

Science sample unit: Evidence is everything

Stage 5

Duration: 10 weeks

Unit context

The context of the unit is three major scientific theories/models – the Theory of Plate Tectonics, the Theory of Evolution by Natural Selection and the Watson-Crick model of DNA. In their investigation of case studies, students develop their ideas about how, through the processes of scientific inquiry, hypotheses are proposed and evidence is gathered that lead to the development and refining of scientific explanations. Students gain an understanding of Science as a collaborative, creative endeavour in which scientific explanations change as new evidence arises or existing evidence is reconceptualised.

Target outcomes

Values and Attitudes

SC5-3VA demonstrates confidence in making reasoned, evidence-based decisions about the current and future use and influence of science and technology, including ethical considerations

Working Scientifically

SC5-5WS produces a plan to investigate identified questions, hypotheses or problems, individually and collaboratively

SC5-6WS undertakes first-hand investigations to collect valid and reliable data and information, individually and collaboratively

SC5-7WS processes, analyses and evaluates data from first-hand investigations and secondary sources to develop evidence-based arguments and conclusions

SC5-8WS applies scientific understanding and critical thinking skills to suggest possible solutions to identified problems

SC5-9WS presents science ideas and evidence for a particular purpose and to a specific audience, using appropriate scientific language, conventions and representations

Knowledge and Understanding

SC5-12ES describes changing ideas about the structure of the Earth and the universe to illustrate how models, theories and laws are refined over time by the scientific community

SC5-13ES explains how scientific knowledge about global patterns of geological activity and interactions involving global systems can be used to inform decisions related to contemporary issues

SC5-15LW explains how biological understanding has advanced through scientific discoveries, technological developments and the needs of society

Unit overview: Evidence is everything

Unit description

The unit focuses on developing students' understanding of Science as providing a distinct view and way of thinking about the natural world. The unit provides three case studies to demonstrate the processes by which scientific knowledge evolves and explanations based on observation and experiment (empirical evidence) gain acceptance by the scientific community.

The case studies demonstrate how past explanations are the basis for contemporary theories and that these explanations are refined and reconceptualised over time as new evidence emerges, frequently as the result of technological advances. Peer review of evidence and theories by the scientific community is fundamental to this process.

Through engaging in Working Scientifically, students gain an understanding of scientific inquiry and how this process extends, clarifies and unites observations and data to develop testable hypotheses and scientific explanations.

The grey-shaded component of the unit overview identifies the sections that have been developed in detail into lesson sequences.

Case study A – The Theory of Plate Tectonics










Students conduct individual and team investigations to analyse how our understanding of global patterns of geological activity has changed over time from Wegener's Theory of Continental Drift to the modern Theory of Plate Tectonics. They recognise that as new evidence from deep-sea research and developing technologies becomes available, scientific understanding advances and past explanations are refined and reconceptualised.






Case study B – The Theory of Evolution by Natural Selection

Students undertake a collaborative group research project to gather, process and present evidence from across the Science disciplines that support the Theory of Evolution by Natural Selection. They identify how the currently available empirical evidence contributes to providing an explanation for the diversity of living things on the Earth.

Case study C – The Watson-Crick Model of DNA

This case study extends students' understanding of how scientific models/theories are used to explain phenomena in the natural world. Students use the Watson-Crick Model of DNA to explain the transfer of genetic information and the changes in genes in a population resulting from natural selection. They research and present scientific evidence to explain antibiotic resistance in bacteria and to make predictions about the current and future implications of continued widespread use of antibiotics by society.




