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.

Resources for students and teachers

downloaded from www.nuffieldfoundation.org/aboutscience

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

Teachers' notes (separate download)

download from www.nuffieldfoundation.org/aboutscience

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Aims

During this lesson you will develop your understanding in the following areas:

- The different purposes of scientific investigations.
- How some investigations are about testing ideas, rather than describing what happens.
- How to identify a broader range of purposes for scientific investigations in response to general questions about the purposes of scientific investigation.

This lesson will provide you with examples from contemporary scientific research which you will be able to use to illustrate your answers.

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1 Describing what happens

Describing a phenomenon or event in more detail because scientists think it might be interesting, and might start significant new areas of research.

2 Testing ideas

Testing predictions generated from models or theories.

3 Developing methods

Advancing scientists' abilities to perform scientific techniques more effectively. For example, by improving yields or cost-effectiveness or environmental impact.

4 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.

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RESEARCH PROJECT CARD 1
PATTERNS OF GROWTH

Physicists have studied the patterns of growth that can be observed in natural phenomena such as ice crystals. It has also been noticed that patterns of growth in some colonies of micro-organisms are similar.

A group of physicists at Tel Aviv University were inspired by similarities in the growth of bacterial colonies and snow crystals. They set out to investigate the point at which the colonies growth showed distinct differences from a crystal due to its living nature. They found that the colony could respond to different surroundings by growing in altered forms.

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RESEARCH PROJECT CARD 2
CERN'S NEW ACCELERATOR

The following quote is from Luciani Maiani, director-general of CERN, the European Laboratory for Particle Physics (January 2000).

'CERN's mission is to create new knowledge on subjects ranging from anti-hydrogen to neutrinos, to the proton's inner structure, to the generation of mass and dark matter.

CERN is currently engaged in a difficult and exciting enterprise, the realisation of a new accelerator, the Large Hadron Collider (LHC), where high-intensity proton beams will collide head-on at unprecedented energies. The extreme conditions will give new research possibilities, to test predicted but as yet unobserved phenomena, and to search for the unknown.'

One research project at CERN has the aim of discovering new elementary particles.

The Standard Model of particle physics unifies aspects of modern particle physics. The model explains how particles get their mass by interaction with an unknown particle suggested by the theoretical physicist Peter Higgs.

If such a particle, called the Higgs boson, were to be discovered by the scientists at CERN, this would provide evidence to strengthen the theory.

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RESEARCH PROJECT CARD 3
CLONES

For some time scientists have been able to produce clones of animal foetal cells that have not specialised to become part of a particular tissue. However, they have been unsuccessful in producing clones from adult cells that have already specialised.

In 1997 researchers at the Roslin Institute in Edinburgh made headlines with the successful rearing of 'Dolly' the sheep. This was unique at the time, as Dolly was a clone of an adult sheep. The set of genes from a donor adult cell was inserted into a recipient unfertilised egg and implanted in a foster mother sheep. This was a new technique developed by scientists at the Roslin Institute. Dolly shares exactly the same DNA as the donor sheep. Since then, American scientists have succeeded in cloning adult cattle.

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RESEARCH PROJECT CARD 4
JUPITER AND ITS MOONS

Images have been sent back to Earth by the Voyager spacecraft of the surface of Europa, one of Jupiter's moons. Unusual features on these pictures have led to theories that water is present beneath the surface of the moon.

In 1989 the Galileo space probe was launched on a mission to collect and relay information about Jupiter and its moons. Despite a number of technical problems, the spacecraft was successful at deploying a probe into the atmosphere of Jupiter and, in 1999, returned the first direct measurements of Jupiter's atmosphere. The Galileo probe has also returned remarkable evidence of cracks in the surface of Europa, which some scientists think provide evidence of a sub-surface ocean on Europa.

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RESEARCH PROJECT CARD 5
GENETIC VACCINES

Vaccines are one of the greatest achievements of modern medicine. They have greatly reduced suffering from a host of diseases. However, successful vaccines have yet to be introduced for many deadly or debilitating disorders, including malaria, AIDS, herpes and hepatitis C. This is because standard immunisation methods work poorly or pose unacceptable risks when targeted against certain illnesses.

A different strategy is needed. One likely approach produces vaccines from genetic material, either DNA or RNA.

Research work into genetic vaccines has now reached the stage of human trials. This follows experiments on animals, where sections of bacterial DNA which code for antigens are inserted into muscle tissue, where they are taken up by the cell and incorporated into the DNA of the cell. This results in cells producing the antigen and initiating an immune response from both antibodies and 'killer cells'. The technique holds the promise of considerable benefits over conventional vaccines.

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RESEARCH PROJECT CARD 6
PROTEIN TRANSPORT ACROSS MEMBRANES

Gunter Blobel was awarded the Nobel Prize for medicine in 1999 for his work on protein transport across membranes. In 1971 Blobel and his colleague proposed a hypothesis to explain how water-loving protein molecules can cross the fatty layers of a membrane.

Blobel and his colleagues had discovered that newly synthesised proteins all had a polypeptide strand that extends out from the body of the protein. This is common to different proteins but with varying sequences of amino acids. They developed a theory that this section allows proteins to snake through the membrane's fatty environment. A research project was designed to test this theory. The results of the research supported their theory. Their findings also indicated that the same peptide section that allows proteins to cross the membrane also directs proteins to their correct places within a cell. This was not something they had predicted.

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RESEARCH PROJECT CARD 7
NEUROTRANSMITTERS

The point at which nerve cells, or neurones, connect is called the synapse. When an electrical impulse of sufficient strength reaches a synapse, a chemical is released called a neurotransmitter. These neurotransmitters interact with protein molecules called receptors on the other side of the synapse. If enough neurotransmitter is released, the neurotransmitter binds to receptor molecules and an electrical impulse is generated at the other side of the synapse. This is how signals are passed between neurones.

Researchers are interested in how the transmission of signals between neurones is controlled. Many drugs work by interacting with neurotransmitters and receptors, thereby affecting transmission between neurones. Researchers at Leeds University are currently working on a project that uses well-established laboratory techniques to find out more about how neurotransmission works in a particular part of the brain. They aim to identify the type of receptors that are present in that area, and manufacture artificial versions of the protein receptors from the gene sequence which is specific to them. The gene sequence they use is taken from recent work that has mapped many of the human genes in detail.

The interaction of these artificially constructed receptor proteins with different substances will then be investigated. This will hopefully lead to information about the ways in which these neurotransmitters and receptors function.

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RESEARCH PROJECT CARD 8
ALTERNATIVE REACTIONS

The vinylalumination reaction is an important reaction in the manufacture of many different commercial products. However the process involves the use of a harmful reagent called HMPA. This makes the reaction costly to perform.

Ramachandran and his colleagues worked to improve this process by finding an alternative reaction that did not involve toxic reagents.

Previous efforts to replace HMPA have increased costs and have been commercially unviable. Now Ramachandran has come up with a new method that uses a compound known as NMO in the place of HMPA.

NMO is relatively cheap and has none of the medical or environmental risks associated with HMPA. NMO also has the added benefit of producing higher yields.