

Fully aligned
with the Australian
Curriculum

Creators and destroyers

Year 6

Earth and space sciences



About this unit

Creators and destroyers

The surface of our Earth is slowly moving and changing over time. On average, a volcanic eruption occurs somewhere on Earth each week. Volcanic eruptions are often seen as devastating events causing destruction, but they are also instrumental in creating new islands and adding to the continents while providing rich fertile soils and mineral deposits.

The *Creators and destroyers* unit is an ideal way to link science with literacy in the classroom. Through hands-on investigations, students explore the structure and formation of volcanoes, and plan and conduct an investigation of the viscosity of magma and its relation to volcano shapes.

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Foreword

Never has there been a more important time for science in Australia. More than ever, we need a scientifically literate community to engage in debates about issues that affect us all. We also need imaginative thinkers to discover the opportunities in our exponentially expanding knowledge base. Teachers play a vital role in nurturing the minds of our future citizens and scientists.

The Australian Academy of Science has a long, proud history of supporting science education. Our primary education program, **PrimaryConnections**: linking science with literacy, now has over 15 years' experience in supporting teachers to facilitate quality learning experiences in their classrooms. Regular evaluations demonstrate the significant impact the program can have on both teacher confidence and student outcomes

PrimaryConnections has been developed with the financial support of the Australian Government and endorsed by education authorities across the country. It has been guided by its Steering Committee, with members from the Australian Government and the Australian Academy of Science, and benefited from input by its Reference Group, with representatives from all States and Territories.

Key achievements of the program include engaging over 24,000 Australian teachers in professional learning workshops, producing multi award-winning curriculum resources, and developing an Indigenous perspective framework that acknowledges the diversity of perspectives in Australian classrooms.

The **PrimaryConnections** teaching and learning approach combines guided inquiry, using the 5Es model, with hands-on investigations. It encourages students to explore and test their own, and others', ideas and to use evidence to support their claims. It focuses on developing the literacies of science and fosters lasting conceptual change by encouraging students to represent and re-represent their developing understandings. Students are not only engaged in science, they feel that they can do science.

This is one of 40 curriculum units developed to provide practical advice on implementing the teaching and learning approach, while meeting the requirements of the Australian Curriculum: Science. Trialled in classrooms across the country and revised based on teacher feedback, and with the accuracy of the teacher background information verified by Fellows of the Academy, the experience of many brings this unit to you today.

I commend **PrimaryConnections** to you and wish you well in your teaching.

Professor John Shine, AC Pres AA

President (2018–2022)

Australian Academy of Science

The PrimaryConnections teaching and learning approach

PrimaryConnections units embed inquiry-based learning into a modified 5Es instructional model. The relationship between the 5Es phases, investigations, literacy products and assessment is illustrated below.

PrimaryConnections 5Es teaching and learning model

Phase	Focus	Assessment focus
ENGAGE	Engage students and elicit prior knowledge	Diagnostic assessment
EXPLORE	Provide hands-on experience of the phenomenon	Formative assessment
EXPLAIN	Develop scientific explanations for observations and represent developing conceptual understanding Consider current scientific explanation	Formative assessment
ELABORATE	Extend understanding to a new context or make connections to additional concepts through a student-planned investigation	Summative assessment of the Science Inquiry Skills
EVALUATE	Students re-represent their understanding and reflect on their learning journey, and teachers collect evidence about the achievement of outcomes	Summative assessment of the Science Understanding

More information on PrimaryConnections 5Es teaching and learning model can be found at:
www.primaryconnections.org.au

Reference: Bybee, R.W. (1997). *Achieving scientific literacy: from purposes to practical action*. Portsmouth, NH: Heinemann.

Developing students' scientific literacy

The PrimaryConnections program supports teachers in developing students' scientific literacy. Scientific literacy is considered the main purpose of school science education and has been described as an individual's:

- scientific knowledge and use of that knowledge to identify questions, acquire new knowledge, explain scientific phenomena and draw evidence-based conclusions about science-related issues
- understanding of the characteristic features of science as a form of human knowledge and enquiry
- awareness of how science and technology shape our material, intellectual and cultural environments
- willingness to engage in science-related issues, and with the ideas of science, as a reflective citizen

Reference: Programme for International Student Assessment & Organisation for Economic Co-operation and Development. (2009). *PISA 2009 assessment framework: key competencies in reading, mathematics and science*. Paris: OECD Publishing.

Linking science with literacy

PrimaryConnections has an explicit focus on developing students' knowledge, skills, understanding and capacities in science and literacy. Units employ a range of strategies to encourage students to think about and to represent science.

PrimaryConnections develops the literacies of science that students need to learn and to represent their understanding of science concepts, processes and skills. Representations in PrimaryConnections are multimodal and include text, tables, graphs, models, drawings and embodied forms, such as gesture and role-play. Students use their everyday literacies to learn the new literacies of science. Science provides authentic contexts and meaningful purposes for literacy learning, and also provides opportunities to develop a wider range of literacies. Teaching science with literacy improves learning outcomes in both areas.

Assessment

Science is ongoing and embedded in PrimaryConnections units. Assessment is linked to the development of literacy practices and products. Relevant understandings and skills are highlighted at the beginning of each lesson. Different types of assessment are emphasised in different phases:



Diagnostic assessment occurs in the *Engage* phase. This assessment is to elicit students' prior knowledge so that the teacher can take account of this when planning how the *Explore* and *Explain* lessons will be implemented.



Formative assessment occurs in the *Explore* and *Explain* phases. This enables the teacher to monitor students' developing understanding and provide feedback that can extend and deepen students' learning.




Summative assessment of the students' achievement developed throughout the unit occurs in the *Elaborate* phase for the Science Inquiry Skills, and in the *Evaluate* phase for the Science Understanding.

To assist with making judgements against the relevant achievement standards of the Australian Curriculum, rubrics for this unit are available on the PrimaryConnections website: <https://primaryconnections.org.au>

Safety



Learning to use materials and equipment safely is central to working scientifically. It is important, however, for teachers to review each lesson before teaching to identify and manage safety issues specific to a group of students. A safety icon  is included in lessons where there is a need to pay particular attention to potential safety hazards. The following guidelines will help minimise risks:

- Be aware of the school's policy on safety in the classroom and for excursions.
- Check students' health records for allergies or other health issues.
- Be aware of potential dangers by trying out activities before students do them.
- Caution students about potential dangers before they begin an activity.
- Clean up spills immediately as slippery floors are dangerous.
- Instruct students never to smell, taste or eat anything unless they are given permission.
- Discuss and display a list of safe practices for science activities.

Teaching to the Australian Curriculum: Science

The Australian Curriculum: Science has three interrelated strands—Science Understanding, Science as a Human Endeavour and Science Inquiry Skills—that together ‘provide students with understanding, knowledge and skills through which they can develop a scientific view of the world’. (ACARA, 2020).

The content of these strands is described by the Australian Curriculum as:

Science Understanding	
Biological sciences	Understanding living things
Chemical sciences	Understanding the composition and behaviour of substances
Earth and space sciences	Understanding Earth’s dynamic structure and its place in the cosmos
Physical sciences	Understanding the nature of forces and motion, and matter and energy
Science as a Human Endeavour	
Nature and development of science	An appreciation of the unique nature of science and scientific knowledge, including how current knowledge has developed over time through the actions of many people
Use and influence of science	How science knowledge and applications affect people’s lives and how science is influenced by society and can be used to inform decisions and actions
Science Inquiry Skills	
Questioning and predicting	Identifying and constructing questions, proposing hypotheses and suggesting possible outcomes
Planning and conducting	Making decisions regarding how to investigate or solve a problem and carrying out an investigation, including the collection of data
Processing and analysing data and information	Representing data in meaningful and useful ways; identifying trends, patterns and relationships in data, and using evidence to justify conclusions
Evaluating	Considering the quality of available evidence and the merit or significance of a claim, proposition or conclusion with reference to that evidence
Communicating	Conveying information or ideas to others through appropriate representations, text types and modes

 Above material is sourced from the Australian Curriculum: Australian Curriculum Assessment and Reporting Authority (ACARA). (2020). *Australian Curriculum: Science*. www.australiancurriculum.edu.au

PrimaryConnections has units to support teachers to teach each Science Understanding detailed in the Australian Curriculum: Science from Foundation to Year 6. Units also develop students’ skills and knowledge of the Science as a Human Endeavour and Science Inquiry Skills sub-strands, as well as specific sub-strands within the Australian Curriculum: English and Mathematics. Detailed information about its alignment with the Australian Curriculum is provided in each unit.

Unit at a glance

Creators and destroyers

Phase	Lesson	At a glance
ENGAGE	Lesson 1 Pompeii and Vesuvius	To capture students' interest and find out what they think they know about how sudden geological changes and extreme weather events can affect Earth's surface. To elicit students' questions about volcanoes.
EXPLORE	Lesson 2 Eruptions! Session 1 Two recounts Session 2 Ready to research	To provide students with hands-on, shared experiences of the effects of a volcanic eruption.
	Lesson 3 Lava creations Session 1 Inside my volcano Session 2 Varying viscosity	To provide students with hands-on, shared experiences of the relationship between volcano shape and lava viscosity.
	Lesson 4 Living on the edge	To provide students with hands-on, shared experiences of the benefits of living near volcanoes.
	Lesson 5 Popping tops (<i>Optional</i>)	To provide students with hands-on, shared experiences of the risks of living near volcanoes.
	Lesson 6 Creators or destroyers? Session 1 Pros and cons Session 2 Deep down	To support students to represent and explain their understanding of the formation and effects of volcanic eruptions on Earth's surface. To introduce current scientific views
ELABORATE	Lesson 7 Where on Earth? Session 1 Dissecting data Session 2 Claims and evidence	To support students to conduct and analyse an investigation of where the majority of Earth's volcanoes are located and why.
EVALUATE	Lesson 8 Volcanoes on show	To provide opportunities for students to represent what they know about how sudden geological changes and extreme weather events can affect Earth's surface, and to reflect on their learning during the unit.

Creators and destroyers—Alignment with the Australian Curriculum

Creators and destroyers is written to align to the Year 6 level of the Australian Curriculum: Science. The Science Understanding, Science Inquiry Skills, and Science as a Human Endeavour strands are interrelated and embedded throughout the unit (see page xii for further details). This unit focuses on the Earth and space sciences sub-strand.

Year 6 Science Understanding for the Earth and space Sciences:	Sudden geological changes and extreme weather events can affect Earth's surface (AUSSSU096)
Incorporation in <i>Creators and destroyers</i> :	Students formulate investigable questions and make predictions to investigate the formation and shape of volcanoes, the location of volcanoes, and the effect of volcanoes on Earth's surface.

 All the material in the first row of this table is sourced from the Australian Curriculum.

Year 6 Achievement Standard

The Australian Curriculum: Science Year 6 achievement standard indicates the quality of learning that students should demonstrate by the end of Year 6.

By the end of Year 6, students compare and classify different types of observable changes to materials. They analyse requirements for the transfer of electricity and describe how energy can be transformed from one form to another when generating electricity. They **explain how natural events cause rapid change to Earth's surface**. They describe and predict the effect of environmental changes on individual living things. **Students explain how scientific knowledge helps us to solve problems and inform decisions** and identify historical and cultural contributions.

Students follow procedures to develop investigable questions and design investigations into simple cause-and-effect relationships. They identify variables to be changed and measured and describe potential safety risks when planning methods. They collect, organise and interpret their data, identifying where improvements to their methods or research could improve the data. They describe and analyse relationships in data using appropriate representations and construct multimodal texts to communicate ideas, methods and findings.

The sections relevant to *Creators and destroyers* are bolded above. By the end of the unit, teachers will be able to make evidence-based judgements on whether the students are achieving below, at or above the achievement standard for the sections bolded above.

Creators and destroyers—Australian Curriculum: Key ideas


In the Australian Curriculum: Science, there are six key ideas that represent key aspects of a scientific view of the world and bridge knowledge and understanding across the disciplines of science. The below table explains how these are represented in *Creators and destroyers*.

Key idea	Incorporation in <i>Creators and destroyers</i>
Patterns, order and organisation	Students interpret secondary data on weekly volcanic activity patterns during the unit. They identify and describe patterns of distribution and relate them to processes happening on different timescales; for example, tectonic plate movement.
Form and function	Students investigate how the form of a volcano depends on variables, such as the viscosity of its lava. They identify that different types of volcanic events are more related to certain forms.
Stability and change	Students discuss how apparently stable environments (such as dormant or extinct volcanoes) can be subject to sudden, violent change. They explore whether that change can be predicted, and how accurately.
Scale and measurement	Students use formal measurements in their investigations. They discuss how volcanic eruptions have short time frames, but are due to processes that occur over geological time.
Matter and energy	Students identify that volcanoes transfer matter and energy from the interior of Earth to the surface.
Systems	Students identify and describe relationships between tectonic plate boundaries and volcanic distribution. They explore different volcanic systems, the types of eruptions that result and how predictable those events are.

Creators and destroyers—Australian Curriculum: Science

Creators and destroyers embeds all three strands of the Australian Curriculum: Science. For ease of reference, the table below outlines the sub-strands covered in *Creators and destroyers*, the content descriptions for Year 6 and their aligned lessons.

Strand	Sub-strand	Code	Year 6 content descriptions	Lessons
Science Understanding	Earth and space sciences	ACSSU096	Sudden geological changes and extreme weather events can affect Earth's surface	1–8
Science as a Human Endeavour	Nature and development of science	ACSHE098	Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena, and reflects historical and cultural contributions	1–8
	Use and influence of science	ACSHE220	Scientific knowledge is used to solve problems and inform personal and community decisions	2–8
Science Inquiry Skills	Questioning and predicting	ACSIS232	With guidance, pose clarifying questions and make predictions about scientific investigations	1, 3, 5, 7
	Planning and conducting	ACSIS103	Identify, plan and apply the elements of scientific investigations to answer questions and solve problems, using equipment and materials safely and identifying potential risks	1, 3, 5, 7
		ACSIS104	Decide variables to be changed and measured in fair tests, and observe, measure and record data with accuracy, using digital technologies as appropriate	3
	Processing and analysing data and information	ACSIS107	Construct and use a range of representations, including tables and graphs, to represent and describe observations, patterns or relationships in data, using digital technologies as appropriate	1–8
		ACSIS221	Compare data with predictions and use as evidence in developing explanations	3, 7
	Evaluating	ACSIS108	Reflect on and suggest improvements to scientific investigation	3
	Communicating	ACSIS110	Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multimodal texts	7, 8

 All the material in the first four columns of this table is sourced from the Australian Curriculum.

General capabilities





The skills, behaviours and attributes that students need to succeed in life and work in the 21st century have been identified in the Australian Curriculum as general capabilities.


There are seven general capabilities and they are embedded throughout the units.

For further information see: www.australiancurriculum.edu.au

For examples of our unit-specific general capabilities information see the next page.

Creators and destroyers—Australian Curriculum general capabilities

General capabilities	Australian Curriculum description	Creators and destroyers examples
Literacy	Literacy knowledge specific to the study of science develops along with scientific understanding and skills. PrimaryConnections learning activities explicitly introduce literacy focuses and provide students with the opportunity to use them as they think about, reason and represent their understanding of science.	In <i>Creators and destroyers</i> the literacy focuses are: <ul style="list-style-type: none"> • science journals • T-charts • TWLH charts • word walls • glossaries • factual recounts • summaries • cross-sections • tables • ideas maps • oral presentations.
 Numeracy	Elements of numeracy are particularly evident in Science Inquiry Skills. These include practical measurement and the collection, representation and interpretation of data.	Students: <ul style="list-style-type: none"> • collect, interpret and represent data about lava and volcanic eruptions.
Information and communication technology (ICT) competence	ICT competence is particularly evident in Science Inquiry Skills. Students use digital technologies to investigate, create, communicate, and share ideas and results.	Students are given optional opportunities to: <ul style="list-style-type: none"> • use interactive resource technology to view, record and discuss information • use the internet to research further information about volcanoes, where they are located and why.
 Critical and creative thinking	Students develop critical and creative thinking as they speculate and solve problems through investigations, make evidence-based decisions, and analyse and evaluate information sources to draw conclusions. They develop creative questions and suggest novel solutions.	Students: <ul style="list-style-type: none"> • formulate, pose and respond to questions • consider different ways of thinking • develop evidence-based claims.
Ethical behaviour	Students develop ethical behaviour as they explore principles and guidelines in gathering evidence and consider the implications of their investigations on others and the environment.	Students: <ul style="list-style-type: none"> • ask questions of others, respecting each other's point of view.
 Personal and social competence	Students develop personal and social competence as they learn to work effectively in teams, develop collaborative methods of inquiry, work safely, and use their scientific knowledge to make informed choices.	Students: <ul style="list-style-type: none"> • work collaboratively in teams • participate in discussions.
 Intercultural understanding	Intercultural understanding is particularly evident in Science as a Human Endeavour. Students learn about the influence of people from a variety of cultures on the development of scientific understanding.	<ul style="list-style-type: none"> • 'Cultural perspectives' opportunities are highlighted. • Important contributions made to science by people from a range of cultures are highlighted.

