Depth Study - Module One

Year 11 Earth and Environmental Science

Content Outcomes of Module One

Inquiry question:

What is the current evidence for the theory of plate tectonics and how did the theory develop?

Students:

Analyse evidence, including data and models, that supports the theory of plate tectonics, including but not limited to:

- the 'jigsaw fit' of the continental shelves (ACSES004, ACSES006)
- matching up identical fossils on different continents (ACSES004, ACSES006)
- the profile of the ocean floor
- the age of sea floor rocks (ACSES004)
- magnetic reversals in sea floor rocks (ACSES035)

Contents

1. Scientific Models

Using models to develop an improved knowledge and understanding of Earth and Environmental Science outcomes.

Activity overview:
Activity 1.1 – What is a model
Activity 1.2 – What models do you know?
Activity 1.3 – Model of the Earth / Universe
Activity 1.4 – Text versus Models

Activity 1.1: What is a Model?

A general definition of a scientific model is that it is a _____and/or _____ and/or _____ representation of an:

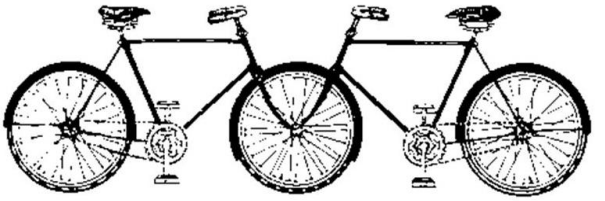
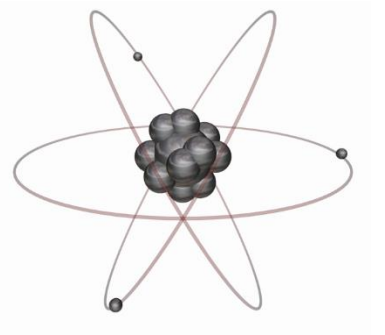
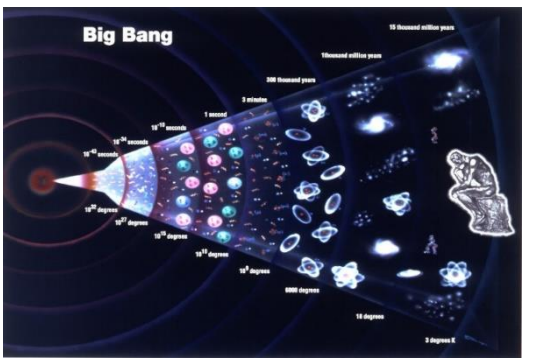
- _____
- _____
- _____
- _____

that is used to _____ and _____phenomena. Models are central to what scientists do, both in their research as well as when communicating their explanations. (Science Hub, 2011)

Simple models can be thought of as copies of _____(e.g. 'model cars', 'model airplanes', 'model railways'). Students often think of models as useful because they are _____ (or even scale reproductions) of actual objects or actions. It is important however to look beyond the _____ _____ between the model and the object or idea being represented. A more developed view is that 'models' can be more than just physical representations of objects.

Models can also be used to _____ _____ and processes in ways that may be impossible to do in the real world. This notion might be reinforced by the everyday use of such terms as '_____ _____ and computer game simulations. Additionally, testing 'models' can lead to their redesign to give improved predictions.

It is helpful to categorise scientific models as:

Mental models -	 Our mental models of how bicycles work can "simulate" this to know it won't work Slide adapted from Saul Greenberg *Image source:* http://bit.ly/2AJjZxK
Expressed models –	 Atom 3D Model by ProLithic 3D (2012) https://www.flickr.com/photos/prolithic/6616679503/ Attribution, Non Commercial (http://creativecommons.org/licenses/by-nc/2.0/) Photo Attribution by PhotosForClass.com
Consensus models -	 *Image source: grandunificationtheory.com* - https://www.universetoday.com/54756/what-is-the-big-bang-theory/

The most useful scientific models will possess:

- Explanatory power

  _____

  _____

  _____

  _____

- Predictive power

  _____

  _____

  _____

  _____

- Consistency across contexts

  _____

  _____

  _____

  _____

- Consistency with other scientific models

  _____

  _____

  _____

  _____

Research: Gilbert & Boulter (1998)

Activity 1.2: What models do you know?

