TEACHING ABOUT SCIENCE

C THEORETICAL MODELS: CONTINENTAL DRIFT

This is a lesson aimed at helping students to develop their understanding of the role of theoretical models in science.

Teachers' notes

Resources for students and teachers (separate download)

download from www.nuffieldfoundation.org/aboutscience

OHT C0.1 Aims of the lesson
Teachers' sheet C1.1 Continental drift theory: historical background (2 sheets)
OHT C1.2 Explanations for the similarity of fossil distribution
OHT C1.3a/b A brief history of continental drift theories
Students' sheet C2.1a Polar wandering paths
OHT C2.2a Polar wandering paths (2 sheets)
Students' sheet C2.1b Mid-ocean ridges
OHT C2.2b Major ocean ridges
Students' sheet C2.1c Mid-ocean faults
OHT C2.2c Mid-ocean faults (2 sheets)
Students' sheet C2.2d Plate tectonic model
OHT C2.2d Plate tectonic model
Students' sheet C2.1e Paleomagnetic data
OHT C2.2e Paleomagnetic data (2 sheets)
Students' sheet C2.2f Eltanin Survey Ship: Magnetic data
OHT C2.2f Eltanin profile
Students' sheet C3.1 Summary sheet

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TEACHING ABOUT SCIENCE

C THEORETICAL MODELS: CONTINENTAL DRIFT

TEACHERS' NOTES

FOCUS

The history behind the eventual acceptance of continental drift by the scientific community provides a vivid example of the way theories in science have developed.

The aim of this teaching task is to illustrate for students the complex relationship between evidence and ideas, and to counteract the common assumption that theories simply emerge from data.

In the case described here an idea that had been around for some years, without attracting strong support from scientists, was picked up again in the 1950s to explain newly emerging oceanographic data.

The activity gives students the opportunity to interpret evidence in relation to a scientific theory in context.

RATIONALE

This teaching sequence aims to develop students' ideas about the role of theoretical models in science. Students tend to see theoretical knowledge as arising unproblematically from gathered evidence – if scientists work carefully and logically, then the answer will be revealed. However, this view does not reflect the complicated social contexts within which scientists operate: evidence from observations or experiments rarely leads to an unambiguous interpretation. As a result, competing groups of scientists often present opposing interpretations of the same data set, with each group using different theoretical models to interpret the data. Furthermore, the process of proposing interpretations of data involves creativity and imagination, as well as careful logical work.

A revolution in thinking occurred in geology in the 1960s; this provides a rich context within which to teach students about the complex factors that lead to the uptake of new ideas within the scientific community.

This lesson will present a more detailed account of the relationship between competing theoretical models and evidence than the somewhat naïve view held by many students. Plate tectonics eventually gained acceptance as a result of its ability to provide explanations for a number of new geophysical observations:

this teaching sequence aims to encourage students to recognise that scientists may interpret new evidence in the light of competing models with the result that one of the models gains acceptance. The teaching sequence also aims to show that there can be a rapid acceptance of a controversial model when the body of evidence supporting it becomes overwhelming.

This lesson describes events that took place at the end of the 1960s. All the evidence presented was published during the late 1950s and 1960s. Up to this time, there was considerable debate about the model of drifting continents that had been proposed to explain apparent similarities in shape, geology and fossil patterns between distant continents such as South America and Africa. In particular, American geophysicists were often opposed to the model of drifting continents. By the end of the decade, however, the majority of scientists accepted the idea of continental drift. Ironically, the most compelling single piece of evidence, that of the Eltanin profile, was collected by an institute with a strong tradition of opposition to continental drift. This activity attempts to explore how changes in the model, and the evidence available, led to this change in opinion.

AS/A2 LINKS

Plate tectonics is not within the subject content of Biology, Chemistry or Physics. However, as shown below, the teaching aims of the lesson do fall within the QCA Subject Criteria. Pilot studies have shown that this activity can be effective and is highly motivating for students. Another advantage of the context is that it could be undertaken at any point during an AS or A2 course. In the pilot study the activity was run successfully during a tutorial lesson with students from Biology, Physics, Chemistry and Geography A-level courses. It could form a part of an induction period or special event.