 All the material in the first two columns of this table is sourced from the Australian Curriculum.

Creators and destroyers—Australian Curriculum: English

Strand	Sub-strand	Code	Year 6 content descriptions	Lessons
Language	Expressing and developing ideas	ACELA1524	Identify and explain how analytical images like figures, tables, diagrams, maps and graphs contribute to our understanding of verbal information in factual and persuasive texts	1, 2, 7
		ACELA1525	Investigate how vocabulary choices, including evaluative language can express shades of meaning, feeling and opinion	2
Literacy	Interacting with others	ACELY1709	Participate in and contribute to discussions, clarifying and interrogating ideas, developing and supporting arguments, sharing and evaluating information, experiences and opinions	1–8
		ACELY1710	Plan, rehearse and deliver presentations, selecting and sequencing appropriate content and multimodal elements for defined audiences and purposes, making appropriate choices for modality and emphasis	7, 8
	Interpreting, analysing, evaluating	ACELY1712	Select, navigate and read texts for a range of purposes, applying appropriate text processing strategies and interpreting structural features, for example table of contents, glossary, chapters, headings and subheadings	1–8
		ACELY1713	Use comprehension strategies to interpret and analyse information and ideas, comparing content from a variety of textual sources including media and digital texts	1–8
	Creating texts	ACELY1714	Plan, draft and publish imaginative, informative and persuasive texts, choosing and experimenting with text structures, language features, images and digital resources appropriate to purpose and audience	8
		ACELY1717	Use a range of software, including word processing programs, learning new functions as required to create texts	8



All the material in the first four columns of this table is sourced from the Australian Curriculum.

Creators and destroyers—Australian Curriculum: Mathematics

Strand	Sub-strand	Code	Year 6 content descriptions	Lessons
Number and Algebra	Number and place value	ACMNA123	Select and apply efficient mental and written strategies and appropriate digital technologies to solve problems involving all four operations with whole numbers	3
Statistics and Probability	Data representation and interpretation	ACMSP147	Interpret and compare a range of data displays, including side-by-side column graphs for two categorical variables	5, 7
		ACMSP148	Interpret secondary data presented in digital media and elsewhere	1–7

 All the material in the first four columns of this table is sourced from the Australian Curriculum.

Creators and destroyers—Australian Curriculum: Design and technologies

Strand	Code	Year 6 content descriptions	Lessons
Processes and Production skills	ACTDEP025	Generate, develop and communicate design ideas and processes for audiences, using appropriate technical terms and graphical representation techniques	2, 8
	ACTDEP027	Negotiate criteria for success that include sustainability to evaluate design ideas, processes and solutions	2, 8
	ACTDEP028	Develop project plans that include consideration of resources when making designed solutions individually and collaboratively	2

 All the material in the first three columns of this table is sourced from the Australian Curriculum.

Cross-curriculum priorities

There are three cross-curriculum priorities identified by the Australian Curriculum:

- Aboriginal and Torres Strait Islander histories and cultures
- Asia and Australia's engagement with Asia
- Sustainability.

Two of these are embedded within *Creators and destroyers*, as described below.



Aboriginal and Torres Strait Islander histories and cultures

The Primary**Connections** Indigenous perspectives framework supports teachers' implementation of Aboriginal and Torres Strait Islander histories and cultures in science.

The framework can be accessed at: www.primaryconnections.org.au

Creators and destroyers focuses on the Western science method of using evidence-based claims about how Earth's surface is shaped by geological events. Aboriginal and Torres Strait Islander Peoples might have other ways of understanding how lands are shaped.

For example, the Dyirbal and Yidiny people explain that the formation of three volcanic crater lakes Yidyam (Lake Eacham), Barany (Lake Barrine) and Ngimun (Lake Euramo) happened "when two newly-initiated men broke a taboo and angered the rainbow serpent" back when the land was bush not rainforest. The description of events (see page 12, end of *Explore* Lesson 2) would be understood by scientists as accurately depicting a volcanic eruption. Geological evidence places the event as occurring more than 10,000 years ago, and pollen samples confirm the land was lush at that time.

Reference: Dixon, R.M.W. (1996). *Origin Legends and Linguistic Relationships*. Oceania Vol. 67, No. 2, Oceania Publications, University of Sydney.

Primary**Connections** recommends working with Aboriginal and Torres Strait Islander community members to access local and relevant cultural perspectives. Protocols for engaging with Aboriginal and Torres Strait Islander community members are provided in State and Territory education guidelines. Links to these are provided on the Primary**Connections** website.

Asia and Australia's engagement with Asia

Creators and destroyers provides opportunities for students to explore volcanic activity throughout the world, including the much higher incidence in some neighbouring Asian countries. They investigate and discuss physical characteristics of volcanoes and discuss the relationship local people share with them.

Teacher background information

This information is intended as teacher information only. It provides teachers with information relevant to the science concept so they can feel more confident and competent to teach each lesson. The content and vocabulary of this information is at a more detailed and advanced level than what is required for students.

Introduction to volcanoes

The surface of Earth is changing constantly. Some changes occur over a vast period of time, such as the uplifting and erosion of mountain ranges or the expansion and contraction of seas. Other changes, such as those created by volcanic eruptions and lava flows, are visible in human timescales, over a period of hours, days or weeks.

Volcanoes form over a rupture in the outermost shell, or crust, of a planet. They allow hot molten rock (magma) to rise from a 'magma chamber' to the surface. Gases dissolved in the lava can build up pockets of pressure, creating violent eruptions that spew tephra (commonly referred to as volcanic ash) into the air. This is a mixture of pulverised rock, minerals and volcanic glass. Lava flows and ash contribute to building volcanic cones. They can also cover wide areas of the surrounding landscape.

Not all volcanic eruptions are explosive. Measures such as the Volcanic Explosivity Index (VEI) attempt to provide classifications. The VEI is logarithmic like the Richter scale, and volcanoes are described progressively as effusive, gentle, explosive, catastrophic, cataclysmic, paroxysmic, colossal, mega-colossal or apocalyptic.

Earth has not had an apocalyptic eruption (VEI 8) since Lake Taupo in New Zealand erupted 26,500 years ago, which ejected thousands of cubic kilometres of tephra into the air and caused tens to hundreds of square kilometres of land to collapse into the magma chamber below, driving even more massive eruptions of exploding magma that flowed outwards in a huge flood of incandescent gas and ash. The caldera (bowl-shaped depression) left from the explosion then filled with water, causing a huge outwash flood when it overflowed. Colossal volcanic eruptions (VEI 6), such as Krakatoa in 1883, dump huge volumes of volcanic gases and dust into the atmosphere that cause cooling of the climate for several years, including more severe winters. Historic famines in Russia and Europe have been linked to colossal eruptions in Peru, New Zealand and elsewhere.

Hydrothermal vents are commonly found near volcanically active places. Water is heated by the hot rocks below, dissolves minerals from them and then rises through fissures to the surface. On land they form features such as hot springs, fumaroles (hot steam vents) or geysers. Under the sea they can form 'black smokers'. Bacteria can survive on the energy of dissolved molecules in that water, forming the basis of complex ecosystems at the bottom of the sea that do not need the energy of the Sun to survive.

Creation of volcanoes

Earth's rigid outer shell (the lithosphere) is divided into segments called tectonic plates. These tectonic plates of rock are moving slowly, either away from, towards or past each other. Different plates move at different speeds but none are currently moving faster than 10 cm a year. Australia is moving northwards at about 7 cm a year. The tectonic plates, forming the

lithosphere (lithos meaning ‘rocky’), lie on top of the asthenosphere—a hot, weak layer in the upper mantle (asthenos meaning ‘without strength’), and each plate varies in thickness and composition. The thicker and lighter parts form the continents, whereas the thinner and denser parts of each plate form the oceanic crust.

The rocks of the asthenosphere are near their melting point, which gives them a high degree of plasticity. This weak layer allows the more rigid lithospheric plates above it to move across Earth’s surface. Underneath the asthenosphere the mantle rocks are again more rigid, but still soft enough to slowly creep in huge convection currents within Earth, which rise after being heated from below by Earth’s core. They sink after losing this heat on contact with the tectonic plates. Water boiling in a pot has similar convection currents; however, the mantle currents move much more slowly.

Where two plates are moving apart (diverging), new crust is formed through volcanic activity. This mainly happens on the sea floor and does not create volcanic islands (with the exception of Iceland). When two tectonic plates converge, denser oceanic rocks of one plate can be pushed beneath the other down into the mantle. Rising temperatures and water released from the descending plate causes melting in the upper mantle, leading to magma formation. The magma is less dense and so rises buoyantly through the surrounding rocks. The magma does not always rise to the surface, but when it does it creates a volcano. This is how the volcanoes such as those of the Pacific Ring of Fire and Mount Etna were created.

Some volcanoes occur far from tectonic plate boundaries; for example, the chain of Islands that form Hawai’i. In the 1970s scientists proposed that there are areas where hot columns of mantle material are rising and melting—mantle plumes or ‘hot spots’. Linear chains of volcanoes form at the surface above these hot spots, marking the movement of the plate over the magma source.

There are no plate boundaries on the Australian continent today so active volcanoes are rare. Australia does include a group of volcanic islands in its territories 4000 kilometres south-west of Perth (two-thirds of the way to Madagascar).

Students’ conceptions

Students might believe that volcanoes are randomly scattered across Earth’s surface and/or that they are found on land only. The majority of volcanoes are situated along tectonic plate boundaries on land and under the oceans.

Students might believe that Earth’s crust is floating everywhere on a layer of molten magma below. The layer of rocks beneath the crust, Earth’s mantle, is almost entirely solid, even though it is very hot and soft. Melting to form magma only occurs in unusual circumstances, mostly related to plate boundaries.

Students might believe that all volcanoes are large, cone-shaped mountains that violently explode from the top. There are many types of volcanoes, including wide plateaus, fissure vents, craters and bulging domes. The levels of silica and dissolved gases in the magma determine whether a volcano erupts explosively or effusively (ie pouring out slow lava streams). In explosive volcanoes, magma and gas may also escape through cracks and weak areas on the sides of the volcano, in addition to the top vent.

Students might believe that volcanoes that have not erupted in hundreds of years are extinct. The life span of some volcanoes is measured in millions of years, so even if it last erupted thousands of years ago, it will be considered as dormant. The absence of a magma source defines an 'extinct' volcano, but this can be hard to predict. Mount Vesuvius was considered extinct until it erupted and destroyed Pompeii in 79 AD. Scientists monitor minor activity, including small earthquakes, inflations and gas emissions, to determine whether a volcano is dormant and whether it is likely to erupt.

To access more in-depth science information in the form of text, diagrams and animations, refer to the Primary**Connections** Science Background Resource, available on the Primary**Connections** website:
www.primaryconnections.org.au

Lesson 1 Pompeii and Vesuvius

AT A GLANCE

To capture students' interest and find out what they think they know about how sudden geographical changes and extreme weather conditions can affect Earth's surface.

To elicit students' questions about volcanoes.

Students:

- observe an animation of the effects of the eruption of Mount Vesuvius
- create a T-chart on volcanoes as 'creators' and 'destroyers'.

ENGAGE

Lesson focus

The focus of the *Engage* phase is to spark students' interest, stimulate their curiosity, raise questions for inquiry and elicit their existing beliefs about the topic. These existing ideas can then be taken account of in future lessons.

Assessment focus



Diagnostic assessment is an important aspect of the *Engage* phase. In this lesson you will elicit what students already know and understand about how:

- sudden geological changes and extreme weather events can affect Earth's surface.

Key lesson outcomes

Science

Students will be able to represent their current understanding as they:

- describe the effects of volcanic eruption
- list ideas on how volcanoes are both 'creators' and 'destroyers'
- list what they know about the formation of volcanoes
- express ideas on where volcanoes are located.

Literacy

Students will be able to:

- use analytical images such as tables and T-charts to display information
- participate in and contribute to discussions, sharing information, experiences and opinions.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page xii).

Teacher background information

Mount Vesuvius is a volcano in Italy, located 9 km east of Naples. It has erupted more than thirty times since the most famous, large and destructive eruption in 79 AD that destroyed Pompeii and Herculaneum. Its last eruption was in 1944.

Mount Vesuvius is considered one of the most dangerous volcanoes in the world because it is active, has a history of erupting violently and is a densely populated volcanic region. Over three million people live nearby.

Equipment

FOR THE CLASS

- class science journal
- word wall
- TWLH chart (see 'Preparation')
- self-adhesive notes

FOR EACH STUDENT

- science journal

Preparation

- Read 'How to use a science journal' (Appendix 2).
- Read 'How to use a word wall' (Appendix 3).
- Read 'How to use a TWLH chart' (Appendix 6). Prepare a four-column chart for the class with the following headings:

Creators and destroyers TWLH chart

What we Think we know	What we Want to learn	What we Learned	How we know

- View the video 'Deconstructing history: Pompeii'. See:
www.history.com/topics/ancient-history/pompeii
Optional: Show students a video of a recent eruption; for example:
education.abc.net.au/home#!/media/31140/iceland-s-volcanic-eruption-2010
Note: Do not introduce students to resources that describe and explain volcanoes, as the purpose of this lesson is to elicit existing ideas.
- *Optional:* Display the class science journal, TWLH chart, and a world map in a digital format.

Lesson steps

- 1 Show students a video of a volcanic eruption (see 'Preparation').



- 2 Discuss the video, asking questions such as:
 - What do you think volcanoes are?
 - What do you think volcanoes look like?
 - How do you think volcanoes are created?
 - How often do you think they erupt? How much warning do you think people have before an eruption?

Note: In the *Engage* phase, do not provide any formal definitions or correct students' answers, as the purpose is to elicit students' prior knowledge.

- 3 Introduce the class science journal and discuss its purpose and features. Record students' thoughts.

Literacy focus

Why do we use a science journal?

We use a **science journal** to record what we see, hear, feel and think so that we can look at it later to help us with our claims and evidence.

What does a science journal include?

A **science journal** includes dates and times. It might include written text, drawings, measurements, labelled diagrams, photographs, tables and graphs.



- 4 Explain that Mount Vesuvius in Europe is considered a very dangerous volcano, as it is active and over three million people live only a few kilometres away. Ask questions such as:

- Would you live near a volcano? Why or why not?
- What might be some reasons for why people choose to live close to a volcano?

Record students' thoughts in the class science journal.



- 5 Explain that volcanoes are seen as both 'creators' and 'destroyers'. Ask students to create a T-chart in their science journal and list reasons why volcanoes are seen that way. Discuss the purpose and features of a T-chart.

Literacy focus

Why do we use a T-chart?

We use a **T-chart** to organise information so that we can understand it more easily.

What does a T-chart include?

A **T-chart** includes two columns with headings. Information is put into the columns based on the headings.

- 6 Allow time for students to complete the activity.

Volcanoes	
<u>Creators</u>	<u>Destroyers</u>
<ul style="list-style-type: none"> • Fear • Destruction • Land masses • Precious minerals • Molten • Caves 	<ul style="list-style-type: none"> • Food sources • People • Cities and buildings • Plant life • Pets/animals

Class work sample of 'Creators and destroyers T-chart'



- 7 Ask students if they were surprised to hear about a volcano occurring in Italy. Discuss what students think they know about the location of volcanoes, asking questions such as:
- Where do you think volcanoes occur?
 - Where do you think you would find the most volcanoes occurring
 - Do you think that volcanoes occur under the sea? Why or why not?
 - Do you think there are volcanoes erupting today? Why or why not?