Content – Skills Working Scientifically	Content – Knowledge and Understanding	Suggested teaching, learning assessment experiences	Adjustments
<p>Processing and Analysing Data and Information</p> <p>WS7.1 Students process data and information by:</p> <p>a. selecting and using a variety of methods to organise data and information, including diagrams, tables, models, spreadsheets and databases   </p> <p>d. applying numerical procedures and mathematical concepts and using digital technologies, where appropriate   </p> <p>Communicating</p> <p>WS9 Students communicate by:</p> <p>b. selecting and constructing an appropriate table, type of diagram, table or graph (histogram or sector, column or line graph) to present information and show relationships clearly and succinctly using digital technologies as appropriate   </p>		<p>Developing a timeline</p> <p>Teacher background</p> <p><i>This activity builds on the students’ Stage 4 knowledge of time scales and assists students to gain an appreciation of the time frame relevant to the case studies in the unit. The timeline focuses on some changes over time in scientific knowledge and technological developments that have increased understanding of the world. The relationship between discoveries in science that have led to developments of new technologies and advances or improvements in technology that have transformed science is also considered.</i></p> <p>Class activity</p> <p>Students work in pairs to create a timeline that storyboards some of the key events showing how scientific knowledge over time has been refined and how some relevant technological developments have changed and advanced our understanding of the world. In a class discussion the students recall the processes for constructing a timeline and agree on how the collected data/information will be recorded and presented. The timeline should be presented in a way that will be readily accessible and could be added to throughout the unit, such as a visual wall display in a learning space or a digital format that can be shared by the students.</p> <p>Some significant events, scientific discoveries and technological advances that are important timeline milestones in the 19th, 20th and 21st centuries and that would provide students with an overview of the time scale relevant to the unit could include:</p> <ul style="list-style-type: none"> • first aeroplane, helicopter, submarine, rocket, satellite, computer • first use of electricity, sonar, atomic energy • first manned space flights and moon landing, robot landing on Mars • first deep-sea exploration of a mid-ocean ridge, an ocean trench • finding of the wreck of the <i>Titanic</i>, <i>HMAS Sydney II</i> • Alexander Flemings discovery of penicillin as a natural antibiotic • Howard Florey and Ernst Chain purify penicillin • James Watson and Francis Crick publish <i>Molecular Structure of Nucleic Acids: A Structure for Deoxyribose Nucleic Acid (DNA)</i> • Watson, Crick and Wilkins receive the Nobel prize for their work on the model of DNA • Alfred Wegener publishes <i>The Origin of Continents and Oceans</i> • Charles Darwin publishes <i>On the Origin of the Species</i> • voyage of <i>The Beagle</i>, including Charles Darwin’s visit to Australia. <p>Throughout the unit, each student establishes and maintains an individual digital and/or hard copy log/learning journal. This would include their record of data/information gathered, their own findings, ideas and conclusions and those of others from group and</p>	<p>Provide a pre-prepared timeline with relevant dates marked and have students plot set events on a timeline. Events could be represented visually and dates provided for additional scaffolding.</p> <p>Provide guided questions for students to answer and record in their log/learning journal, eg</p> <ul style="list-style-type: none"> • What was the topic/question?

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		class discussions. The log/learning journal will be used as a record for students to share, monitor and reflect on their own learning and for the teacher to provide feedback.	<ul style="list-style-type: none"> List 2–3 things you learned about the topic/question.
<p>Planning Investigations</p> <p>WS5.1 Students identify data to be collected for an investigation by:</p> <ol style="list-style-type: none"> describing the purpose of an investigation explaining why certain types of information need to be collected in a range of investigation types   selecting possible sources of data, including secondary sources, relevant to the investigation <p>WS5.2 Students plan first-hand investigations by:</p> <ol style="list-style-type: none"> planning and selecting appropriate investigation methods including fieldwork and laboratory experimentation, to collect reliable data (AC SIS165, AC SIS199)    describing a logical procedure for undertaking a range of investigation types <p>Problem Solving</p> <p>WS8 Students solve problems by:</p> <ol style="list-style-type: none"> describing strategies to develop a range of possible solutions to an identified problem 		<p>The collection of reliable evidence</p> <p>Teacher background</p> <p><i>In this activity, students use their Working Scientifically skills to develop a procedure to access reliable sources of data/information that provide scientific explanations based on empirical evidence (observation and experimentation), which can be used to support a particular idea/theory. They consider what makes the selected data/information reliable and how it provides valid evidence to answer the question. Students reflect on how the process of peer review contributes to improving the proposed procedure to investigate the questions.</i></p> <p>Class activity</p> <p>The class brainstorm and record as a mind map, their ideas about how reliable and valid scientific evidence is gathered and used to construct testable explanations and predictions about natural phenomena.</p> <p>Group activity</p> <p>In this activity the class works in three groups. Each group of students develops a plan for a logical procedure to locate at least three reliable sources of evidence to answer one of the following questions:</p> <ol style="list-style-type: none"> Is the Earth flat? Is the Earth the centre of the solar system? Was the moon formed at the same time as the Earth? <p>Each group prepares an outline of their procedure, including how they evaluated the reliability and validity of the sources of evidence and why these would provide scientifically accurate evidence to answer the question being investigated.</p> <p>Class activity</p> <p>A representative from each group presents a brief overview of the proposed procedure and the reasons for the evidence selected. With teacher guidance, the class acts as a peer review panel to evaluate each of the proposed procedures. They provide suggestions to refine the method and improve the quality of the data/information collected.</p> <p>With teacher-guided questioning, students reflect on what they know and have learned about gathering valid and reliable scientific evidence to answer a question and the role of peer review in the process of making scientific explanations public.</p>	<p>Careful selection of groups is needed to ensure students have appropriate peer modelling and assistance. Group roles may need to be specified OR groups formed on the basis of ability so that additional teacher assistance and scaffolding can be used for the group(s) that may experience difficulties. In this case, the questions assigned should match the group's ability.</p>