Teaching about the way that scientific theories develop features in the QCA 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/physics should encourage students to develop an understanding of the link between theory and experiment.

• AS and A-level specifications in physics should show 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.

C3.2 Read and synthesise information from two extended documents about a complex subject.

Portfolio evidence of this could be in the form of a record of what was read including notes, highlighted text or answers to questions about the material.

TEACHING SEQUENCE

Introduction (brief)

Resources OHT C0.1 'Aims of the lesson'.

Points to raise This lesson will be rather different from many science lessons (not much 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 is the purpose of theoretical models in science and how are they developed?'.

Students will be expected to present evidence and opinions clearly to the whole class (link to key skills).

In this opening presentation the teacher introduces the main aims of the lesson, emphasises the unusual nature of the lesson (history of science, no writing and lots of discussion), and highlights how learning about theoretical models links to other areas of A-level courses.

Activity C1 (10 minutes)

The story should be presented in a way that highlights the key issue: the idea that continents have drifted was developed at the start of the twentieth century, yet until the 1960s there was no consensus of opinion. Scientists were divided between the idea of fixed continents and continental drift. Indeed, until the 1970s scientists were divided on the issue, with many key experts holding the view that continents do not drift. So what changed? Why did the debate shift in the favour of continental drift?

Aims At the end of this activity students should:
1.1 have a basic knowledge of how the idea of continental drift came to be accepted by scientists;
1.2 understand that evidence can legitimately be interpreted in more than one way.

Teacher presentation of C1 (10 minutes)

Resources: Teacher's sheet C1.1 Continental drift theory: historical background (2 sheets), OHT C1.2 Explanations for the similarity of fossil distribution
OHT C1.3 A brief history of continental drift theories (2 sheets)

Instruction to the teacher	Commentary
Present the historical background to the activity in the form of a story. The key points are: **1** Pre-1900. Several people have noted the similarities in shape, geology and fossil record between South America and Africa. Some geologists suggested the possibility of large scale continental movement but most hold the view that major tectonic movement is due to the contraction of the Earth. The similarities observed were put down to a land bridge severed by erosion or sinking of the ocean basin. **2** 1910: Frank Taylor published a theory of continental drift but itwas largely ignored. He suggested that, in the past, the Earth had been spherical with massive continents at the poles. His implausible theory was that these continents had been dragged apart by gravity when at some point in geological history the Earth captured its moon. **3** 1912: Alfred Wegener contributed to the debate by publishing a more coherent argument for drift based on the evidence of: • match between coastlines of South America and Africa; • identical fossils found on both continents; • matching areas of rock strata on both continents. **4** 1912–40: widespread criticism of Wegener's theory centred on: • the lack of a plausible mechanism to explain how continents move; • the lack of marks on the ocean floor which would be expected if the continents had forced their way through the ocean sediments; • possible alternative explanations for the fossil and stratigraphical evidence such as sunken land bridges (OHT C1.2). **5** 1944: Arthur Holmes suggested a mechanism for drift based on convection currents in the Earth's mantle, which could cause the movement of continents. **6** 1950–60. A post-war boom in oceanography, particularly in America where there was a lot of opposition to the idea of drift, generated a lot of new evidence about the ocean floors. New techniques in paleomagnetism were developed.	The key points to stress in describing the background are that for a long time many scientists were sceptical of the theory of continental drift because: • there was no mechanism suggested to explain how continents might move; • the evidence for drift was either disputed (as in matching continental outlines) or could be explained by alternative theories (as in the matching of fossils across continents which many thought was the result of land bridges – see OHT C1.2). Until the 1960s there remained considerable resistance to the idea that continents are moving. A more detailed background is provided on teacher's resource sheet C1.1. It is suggested that teachers become familiar with this information before the lesson.