Record students' thoughts in the class science journal.

- 8 Introduce the TWLH chart. Discuss its purpose and features.

Literacy focus

Why do we use a TWLH chart?

We use a **TWLH chart** to show our thoughts and ideas about a topic before, during and after an investigation or activity.

What does a TWLH chart include?

A **TWLH chart** includes four sections with the headings: What we **T**hink we know, What we **W**ant to learn, What we **L**earned, and **H**ow we know. Words or pictures can be used to show our thoughts and ideas.

- 9 Discuss with students what rows to add to the table; for example, 'Volcanoes as creators', 'Volcanoes as destroyers' and 'Where and why volcanoes form'. Ask students to Think:Pair:Share with a partner and write on self-adhesive notes what they know about volcanoes. Add students' ideas under the '**T**' column of 'What we **T**hink we know'.
- 10 Ask students what questions they have about volcanoes and write them on self-adhesive notes. Place the notes in the appropriate row under the '**W**' column of 'What we **W**ant to know'.
- 11 Introduce the class word wall. Discuss its purpose and features.

Literacy focus

Why do we use a word wall?

We use a **word wall** to record words we know or learn about a topic. We display the **word wall** in the classroom so that we can look up words we are learning about and see how they are spelled.

What does a word wall include?

A **word wall** includes a topic title or picture and words that we have seen or heard about the topic.

- 12** Ask students what words from today's lesson would be useful to place on the word wall.

Curriculum links

Geography

- Practise using longitude and latitude lines to find famous volcanoes.
See: <https://www.3dgeography.co.uk/volcano-worksheets>

Lesson 2 Eruptions!

AT A GLANCE

To provide students with hands-on, shared experiences of the effects of a volcanic eruption

Session 1 Two recounts

Students:

- watch a video and read an eyewitness account of the events of the eruption of Mount Vesuvius
- begin planning a secondary data investigation into the location of volcanoes.

Session 2 Ready to research

Students:

- begin researching a well-known volcano.

Lesson focus

The *Explore* phase is designed to provide students with hands-on experiences of the science phenomenon. Students explore ideas, collect evidence, discuss their observations and keep records such as science journal entries. The *Explore* phase ensures all students have a shared experience that can be discussed and explained in the *Explain* phase.

Assessment focus



Formative assessment is an ongoing aspect of the *Explore* phase. It involves monitoring students' developing understanding and giving feedback that extends their learning. In this lesson you will monitor students' developing understanding of how:

- sudden geological changes and extreme weather events can affect Earth's surface.

You will also monitor their developing science inquiry skills (see page xi).

Key lesson outcomes

Science

Students will be able to:

- identify key features of volcanic eruptions
- compare the reliability of different sources of evidence.

Literacy

Students will be able to:

- select, navigate and read factual texts to source information on a selected volcano
- use comprehension strategies to analyse and compare information between two texts on a volcanic eruption
- participate in and contribute to discussions, developing and supporting arguments.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page xii).

Teacher background information

A volcano forms where a fissure or vent allows magma (hot, molten rock) to reach Earth's surface. An eruption occurs when magma reaches the surface, at which point it can be referred to as lava. Explosive eruptions occur when dissolved gas, mostly water, is released from the magma under high pressure. This does not always happen; for example, the volcanoes in Hawai'i are shield volcanoes that steadily produce lava flows with little dissolved gas from various vents around the summit without explosions. The shape of the volcanic cone is a reflection of how explosive the eruptions are, which in turn depends on the type of magma and the amount of gas.

It is not necessarily the lava itself that makes volcanic activity dangerous. Explosive eruptions can create fast-moving flows, or avalanches, of ash and rock suspended in hot gas. These 'pyroclastic flows' rush down the sides of the volcanoes and can reach speeds of up to 300 km/h. These pyroclastic flows are extremely dangerous and can flatten objects in their path, and their heat incinerates any living things it encounters. Hot plumes of ash rise high in the air; some so high they enter the stratosphere and affect the weather around the globe. Explosions in the Southern Hemisphere have been historically linked with recorded famines in Europe and Russia—a phenomenon known as 'volcanic winters'. A modern hazard is that the particles can damage aircraft, especially their engines.

Media coverage of volcanic activity is sporadic, as many ongoing volcanic events are below the sea, in uninhabited areas and/or do not cause a loss of life. Depiction in films and stories overemphasises sensational deaths, such as by poisonous gases, lava flows and fear and panic during evacuation. In reality, ash flows and mudslides formed by heavy rains mixing with loose volcanic ash are the major causes of fatalities. As for many catastrophic events, starvation and disease also continue to claim lives long after the event itself.

Students' conceptions

Students might believe that volcanic eruptions are due to chemical reactions, including explosives, or fire. The heat of an explosion is due to the heat of the magma rather than fire

and does not cause the event. Chemical reactions, in particular bicarbonate of soda and vinegar, are commonly used to mimic the gaseous build-up of explosive eruptions. However, in reality, it is the decompression of dissolved gases, such as carbon dioxide, in the magma itself that creates the explosions.

Students might believe that volcanoes erupt only through the top vent; however, the magma may also emerge through vents in the side.

Session 1 Two recounts

Equipment

FOR THE CLASS

- class science journal
- word wall
- TWLH chart
- a copy of the Weekly Volcanic Activity Report (see 'Preparation')
- self-adhesive dots
- large world map with latitude and longitude lines
- 1 enlarged copy of 'Volcanoes investigation planner' (Resource sheet 1)
- 1 enlarged copy of 'An eyewitness story' (Resource sheet 2)

FOR EACH STUDENT

- science journal
- 1 copy of 'Volcanoes investigation planner' (Resource sheet 1)
- 1 copy of 'An eyewitness story' (Resource sheet 2)
- *optional*: A4 size world map

Preparation

- Read 'How to use a glossary' (Appendix 4).
- In the class science journal, prepare two columns for the glossary, as shown.

Creators and destroyers glossary

Term	Description

- Prepare a large world map marked with latitude and longitude lines for the class to place self-adhesive dots of the location of weekly volcanic activity.
Optional: Colour-code the self-adhesive dots; for example, yellow for predicted sites, red for current activity and blue for volcanoes that are not currently active.
- Print out a copy of the 'Weekly Volcanic Activity Report'. See: www.volcano.si.edu/reports_weekly.cfm

- Prepare the video produced by Museum Victoria on a re-creation of Mount Vesuvius erupting. See: <https://museums victoria.com.au/learning/learning-lab/ancient-roman-empire/recreation-of-vesuvius-erupting/>
- *Optional:* Display 'Volcanoes investigation planner' (Resource sheet 1) and 'An eyewitness story' (Resource sheet 2) in a digital format.

Lesson steps

- 1 Review the previous lesson using the TWLH chart, glossary and the class science journal. Focus students' attention on what they think about volcanic eruptions.
- 2 Introduce the world map (see 'Preparation'). Explain that the class will be collecting and representing data on current volcanic activity while they study volcanoes. Discuss how scientists sometimes rely on other scientists' observations and data when they cannot directly observe what is happening and/or cannot set up their own monitoring stations.
- 3 Introduce the enlarged copy of 'Volcanoes investigation planner' (Resource sheet 1) and read through with students. Explain that students will complete the investigation and look for patterns to allow them to answer the investigation question later in the term.
- 4 Ask students to complete the planning section of the investigation planner. Place self-adhesive dots on the large world map where students think volcanoes are located. Ensure the dots are easily recognisable; for example, by marking them 'P' for prediction or colour-coding them (see 'Preparation').

Optional: Show students the website where the weekly report will come from and ask them to source the data each week.

Volcanoes investigation planner

PrimaryConnections
By
PrimaryConnections
Creators and destroyers

Name: _____ Date: _____

Secondary data investigation

What is the question for investigation? <i>Where do volcanoes occur?</i>	What are your current ideas? <i>I think that volcanoes occur anywhere where magma can escape from the Earth's core.</i>
Describe how you will collect the data: <i>We will collect data from a weekly volcanic eruptions report from scientists monitoring volcanoes.</i>	How will you present the data? <i>As a map with dots showing the locations of volcanic eruptions.</i>

Results

What did you find out from the data? What patterns can you see?

My claim is:

My evidence is:

Copyright © Australian Academy of Science 2015. Resource sheet 1

Work sample of 'Volcanoes investigation planner' (Resource sheet 1)

- 5 On the world map, place self-adhesive dots on locations of the previous week's new volcanic activity.

Optional: Ask students to mark the locations of the volcanoes on their own map.

- 6 Discuss the purpose and features of a glossary. Explain to students that as the unit progresses, they will create a glossary in their science journal.

Literacy focus

Why do we use a glossary?

We use a **glossary** to provide definitions of technical terms that relate to a particular subject matter or topic.

What does a glossary include?

A **glossary** includes a list of technical terms in alphabetical order, accompanied by a description or an explanation of the term in the context of the subject.

- 7 Model how to develop a glossary in the class science journal, using the term 'volcanic eruption'. Write the term in the science journal and invite students to describe what they think the term means. Add an agreed description of the term 'volcanic eruption' to the glossary.

Note: Encourage students to revisit the glossary as the unit progresses so they can change or confirm their descriptions of key vocabulary.

- 8 Remind students of the video that they watched in the previous lesson. Explain that students will now be watching an animation of what the eruption might have looked like.
- 9 Ask students to predict what they think they will see in the video, and to record their predictions in their science journal.
- 10 Watch the video of the animation of Mount Vesuvius erupting (see 'Preparation'). Ask students to record their observations in their science journal.



- 11 Discuss the video and ask questions such as:
- What did you see happening as the volcano erupted?
 - What happened that you expected to see?
 - What happened that you didn't expect to see?
 - How accurate do you think the video is? What makes you think that?
 - What sources of evidence could have been used to reconstruct the events? (e.g. geological, geographical, archaeological, historical).

Record students' ideas in the class science journal.

- 12 Introduce the enlarged copy of 'An eyewitness story' (Resource sheet 2). Read through and discuss. Discuss the purpose and features of a factual recount.

Literacy focus

Why do we use a factual recount?

We use a **factual recount** to describe experiences we have had. We can read a **factual recount** to find out about things that have happened to someone else

What does a factual recount include?

A **factual recount** might include descriptions of personal feelings and other people who were part of the events. It is often written in the past tense.

Optional: Watch and listen to a reading of the letters of Pliny the Younger. See: eruptionmtvesuvius.weebly.com/plinys-letters.htm



- 13** Discuss the major moments of the eruption using both Pliny's recount and information from the video. Ask questions such as:
- What was similar about the two recounts?
 - What was different about the two recounts? Why do you think that is?
 - What do you think were the key characteristics of the eruption?
 - Do you think all volcanoes would have the same types of eruptions? How might they be similar or different?

Record students' thoughts in the class science journal.

- 14** Add words that students might be unsure of to the glossary and the word wall; for example, 'pumice'.
- 15** Update the TWLH chart and word wall.

Volcanoes investigation planner

Name: _____ **Date:** _____

Secondary data investigation

What is the question for investigation? 	What are your current ideas?
Describe how you will collect the data: 	How will you present the data?

Results

What did you find out from the data? What patterns can you see?

My claim is:

My evidence is:

An eyewitness' story

Mount Vesuvius, on the west coast of Italy, erupted in 79 AD and destroyed the nearby city of Pompeii. A detailed account of the disaster was recorded by Pliny the Younger, who was just 18 years old and living in the town of Misenum, just 20 kilometres from Pompeii. He describes the events of the second day in a letter to his friend Tacitus.

... cloud of unusual size and appearance. ... The cloud was rising from a mountain—at such a distance we couldn't tell which, but afterwards learned that it was Vesuvius. I can best describe its shape by likening it to a pine tree. It rose into the sky on a very long 'trunk' from which spread some 'branches'. Some of the cloud was white, in other parts there were dark patches of dirt and ash.

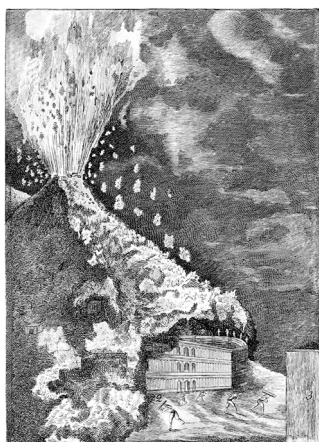
The carts that we had ordered brought were moving in opposite directions, though the ground was perfectly flat, and they wouldn't stay in place even with their wheels blocked by stones. In addition, it seemed as though the sea was being sucked backwards, as if it were being pushed back by the shaking of the land. Certainly the shoreline moved outwards, and many sea creatures were left on dry sand. Behind us were frightening dark clouds, rent by lightning twisted and hurled, opening to reveal huge figures of flame. These were like lightning, but bigger ...

It wasn't long thereafter that the cloud stretched down to the ground and covered the sea ...

Now came the dust, though still thinly ... We had scarcely sat down when a darkness came that was not like a moonless or cloudy night, but more like the black of closed and unlighted rooms. You could hear women lamenting, children crying, men shouting ...

It grew lighter, though that seemed not a return of day, but a sign that the fire was approaching. The fire itself actually stopped some distance away, but darkness and ashes came again, a great weight of them. We stood up and shook the ash off again and again, otherwise we would have been covered with it and crushed by the weight ...

At last the cloud thinned out and dwindled to no more than smoke or fog. Soon there was real daylight. The sun was even shining, though with the lurid glow it has after an eclipse. The sight that met our still terrified eyes was a changed world, buried in ash-like snow.



About 2000 residents of Pompeii survived the initial eruption of Vesuvius. A second more powerful eruption the following morning killed everyone who had remained in the city. When rain mixed with the ash it formed a sort of concrete preserving the city and the bodies within it.

Reference: *The Destruction of Pompeii, 79 AD*, EyeWitness to History, www.eyewitnesstohistory.com/pompeii.htm (1999).

Image: "Tesoro letterario di Ercolano p87" by Giacomo Castrucci - Tesoro letterario di Ercolano page 87. Licensed under Public Domain via Wikimedia Commons – http://commons.wikimedia.org/wiki/File:Tesoro_letterario_di_Ercolano_p87.jpg#/media/File:Tesoro_letterario_di_Ercolano_p87.jpg

Session 2 Ready to research

Equipment

FOR THE CLASS

- class science journal
- word wall
- team skills chart
- team roles chart
- TWLH chart
- 1 enlarged copy of 'A volcano' (Resource sheet 3)
- multimedia resources on volcanoes (see 'Preparation')

FOR EACH TEAM


- each team member's science journal
- role wristbands or badges for Director, Manager and Speaker
- 1 copy of 'A volcano' (Resource sheet 3) per team member

Preparation

- Read 'How to organise collaborative learning teams' (Appendix 1). Display in the classroom an enlarged copy of the team skills chart and the team roles chart. Prepare role wristbands or badges.
- Prepare an enlarged copy of 'A volcano' (Resource sheet 3).
- Identify a volcano for each team to study; for example:

• Krakatoa	• Mount Kilauea	• Cotopaxi
• Nevado del Ruiz	• Mount Saint Helens	• Yellowstone Caldera
• Mount Merapi	• Aconcagua	• Eyjafjallajokull
• Mount Fuji	• Ngauruhoe	• Hekla
• Pinatubo	• Mount Tambora	• Mount Pelée
• Whakaari (White Island)	• Paricutin	• Kawah Ijen
• Tungurahua	• Mount Nyiragongo	• Mount Etna
• Stromboli	• Mauna Loa	• Thera
- Collect multimedia resources, including books, posters and images, on the volcanoes listed above. Place this in an accessible area of the classroom for students to consult over the course of the unit.
- Determine deadlines for the creation of the information product (see Lesson step 9).
- *Optional:* Display 'A volcano' (Resource sheet 3) in a digital format.

Lesson steps

- 1 Review the previous lesson, using the TWLH chart, glossary and the class science journal. Focus students' attention on the key characteristics of the eruption of Pompeii.
- 2 Explain that students will be working in collaborative learning teams to research a volcano over the course of the unit. Introduce an enlarged copy of 'A volcano' (Resource sheet 3), and read through with students.
-  3 Explain that teams will complete their copy of 'A volcano' (Resource sheet 3) by summarising information on their volcano over the course of the unit. Discuss the purpose and features of a summary.