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<p>b. assessing strategies that have been identified as possible solutions to an identified problem</p>			
<p>Conducting Investigations WS6 Students conduct investigations by:</p> <ul style="list-style-type: none"> a. individually and collaboratively using appropriate investigation methods, including fieldwork and laboratory experimentation, to collect reliable data (ACSIS165, ACSIS199) 🏠 b. safely constructing, assembling and manipulating identified equipment ⭐ c. selecting and using appropriate equipment, including digital technologies, to systematically and accurately collect and record data (ACSIS166, ACSIS200) ⭐ 🖥️ e. reporting data and information, evidence and findings, with accuracy and honesty 📏 <p>Processing and Analysing Data and Information WS7.1 Students process data and information by:</p> <ul style="list-style-type: none"> e. identifying data which supports or discounts a question or hypothesis 	<p>Earth and Space ES2 The theory of plate tectonics explains global patterns of geological activity and continental movement. (ACSSU180)</p> <p>Students:</p> <ul style="list-style-type: none"> a. outline how the theory of plate tectonics changed ideas about the structure of the Earth and continental movement over geological time b. relate movements of the Earth's plates to mantle convection currents and gravitational forces c. outline how the theory of plate tectonics explains earthquakes, volcanic activity and formation of new landforms 📍 d. describe how some technological developments have increased scientific understanding of global patterns in geological activity, including in the Asia-Pacific region 📍 ⚙️ 	<p>Case study A: The development of the Theory of Plate Tectonics</p> <p>Teacher background <i>The activities assist students to gain an understanding of the way that scientific knowledge accumulates and explanations are refined and reconceptualised as new evidence becomes available. The development of the Theory of Plate Tectonics (1965) is traced from its basis in two earlier theories, which incorporated the scientific evidence available at the time: The Theory of Continental Drift (1915) and The Theory of Sea Floor Spreading (1960). This case study shows the tentative nature of scientific explanations, how past explanations form the basis for contemporary and future explanations, and the interrelationship between advances in scientific understanding and technological developments.</i></p> <p><i>This case study builds on and extends students' knowledge of the structure of the Earth from Stage 4 and could be presented in the context of a narrative. The case study emphasises the nature of scientific theories in providing explanations and predictions that can be tested and either supported or rejected by observation or experimentation (empirical evidence).</i></p> <p>The Theory of Continental Drift</p> <p>Class activity Students work in groups to research, using websites and literature, in order to produce a 2–4 minute contribution for a 30-minute multimedia presentation. This is to be a hypothetical 'current affairs' program set in the 1920s that presents the evidence published by Alfred Wegener supporting the new Theory of Continental Drift.</p> <p>Group activity Each group designs, constructs and videos their model representing the selected evidence, with a brief explanation of how the evidence supports the Theory of Continental Drift. In their individual logs/learning journals, students record the steps used by the group in the process of preparing the video segment for the evidence presented.</p> <p>One group is the 'anchor' presenting an introduction to the program 'Wegener and the Theory of Continental Drift'. They would also present a concluding summary that includes reference to the lack of support by the scientific community for the explanation provided by Wegener of the mechanism by which the continents moved.</p>	<p>Provide directions for the whole class that promote inclusion of students in group work, eg each person in the group has a specific role. Roles could include researching information in the form of answering guided questions, collecting/creating images and editing the presentation. Scaffold and explain these roles to students.</p>