Link with the next activity

Set the scene for the mini conference.
• What changed people's minds about continental drift?
• How did the scientific community come to accept the idea of continental drift?

Activity C2 (40 minutes)

Students are provided with a description of a piece of evidence that appeared during the 1950s in the post-war boom in oceanographic study. The notes explain how the observations made can be interpreted using the continental drift theory. Students are asked to prepare to present this evidence and their opinion of it at a mock conference. They are provided with an OHP transparency to provide a focus to their presentation.

In chairing the 'conference', the teacher should make the aims of the activity clear by summarising the points made by the students and steering questions from other students to highlight key points.

Aims At the end of this part of the lesson students should:

2.1 understand how new evidence can be interpreted in the light of competing theories and can lead to the acceptance of one of the theories by the scientific community;

2.2 recognise that there can be a rapid acceptance of an existing theory when the body of evidence supporting it becomes overwhelming.

Resources:

Students' sheet C2.1A Polar wandering paths
OHT C2.2A Polar wandering paths (2 sheets)

Students' sheet C2.1B Mid-ocean ridges
OHT C2.2B Major ocean ridges

Students' sheet C2.1C Mid-ocean faults
OHT C2.2C Mid-ocean faults (2 sheets)

Students' sheet C2.2D Plate tectonic model
OHT C2.2D Plate tectonic model

Students' sheet C2.1E Paleomagnetic data
OHT C2.2E Paleomagnetic data (2 sheets)

Students' sheet C2.2F Eltanin survey ship: Magnetic data
OHT C2.2F Eltanin profile

Student activity C2 (20 minutes)

Instructions to students	Commentary
In pairs or groups, prepare a brief presentation of the evidence. Key points are highlighted in bold type on your sheet. An overhead transparency is provided to support the presentation.	There are six pieces of evidence to present – for each one there is a student information sheet and an OHT. The evidence varies in its complexity so should be allocated to students according to ability and confidence. • Relatively straightforward: B Mid-ocean ridges / D Plate tectonic model. • Moderately complex: C Mid-ocean faults • More difficult: A Polar wandering paths E Paleomagnetic data / F Eltanin profile.

Mock conference (20 minutes)

Instruction	Commentary
Each group of students presents: • the evidence they have been given. • their opinion of the evidence.	If students lack confidence at speaking in front of an audience, the briefing sheets could be used as speaker's notes or even scripts in conjunction with the OHTs. It is suggested that the evidence be presented in chronological order: A Polar wandering paths B Mid-ocean ridges C Mid-ocean faults D Plate tectonic model E Paleomagnetic data F Eltanin ship survey It is important that the teacher supports this part of the sequence by: • summarising the key points of the presentation; • taking questions from other students or leading questions in a way that highlights the key points of the activity.

Activity C3 (5 minutes)

Aim **3.1** to highlight some of the issues raised during the lesson.

Resources Student sheet C3.1 Summary sheet

Instruction to the teacher	Commentary
Students are given a series of statements that express opinions about the development of continental drift theory as presented in activities C1 and C2. Read through each statement and ask students to respond in agreement or disagreement.	This activity should form a brief summary of the key points of the development of continental drift theory as presented.

Closing the teaching sequence (5 minutes)

Resources OHT C0.1 'Aims of the lesson'

The sequence ends with a review of what the students have learnt, following the aims presented above. It should be stressed that these ideas about theoretical models will be revisited in future lessons in A-level courses.

Points to raise	Commentary
Go through OHT C0.1 'Aims of the lesson'. Emphasise the key points. Students could be encouraged to use the ideas covered in this lesson when they come across articles about the work of professional scientists in their background reading or on television. They could ask themselves the question: 'What is the purpose of this particular piece of research?'	Trials of this teaching sequence have shown that: • it is critical that sufficient time is left for a meaningful summary; • students need to feel that they have learnt something from this lesson; • emphasise the links between what students have learnt and the rest of their science course(s).