1. Consider your years of scientific learning. What models have you encountered? (The list can include scientific models you are aware of outside of the classroom).

2. What model do you believe is the best (to improve your learning of the concept) and why is it the best model?

3. View the URL provided below and watch the segment Models in Marine Science. Professor John Montgomery discusses how and why scientists use models, with climate change as an example.

   URL: https://www.sciencelearn.org.nz/resources/575-scientific-modelling

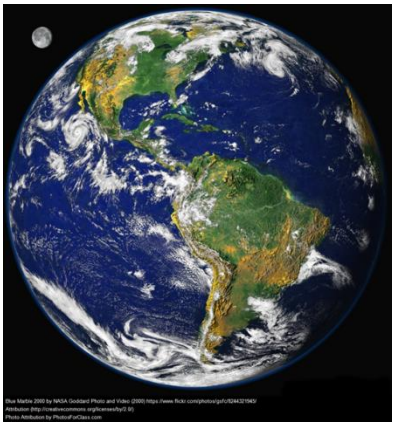
   Source: *Science Learning Hub. Scientific modelling.*

4. Take notes from the website above using the following headings:

A. Why scientists use models
B. Building a model
C. Using models for predicting
D. How do we know if a model works?
E. Nature of science.

Activity 1.3: Model of the Earth / Universe

The model of the Earth and / or universe has changed significantly over time.



1. Research and represent the changing model over time. You may choose to represent/model the changes any way you can within the allocated time period (e.g. with pictures, play dough, a comic strip etc).

2. After you have modelled these developments, in your groups/class consider the following questions and record your ideas/ discussion.

A. What changes the model has specifically undergone?
B. Over what period of time have the changes occurred?
C. Why have the changes/developments in the model have occurred?
D. What new information or technology may have led to your rethinking of the design of the original model?

Activity 1.4: Text versus Models.

Complete the following information about your Depth Study in consultation with your teacher and class.

Depth Study Title:

Using models to develop an improved knowledge and understanding of Earth and Environmental Science outcomes.

Depth Study Question and Hypothesis:

Question:
Do we, (the students) gain a better knowledge and understanding of concepts by using models?

Hypothesis): *(students and teachers design hypothesis for study together)*

Your teacher will allocate you materials or relevant textbook sections of theory to present the content below.

NSW Syllabus for the Australian Curriculum

Evidence for the Theory of Plate Tectonics
Inquiry question: What is the current evidence for the theory of plate tectonics and how did the theory develop?

Students:
Analyse evidence, including data models, that supports the theory of plate tectonics, including but not limited to:

- The 'jigsaw fit' of the continental shelves (ACSES004, ACSES006)
- Matching up identical fossils on different continents (ACSES004, ACSES006)
- The profile of the ocean floor
- The age of sea floor rocks (ACSES004)
- Magnetic reversals in seas floor rocks (ACSES035)

1. You should spend 20-30 minutes generating your own notes under the heading 'Evidence for the Theory of Plate Tectonics', and using subheadings;
    a) Continental shelves 'jigsaw fit'
    b) Matching of fossils
    c) Age of the seafloor
    d) Magnetic reversals in sea floor rocks
    e) Ocean floor profile

N.B: the rationale of this activity is that you will be asked to assess, analyse and formulate an opinion on learning material by predominately text-based information versus that of model based learning / teaching of the same content.