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<p>being investigated or a proposed solution to a problem ❄️</p> <p>WS7.2 Students analyse data and information by:</p> <p>d. using knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS170, ACSIS204)</p> <p>e. synthesising data and information to develop evidence-based arguments</p> <p>f. evaluating conclusions and evidence, including identifying sources of uncertainty and possible alternative explanations (ACSIS171, ACSIS205) ❄️</p> <p>Problem Solving</p> <p>WS8 Students solve problems by:</p> <p>a. describing strategies to develop a range of possible solutions to an identified problem</p> <p>b. assessing strategies that have been identified as possible solutions to an identified problem</p> <p>c. applying the processes of Working Scientifically in developing creative solutions to problems ❄️ ⚖️ 👤</p> <p>d. using cause-and-effect relationships to explain</p>		<p>Class activity</p> <p>The students view their multimedia presentation. They discuss and evaluate the consistency of the Theory of Continental Drift with the evidence presented and identify that Wegener’s explanation was unable to provide evidence for the proposed mechanism for the movement of the continents. The class jointly constructs a summary of the evidence presented, which each student records in their log/learning journal.</p> <p>The Theory of Sea Floor Spreading</p> <p>Individual or group activity</p> <p>This activity engages students in undertaking first-hand practical experiences related to some technological advances that have led to the accumulation of new evidence about the nature of the ocean floor. It provides students with an example of how, as a result of technological developments, new data/information becomes available that advances scientific understanding. As scientific knowledge advances, ideas/theories are refined and reconceptualised in the light of the new findings, and scientists are better able to provide more accurate and/or complete scientific explanations for phenomena in the natural world.</p> <p>Students work individually and collaboratively at a series of workstations (Attachment A: The Theory of Sea Floor Spreading). Each student uses the teacher-provided scaffold (Attachment B: Evidence from the Sea Floor) to gather, record and collate their findings from the first-hand investigations and secondary sources provided at the workstation.</p> <p>In groups, the students review the data/information collected including, as appropriate, additional information from class discussion.</p> <p>Class activity</p> <p>With teacher-guided questioning, the students:</p> <ul style="list-style-type: none"> reflect on how technological developments led to the accumulation of new evidence and how this evidence enabled scientists to provide a more accurate scientific explanation about the nature of the ocean floors summarise how the evidence provides support for the Theory of Sea Floor Spreading. <p>The Theory of Plate Tectonics</p> <p>Pair activity</p> <p>In this literacy activity, students further develop their understanding of the nature of the processes involved in gathering, testing and presenting reliable data/information from across Science disciplines for peer review and open public scrutiny. As the body of scientific knowledge continues to increase, scientists are able to refine and reconceptualise evidence to provide better or alternative explanation for phenomena in the natural world.</p> <p>Students individually read and summarise the information provided about the development</p>	<p>Refer to Attachments A and B for adjustments.</p>

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<p>ideas</p> <p>e. using models to explain phenomena and make predictions 📊 ⚙️</p> <p>f. applying critical thinking in considering suggested proposals, solutions and conclusions, including a consideration of risk ⚙️</p> <p>g. evaluating different approaches used to solve problems (ACSIS172, ACSIS206)</p> <p>Communicating WS9 Students communicate by:</p> <p>a. selecting and using in presentations, for different purposes and contexts, appropriate text types including discussions, explanations, expositions, procedures, recounts or reports 🗣️</p> <p>d. proposing ideas that demonstrate coherence and logical progression ⚙️ 🎓</p> <p>e. presenting scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations for specific audiences (ACSIS174, ACSIS208) 🗣️</p>		<p>of the Theory of Plate Tectonics (Attachment C: The Story of the Development of the Theory of Plate Tectonics). In pairs they work collaboratively to answer the questions and complete, from secondary sources, a summary of the Theory of Plate Tectonics including drawing and labelling the major plates on a provided world map.</p> <p>In a discussion focusing on the significance of the processes of review by the scientific community, students describe some of the steps presented in the information about how scientific knowledge accumulates and is refined and extended as new evidence arises or existing evidence is reconceptualised.</p> <p>Emerging evidence to support the Theory of Plate Tectonics Class activity Students investigate how emerging data/information from seismic studies and the distribution of volcanoes, continues to refine our understanding of the structure of the Earth and provides evidence to support the Theory of Plate Tectonics (Attachment D: Evidence to support the Theory of Plate Tectonics).</p> <p>Class activity Students reflect on their learning during this case study by:</p> <ul style="list-style-type: none"> including on the timeline constructed by the class, the key milestones that led to the development of the Theory of Plate Tectonics outlining how the development of the Theory of Plate Tectonics changed ideas about the structure of the Earth and continental movement over geological time constructing a flowchart to show the processes involved in the development of the Theory of Plate Tectonics summarising in their log/learning journals, their understanding of how science knowledge accumulates and explanations are refined. 	<p>Refer to Attachment C for adjustments.</p> <p>Provide visual or word prompts of key milestones for inclusion on the timeline; complete a close passage in relation to the Theory of Plate Tectonics; provide a template for the flowchart or sections of the flowchart for students to put together; provide guided questions for students to answer in their log/learning journal.</p>