Literacy focus

Why do we use a summary?

We use a **summary** to present the main points of a topic or text.

What does a summary include?

A **summary** includes a precise description of the main points of a topic or text.

- 4 Explain that teams will use their collected information to design, produce and present an information product about their volcano. Discuss different multimedia presentations they could develop, such as posters, visual slides, 3D models or animations. Explain that their product should be made to inform an audience about how the volcano was formed and explain changes that occurred in the landscape due to the volcanic eruption.
- 5 Discuss the possible audiences for their presentation; for example, their peers, or another class in the school.
- 6 Ask students to suggest criteria for the information products; for example:
 - must have scientifically accurate information
 - contain clear, concise communication
 - be engaging and interesting
 - have minimal impact on the environment.
- 7 Assign a volcano to each team or ask teams to choose a volcano (see 'Preparation') from the list of volcanoes. Ask students to use the remainder of the session to begin researching the following information:
 - Age, location and appearance (shape) of the volcano
 - When it last erupted.
-  8 Form teams and allocate roles. Allow time for teams to begin researching information about their volcano.
If students are using collaborative teams for the first time, introduce and explain the team skills chart and team roles chart. Explain that students will wear role wristbands or badges to help them (and you) know which role each team member has.
-  9 Explain that as the unit progresses, teams are expected to:
 - a. make a collaborative decision about the type of information product they plan to produce
 - b. discuss their individual design ideas



- c. agree on techniques and a sequence for the development of the information product
 - d. develop a plan that considers time and available resources, including technology
 - e. allocate particular tasks to team members
 - f. complete the task by the deadline.
- 10** Suggest that teams might use ideas maps, annotated drawings or brainstorming to help develop their ideas. Remind teams to revise and update the information included as they learn about volcanoes.
- 11** Update the TWLH chart and word wall.

Curriculum links

Aboriginal and Torres Strait Islander histories and cultures

- Read and discuss how Indigenous people have preserved eyewitness accounts of historical events. For example, the following translation from the Ngadjjob people about the creation of the lakes Yidyam (Lake Eacham), Barany (Lake Barrine) and Ngimun (Lake Euramo), which scientists estimate happened over 10,000 years ago.

"It is said that two newly-initiated men broke a taboo and angered the rainbow serpent, major spirit of the area (as of most of Australia). As a result the camping-place began to change, the earth under the camp roaring like thunder. The wind started to blow down, as if a cyclone were coming. The camping-place began to twist and crack. While this was happening there was in the sky a red cloud, of a hue never seen before. The people tried to run from side to side but were swallowed by a crack which opened in the ground ..."

Reference: Dixon, R.M.W. (1996). Origin Legends and Linguistic Relationships. Oceania Vol. 67, No. 2, Oceania Publications, University of Sydney.

- PrimaryConnections recommends working with Aboriginal and Torres Strait islander community members to access local and relevant cultural perspectives. Protocols for engaging with Aboriginal and Torres Strait Islander community members are provided in State and Territory education guidelines. Links to these are provided on the PrimaryConnections website: www.primaryconnections.org.au.

English

- Compare accounts of the different eruptions, analysing and evaluating similarities and differences.
- Compare choices made by authors on accounts of the same eruption; for example vocabulary choice and narrative viewpoint.
- Ask students to write a news article on the eruption, as if they were reporting in 79 AD.

A volcano

Name: _____ **Date:** _____

Volcano name:	Location:
Type of volcano:	Number of eruptions over the past 100 years:
Closest city:	Distance closest city is from the volcano:
Population of closest city:	Date of last eruption:
Last eruption details:	Diagram of shape of volcano:
Benefits of living nearby	
Risks to local population:	
Other information:	

Lesson 3 Lava creations

AT A GLANCE

To provide students with hands-on, shared experiences of the relationship between volcano shape and lava viscosity.

Session 1 Inside my volcano

Students:

- create a cross-section of the interior of their volcano.

Session 2 Varying viscosity

Students:

- plan and conduct an investigation into whether the viscosity of a volcano's lava affects its shape
- relate their findings to the shape of the volcano they are investigating.

Lesson focus

The *Explore* phase is designed to provide students with hands-on experiences of the science phenomenon. Students explore ideas, collect evidence, discuss their observations and keep records such as science journal entries. The *Explore* phase ensures all students have a shared experience that can be discussed and explained in the *Explain* phase.

Assessment focus



Formative assessment is an ongoing aspect of the *Explore* phase. It involves monitoring students' developing understanding and giving feedback that extends their learning. In this lesson you will monitor students' developing understanding of how:

- sudden geological changes, such as from volcanic eruptions, can affect Earth's surface.

You will also monitor their developing science inquiry skills (see page xi).

Key lesson outcomes

Science

Students will be able to:

- identify the internal features of a volcano
- compare the behaviour of liquids with different viscosities
- plan and conduct a fair test
- relate the viscosity of lava to the shape of a volcano.

Literacy

Students will be able to:

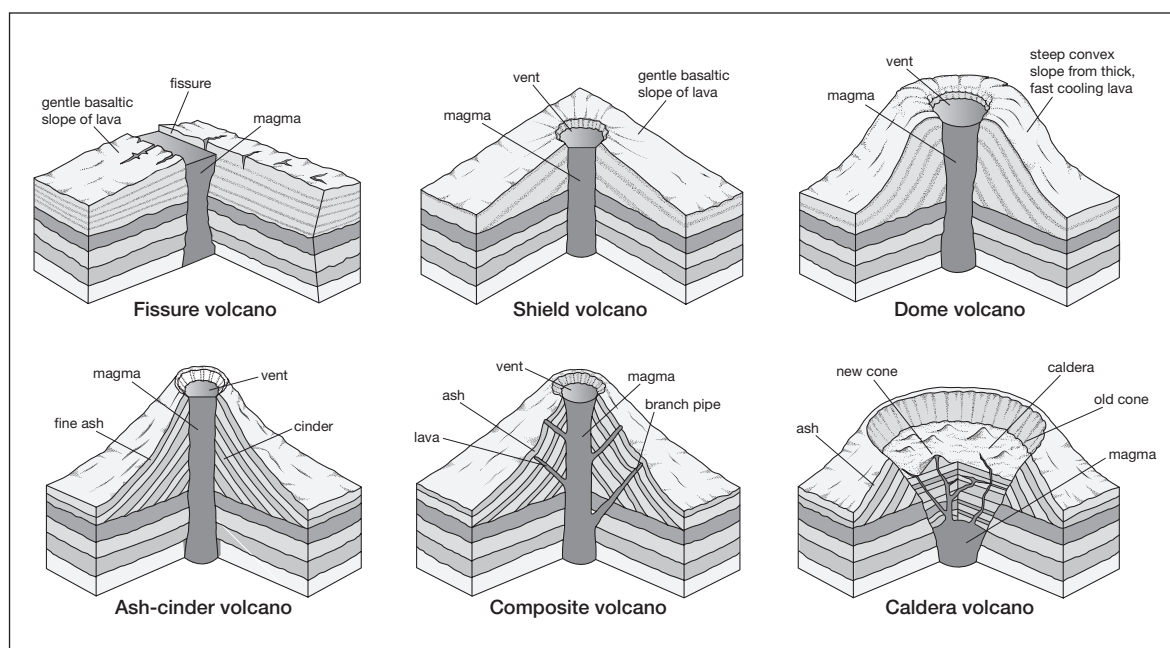
- draw a cross-section to represent ideas about the interior of a volcano
- use scientific vocabulary to describe the interior of a volcano
- participate in and contribute to discussions, sharing and evaluating information and opinions.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page xii).

Teacher background information

Lava and shapes of volcanoes

When magma (hot, molten rock) reaches Earth's surface through a vent called a volcano, we call it lava. The viscosity of lava plays a key role in determining the shape a volcanic mountain will take. Thin, runny (low-viscosity) lavas produce volcanoes that are low, flat and shield shaped. High-viscosity lavas produce steep-sided lava domes (narrow bases but not very tall, usually just a few hundreds of metres high) and the mid-viscosity lavas form large, tall, stratovolcanoes (composite) with slope angles in between those of shields and domes.



Types of volcano

Lava viscosity is influenced by factors such as the mineral, water and gas content, and the temperature of the lava. Lavas rich in elements that create chemical bonds stick together more and are therefore more viscous. This means that adding water, which can create more weak electronic bonds, actually increases magma's viscosity. This is counterintuitive as we generally use water in the kitchen to make solutions 'runnier' (less viscous).

The cooler a liquid is, the more viscous it is. It is simple to see this in the kitchen: warming honey will make it flow better. Magma is formed when rocks reach a certain temperature—their 'melting point'. This melting point depends on a number of factors, including the presence of water. Water lowers the melting point of the rocks that form magma, which means that magma can form at cooler temperatures. The resultant magma is therefore more cool and viscous than other magmas formed with less water.

Advantages and disadvantages of the chosen model

Students use a mixture of flour and water to simulate lava. This equipment is easy to source and quite safe to use. By modifying the amount of water, students can create solutions of different viscosity. However, it is important to highlight that this model does not explain why different magmas have different viscosity. In particular, adding more water makes magma more viscous, not less, as discussed above.

In this model, the high-viscosity mix creates the tallest mountains. Some of them may get so tall they collapse, which happens to real volcanoes as well. However, the height is also dependent on the quantity of lava produced and the presence of ash cover. Viscosity determines the steepness of the sides in nature, as well as in this model.

Students' conceptions

Students might only identify tall peaks with craters at their summit as volcanoes. These are the most iconic landforms, and are more likely to be photographed, drawn and discussed. The far more common subduction volcanoes are largely underwater, and are therefore less likely to be thought of.

Session 1 Inside my volcano

Equipment

FOR THE CLASS

- class science journal
- word wall
- TWLH chart
- world map and self-adhesive dots (see Lesson 1)
- copy of the Weekly Volcanic Activity Report (see 'Preparation')
- factual texts or videos on the interior of a volcano (see 'Preparation')
- *optional*: factual videos showing lava flows (see 'Preparation')

FOR EACH STUDENT

- science journal

Preparation

- Print out a copy of the 'Weekly Volcanic Activity Report'. See: www.volcano.si.edu/reports_weekly.cfm
 - Find videos or texts that show the interior of a volcano; for example:
<https://www.skwirk.com.au/esa/volcanoes>
<https://museumsvictoria.com.au/learning/learning-lab/ancient-roman-empire/recreation-of-vesuvius-erupting/>
 - *Optional:* Find videos showing different lava flows; for example:
<http://www.volcanovideo.com/p8vidclp.htm>
- Note:** Do not source videos or texts that explain how the viscosity of the lava affects the shape of the volcano, as students will be investigating the relationship between those two variables in the next Session.

Lesson steps

- 1 Introduce the 'Weekly Volcanic Activity Report' (see 'Preparation'). As a class, place self-adhesive dots on locations of the previous week's volcanic activity onto the world map. *Optional:* Using distinctive self-adhesive dots; for example, different colours or marked with a star, plot the locations of the volcanoes teams are currently researching.
- 2 Review the previous lesson using the TWLH chart, glossary and the class science journal, focusing students' attention on the major moments of the Mount Vesuvius eruption.
- 3 Ask students to draw in their science journal the shape of the volcano they are investigating and then draw what they think is inside it. Discuss the purpose and features of a cross-section.

Literacy focus

Why do we use a cross-section?

We use a **cross-section** to show the inside of an object.

What does a cross-section include?

A **cross-section** includes a title, a drawing and an indication of scale. The main features are labelled and lines or arrows connect the label to the feature.



- 4 Watch a video or read a text on the interior of volcanoes (see 'Preparation'). Ask questions such as:

- What did the video tell us about volcanoes?
- Are all volcanoes the same shape?
- How have your ideas changed?

- 5 Agree on descriptions for terms used, including 'vent', 'magma' and 'lava', and add them to the glossary.



- 6 Ask students to update their cross-sections and share with the class. Discuss how volcanoes have similar internal features, such as magma chambers and vents, but that they can be very different shapes and sizes.



- 7 Ask students what variables might affect the shape of a volcano. Record students' ideas in the class science journal.
- 8 Explain that while all magma is made of liquid rock, its composition and temperature varies from place to place, which means it has different properties; for example, how runny (viscous) it is. Ask students to describe the term 'viscosity' and add an agreed description to the glossary in the class science journal.
- 9 *Optional:* Introduce text or videos showing viscous lava flows (see 'Preparation').
- 10 Explain that in the next Session students will be working in their collaborative learning teams to investigate whether the viscosity of a volcano's lava could affect its shape.
- 11 Update the TWLH chart and word wall.

Session 2 Varying viscosity

Equipment

FOR THE CLASS

- class science journal
- word wall
- team skills chart
- team roles chart
- TWLH chart
- 1 enlarged copy of 'Lava investigation planner' (Resource sheet 4)
- *optional:* digital camera
- *optional:* factual videos about different volcano types (see 'Preparation')

FOR EACH TEAM

- each team member's science journal
- role wristbands or badges for Director, Manager and Speaker
- water
- 3 plastic cups with $\frac{1}{4}$ cup of flour in each
- 3 smooth plastic plates
- 1 stopwatch
- 1 plastic spoon
- 1 tablespoon
- 1 ruler
- 1 copy of 'Lava investigation planner' (Resource sheet 4) per team member
- *optional:* red food colouring

Preparation

- Read 'How to conduct a fair test' (Appendix 5).
- Read 'How to facilitate evidence-based discussions' (Appendix 7).
- Read 'How to write questions for investigation' (Appendix 8).
- Prepare an enlarged copy of 'Lava investigation planner' (Resource sheet 4).
- *Optional:* Find videos showing different types of volcanoes; for example, <https://www.pbs.org/wgbh/nova/video/meet-the-volcanoes/>
- *Optional:* Display 'Lava investigation planner' (Resource sheet 4) in a digital format.

Lesson steps

- 1 Review the previous Session, using the TWLH chart, glossary and the class science journal. Focus students' attention on the question of whether the viscosity of a volcano's lava could affect its shape
- 2 Explain that students will be working in collaborative learning teams to investigate whether the viscosity of a volcano's lava could affect a volcano's shape.
- 3 Discuss how to investigate this; for example, by pouring liquids of different viscosities onto plates and observing the shape created. Discuss what it would be useful to measure/observe; for example, the shape created and the area the liquid flows over.
- 4 Model how to write a question for investigation; for example, 'What happens to the shape that a poured liquid takes on when we change the viscosity of the liquid?'
- 5 Discuss how to keep the test fair; for example, by keeping the rate of pour the same and making observations after the same amount of time. Ask teams to identify what they will:

Change: the viscosity of the liquid (by changing the relative amount of flour and water)

Measure/Observe: the width that the base of the liquid spreads to after 2 minutes, and the steepness of the slope created after 2 minutes.

Keep the same: the temperature of the liquid; the rate at which the liquid is poured; the amount of liquid poured; the surface on which it is poured; and where the liquid is poured.

- 6 Explain each team will prepare three liquids of different viscosity by adding a set amount of water to each cup containing flour and stirring

High viscosity: add 3 tablespoons of water

Medium viscosity: add 6 tablespoons of water

Low viscosity: add 9 tablespoons of water

Discuss how adding the same amount of water for each viscosity of liquid makes the results of teams more easily comparable.

- 7 Introduce the enlarged copy of 'Lava investigation planner' (Resource sheet 4). Read through and model how to record observations. Discuss the purpose and features of a table.

Literacy focus

Why do we use a table?

We use a **table** to organise information so that we can understand it more easily.

What does a table include?

A **table** includes a title, columns with headings and information organised under each heading.

- 8 Form teams and allocate roles. Ask Managers to collect team equipment.
- 9 Allow time for teams to plan and conduct their investigations and record their results on their copy of 'Lava investigation planner' (Resource sheet 4).

Optional: Take digital photos of investigations.





Different viscosities in lava investigation

- EXPLORE
- 10 Ask Speakers to present their results to the class. Encourage students to discuss each other’s findings using the Science Question Starters (see Appendix 7)
Optional: Ask teams to graph their results.