2. Evidence for the Theory of Plate Tectonics

Activity overview:

- Activity 2.1 – Introduction to the 'jigsaw fit' of the continental shelves (ACSES004, ACSES006)
- Activity 2.2 – Make a model to demonstrate jigsaw fit (ACSES004) and matching up identical fossils on different continents (ACSES006)
- Activity 2.3 – Introduction to the age of sea floor rocks (ACSES004) and magnetic reversals in sea floor rocks (ACSES035)
- Activity 2.4 – Make a model of the mid ocean ridge (ACSES004, ACSES035)
- Activity 2.5 – Make a model of a profile of the ocean floor.

Activity 2.1: Introduction to the Jigsaw Fit of the Continental Shelves

Introduction - Access the following website and complete the cloze passage:

URL: https://www.sciencelearn.org.nz/resources/952-continental-drift

Source: Science Learning Hub – Article Continental Drift

The Earth's _____ have not always been where they are at _____. If you look at a map of the world, you might notice what _____ _____ noticed – that the continents look as if they could _____ together like a big _____ puzzle if you were able to _____ them _____. Wegener published his _____ in _____. He tried to explain how the Earth _____ apart, but he was unable to give a _____ _____. Many years later, though, this theory began to gain popularity, and now we understand more how it is possible that _____ _____ can _____.

1. Watch the video clip 'Tectonic plates animation', and in the space below write 3 points from the video.

1.
2.
3.

Continental drift is the concept that the Earth's continents _____ relative to each other, with the Earth's _____ being _____ into _____.

Activity 2.2: Evidence for Continental Drift and Matching Fossils – making a model

Outcomes:

1. To make a model to demonstrate the jigsaw fit of the continents that made up Gondwana.
2. Map the distribution of fossils on Gondwana.

Equipment:

- ☐ Student puzzle pieces on cardboard
- ☐ Map of the world today (supplied by your teacher)
- ☐ Coloured pencils
- ☐ Scissors
- ☐ Glue

Method:

1. In groups of 2-3 cut out the continents as close to the margins of the continents as possible.
2. Label the continents using the current map of the world if needed.
3. Join the continents so they match up like a jigsaw puzzle.
4. Using the Internet, Google search keywords such as "Gondwana fossils" to find a map of Gondwana that shows the fossils that have been found on the continents (aim to find information on 4 fossils)
5. Compare the jigsaw map your group has constructed against the one you find. Check the continents are arranged correctly and if they are glue them on to cardboard, (if not rearrange them to form Gondwana)
6. Using the coloured pencils (one for each type of fossils), colour in areas on Gondwana to show the location of fossils found on the continents. Include a key to the side of your map
7. Annotate the map to name the fossils with a brief description of what they are and how they could not have dispersed with the continents in their present-day location.

Activity 2.3: Introduction to Seafloor Rocks

i. Magnetic Reversals, and
ii. Determining age.

Introduction

Watch the following video clip and answer the questions below -

URL: https://www.youtube.com/watch?time_continue=86&v=BCzCmldiaWQ
Source: *YouTube : Magnetic reversals and Sea Floor Spreading*

Answer the following questions:

1. Draw the Earth and its invisible magnetic fields

2. Every few million years the earth's magnetic fields: _____

3. Explain what happens to the magnetic minerals in the lava when it cools to form rock.

4. Outline the differences in magnetic field of the lava layers over time.

5. What are magnetic polarity reversals?

6. Draw a labelled diagram of the seafloor spreading and magnetic reversals from the video (find at 2.48 minutes).

7. On the diagram above, label the youngest and oldest rock.
8. From the video, and your reading knowledge, write a summary of patterns in the age of rocks and magnetic reversals on the seafloor.

Activity 2.4: Making a model of the seafloor

In this activity you will make a model of the mid ocean ridge. The model will show patterns in the age of rocks and magnetic reversals where the seafloor is spreading.