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<p>Conducting Investigations WS6 Students conduct investigations by:</p> <p>e. reporting data and information, evidence and findings, with accuracy and honesty </p> <p>Processing and Analysing Data and Information WS7.1 Students process data and information by:</p> <p>c. accessing data and information by using a range of appropriate digital technologies </p> <p>e. identifying data which supports or discounts a question or hypothesis being investigated or a proposed solution to a problem </p> <p>WS7.2 Students analyse data and information by:</p> <p>d. using knowledge of scientific concepts to draw conclusions that are consistent with evidence (AC SIS170, AC SIS204)</p> <p>e. synthesising data and information to develop evidence-based arguments</p> <p>Communicating WS9 Students communicate by:</p> <p>a. selecting and using in presentations, for different</p>	<p>Living World LW4 The theory of evolution by natural selection explains the diversity of living things and is supported by a range of scientific evidence. (ACSSU185)</p> <p>Students:</p> <p>a. describe scientific evidence that present-day organisms have evolved from organisms in the past</p> <p>b. relate the fossil record to the age of the Earth and the time over which life has been evolving</p>	<p>Case study B: The Theory of Evolution by Natural Selection Teacher background <i>This case study assists students to develop their understanding of how evidence from across the Science disciplines contributes to providing contemporary explanations. They research to identify evidence that supports the Theory of Evolution by Natural Selection and how it explains the diversity of living things.</i></p> <p>Team activity Students undertake a collaborative group project to research and present examples of scientific evidence cited by scientists in support for the Theory of Evolution by Natural Selection. This evidence is to be included in a science webpage/magazine that can be accessed by the school community and is an important resource to be used by Stage 5 science students. The information presented for the webpage/magazine must be informative, scientifically accurate, visually appealing and interestingly written using an appropriate text type. It should be no longer than 300 words. Each team researches the teacher-provided secondary sources to gather and prepare the information for their part of the webpage/magazine describing the evidence and how it explains the diversity of living things. The information submitted by each team should be accompanied by a brief outline of the method used to research the information and include appropriately acknowledged sources.</p> <p>Class activity The students peer review the webpage/magazine and evaluate the information present in relation to the criteria identified for the activity.</p> <p>Individual activity Students reflect on their own learning by:</p> <ul style="list-style-type: none"> summarising in their log/learning journal, the examples of the scientific evidence from across the disciplines that supports the theory outlining how the collected scientific evidence explains the diversity of living organisms. 	<p>Guide students' research or provide a summary of information that can be used rather than have the students undertake the research.</p> <p>Provide a scaffold for composing the text, including sentence starters and examples of language, eg jargon. Assign group roles, eg complete a table of information, provide visuals for the article, write a section of the article.</p> <p>Provide guided questions or checklist to assist peer review.</p>

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<p>purposes and contexts, appropriate text types including discussions, explanations, expositions, procedures, recounts or reports 📖</p>			
<p>Conducting Investigations WS6 Students conduct investigations by:</p> <ol style="list-style-type: none"> individually and collaboratively using appropriate investigation methods, including fieldwork and laboratory experimentation, to collect reliable data (ACSIS165, ACSIS199) 🧪 <p>Processing and Analysing Data and Information WS7.1 Students process data and information by:</p> <ol style="list-style-type: none"> selecting and extracting information from tables, flow diagrams, other texts, audiovisual resources and graphs, including histograms and column, sector or line graphs 📊 <p>WS7.2 Students analyse data and information by:</p> <ol style="list-style-type: none"> critically analysing the validity of information from secondary sources (ACSIS172, ACSIS206) ⚙️ <p>Problem Solving WS8 Students solve</p>	<p>Living World LW3 Advances in scientific understanding often rely on developments in technology, and technological advances are often linked to scientific discoveries. (ACSHE158, ACSHE192)</p> <ol style="list-style-type: none"> identify that during reproduction the transmission of heritable characteristics from one generation to the next involves DNA and genes (ACSSU184) identify that genetic information is transferred as genes in the DNA of chromosomes outline how the Watson-Crick model of DNA explains: <ul style="list-style-type: none"> the exact replication of DNA changes in genes (mutation) <p>LW4 The theory of evolution by natural selection explains the diversity of living things and is supported by a range of scientific evidence. (ACSSU185)</p> <ol style="list-style-type: none"> explain, using examples, how natural selection 	<p>Case study C: The Watson Crick Model of DNA Teacher background <i>This case study extends students' understanding of how scientific models/theories are used to explain phenomena in the natural world. Students use the model of DNA to explain the transfer of genetic information and changes in genes in a population resulting from natural selection. They research and present scientific evidence to explain antibiotic resistance in bacteria and to make predictions about the current and future implications of the continued widespread use of antibiotics by society.</i></p> <p>Students undertake a variety of class, group and individual activities to:</p> <ul style="list-style-type: none"> present for inclusion on their timeline, some examples of evidence that was available to James Watson and Francis Crick in the development of the model of DNA such as the work of Richard Altmann, Erwin Chargaff, Maurice Wilkins and Rosalind Franklin investigate the Watson-Crick model of DNA and how it can be used to explain: <ul style="list-style-type: none"> transfer of genetic information from one generation to the next changes in genes (mutations) research an example of how changes in genes (mutations) produces variation in the genetic information in populations that is acted on by natural selection such as antibiotic resistance in bacteria. <p>In a team activity, students work in small groups to produce a presentation for a group of international health and science delegates at a Science symposium. They research and prepare a short, scientifically accurate, evidence-based argument that includes social and ethical considerations on how existing and new evidence has increased scientific understanding of antibiotic resistance in bacterial populations and its impact on society. A representative selected by each team presents their findings and conclusion to the class which represents the delegates at the symposium. They communicate to the class the scientific knowledge on which to make an informed decision.</p> <p>Based on the evidence in the team presentations, the symposium is to present its recommendations to support the reduction of the continued widespread use of antibiotics.</p>	<p>Careful consideration of groups to ensure peer modelling and support OR groups formed based on ability so that teacher assistance can be provided if required.</p> <p>Provide a scaffold to assist with research and easily accessible information, or a summary of information.</p>

