:<br>- either present a defined list (OHT F4.1) at this point<br>- or use the student feedback to generate a list and introduce the defined list at the end of activity F4. |

## Activity F4 (10 minutes)

**Resources** OHT F4.1 Purposes of scientific research

**Aims** At the end of this activity students should:

**F4.1** be able to identify a broader range of purposes for scientific investigations, in response to general questions about the purposes of scientific investigation;

**F4.2** be able to illustrate their answers with examples from contemporary scientific research presented through the teaching activity.

| Instructions / Task for students | Commentary |
|---|---|
| Each pair of students should be given the remaining cards and asked to categorise each piece of research according to the purpose of the research. They may use the list generated from the group feedback on activity F1, or the categories shown on OHT F4.1 if something more concise is needed. | Suggested categories are as follows.<br>• Describing what happens – finding out about a phenomenon or event because scientists think it might be interesting and might start significant new areas of research (cards 1 and 4).<br>• Testing ideas – testing predictions made from models or theories (cards 2 and 6).<br>• Developing methods – advancing scientists' abilities to perform scientific techniques more effectively. For example, by improving yields or cost effectiveness or environmental impact (cards 3, 5 and 8).<br>• Focussing on problems (rather than methods and ideas) – using well-established methods and techniques to investigate new questions. The questions might come from scientific, commercial or social concerns (card 7). For example developing ways to deal with new resistant strains of bacteria. |

| Dealing with the discussion | Commentary |
|---|---|
| Finally brief feedback should be taken from students by asking them to give examples of each of the kinds of research outlined on OHT F4.1. | The aim of the list on OHT F4.1 is to provide a more focussed conclusion to the activity than is likely to be provided by the list of purposes generated in activity F3. This list may already have been introduced in F3. |

## Closing the teaching sequence (10 minutes)

**Resources** OHT F0.1 'Aims of the lesson'

The feedback of student responses to activity F3 should lead into a clear summary of the range of purposes of research presented in this activity.

The sequence ends with a recap of what the students have learnt following the aims presented above.

| Points to raise | Commentary |
|---|---|
| Go through OHT F0.1 'Aims of the lesson'. Emphasise the key points. Say how you will be looking for students to draw on the ideas here in later lessons. | Trials of this teaching sequence have shown the following.<br>• It is critical that sufficient time is left for a meaningful summary.<br>• Students need to feel that they have learnt something from this lesson.<br>• Emphasise the links between what they have learnt and the rest of their science course(s).<br><br>It may be appropriate to refer back to the posters generated in activity F1 to highlight the purposes which were new to students in this lesson. |