Equipment

- ☐ Cardboard template of oceanic lithosphere
- ☐ Model of the mid ocean ridge (MOR)
- ☐ Scissors
- ☐ Sticky Tape
- ☐ Glue

Method

1. Print template A (model of oceanic lithosphere) onto cardboard.
2. Students are to cut out the black lines so that they are completely gone from the cardboard.
3. Template B is to be cut out as per the student method.
4. The three sections of lava flow are to be inserted into the slots on template A.
5. The two pieces of continent are then pulled apart horizontally to show the patterns in the age of rocks and the patterns in the magnetic reversals as seafloor spreading occurs.
6. Once the model is constructed, the students then answer questions that relate to the model.

Answer the following questions:

1. Name a tectonic boundary where this process is occurring

_____

2. Describe the process that occurs at a spreading centre

_____

_____

_____

3. Outline the pattern observed in the age of the rocks as the continents are moved apart

4. What do you notice about the patterns of magnetic reversal in the rocks as the continents are moved apart?

5. Explain how magnetic reversals are preserved in the rock on the ocean floor.

Activity 2.5: Model of a profile of the ocean floor

Introduction

In the space below recall 5 points on mapping of the ocean floor from the readings given to you by your teacher and your own knowledge on features found on the ocean floor.

1.
2.
3.
4.
5.

There are two parts to this activity:

- Part 1 - Build a model of the ocean floor
- Part 2 - Swap models between groups and graph the ocean floor profile

Part 1: Model of the Ocean Floor

Complete the steps below to make a model of the ocean floor

Equipment

For each group collate:

	Shoebox		Tape		Scissors		Bamboo skewer
	Craft items e.g. cotton wool, cotton balls/wool		PVA glue		Graph paper		Ruler

Method:

1. In the space below sketch a plan of the side of the ocean floor you will be modelling. Brainstorm some features with your group that could be included in the model before starting.

2. Using the craft materials supplied make a model of the planned ocean floor inside the shoe box.
3. When the model is complete place the lid of the shoebox on the base and tape them together.
4. Using the bamboo skewer and a ruler, punch 20 evenly spaced holes in the top of the shoebox in a line down the centre of the box, they should cover the whole box. They should be large enough for the skewer to be placed into the hole and pushed down to the bottom of the model sea floor.

Part 2: Swap models between groups and graph the ocean floor profile

1. Swap your shoe box with another group.
2. Turn a bamboo skewer into a ruler by placing a dot on the skewer from the tip to the end every centimetre.
3. Place the wooden skewer into the first hole at the left of the shoebox. Count the number of dots on the skewer that are below the top of the shoebox. Record these in centimetres in the table below.
4. Continue this for all holes on the top of the shoebox.
5. Once complete, on the graph paper create a graph with location on the x axis (these will be the number 1-20 for the holes in the top of the shoebox) and Depth (cm) on the y axis. NB these will be numbered 1 at the top of the y axis down to an appropriate number (depending on the depth of the ocean floor models) at the bottom of the y axis (where 0 would normally be placed).
6. Plot the depth on the graph paper.
7. Once this is complete, compare the graph to the ocean floor inside the box.
8. Label the features of the ocean floor present inside the box and on the graph paper.

Results

Location	Depth (cm)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

Answer the following questions

1. Describe some of the benefits of using this model
2. Outline any limitations to the model
3. If you were to make this model again, identify some changes you might make

3. Assessment of understanding theory via text or models

Consider the Plate Tectonics models you have been taught and reflect on whether using models assisted or improved your knowledge and understanding of the topics covered compared to reading text by completing Tables 1 and 2.

Table 1

MODEL	STRENGTHS of the Model	WEAKNESSES of the Model
Continental shelves 'jigsaw fit' Lesson		
Matching of Fossils Lesson		
Age of the Seafloor Lesson		
Magnetic Reversals Lesson		
Ocean Floor Profile Lesson		

Table 2:

Question	Yes	Unsure	No
I enjoyed learning the content with the use of models more than text based work. Explain below why have you responded this way:			
I feel like I have a greater understanding of the content when models were used. Explain below why have you responded this way:			
The models were confusing and distracted me from the content. Explain below why have you responded this way:			
The models based on Plate tectonics were effective in showing me what the text was explaining. Explain below why have you responded this way:			
Consider your preferred learning style - text only or model +text. Did you think there was more content that you understood more clearly via this teaching method? Explain below why have you responded this way:			

4. The Use of Models in the Forestry Industry

Complete the following cloze passage:

Forest growth models attempt to _____ the growth of a forest and are commonly used for two main reasons.