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<p>problems by:</p> <p>d. using cause-and-effect relationships to explain ideas</p> <p>e. using models to explain phenomena and make predictions 📊 ⚙️</p> <p>Communicating</p> <p>WS9 Students communicate by:</p> <p>d. proposing ideas that demonstrate coherence and logical progression ⚙️ 🎓</p> <p>e. presenting scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations for specific audiences (AC SIS174, AC SIS208) 🎓</p>	<p>relates to changes in a population, eg in the development of resistance of bacteria to antibiotics and insects to pesticides 🎓</p> <p>d. outline the roles of genes and environmental factors in the survival of organisms in a population ⚙️</p>		
		<p>Reflecting on learning</p> <p>Students reflect on their learning in the unit, including:</p> <ul style="list-style-type: none"> • why scientific explanations can and do change as new evidence becomes available • how scientific knowledge advances and how contemporary scientific explanations are developed and refined by the processes of science, including hypothesis testing and peer review • how their understanding of the scientific inquiry process assists them to use scientific explanations to make reasoned, evidence-based decisions involving science-related personal, social and global issues relevant to their lives. 	<p>Provide guided questions to assist student reflection, such as:</p> <ul style="list-style-type: none"> • What is evidence? • Why is evidence important? • What is one piece of evidence you have learned that supports a scientific explanation?

Resources	Assessment overview
<p>Materials and equipment required for hands-on practical investigations, including:</p> <ul style="list-style-type: none"> • convection current models, eg rice and oil, potassium permanganate (KMnO₄) • sea-floor spreading models, eg polystyrene, cardboard • world maps, Pacific ocean map, Atlantic ocean map. <p>Online file sharing: Google Earth, SkyDrive, School Portal</p> <p>Applications: Excel and Numbers Spreadsheets</p> <p>Presentation applications: PowerPoint, SMART Notebook</p> <p>Word-processing/Publishing: Word, Publisher, Pages</p> <p>References</p> <p><i>Teaching About Evolution and the Nature of Science</i>, Washington, DC: National Academy Press, 1998</p> <p>Websites</p> <ul style="list-style-type: none"> • www.geomapapp.org/index.htm • http://oceanexplorer.noaa.gov • http://sydney.edu.au/science/uniserve • www.ucmp.berkeley.edu/geology/tectonics.html • www.pbs.org/wgbh/aso/tryit/tectonics/ • www.learner.org/interactives/dynamicearth/drift.html • www.earthexplorer.com/2008-11/Nautilus_Masters_the_Sea.asp • www.research.noaa.gov/oceans/t_technology.html • http://evolution.berkeley.edu › Home › Lines of Evidence • www.bbc.co.uk › ... › AQA (Pre-2011) › Evolution and environment Evolution and environment • http://monash.edu/monashmag/articles/outsmarting-the-superbugs.htmlhttp://www.betterhealth.vic.gov.auhttp://textbookofbacteriology.net/resantimicrobial.html.net/resantimicrobial.html • www.who.int/mediacentre/factsheets/fs194/en/ • www.actionbioscience.org/newfrontiers/kardar.html • http://cid.oxfordjournals.org/content/46/2/155.full 	<p>Assessment opportunities could include:</p> <ul style="list-style-type: none"> • student records and reflections in individual portfolios • records of practical investigations • processing and analysing data • cause-and-effect reasoning • student self-assessment of learning using a teacher-provided evaluation sheet • listed criteria to assess team presentations • ability of each student to reflect on their own learning.