11 As a class evaluate the investigation, asking questions such as:
 - What went well?
 - What did you find difficult?
 - How could you improve the investigation next time (fairness, accuracy)?
 - What were the advantages of using this model for investigating the viscosity of lava?
 - What were the disadvantages or limitations of using this model?

Record students’ thoughts in the class science journal.

Lava investigation planner

Results

Viscosity	Speed of flow (slow, medium or fast?)	Area of the base	Steepness of slope
High 2lbs water	slow	7cm	2cm
Medium 2.5lbs water	medium	9cm	1cm
Low 3.5lbs water	fast	12.5cm	2mm

Explaining results

Did the viscosity of the liquid affect the speed of its flow? How?

The viscosity of the liquid did affect the speed of its flow. The higher the viscosity, the slower its flow is. The lower the viscosity is, the faster the flow is.

Did the viscosity of the liquid affect the area of the base? How?

Yes, because the lower the viscosity is, the bigger the area of the base is because it spreads more than the high viscosity fluid.

Did the viscosity of the liquid affect the steepness of the slope? How?

Yes, it did because the high viscosity doesn't spread as much. Therefore, the higher the viscosity, the steeper the slope is.

Did your results match your predictions? Why do you think that is?

yes, because I thought that the lower viscosity flows faster than the higher viscosity which is true. I also thought the area of the base of the high viscosity will be smaller than the low viscosity.

Based on your results, do you think the viscosity of a volcano's lava could affect its shape? What makes you think that?

Yes, because after the volcano has erupted, the lava sets into rock. If the lava has a high viscosity, it doesn't spread as much so the volcano will be taller than a volcano with lava that is a low viscosity.

Resource sheet 4

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Wow! Excellent thinking

Work sample ‘Lava investigation planner’ (Resource sheet 4)



- 12** Ask students to review the cross-section they created in Session 1 and make claims about the likely viscosity of the lava of the volcano they are investigating based on its shape. For example:



My claim: 'My volcano has lava of low viscosity.' My evidence: 'In our investigation, the low-viscosity liquid formed a low and flat shape, which matches the shape of my volcano.'



- 13** Discuss how the students have only investigated one variable that could affect the shape of a volcano. Review students' initial thoughts about variables that might affect the shape of a volcano and discuss how those might be investigated.

- 14** *Optional:* Introduce text or videos about different volcano types (see 'Preparation').

- 15** Update the TWLH chart and word wall.



- 16** Allow time for teams to update their planning and to research their information product about a volcano (see Lesson 2, Session 2).

Curriculum links

Science

- Investigate the properties of lava compared to magma; for example, by reading: <https://www.nationalgeographic.com/news/2018/05/volcano-magma-lava-difference-science/>

Lava investigation planner

Name: _____ **Date:** _____

Other members of your team: _____

<p>What are you going to investigate?</p>		<p>What do you think will happen? Explain why.</p>	
<p>Can you write it as a question?</p>		<p>Give scientific explanations for your prediction.</p>	
<p>To make the test fair, what things (variables) are you going to:</p>			
<p>Change?</p>	<p>Measure?</p>	<p>Keep the same?</p>	
<p>Change only one thing.</p>	<p>What would the change affect</p>	<p>Which variables will you control?</p>	
<p>Describe how you will set up your investigation.</p>		<p>What equipment will you need?</p>	
<p>Use drawings if necessary.</p>		<p>Use dot points.</p>	

Lava investigation planner

Results

Viscosity	Width of liquid (after 2 min)	Steepness of slope (Draw it.)
High		
Medium		
Low		

Explaining results

How did the viscosity of the liquid affect the shape of the volcano?

Did your results match your predictions? Why do you think that is?

Based on your results, do you think the viscosity of a volcano's lava could affect its shape?
 What makes you think that?

Lesson 4 Living on the edge

AT A GLANCE

To provide students with hands-on, shared experiences of the benefits of living near volcanoes.

Students:

- create an ideas map about benefits of living near a volcano
- read factual texts
- compare living near a volcano with other natural hazards.

Lesson focus

The *Explore* phase is designed to provide students with hands-on experiences of the science phenomenon. Students explore ideas, collect evidence, discuss their observations and keep records such as science journal entries. The *Explore* phase ensures all students have a shared experience that can be discussed and explained in the *Explain* phase.

Assessment focus



Formative assessment is an ongoing aspect of the *Explore* phase. It involves monitoring students' developing understanding and giving feedback that extends their learning. In this lesson you will monitor students' developing understanding of how:

- sudden geological changes, such as volcanic eruptions, and extreme weather events can affect Earth's surface.

You will also monitor their developing science inquiry skills (see page xi).

Key lesson outcomes

Science

Students will be able to:

- discuss the difference between dormant and extinct volcanoes
- identify benefits of living near a volcano
- discuss the effects of other natural events on Earth's surface.

Literacy

Students will be able to:

- interpret and analyse information from a factual text
- create an ideas map
- participate in and contribute to discussions
- share and evaluate information and ideas.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page xii).

Teacher background information

Why live near a volcano?

Many people live near volcanoes across the world. There are a number of possible reasons:

- **Connection to place:** People may have a strong connection to the land and history of a place, guiding their desire to reside in a particular area.
- **Mineral-rich soils:** Lava and ash from volcanoes contain rich sources of nutrients for plants and make productive lands to till.
- **Mining:** Lava can contain gold, silver, diamonds, copper and zinc. Volcanic products such as pumice and volcanic ash are also collected for use in a variety of products from hand soaps to concrete.
- **Tourism:** Each year millions of people travel to visit volcanoes, for their scenery, skiing and/or hydrothermal springs. This creates lots of hospitality jobs for local populations.
- **Geothermal energy:** The rising steam around volcanoes can be used to turn turbines to produce electricity (similarly to harnessing wind or water for energy).
- **Access to ports:** Volcanoes may occur near natural ports, bringing commerce and activity to a region.
- **Access to land:** In particularly populated zones, volcanic land may be a necessary resource for housing.

Volcanoes can be categorised as either ‘active’, ‘dormant’ (no eruptions in 10,000 years) or ‘extinct’ (no magma accumulating in the chamber). However, these are loose categorisations, and may lead to a false sense of security—volcanoes that were previously believed to be extinct have erupted.

An issue with classifying volcanoes as ‘extinct’ is that volcanoes operate over very long time spans. For example, the volcano beneath Yellowstone National Park in the United States has erupted three times: 2.1 million, 1.3 million, and 640,000 years ago. Some fear it may happen again soon but those figures are large approximations. The chance of an eruption happening in this century is 1 in 1000.

Equipment

FOR THE CLASS

- class science journal
- word wall
- TWLH chart
- world map and self-adhesive dots (see Lesson 1)
- a copy of the Weekly Volcanic Activity Report (see 'Preparation')
- ideas map (see 'Preparation')
- 1 enlarged copy of 'Natural hazards' (Resource sheet 5)
- 1 set of cards with names of hazards (see 'Preparation')
- factual texts or videos on the benefits of living near a volcano (see 'Preparation')
- *optional:* factual texts or videos about different natural hazards (see 'Preparation')

FOR EACH STUDENT

- science journal
- 1 copy of 'Natural hazards' (Resource sheet 5)

Preparation

- Print out a copy of the 'Weekly Volcanic Activity Report'. See: www.volcano.si.edu/reports_weekly.cfm
- Find videos or texts about living near a volcano; for example: '5 reasons to live near a volcano'. See: <https://www.youtube.com/watch?v=27PKn9csG18>
- Prepare an enlarged copy of 'Natural hazards' (Resource sheet 5).
- Prepare a set of seven cards with the names of hazards: 'Volcanic eruption', 'Flood', 'Bushfire', 'Earthquake', 'Tsunami', 'Tropical cyclone', and 'Landslide'.
- Prepare for an ideas map by writing the title 'Living near a volcano' in the centre of a double-page spread in the class science journal or in the centre of a large sheet of paper.
- *Optional:* Find videos or texts about natural events or extreme weather; for example: 'Extreme weather'. See: <http://www.abc.net.au/catalyst/stories/3796205.htm>
- *Optional:* Display the enlarged copy of 'Natural hazards' (Resource sheet 5) in a digital format.

Lesson steps

- 1 Review previous lessons using the TWLH chart, glossary and the class science journal. Focus students' attention on the effects of a volcanic eruption.
- 2 Introduce the 'Weekly Volcanic Activity Report' (see 'Preparation'). As a class, place self-adhesive dots on locations of the previous week's volcanic activity onto the world map.
- 3 As a class discuss the map, asking students if any of the identified volcanoes are in populated zones.
- 4 Explain that one in four people on Earth live close to a volcano, although some of those volcanoes are considered to be dormant or extinct. Discuss how Mount Vesuvius was thought to be extinct until it erupted in 79 AD. Add an agreed description of the terms 'dormant' and 'extinct' to the glossary in the class science journal.
- 5 Introduce the class ideas map (see 'Preparation'). Discuss the purpose and features of an ideas map.

Literacy focus

Why do we use an ideas map?

We use an **ideas map** to show what we think about a topic.

What does an ideas map include?

An **ideas map** includes a title in the centre. Ideas are written around it and arrows are drawn between similar ideas. An **ideas map** might include pictures and symbols.



- 6 Ask students to suggest reasons why people might choose to live close to a volcano while knowing that there are risks of it erupting. Record students' ideas on the class ideas map.



- 7 Show students a video on why people live near volcanoes (see 'Preparation').
- 8 Update the class ideas map with new information learned about why people live near volcanoes.

- 9 Discuss how volcanic eruptions are natural events that cause changes to Earth's surface and affect people who live in the area. Ask students what other natural events might cause changes to Earth's surface; for example, tsunamis, mudslides, hurricanes, bushfires, drought and avalanches.

Record students' ideas in the class science journal.

- 10 Introduce the enlarged copy of 'Natural hazards' (Resource sheet 5). Read through and discuss why the term 'hazards' is used to describe these events (i.e they pose a danger or risk). Add an agreed description of the term 'hazard' to the class glossary.

Note: Be sensitive to students' experiences while facilitating this discussion. Some students may have been directly affected by natural hazards, or have family members that have been affected.



- 11** Discuss how people live in areas prone to natural hazards for many different reasons; for example, areas prone to cyclones have tropical climates that are good for growing some types of fruit such as bananas. Ask students to think of reasons why people might choose to live in areas affected by different natural hazards, and record students' ideas in the class science journal.

Optional: Ask students to work in teams to create an ideas map to present to the class about living in an area affected by one of the hazards. Introduce collected resources for students to consult (see 'Preparation').

- 12** Show students two of the prepared cards, 'Volcanic eruption' and 'Flood' (see 'Preparation'). Place the cards on walls on opposite sides of the classroom and create room for an imaginary line between the two signs. Explain that students will stand along this line to identify which natural hazard-affected area they would prefer to live in. Discuss how hazards can be linked; for example, earthquakes can cause tsunamis and landslides, but for the purposes of the exercise students are simply comparing two potential hazards.

- 13** Ask students to stand along the line, depending on whether they would prefer to live in an area predominantly affected by floods or by volcanic eruption

- The more they would prefer to live in a flood zone, the closer they will stand to the 'Flood' sign.
- The more they would prefer to live near a volcano, the closer they will stand to the 'Volcanic eruption' sign.
- If they don't have a strong preference they stand equidistant from the two cards. Explain that this is called a 'continuum'. Encourage students to refer to their science journal, the class science journal, the ideas map and their copy of 'Natural hazards' (Resource sheet 5) when making their decision.



- 14** Ask students to discuss the reasons for their position with other students who are standing nearby.

- 15** Ask some students to explain to the class their reasoning for why they are standing where they are on the continuum.

- 16** Repeat, comparing other hazards.

Optional: Ask students to draw a continuum line for each of the comparisons in their science journal and mark a cross on the line according to their response.

- 17** Update the 'L' column of the TWLH chart about what students have learned from today's lesson. Update the word wall.

Curriculum links

Science

- Investigate how plants respond to ash in their soils at different concentrations.
- Compare geothermal energy production with other forms of electricity production.
- Research a natural disaster and the effect it had on the local area and the people living there.

Natural hazards

Hazards	are caused by ...	They occur ...	The chance of occurrence is ...	They affect Earth's surface by ...
Floods	... intense rainfall that leads to there being more water than can be drained away or absorbed by the ground.	... in areas near rivers or lakes, but flash floods can strike areas not usually covered by water.	... highest during the rainy season and in places that are low lying.	... washing away soil and vegetation and transferring them to other places.
Bushfires	... natural events such as lightning strikes. They can also be caused by humans, such as arsonists, careless smokers, or by carelessly lit campfires.	... in areas with large amounts of dry wood and scrub to fuel the fire.	... highest in the dry season and in areas that have lots of plants that burn easily.	... destroying the natural vegetation cover, which means that the soil can then be blown away by the wind.
Earthquakes	... the sudden release of energy along cracks on Earth's surface, called fault lines. The energy comes from the movement of Earth's tectonic plates (and is felt as shaking).	... most often near the edges of tectonic plates but can also occur elsewhere.	... highest in regions where there is lots of tectonic plate movement.	... shaking the ground violently and moving the surface up, down or sideways.
Tsunamis	... underwater earthquakes, volcanic eruptions or landslides. These cause sudden movements of a massive amount of water, creating a wave that is much more powerful than normal waves.	... most often where two tectonic plates are pushing together. Tsunamis can travel long distances through the ocean until they break against a coastline.	... highest in areas where an ocean plate slides beneath another tectonic plate.	... washing beaches, soil and vegetation out to sea or carrying debris inland. The effect is greatest in unprotected coastal areas.
Tropical cyclones (can also be called a hurricane or typhoon)	... massive storms that form over warm oceans. They can produce destructive winds, torrential rains, storm tides, and high waves.	... usually in tropical areas, although they can also move into non-tropical areas.	... highest during the wet season. They build up offshore and then break on land.	... causing extensive erosion and destroying vegetation along coastlines and in inland places. Heavy rainfall can lead to landslides.
Landslides	... events such as extreme rainfall or earthquakes that lead to the sudden movement of rocks.	... in places with a steep enough slope and unstable enough ground or snow.	... highest in places that have steep, unstable slopes.	... moving rocks and rubble down the slope. This can change the shape of mountains, build up rocks in new places and block river drainage.

Lesson 5 Popping tops (Optional)

AT A GLANCE

To provide students with hands-on, shared experiences of the risks of living near volcanoes.

Students:

- watch a video on the risks of living near a volcano
- use a film canister to explore predicting an 'eruption'
- discuss the difficulty of predicting volcanic eruptions.

Lesson focus

The *Explore* phase is designed to provide students with hands-on experiences of the science phenomenon. Students explore ideas, collect evidence, discuss their observations and keep records such as science journal entries. The *Explore* phase ensures all students have a shared experience that can be discussed and explained in the *Explain* phase.

Assessment focus



Formative assessment is an ongoing aspect of the *Explore* phase. It involves monitoring students' developing understanding and giving feedback that extends their learning. In this lesson you will monitor students' developing understanding of how:

- sudden geological changes, such as volcanic eruptions, can affect Earth's surface.

You will also monitor their developing science inquiry skills (see page xi).

Key lesson outcomes

Science

Students will be able to:

- discuss the risks of living near a volcano
- identify the signs that a volcano might erupt
- investigate a simplified model of volcanic eruption.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page xii).

Literacy

Students will be able to:

- make and record observations
- engage in discussion to compare ideas.

Teacher background information

Signs that a volcano might erupt

- **Increases in seismic activity:** Volcanoes are associated with an ongoing low level of small earthquakes. An increase in the level of activity, such as the earthquakes experienced by the people of Pompeii in the days preceding the eruption of Mount Vesuvius, can signify that magma is pushing through rock close to the surface and that an eruption is imminent. Scientists can use seismographs to monitor the activity. Knowing about the types of earthquakes, and where they started, provides better information about the risks of eruption.
- **Increases in gas production:** As magma reaches the surface, the pressure lowers and gases dissolved in it escape. A rise in the percentage of sulfur dioxide, which smells like rotten eggs, is an important sign, as it can reflect an increase of gas production in general. Correlation spectrometers (COSPECS) can measure amounts of sulfur dioxide in the gases to provide more detailed information.
- **Ground deformation:** Swelling of the slopes of a volcano can indicate that magma is filling the chamber below, near the surface. Scientists monitoring an active volcano will often measure the tilt of the slope and track changes in the rate of swelling, using tiltmeters and geodimeters. Satellites and webcams are also useful tools. An increased rate of swelling is a good sign that an eruption is imminent, especially if accompanied by increases of gas and tremors.