1. _____
   _____
   _____
   _____
2. _____
   _____
   _____

Commercial forestry depends on reliable estimators of _____ _____ (Basal Area - BA) and has motivated much work on developing statistically based growth models.

Forest growth and yield models are used in other applications e.g. investigation of impacts of _____ _____.

Practical examples of the models:

1. Using approximately 20-30 mins to read each of the sources, highlight the USE of the model/s and WHY the model/s information is needed by the user (if this information is addressed). *N.B:* only focus on what information the model is supposed to do/collect and why is might be needed.

Source 1	Source: Food and Agriculture Organization of the United Nations. Model and demonstration Forests. URL: http://www.fao.org/forestry/modelforests/en/
Source 2	Source: Washington State University, April 26, 2016 Model predicts how forests will respond to climate change URL: https://www.sciencedaily.com/releases/2016/04/160426162555.htm
Source 3	Source: CSIRO, Forests in the landscape URL: https://www.csiro.au/en/Research/LWF/Areas/Landscape-management/Forests
Source 4: Abstract Only	Source: A Novel Modelling Approach for Predicting Forest Growth and Yield under Climate Change M. Irfan Ashraf ,Fan-Rui Meng,Charles P.-A. Bourque,David A. MacLean . PLoS ONE 10(7): e0132066.Published: July 14, 2015 URL: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0132066

2. Spend 10 minutes with your class discussing this information with a focus on the need for models in the future within industries like forestry.

Notes: Importance of models in the Forestry Industry

References

1. NSW Education Standards Authority www.syllabus.nesa.nsw.edu.au/earth-and-environmental-science-stage6/depth-studies/ Accessed 1/9/2017
2. Science Learning Hub: www.sciencelearn.org.nz/resources/575-scientific-modelling Accessed 1/9/2017
3. Credit: grandunificationtheory.com www.universetoday.com/54756/what-is-the-big-bang-theory/ Accessed 16/8/2017
4. Information of modelling based on work from Department of Education and Training Victorian Government www.education.vic.gov.au/school/teachers/teachingresources/discipline/science/continuum/Pages/scimodels.aspx Accessed 1/8/2017
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7. The Dynamic Planet Teaching Companion Packet www.volcanoes.usgs.gov/vsc/file_mngr/file-139/This_Dynamic_Planet-Teaching_Companion_Packet.pdf Accessed 16/8/2017
8. Earth Learning Idea – the continental jigsaw puzzle www.earthlearningidea.com/PDF/85_Continental_jigsaw_puzzle.pdf Accessed 25/9/2017
9. YouTube : Magnetic reversals and Sea Floor Spreading Accessed 21/8/2017 www.youtube.com/watch?time_continue=86&v=BCzCmldiaWQ Accessed 25/9/2017
10. Food and Agriculture Organization of the United Nations. Model and demonstration Forests.: www.fao.org/forestry/modelforests/en/ Accessed 16/8/2017
11. Washington State University, April 26, 2016_Model predicts how forests will respond to climate change - Accessed 16/8/2017 www.sciencedaily.com/releases/2016/04/160426162555.htm
12. CSIRO, Forests in the landscape - Accessed 16/8/2017 www.csiro.au/en/Research/LWF/Areas/Landscape-management/Forests
13. A Novel Modelling Approach for Predicting Forest Growth and Yield under Climate Change. M. Irfan Ashraf, Fan-Rui Meng, Charles P.-A. Bourque, David A. MacLean. PLoS ONE 10(7): e0132066.Published: July 14, 2015 www.journals.plos.org/plosone/article?id=10.1371/journal.pone.0132066_ Accessed 16/8/2017

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