Attachments
Stage 5: Evidence is everything

A: The Theory of Sea Floor Spreading

Students work individually and collaboratively at a series of workstations to investigate some of the new evidence about the nature of the ocean floors that has emerged as a result of technological developments.

Workstation activities include:

- using Google Earth to describe the major physical features of the ocean floors
- collecting information on how different technologies have provided evidence about the features of the ocean floors, eg echo sounders, magnetometers, dredges, grabs and sea floor core samplers (ocean drilling), Satellite Altimetry (gravity measurements), remote-control robots
- sketching maps to show the age of ocean floor rocks determined by ocean floor sampling and analysis
- illustrating the concept of convection currents in the mantle by placing rice grains onto a layer of oil in a beaker of water and heating gently
- using a pneumatic trough filled with water, two pieces of polystyrene (labelled continent A and continent B) and a heat source to model convection currents
- using a long heater (copper coil around a glass rod) in an enamel dish with crystals of $KMnO_4$ to model the movement of material along the mid-ocean ridge
- modelling the formation of the ocean floor using a cardboard cut-out with paper and coloured pencils to mark/represent the magnetic anomaly pattern
- using teacher-selected internet sites/journal articles.

Adjustment

Activities may be adjusted in the following ways:

- teacher/peer modelling and assistance
- finding an image of one piece of technology and describing what it is used for
- identifying layers of ocean floor rocks in a sketch or diagram
- following clear written and/or visual instructions to undertake an experiment to demonstrate convection currents
- accessing texts that match students' reading level (multimedia texts and texts that use visuals to support understanding may be appropriate).

B: Evidence from the sea floor

Students construct or use a table such as the scaffold below to record the data/information and results gathered in the investigation.

The evidence for sea floor spreading	The method by which evidence was collected	The developing technology used to collect the evidence	The description of a model which demonstrates the evidence
eg profile of the ocean floor	ship's echo sounder	magnetometers	magnetic reversals captured in the oceanic crust formed at the mid-ocean ridge.

Adjustment

Adjust the categories in the table for students to complete, eg Draw a picture to represent how the sea floor spreads, How did people collect the evidence?, Name a piece of equipment/technology used to collect the evidence.

C: The Story of the Development of the Theory of Plate Tectonics

Students read the summary below (adapted from Wikipedia) and individually answer the questions. The class collates the answers and students add to their logbooks additional class responses.

The Story of the Development of the Theory of Plate Tectonics

In 1915 Alfred Wegener, an astronomer and meteorologist, published his Theory of Continental Drift. This was based on evidence collected by scientists over a number of years. The theory was not readily accepted by the scientific community because the mechanism he suggested for continental drift was flawed.

Prior to the 1930s, the ocean basins were assumed to be deep and relatively flat. As a result of the development of new technology during World War II, such as sonar, which was developed to produce accurate ocean floor maps for submarines, this idea changed.

In 1960 Harry Hess proposed the Theory of Seafloor Spreading, taking into account the new evidence from this echo sounding. He proposed that a possible mechanism for Continental Drift was convection currents in the mantle causing the ocean floors to spread apart. His hypothesis was that the rocks on the ocean floor could be no older than 200–300 million years. New technology for measuring the palaeomagnetism of the ocean floors was used to test his ideas. In 1963 Vine and Matthews were able to interpret the palaeomagnetic data and thus provide incontestable evidence to support Hess's Theory of Seafloor Spreading.

In 1965 the Theory of Plate Tectonics (initially called 'New Global Tectonics') became quickly accepted in the scientific world, with numerous papers published outlining the model for Plate Tectonics and defining the concepts. Tuzo Wilson added the concept of transform faults to the model of Plate Tectonics, thus explaining the mobility of the plates.

The 1965 Royal Society of London Symposium on Continental Drift is regarded as the time of the official acceptance by the scientific community of the Theory of Plate Tectonics. At this symposium, [Edward Bullard](#) and his co-workers used a computer calculation/simulation to demonstrate how the continents along both sides of the Atlantic Ocean would best fit to close the ocean. This became known as 'Bullard's Fit'. PMSB Iacket, EC Bullard and SK Runcorn published the abstracts from this symposium. In 1966 Wilson published a paper that introduced the concept of what is now known as the 'Wilson Cycle'.

In 1967 at the American Geophysical Union's meeting, William J Morgan proposed that the Earth's surface consists of 12 rigid plates that move relative to each other. Two months later, Xavier Le Pichon published a complete plate tectonic model based on 6 major plates with their relative motions. This marked the final acceptance by the scientific community of the Theory of Plate Tectonics. In the same year, Dan McKenzie and Robert Parker independently presented a model similar to Morgan's, using translations and rotations on a sphere to define the plate motions.