Can we predict when a volcano will erupt?

Volcanologists refer to ‘forecasting’ eruptions; the same way meteorologists ‘forecast’ the weather. Both systems have predictive models but are working with highly variable systems. Our understanding of eruptions has come a long way and so has our ability to forecast them. For example, in 1991 Mount Pinatubo in the Philippines became active. Volcanologists took readings, looked at evidence from past eruptions and completed a hazard assessment. They managed to convince the local population that it was a real threat and an evacuation saved over 20,000 lives.

One contributing factor to the success of the evacuation was that the volcano’s activity swiftly culminated with a devastating eruption. A similar case for Tungurahua in Ecuador led to the evacuation of 15,000 people in 1999, but the eruption did not occur and it was labelled an economic and political disaster. People in the region were evacuated several more times during the next decade, with many becoming very sceptical. The volcano has since erupted, in 2013 for example, but not with the same level of devastation as Mount Pinatubo.

One of the key issues with forecasting whether a volcano will erupt is that it needs to be under constant surveillance, preferably with a record of baseline activity and knowledge of its eruption history. However, many volcanoes across the world are not monitored, even if they are active. The shortage of funds, people and equipment makes it more difficult to forecast sudden events. Volcanoes rarely ‘erupt without warning’; rather, the events preceding the eruption have not been monitored.

Advantages and disadvantages of the model produced

In this activity the volcano is modelled by a container with a lid that seals tightly and pops off (rather than screws or clips). This is a good model for certain types of explosive volcanoes in which a 'cap' of hard rock forms. It is important to note with students that not all volcanic eruptions are violent or can be modelled this way; otherwise this activity may reinforce existing conceptions. Fizzing tablets produce gas through a chemical reaction, unlike volcanoes in which dissolved gas is released through release of pressure. A better analogy is the rise of bubbles of dissolved carbon dioxide when you begin to unscrew a bottle of fizzy drink. The advantage of using fizzing tablets is that the release of the gas building up to an explosive event is a complex reaction with many variables that can affect it, highlighting the difficulties of exact predictions in a complex system.

Students' conceptions

Students might hold alternative views of why volcanoes erupt, including that it is wind blowing over the tops of volcanic mountains that causes them to erupt (this idea dates back to the ancient Greeks). These views can be tied with different ways of understanding Earth's formation and its landscapes. Scientists explain that volcanic eruptions depend on a number of variables, including the filling of a magma chamber and, for some volcanoes, the decompression of dissolved gases.

Some students might think that if volcanoes do not erupt, then the pressure inside Earth will cause it to explode. However, in comparison to Earth's size, it is a very small pocket in its crust that is under pressure prior to a volcanic eruption.

Equipment

FOR THE CLASS

- class science journal
- team skills chart
- team roles chart
- TWLH chart
- word wall
- 1 container with a pop-on lid (e.g. a plastic film canister with lid)
- 1 small measuring cup
- 1 fizzy tablet (e.g. Be occa™, cut in half)
- 1 stopwatch
- 1 pair of safety glasses
- factual texts or videos on the risks of living near a volcano (see 'Preparation')
- a copy of the Weekly Volcanic Activity Report

FOR EACH TEAM

- each team member's science journal
- role wristbands or badges for Director, Manager and Speaker
- 1 container with a pop-on lid (e.g. a plastic film canister with lid)
- 1 small measuring cup
- 3 fizzy tablets (eg. Be occa™, cut into halves)
- 1 stopwatch
- 1 pair of safety glasses

Preparation

- Print out a copy of the 'Weekly Volcanic Activity Report'. See: www.volcano.si.edu/reports_weekly.cfm

- Find videos or texts on the risks of living near a volcano; for example: <http://education.abc.net.au/home#!/media/31149/volcanoes-and-people.htm>
- Collect containers with lids that seal tightly and pop off (rather than screw or clip). Many stores now sell empty film canisters for this use, but tins with lids that you press on or other tubes with pop-on caps work just as well.
- Identify an area for students to ‘explode’ their volcanoes; for example, outside on a hard surface. Drops of liquids may spray when the lids pop. If the area is carpeted ensure protections are in place.
- Practise making the ‘volcano’ explode before conducting the investigation: measure 20 mL of water into the canister, add half a fizzy tablet, quickly put the lid on, stand back and observe what happens. There should be enough time for students to put the lid on, place it down and back away. If there is not, modify the relative amounts of water and tablet to ensure that the activity is as safe as possible.
- Draw a table in the class science journal with the following headings.

‘Volcanic eruption’ model investigation

Trial	Time

Lesson steps

- 1 Review the previous lesson, using the TWLH chart, glossary and the class science journal. Focus students’ attention on the idea of ‘dormant’ and ‘extinct’ volcanoes. Introduce the ‘Weekly Volcanic Activity Report’ (see ‘Preparation’). As a class, place self-adhesive dots on locations of the previous week’s volcanic activity onto the world map.
- 2 Show students a video of the risks of living near a volcano (see ‘Preparation’).
- 3 Discuss the video and ask students questions such as:
 - In the video, a local girl says Vesuvius is an extinct volcano. Why isn’t Vesuvius considered to be extinct?
 - Scientists are monitoring Vesuvius for activity. What signs are they looking for?
 - What are the dangers of living near a volcano that were discussed in the video?
- 4 Explain that volcanologists are scientists who study volcanoes, and one thing they do is try to forecast when a volcano might erupt. Ask students questions such as:
 - What kinds of things might volcanologists look for to see if a volcano is about to erupt?
 - When is it very important to know if a volcano is about to erupt? (When people are living nearby; when it is likely to be destructive.)
 - Do you think predicting the day on which an eruption might occur is possible? Why do you think that?



Record students’ ideas in the class science journal.



- 5 Introduce the container with a lid (see ‘Preparation’) and the fizzy tablets. Discuss with students how this is a model of a volcano with a lava ‘cap’ and where gas is being released from the magma below. Ask students if it is a good model for the volcano they are researching, and ask them to give reasons for their answer.

- 6 Explain that in both the model and explosive eruptions the lid pops due to pressure from gas but that the reasons for the build-up of gas are very different (see 'Teacher Background Information').

- 7 Model how to set off a 'volcanic eruption' with the model (see Preparation'). Ask a student to time from when the lid goes on to when it pops off, using a stopwatch



Safety note: Explain that because of the explosive aspect of this investigation and the danger to their eyes, the team member near the 'volcano' must wear safety glasses until the lid has popped. Other team members must stand away from the canister.

Discuss other safety measures; for example, asking for your assistance if their 'volcano' has not erupted after a certain period of time (rather than putting their faces over it to examine it).

- 8 Introduce the table in the class science journal, and review the purpose and features of a table. In the relevant columns, record 'Class test' and the time taken. Discuss how the time scale of volcanic eruptions is much, much longer.

- 9 Explain that students will be working in collaborative learning teams to investigate the question 'Can we predict the eruption of a canister filled with water and a fizzy tablet to the exact second?'



- 10 Ask students to brainstorm what variables might affect the time it takes for the lid to pop off. (The amount of water; the size of the tablet; the time it takes to place the lid on the canister; the temperature of the water in which the tablet is placed.)

- 11 Explain that since teams will be attempting to predict the explosion, they should keep all variables as similar as possible.

- 12 Explain that teams will do three repeat trials of the investigation and that before each trial they will predict the time that they think it will take for the lid to pop off. Ask students why they think it is important to do repeat trials. (There might be variation caused by slight changes in the experiment; doing more than one trial allows you to calculate an average time, which is more likely to be accurate.)

- 13 Ask students to draw a table in their science journal with the following headings.

Trial	Predicted time	Actual time	Difference (seconds)



- 14 Model how to fill in the table. Explain how to calculate how close their prediction was by subtracting the smaller time from the larger (to avoid having negative numbers). Discuss how to subtract one time from another; for example, by first converting them both to seconds.

- 15 Explain that the purpose of the investigation is to see how close students can come to predicting the eruption, but that ultimately it is not important if their guess is not close to the actual result.



- 16 Allow time for students to conduct the investigation and record their results.



- 17 As a class, complete the table in the class science journal. Discuss the investigation, asking questions such as:

- Does the data show any patterns?
- Why did the time vary? What variables might have been different between trials?
- Did it get easier to predict the time with the repeats? Why or why not? *Optional:*

For advanced classes, discuss the mean and average of the dataset.



- 18** *Optional:* As a class tally the accuracy of students' predictions for certain time intervals and create a bar graph; for example: '0 seconds', '1–2 seconds', '3–5 seconds', '5–10 seconds', '10–20 seconds', 'more than 20 seconds'.



- 19** Discuss what students have learned about the predictability of this relatively simple system. Ask students questions such as:



- In what ways was this model similar to predicting a volcanic eruption? (For example, explosive eruptions release gas under pressure, it has a sealed chamber, it isn't easy to predict exactly when it will erupt.)
- In what ways was it different? (For example, volcanic eruptions don't occur due to chemical reactions, it takes much longer for gas to build up, the eruptions occur over a longer time, some volcanoes erupt from the side not the top.)
- Were there any warning signs that the lid was about to pop? (For example, the container lid was bulging.)
- What kinds of warning signs might scientists look for? (See Lesson step 21.)
- How might scientists know what is inside the volcano? (By studying past eruptions of the same volcano; by analysing rock and gas samples.)

Record students' thoughts in the class science journal.



- 20** Discuss different explosive models that are used as examples of how volcanoes erupt. Ask questions such as:

- What are the advantages of using a model?
- Does the model used today reflect the likely eruptions of your volcano
What makes you think that?
- What are the disadvantages or limitations of using this model?
- What other models can you think of to simulate volcanic eruptions?

- 21** Explain that scientists have many different signs that they look for when evaluating the likelihood of a volcanic eruption, including bulging of the mountain, frequency and nature of gas emissions, and frequency and intensity of earthquakes. They also study past explosions to help them predict what might happen.

- 22** Update the TWLH chart and word wall.

Curriculum links

Science

- Students plan and conduct a fair test of one of the variables that might affect the speed of the lid popping off; for example, by varying the temperature of the water.
- Watch a video about predicting eruptions. See:
<http://education.abc.net.au/home#!/media/30087/volcanic-eruptions-at-mount-ruapehu>

Lesson 6 Creators or destroyers?

AT A GLANCE

To support students to represent and explain their understanding of the formation and effects of volcanic eruptions on Earth's surface.

To introduce current scientific views

Session 1 Pros and cons

Students:

- review and update their T-chart from Lesson 1
- view a video on volcanoes as 'creators' and 'destroyers'.

Session 2 Deep down

Students:

- draw a cross-section of Earth's interior
- view a video and update their cross-section.

Lesson focus

In the *Explain* phase students develop a literacy product to represent their developing understanding. They discuss and identify patterns and relationships within their observations. Students consider the current views of scientists and deepen their own understanding.

Assessment focus



Formative assessment is an ongoing aspect of the *Explain* phase. It involves monitoring students' developing understanding and giving feedback that extends their learning. In this lesson you will monitor students' developing understanding of how:

- sudden geological changes, such as from volcanic eruptions, can affect Earth's surface.
- You are also able to look for evidence of students' use of appropriate ways to represent what they know and understand about how volcanic eruptions can affect Earth's surface and give them feedback on how they can improve their representations.

Key lesson outcomes

Science

Students will be able to:

- explain what Earth's interior looks like and where magma comes from
- explain why volcanoes are considered as both creators and destroyers.

Literacy

Students will be able to:

- update ideas on volcanoes in a T-chart
- participate in and contribute to discussions, and clarify ideas.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page xii).

Teacher background information

The interior of Earth modelled as composition layers

This model separates the layers inside the Earth according to the composition of the rocks. It is based partly on observations of pieces on mantle rocks brought up from more than 100km down by volcanoes, and of the composition of meteorites. Some meteorites have resulted from collisions between large asteroids that had separated into similar layers as those of Earth. Scientists also use what they know of the properties of different minerals, such as densities and melting points, and the way they transmit seismic waves, for example, from earthquakes.

This model divides Earth into three layers: the core made of metal (mainly iron); the mantle made of dense silicates (rocks with lots of silicon and oxygen); and the crust made up mostly of lighter silicate minerals. Earth's crust is the only layer that we can observe directly.

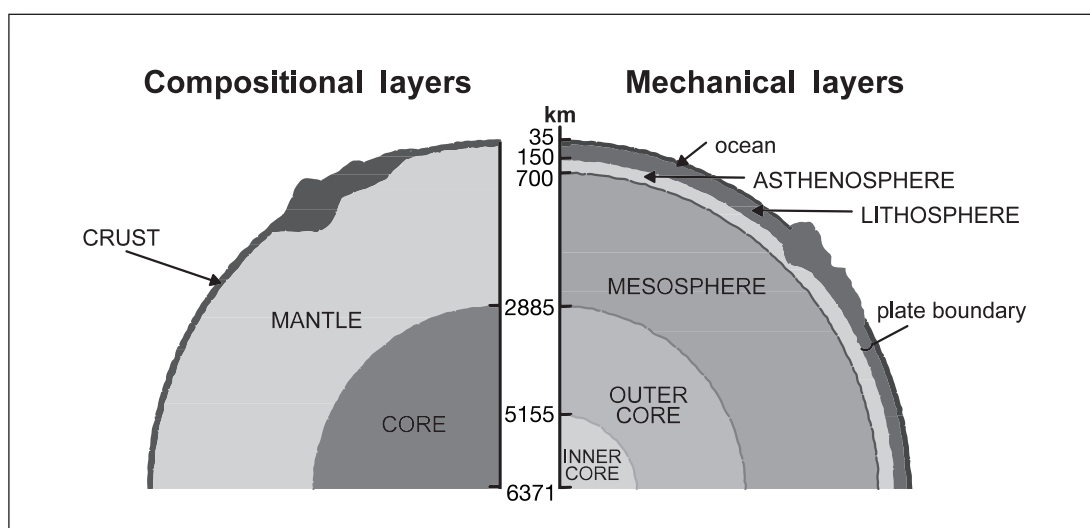


Diagram 1: Two complementary models of Earth's internal structure

The interior of Earth modelled as mechanical layers

This model is based on the physical properties of the rocks, deduced by looking at how seismic waves from earthquakes travel through them. For example, there is a type of seismic wave that does not travel through liquids, allowing us to tell that the outer core is molten.

This model explains the movement of tectonic plates. The lithosphere (composed of the crust and the top part of the mantle) is the hard, rocky shell broken into plates. The asthenosphere is the weakest part of the mantle, which acts as a lubricating layer, allowing the lithospheric plates to move across it. Underneath is the mesosphere, which is stronger but still quite soft and able to flow in very slow-moving convection currents. The core is divided into a liquid outer core and a solid inner core. Earth’s magnetic field has its origin in electrical currents powered by convection in the molten iron of the outer core.

Table: Mechanical layers of Earth and their properties

Layer	Composition	Physical properties
Lithosphere (outer mantle + crust)	Silica-rich rocks	Solid, forms tectonic plates 10°C – 1300°C
Asthenosphere (middle mantle)	Silica-poor rocks (silicates)	Semi-solid, enables plates to move ~2900°C – 1300°C
Mesosphere (inner mantle)	Silica-poor rocks (silicates)	Solid, undergoes slow convection ~2900°C – 4300°C
Outer core	Metal (iron–nickel alloy)	Liquid, creates Earth’s magnetic field ~4300°C – 5400°C
Inner core	Metal (iron–nickel alloy)	Solid ~5400°C, same as surface of the Sun

Students’ conceptions

Students might believe that Earth’s mantle is liquid rock, given how hot it is. In order for a substance to melt or to boil, it needs to reach a certain temperature—the ‘melting point’ or ‘boiling point’. However, that temperature also depends on the pressure. The higher the pressure, the higher the melting or boiling point. Water boils at only 71°C on the top of Mount Everest because the air pressure is lower than at sea level. The asthenosphere is near its melting point but has only about 3% melted rock in it; the remainder is solid but very hot and soft.

