BRITISH COUNCIL

TEACHER GUIDANCE SHEET

Thinking like a scientist

Charles Darwin came up with a new idea – a hypothesis – to explain the origin of species. It is now a theory with a well-established body of evidence behind it.

The Thinker by Auguste Rodin

Charles Darwin was one of the greatest scientists who ever lived. Although we may all now think we know what a scientist is, the professional scientist is a relatively recent invention. Darwin's work illustrates some of the key aspects of what a scientist does – particularly the role of *hypothesis* and *theory*.

Science may be thought of as the search for explanations for natural phenomena. It is based on a set of approaches known as the 'scientific method'. Of central importance to the scientific method is the hypothesis – an explanation put forward to explain a natural phenomenon, a set of observations or the results of an experiment.

A hypothesis is a guess, but one rooted in reality. If evidence appears that contradicts a hypothesis, it is revised or abandoned and replaced by another. So a hypothesis is generally considered *provisional* – the current 'best guess'. Its main function is to make predictions which can be tested.

If a hypothesis does not make any testable predictions, it cannot be shown to be wrong (is not *falsifiable*). This type of hypothesis is considered to be inconsistent with the scientific method.

If a hypothesis gathers a lot of supporting evidence, it may become elevated to the level of theory. Although in everyday use these terms are used interchangeably, in science they have distinct meaning. A theory should be supported by a wider range of evidence, and be broader in the significance of its predictions.

- A Darwinian hypothesis: that Darwin's finches on the Galapagos Islands originated from a single species and diverged to fill different ecological niches (adaptive radiation).
- A Darwinian theory: new species are formed from existing species through the action of natural selection.

This specific use of the term 'theory' can cause confusion, as it may imply that Darwin's theory is 'unproven'. In fact, the theory of evolution is well supported by many lines of evidence and is a highly successful scientific theory.

In this activity, students develop a hypothesis to explain a set of findings from a team of space explorers. As they receive more information, they are encouraged to revise their hypothesis. They also estimate how confident they are in their conclusions – a useful reminder that cutting-edge science is a dynamic process in which there is considerable uncertainty.

Darwin NOW

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Activity

1 Divide your class up into groups of four or five students. Each group is to take on the role of scientific advisers, interpreting information sent by explorers from the distant planetoid Huxley. They have to come up with hypotheses to explain the phenomena observed on the planet.

2 Give each of the groups the first two despatches from planetoid Huxley. Ask them to make a hypothesis that would explain the observed phenomena. Each group should decide, on a scale of 1–100, how confident it is in its hypothesis.

3 When they have completed the first part of their sheet, give the groups the second two despatches.

4 Repeat for the next two pairs of despatches. At the end, the groups should produce a final hypothesis and suggest two experiments or observations that could be undertaken to test the hypothesis. ‘Experiments’ would be specific interventions carried out on the living things on the planetoid. ‘Observations’ would be non-interventional – such as collecting data from part of the planetoid.

Guidance

You may need to emphasise to your students that there are no ‘right’ and ‘wrong’ answers, particularly at early stages when they will not know much about the planetoid Huxley. By thinking creatively, they should be able to come up with many possible explanations. They could whittle these down by considering which are the most plausible, make fewest assumptions or involve fewest unusual sets of circumstances.

As they gain more data, students may want to refine their hypothesis, adding to it or altering it slightly. They may need to abandon it entirely if contradictory information emerges.

You may want to ask each group of students to share their final hypotheses with the class. The class could also discuss which experiments would be most useful tests. Students may have a tendency to suggest experiments that confirm their hypothesis. In fact, a good experiment sets out to test an idea rigorously – tries to make it fail. To test the strength of a steel bar, it is more revealing to test it with heavy weights than light ones. The same is true of scientific hypotheses. A scientific theory can never be proven, just backed up by varying amounts of evidence. No matter how much evidence may support it, a single piece of inconsistent data can reveal its flaws.

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Further Work

1 Encourage your students to find out about Occam's razor. Although not a scientific law, it is a useful tool in logical thinking. In everyday language, it means not resorting to complicated solutions when simple ones are adequate.

2 You could use this activity to discuss other scientific concepts with your students, such as:

- **Hypotheses** [suggested explanations for observed phenomena]
- **Theories** [well-substantiated explanations generally covering a range of phenomena]
- **Laws** [precise descriptions, often mathematically defined, of natural phenomena]
- **Facts** [verified truths or concepts].
- **Proofs** [strictly speaking, a formal set of mathematical steps demonstrating something to be true; sometimes used in science when there is overwhelming evidence in support of a hypothesis or theory, though technically scientific theories cannot be proved (as Albert Einstein put it, "No amount of experimentation can ever prove me right; a single experiment can prove me wrong.")]

3 Darwin's work on evolution provides a framework for thinking about the development of hypotheses and theories and how they change over time. In 1837, Darwin sketched his first 'tree of life', headed 'I think:'. This could be thought of as his initial hypothesis. He went on to collect a great deal of evidence in support of this hypothesis and developed his thinking to propose a general mechanism to explain how the tree of life came about. This was Darwin's theory of evolution by natural selection.

Darwin's theory also made predictions. Perhaps the most famous is that of the Malagasy orchid *Angraecum sesquipedale*, which had nectar stores at the end of a 30cm tube. He predicted that a moth must exist with an equally long tongue – and in 1903 such a moth was discovered.

4 Darwin did not get everything right. The mechanisms of heredity were a complete mystery in his day. He suggested a hypothesis based on 'gemmules' which were found in body cells and migrated into reproductive cells, thus ensuring that offspring received information from every part of the body. It was a plausible explanation at the time, but experiments showed it to be completely wrong.

Dispatches 1-2

All flopadopalots seen at the North Pole are green.

All flopadopalots seen at the South Pole are red.

Dispatches 3-4

It is cold at the North Pole.

It is hot at the South Pole.

Dispatches 5-6

A vicious carnivore, the Ravenous Wee Beastie, lives only at the North Pole.

The atmosphere at the North Pole is rich in chlorinated compounds.

Dispatches 7-8

The planet is covered in a tasty red seaweed, which turns animals red when they eat it.

A wide river separates the land masses of the north and the south.