Questions

1. Is 'New Global Tectonics' a better name for the Theory of Plate Tectonics? Explain your answer.
2. Can a single scientist claim to have developed the Theory of Plate Tectonics? Explain your answer.
3. What do you understand by the term 'model' as it is used in science?
4. Why are scientific models regarded as evidence?
5. What are 'scientific symposiums' and why are they important?
6. What are other ways for scientists to communicate their findings and ideas?
7. Why is this communication so important in science?
8. If new evidence is presented, what processes would need to occur to validate this evidence?
9. What would happen if this new evidence refuted the Theory of Plate Tectonics?

Adjustments

The text may need to be simplified. Read the text as a whole class first, and then the teacher models, highlighting key words. Students use note-making techniques to identify the main ideas, eg graphic organiser or table.

Provide questions as a three-level guide. Students experiencing difficulty may only complete level one or two questions.

D: Evidence to support the Theory of Plate Tectonics

Students investigate how emerging data/information from seismic studies and the distribution of volcanoes continues to refine our understanding of the structure of the Earth and provides evidence to support the Theory of Plate Tectonics.

Problem 1: How does seismic evidence provide an explanation of what is happening at divergent and convergent plate boundaries?

In this practical experience students process and analyse data and information relating to the surface distribution of earthquake epicentres at plate boundaries and the variation of depth of earthquake foci at plate boundaries.

In pairs, students:

- plot on an Atlantic ocean map, the location of earthquake epicentres at the divergent plate boundary, ie mid-Atlantic ridge
- plot on a cross-section of this mid-ocean ridge, the depth of earthquake foci
- repeat the above steps using an example of a convergent plate boundary in the Pacific ocean, eg Tonga trench
- compare the map and cross-section of each example of an ocean floor.

Using the gathered data/information of what is happening below the Earth's surface at divergent and convergent plate boundaries, students apply critical thinking skills to suggest a model to explain the geological processes occurring at these boundaries and an answer to the question posed.

Class activity

- Each pair of students outlines for the class the model they are proposing to answer the question.
- The class reviews the models proposed by each pair and considers the answer to the question by reference to the Plate Tectonic Model.
- Students assess the quality of the conclusions made by each pair in the light of class conclusions.

Problem 2: How does the distribution of the two main types of volcanoes provide an explanation of the processes occurring at divergent and convergent plate boundaries?

Individual activity

Students record an outline of the general features of explosive and effusive volcanoes. For one of the teacher-allocated volcanoes, students research and mark its location on a large map of either the Pacific ocean or the Atlantic ocean, which collates the class findings for a variety of volcanoes. Some suggested volcanoes are:

- explosive volcanoes to be plotted on and near the Pacific Ocean – Mt Fuji, Mt Bandai, Mt St. Helens, Villarrica, Llaima volcano, Chaiten volcano, El Chichon, Mt Redoubt, Aleutian and Kamchatka volcanic arcs, Mayon volcano, Canlaon, Pinatubo, Mt Tambora, Mt Merapi, Kelud, Mt Ruapehu, White Island, Tongan volcanic arc
- effusive volcanoes to be plotted on the Atlantic Ocean – Grimsvotn, Skafta, Laki, Eyjafjallajokull, Canary Islands, Bear Seamount, Madeira, Tristan Hotspot, Azores.

Group activity

The students compare the class-produced maps of the distribution of explosive and effusive volcanoes with their maps of the major tectonic plates. They apply critical thinking to suggest an explanation for the different volcanic processes occurring at divergent and convergent boundaries. They compare their results and conclusions.

Groups use cause-and-effect relationships to explain their ideas and make predictions about future volcanic and earthquake activity. They discuss questions raised using the Plate Tectonic Model to explain phenomena.

Students reflect on the class discussion and individually record a summary in their logs/learning journals of their findings, conclusions and annotations of ideas and observations made during the class discussion.

Adjustments

- Provide a simple table showing earthquake epicentres and the depth of earthquake foci for a convergent plate boundary. Students label a map of this boundary using this information and complete some guided questions, eg What are the differences between the epicentres in each ocean? How are the depths of earthquake foci different? Why do the depths of earthquake foci vary?
- Provide easily accessible resources for students to research their volcano, or a summary of relevant information supported by visual images. Provide guided questions to support an understanding of the differences between the volcanoes (explosive and effusive) or use a Venn diagram or comparison chart. Provide guided questions for logs/learning journals that encourage students to make some connections between the type of volcanoes and the plate boundaries.