EXPLAIN

Session 1 Pros and cons

Equipment

FOR THE CLASS

- class science journal
- word wall
- team skills chart
- team roles chart
- TWLH chart
- world map and self-adhesive dots (see Lesson 1)
- a copy of the Weekly Volcanic Activity Report (see 'Preparation')
- factual texts or videos on volcanoes as creators and destroyers (see 'Preparation')

FOR EACH TEAM

- each team member's science journal
- role wristbands or badges for Director, Manager and Speaker

Preparation

- Print out a copy of the 'Weekly Volcanic Activity Report'. See: www.volcano.si.edu/reports_weekly.cfm
- Find videos or texts about volcanoes as creators and destroyers; for example: video.nationalgeographic.com.au/video/101-videos/volcanoes-101

EXPLAIN

Lesson steps

- 1 Introduce the 'Weekly Volcanic Activity Report' (see 'Preparation'). As a class, place self-adhesive dots on locations of the previous week's volcanic activity onto the world map.
- 2 Use the TWLH chart, glossary and class science journal to review what students have learned about volcanoes and the effect of volcanic eruptions on the landscape.
- 3 Discuss the term 'creators and destroyers'. Using the class science journal and TWLH chart, review what students initially thought about why volcanoes are called both of these terms.
- 4 Review the purpose and features of a T-chart. Explain that students will be working in their collaborative learning teams to create a new T-chart about volcanoes as creators and destroyers. Encourage students to record both what they think and why they think that (claims and evidence).
- 5 Re-form teams. Allow time for teams to complete the activity.
- 6 Ask Speakers to present their team's T-chart and highlight any changes or edits to it compared to Lesson 1.
- 7 Show students the video that discusses volcanoes as both creators and destroyers (see 'Preparation').





- 8 Review the video asking students if there is any further information from the video that can be added to their 'creators and destroyers' T-chart.
- 9 Ask students if there are any further questions that they have from watching the video. Add questions to the 'What we want to Learn' column of the TWLH chart.
- 10 Update the word wall with words and images.

Session 2 Deep down

Equipment

FOR THE CLASS

- class science journal
- word wall
- TWLH chart
- factual texts or videos on Earth's interior (see 'Preparation')

FOR EACH STUDENT

- science journal
- a copy of 'A volcano' (Resource sheet 3) from Lesson 2, Session 2

Preparation

- Find videos or texts that show Earth's interior; for example:
<http://education.abc.net.au/home#!/media/30528/below-earth-s-crust>
- *Optional:* Display texts that show Earth's interior.

Lesson steps

- 1 Review previous lessons using the TWLH chart, glossary and the class science journal, focusing students' attention on what they think they know about magma and where it comes from.
- 2 Discuss what students think they know about Earth's interior. Ask questions such as:
 - Could you dig a tunnel through Earth? Why or why not?
 - What would you find inside Earth
 - Would (...) be solid or liquid? Hard or soft? What makes you say that?
 - What is the temperature inside Earth?
 Record students' thoughts in the class science journal.
- 3 Ask students to draw a cross-section in their science journal showing what they think they know about Earth's interior. Revise the purpose and features of a cross-section.
- 4 Allow time for students to complete the activity.
- 5 Watch a video or read a text on Earth's interior (see 'Preparation').

- 6 Ask students to revise and update their cross-sections, using colours to represent the temperature of the different layers of Earth.
- 7 As a class, discuss the completed cross-section diagrams. Ask questions such as:
 - How was your diagram different from what you thought Earth's interior might be like?
 - Where do you think the heat comes from in a volcanic eruption?
- 8 Discuss with students how there is no layer of 'magma' within Earth. Explain that the rocks inside Earth do not liquefy into magma, as there is too much pressure, but that small pockets of magma form in the lithosphere or crust under certain conditions.
- 9 Allow time for teams to update their planning and drafts for their information product about the volcano they are investigating (see Lesson 2, Session 2).
- 10 Update the TWLH chart and word wall.

Curriculum links

Science

- Play the video activity 'Research volcanoes for World Wonders TV show'. See: <http://education.abc.net.au/home#!/media/31635/world-wonders-tv-show-volcanic-eruption>
- Create 3D models of Earth's interior using modelling clay.

Lesson 7 Where on Earth?

AT A GLANCE

To support students to conduct and analyse an investigation of where the majority of Earth's volcanoes are located and why.

Session 1 Dissecting data

Students:

- represent and analyse secondary data to identify the location of currently active volcanoes
- conduct research into explanations of why volcanoes are located where they are.

Session 2 Claims and evidence

Students:

- present their team's claims and evidence about where the majority of volcanoes are located
- present research about explanations of why volcanoes are located where they are.

Lesson focus

In the *Elaborate* phase students plan and conduct an open investigation to apply and extend their new conceptual understanding in a new context. It is designed to challenge and extend students' science understanding and science inquiry skills.

Assessment focus



Summative assessment of the Science Inquiry Skills is an important focus of the *Elaborate* phase (see page v).

Key lesson outcomes

Science

Students will be able to:

- analyse secondary data to identify the area of the location of most of Earth's volcanoes
- conduct research into why volcanoes are located along the edges of tectonic plates.

Literacy

Students will be able to:

- read and interpret different texts from different sources
- present and analyse information in tables, maps or graphs.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page xii).

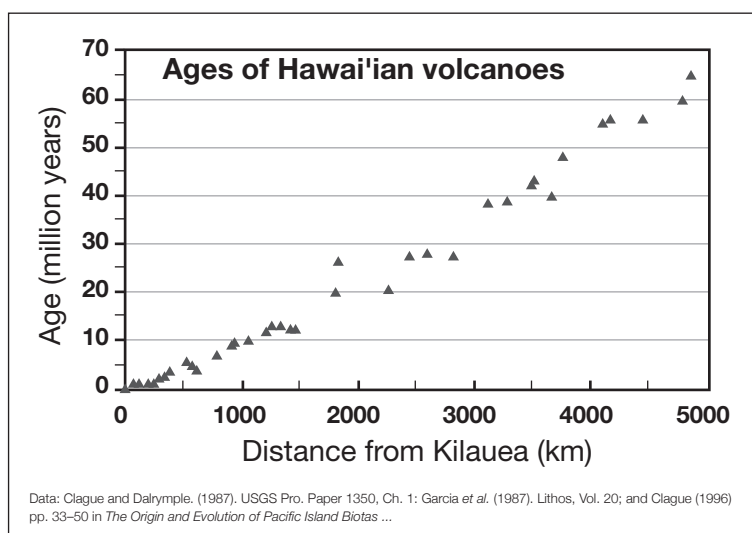
Teacher background information

The Ring of Fire

The Pacific Ocean is surrounded on many sides by zones of plate convergence and subduction. The dense, oceanic rocks of one plate are pushed beneath the other plate and descend into the mantle. There the water they contain is released, lowering the melting point of the mantle rocks, which then melt. This creates pockets of lighter magma that rise within the mantle. If they reach the surface, they create a volcano.

Hot spots

Not all volcanoes are formed along the boundaries of tectonic plates. Studying the islands of Hawai'i gave rise to the theory in the 1960s that their formation was due to the slow movement of a tectonic plate over an area of magma generation in the mantle, also called a 'hotspot'. The theory is that hotspots are thin, convection columns of rising mantle material, like a 'mantle plume'. This rising mantle plume experiences lower pressures, so the rocks begin to melt and form magma that feeds these isolated volcanoes that are far from a plate boundary. As the plate moves over the plume, successive volcanoes are formed and then, in turn, carried away from the magma source and become extinct. This explains the fact that the measured ages of the volcanoes near Hawai'i are in direct proportion to their distance from the current active ones on the big Island of Hawai'i at the south-east end of the chain (see graph).



It was an Australian scientist, Ian McDougall, who first dated the Hawai'ian islands using a revolutionary rock dating technique (potassium–argon dating). Many scientists did not think it was possible to date such 'young' volcanic rocks. Not only was he able to date the islands but also to quantify the rate of migration of the volcanism along the chain at ~10 cm/year. This evidence strongly supported Tuzo Wilson's model of volcanic hotspots.

Australian volcano chain

The longest chain of continental volcanoes in the world was recently discovered in Australia. Called the 'Cosgrove hotspot track', it stretches for more than 2000 km from Queensland down to Victoria. The mantle plume hotspot that created this volcanic chain is now believed to be located in the Bass Strait.

Students' conceptions

Students might believe that magma comes from a liquid layer in the mantle. The intense pressure inside the mantle means that the rock is still solid. Magmas are only produced where the upper mantle is disturbed in some way; for example, where rising convection currents reduce the pressure or where subduction adds water, which lowers the melting point.

Students might believe that volcanoes are randomly scattered across Earth, whereas the majority are located along tectonic plate boundaries. Volcanoes are found on land and under the ocean's surface, as well as in areas with cold climates like Antarctica.

Session 1 Dissecting data

Equipment

FOR THE CLASS

- class science journal
- word wall
- team skills chart
- team roles chart
- TWLH chart
- world map, mapping Weekly Volcanic Activity Report (see Lesson 1)
- enlarged copy of 'Volcanoes investigation planner' (Resource sheet 1) from Lesson 1
- 1 enlarged copy of 'Volcanoes investigation record' (Resource sheet 6)

FOR EACH TEAM

- each team member's science journal
- role wristbands or badges for Director, Manager and Speaker
- each team member's copy of 'Volcanoes investigation planner' (Resource sheet 1) from Lesson 1
- 1 copy of 'Volcanoes investigation record' (Resource sheet 6)

Preparation

- Print out a copy of the 'Weekly Volcanic Activity Report'. See: www.volcano.si.edu/reports_weekly.cfm
- Prepare an enlarged copy of 'Volcanoes investigation record' (Resource sheet 6).
- *Optional:* Display 'Volcanoes investigation record' (Resource sheet 6) in a digital format.

Lesson steps



- 1 Review the previous lesson, using the TWLH chart, glossary and the class science journal. Focus students' attention on the fact that magma does not form deep inside Earth.
- 2 Revisit the enlarged copy of 'Volcanoes investigation planner' (Resource sheet 1). Explain that students are now going to complete their investigation.
- 3 Review the map on which students have been tracking the 'Weekly Volcanic Activity Report' (see 'Preparation'). Ask students questions such as:
 - What pattern(s) can you see in the data that we have collected?
 - How does this compare with your initial ideas?
 - What are the limitations of the data we have analysed to date? (e.g. it only represents currently active volcanoes.)
 - How do you think a map of all the volcanoes in the world would compare with this one?
- 4 Explain that students will be working in collaborative learning teams to investigate where the majority of volcanoes have formed and why the volcanoes form there. Discuss data sources that teams could consult to get a more complete map of the distribution of volcanoes.
- 5 Introduce the enlarged copy of 'Volcanoes investigation record' (Resource sheet 6). Read through and discuss with students. Encourage teams to consult at least two different credible sources.
- 6 Discuss with the class different sources that provide credible information; for example, websites that are used by the school to research information, science books and science magazines.
- 7 Form teams and allocate roles. Allow time for students to conduct their investigation.
- 8 Ask students to complete their copy of 'Volcanoes investigation planner' (Resource sheet 1) once their team has analysed the available evidence. Explain that teams will present their results at the next session.
- 9 Re-form teams and allow time for students to plan and conduct their investigation.
- 10 Update the TWLH chart and word wall.



PrimaryConnections Creators and destroyers	
Volcanoes investigation record	
What do others say? (Use diagrams where possible)	
Question: Where are the majority of volcanoes formed and why are they formed there?	
Source:	Book - 'Volcanoes' by Lucy Floyd
Answer to question:	Most of the world's volcanoes form around the Pacific Ocean in an area called the Ring of Fire. The Earth's crust is made up of plates. Volcanoes form at the edges where two plates meet. When the plates bump into each other magma escapes.
Source:	Website - www.sciencetalks.co.nz
Answer to question:	75% of volcanoes are found in the Ring of Fire which is an area around the Pacific Ocean where tectonic plates meet.
Reflections:	My view (hasn't) changed because I thought that volcanoes could form anywhere where there were mountains.

Work sample of 'Volcanoes investigation record' (Resource sheet 6)

Volcanoes investigation record

Name: _____ **Date:** _____

What do others say? (Use diagrams where possible.)

Question: Where are the majority of volcanoes formed and why are they formed there?

Source:

Answer to question:

Source:

Answer to question:

Reflections:

My ideas have/haven't changed because:

Session 2 Claims and evidence

Equipment

FOR THE CLASS

- class science journal
- word wall
- team skills chart
- team roles chart
- TWLH chart
- world map mapping Weekly Volcanic Activity Report (see Lesson 1)
- materials to create information products on volcanoes (see Lesson 2, Session 2)
- *optional*: world map showing tectonic plates

FOR EACH TEAM

- science journal
- role wristbands or badges for Director, Manager and Speaker
- each team member's copy of 'Volcanoes investigation planner' (Resource sheet 1) from Lesson 1
- a copy of 'Volcanoes investigation record' (Resource sheet 6) from Lesson 7, Session 1
- each team member's copy of 'A volcano' (Resource sheet 3) from Lesson 2, Session 2

Preparation

- Read 'How to facilitate evidence-based discussions' (Appendix 7).
- *Optional*: Display 'Volcanoes investigation record' (Resource sheet 6) in a digital format.

Lesson steps

- 1 Allow time for teams to finish conducting their investigation and complete their copies of 'Volcanoes investigation planner' (Resource sheet 1) and 'Volcanoes investigation record' (Resource sheet 6).
- 2 Explain that teams will make an oral presentation of their results. Discuss the purpose and features of an oral presentation.

Literacy focus

Why do we use an oral presentation?

We use an **oral presentation** to entertain or provide information for an audience.

What does an oral presentation include?

An **oral presentation** is a speech that has an introduction, main part and conclusion. It might be serious or funny, depending on the topic and audience.



- 3** Ask teams to present the results of their investigation from the previous session. Ask questions such as:
 - What is your team's claim about where the majority of the volcanoes are located?
 - What is your evidence to support that?
 - What information did you find about why volcanoes are located in those areas?
 - How have your ideas changed?
- 4** Encourage students to question teams using the Science Question Starters in Appendix 7.

Optional: Introduce a world map showing the tectonic plates. Compare it with the world map of the Weekly Volcanic Activity. Discuss observations that students make.
- 5** Update the TWLH chart with claims and evidence from team investigations.
- 6** Allow time for teams to work on their information product about the volcano they are investigating (see Lesson 2, Session 2).
- 7** Update the class word wall.

Lesson 8 Volcanoes on show

AT A GLANCE

To provide opportunities for students to represent what they know about how sudden geological changes and extreme weather events can affect Earth's surface, and to reflect on their learning during the unit.

Students:

- create and/or present information about their researched volcano
- review and reflect on their learning during the unit.

Lesson focus

In the *Evaluate* phase students reflect on their learning journey and create a literacy product to re-represent their conceptual understanding.

Assessment focus



Summative assessment of the Science Understanding descriptions is an important aspect of the *Evaluate* phase. In this lesson you will be looking for evidence of the extent to which students understand how:

- sudden geological changes and extreme weather events can affect Earth's surface.

Key lesson outcomes

Science

Students will be able to:

- explain how a selected volcano was formed
- explain changes that occurred in the landscape due to the volcanic eruption.

Literacy

Students will be able to:

- plan, draft and publish informative texts, including images and digital resources appropriate to purpose and audience
- plan and deliver an oral presentation on a selected volcano
- contribute to discussions about their learning journey.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page xii).

Equipment

FOR THE CLASS

- class science journal
- word wall
- team skills chart
- team roles chart
- TWLH chart
- enlarged copy of 'A volcano' (Resource sheet 3) from Lesson 2, Session 2
- prepared poster or model of a volcano (see 'Preparation')



FOR EACH TEAM

- each team member's science journal
- role wristbands or badges for Director, Manager and Speaker
- a copy of 'A volcano' (Resource sheet 3) from Lesson 2, Session 2

Preparation

- Source an image or video of a student-made poster or model of a volcano for students to evaluate; for example, see: http://educatoral.com/09-10_volcano_projects.html
Or make a volcano model; for example, see: <http://www.volcanolive.com/model.html>

Lesson steps

- 1 Review the unit, using the TWLH chart, glossary and class science journal.
Ask questions such as:
 - What did we know about volcanoes at the beginning of the unit?
 - What questions did we have?
 - What have we learned? What claims have we made?
 - What evidence do we have for the claims that we made?
 - What questions weren't answered? How can we find the answers to the questions
- 2 Revise the enlarged copy of 'A volcano' (Resource sheet 3) from Lesson 2, Session 2. Remind students of the information product that they have been developing since Lesson 2, Session 2 and review the design criteria that they brainstormed.
- 3 Introduce the poster or model of a volcano (see 'Preparation'). Ask students to use the criteria they developed to evaluate the poster or model. Ask students what they might change or add to the list of design criteria.
- 4  Re-form teams and allow time for teams to review and update their information product, given the revised criteria.
- 5  When teams have completed their information product, allow time for each team to present their information product to the class and/or the intended audience.
- 6 Ask the audience to complete their evaluation of each team's presentation using the agreed criteria from Lesson step 3.
- 7 Ask audience members to provide feedback on how well the team addressed the agreed criteria and what the team could have done differently to improve their product.



8 Ask students to conduct a self-assessment of learning by completing sentences in their science journal, such as:

- I really enjoyed ... because ...
- I didn't enjoy ... because ...
- The activity that helped me learn the most about volcanoes was ...
- Before I thought ... and now I know ...
- My ideas haven't changed about ...
- I am still not sure about ...
- I would like to know more about ...

Appendix 1

How to organise collaborative learning teams (Year 3–Year 6)

Introduction

Students working in collaborative teams is a key feature of the PrimaryConnections inquiry-based program. By working in collaborative teams students are able to:

- communicate and compare their ideas with one another
- build on one another's ideas
- discuss and debate these ideas
- revise and rethink their reasoning
- present their final team's understanding through multimodal representations.

Opportunities for working in collaborative learning teams are highlighted throughout the unit.

Students need to be taught how to work collaboratively. They need to work together regularly to develop effective group-learning skills.

The development of these collaborative skills aligns to descriptions in the Australian Curriculum: English (see page xiii).

Team structure

The first step towards teaching students to work collaboratively is to organise the team composition, roles and skills. Use the following ideas when planning collaborative learning with your class:

- Assign students to teams rather than allowing them to choose partners.
- Vary the composition of each team. Give students opportunities to work with others who might be of a different ability level, gender or cultural background.
- Keep teams together for two or more lessons so that students have enough time to experience working together successfully.
- If you cannot divide the students in your class into teams of three, form two teams of two students rather than one team of four. It is difficult for students to work together effectively in larger groups.
- Keep a record of the students who have worked together as a team, so that by the end of the year each student has worked with as many others as possible.

Team roles

Students are assigned roles within their team (see below). Each team member has a specific role but all members share leadership responsibilities. Each member is accountable for the performance of the team and should be able to explain how the team obtained its results. Students must therefore be concerned with the performance of all team members. It is important to rotate team jobs each time a team works together, so that all students have an opportunity to perform different roles.

For Year 3–Year 6, teams consist of three students: Director, Manager and Speaker. (For F–Year 2, teams consist of two students: Manager and Speaker.) Each member of the team should wear something that identifies them as belonging to that role, such as a wristband, badge or colour-coded peg. This makes it easier for you to identify which role each student is doing, and it is easier for the students to remember what they and their team mates should be doing.

Manager

The Manager is responsible for collecting and returning the team's equipment. The Manager also tells the teacher if any equipment is damaged or broken. All team members are responsible for clearing up after an activity and getting the equipment ready to return to the equipment table.

Speaker

The Speaker is responsible for asking the teacher or another team's Speaker for help. If the team cannot resolve a question or decide how to follow a procedure, the Speaker is the only person who may leave the team and seek help. The Speaker shares any information they obtain with team members. The teacher may speak to all team members, not just to the Speaker. The Speaker is not the only person who reports to the class; each team member should be able to report on the team's results.

Director (Year 3–Year 6)

The Director is responsible for making sure that the team understands the team investigation and helps team members focus on each step. The Director is also responsible for offering encouragement and support. When the team has finished, the Director helps team members check that they have accomplished the investigation successfully. The Director provides guidance but is not the team leader.

Team skills

Primary**Connections** focuses on social skills that will help students work in collaborative teams and communicate more effectively.

Students will practise the following team skills throughout the year:

- move into your teams quickly and quietly
- speak softly
- stay with your team
- take turns
- perform your role.

To help reinforce these skills, display enlarged copies of the team skills chart (see the end of this Appendix) in a prominent place in the classroom.

Supporting equity

In science lessons, there can be a tendency for boys to manipulate materials and girls to record results. Primary**Connections** tries to avoid traditional social stereotyping by encouraging all students, irrespective of their gender, to maximise their learning potential. Collaborative learning encourages each student to participate in all aspects of team activities, including handling the equipment and taking intellectual risks.

Observe students when they are working in their collaborative teams and ensure that both girls and boys are participating in the hands-on activities.

TEAM ROLES

Manager

Collects and returns all materials the team needs

Speaker

Asks the teacher and other team speakers for help

Director

Makes sure that the team understands the team investigation and completes each step

TEAM SKILLS

- 1** Move into your teams quickly and quietly
- 2** Speak softly
- 3** Stay with your team
- 4** Take turns
- 5** Perform your role

Appendix 2

How to use a science journal

Introduction

A science journal is a record of observations, experiences and reflections. It contains a series of dated, chronological entries. It can include written text, drawings, measurements, labelled diagrams, photographs, tables and graphs.

Using a science journal provides an opportunity for students to be engaged in a real science situation as they keep a record of their observations, ideas and thoughts about science activities. Students can use their science journals as a useful self-assessment tool as they reflect on their learning and how their ideas have changed and developed during a unit.

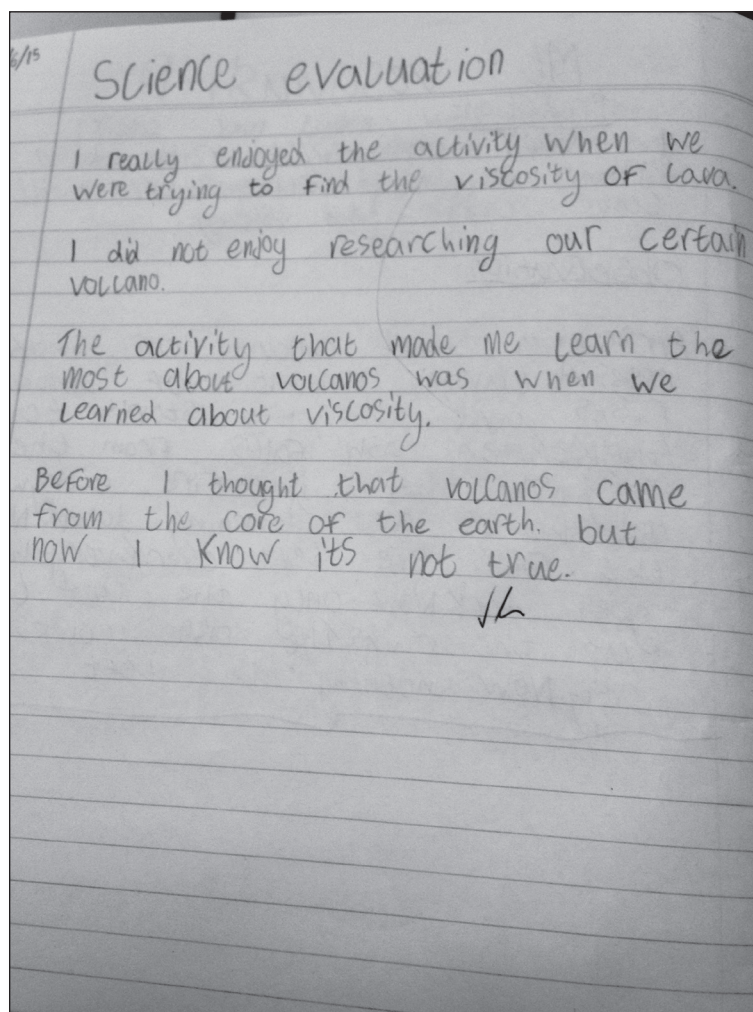
Monitoring students' journals allows you to identify students' alternative conceptions, find evidence of students' learning and plan future learning activities in science and literacy.

Keeping a science journal aligns to descriptions in the Australian Curriculum: Science and English. See pages xi and xiii.

Using a science journal

- 1 At the start of the year, or before starting a science unit, provide each student with a notebook or exercise book for their science journal or use an electronic format. Tailor the type of journal to fit the needs of your classroom. Explain to students that they will use their journals to keep a record of their observations, ideas and thoughts about science activities. Emphasise the importance of including pictorial representations, as well as written entries.
- 2 Use a large project book or A3 paper to make a class science journal. This can be used at all year levels to model journal entries. With younger students, the class science journal can be used more frequently than individual journals and can take the place of individual journals.
- 3 Make time to use the science journal. Provide opportunities for students to plan procedures and record predictions, and reasons for their predictions, before an activity. Use the journal to record observations during an activity and reflect afterwards, including comparing ideas and findings with initial predictions and reasons. It is important to encourage students to provide evidence that supports their ideas, reasons and reflections.
- 4 Provide guidelines in the form of questions and headings, and facilitate discussion about recording strategies such as making notes, lists, tables and concept maps. Use the class science journal to show students how they can modify and improve their recording strategies.
- 5 Science journal entries can include narrative, poetry and prose as students represent their ideas in a range of styles and forms.
- 6 In science journal work, you can refer students to display charts, pictures, diagrams, word walls and phrases about the topic displayed around the classroom. Revisit and revise this material during the unit. Explore the vocabulary, visual texts and ideas that have developed from the science unit, and encourage students to use them in their science journals.

- 7 Combine the use of resource sheets with journal entries. After students have pasted their completed resource sheets into their journal, they might like to add their own drawings and reflections
- 8 Use the science journal to assess student learning in both science and literacy. For example, during the *Engage* phase, use journal entries for diagnostic assessment as you determine students' prior knowledge.
- 9 Discuss the importance of entries in the science journal during the *Explain* and *Evaluate* phases. Demonstrate how the information in the journal will help students develop literacy products, such as posters, brochures, letters and oral or written presentations.



Creators and destroyers science journal

Appendix 3

How to use a word wall

Introduction

A word wall is an organised collection of words and images displayed in the classroom. It supports the development of vocabulary related to a particular topic and provides a reference for students. The content of the word wall can be words that students see, hear and use in their reading, writing, speaking, listening and viewing.

Creating a class word wall, including words from different dialects and languages, aligns to descriptions in the Australian Curriculum: English (see page xiii).

Goals when using a word wall

A word wall can be used to:

- support science and literacy experiences of reading, viewing, writing and speaking
- provide support for students during literacy activities across all key learning areas
- promote independence in students as they develop their literacy skills
- provide a visual representation to help students see patterns in words and decode them
- develop a growing bank of words that students can spell, read and/or use in writing tasks
- provide ongoing support for the various levels of academic ability in the class
- teach the strategy of using word sources as a real-life strategy.

Organisation

Position the word wall so that students have easy access to the words. They need to be able to see, remove and return word cards to the wall. A classroom could have one main word wall and two or three smaller ones, each with a different focus; for example, high-frequency words.

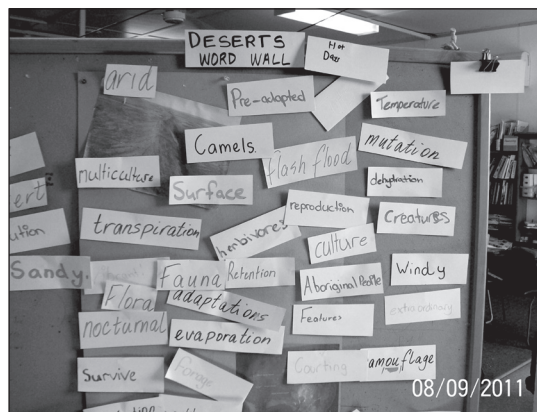
Choose a robust material for the word cards. Write or type words on cardboard and perhaps laminate them. Consider covering the wall with felt-type material and backing each word card with a self-adhesive dot to make it easy for students to remove and replace word cards.

Word walls do not need to be confined to a wall. Use a portable wall, display screen, shower curtain or window curtain. Consider a cardboard shape that fits with the unit; for example, an apple for a needs unit.

The purpose is for students to be exposed to a print-rich environment that supports their science and literacy experiences.

Organise the words on the wall in a variety of ways. Place them alphabetically, or put them in word groups or groups suggested by the unit topic; for example, words for a volcano unit might be organised under headings such as 'Volcano shapes' and 'Volcano structure'.

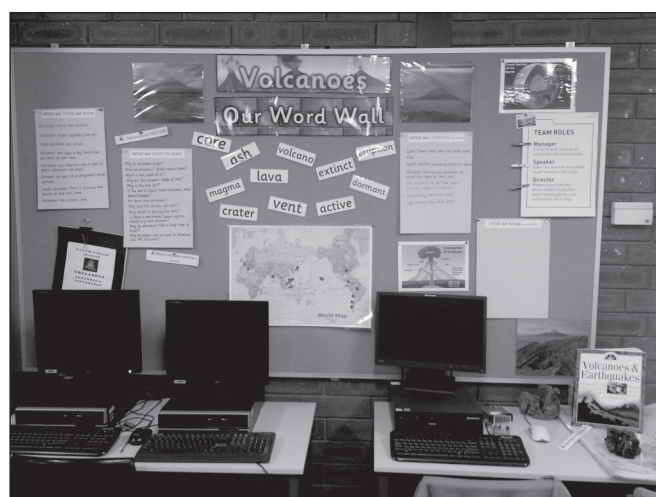
Invite students to contribute words from different languages to the word wall. Group words about the same thing; for example, different names of the same piece of clothing on the word wall so that students can make the connections. Identify the different languages used; for example, by different-coloured cards or pens to record the words.



Desert survivors word wall

Using a word wall

- 1 Limit the number of words to those needed to support the science and literacy experiences in the classroom.
- 2 Add words gradually and include images where possible, such as drawings, diagrams or photographs. Build up the number of words on the word wall as students are introduced to the scientific vocabulary of the unit
- 3 Encourage students to interact with the word wall. Practise using the words with students by reading them and playing word games. Refer to the words during science and literacy experiences and direct students to the wall when they need a word for writing. Encourage students to use the word wall to spell words correctly.
- 4 Use the word wall with the whole class, small groups and individual students during literacy experiences. Organise multi-level activities to cater for the individual needs of students.



Creators and destroyers word wall

Appendix 4

How to use a glossary

Introduction

A glossary is a list of technical terms that relate to a particular subject matter or topic, generally accompanying a document. Each term is accompanied by a description or explanation of the term within the context of the subject. A glossary entry is generally more descriptive than a dictionary definition

Creating a class glossary can be used to:

- elicit students' prior understanding of subject-specific term
- develop a growing bank of descriptions to help students understand and use new words in written and oral tasks
- support students' understanding of scientific descriptions and explanations
- develop the strategy of using word sources as a real-life, valuable investigative research strategy.

Using a class glossary

- 1 Introduce a term and discuss what it might mean within the context of the unit. Possible strategies include students connecting the word to a feature or aspect of the topic, and students using the word in a spoken sentence to explain topic, concept or context.
 - 2 Create a shared understanding of the term, and record it in the science journal or as part of the word wall.
 - 3 Introduce the conventional technical meaning of the term, where appropriate.
 - 4 Encourage students to practise using the terms in the glossary to become familiar with them. Students may wish to amend a description of a word after becoming more familiar with how it is used in a particular context. This may occur when writing, talking or making annotations to diagrams.
 - 5 Integrate the glossary across all curriculum areas, where appropriate. For example, during a literacy lesson discuss various meanings for the term.
 - 6 The glossary could be a part of the science journal or the word wall for a particular unit.
- Note:** It is important to ask students for 'descriptions' of the terms rather than 'definitions' 'Definitions' are often viewed as fixed and unchangeable, whereas 'descriptions' support students to see that ideas can change as their understanding develops.

Appendix 5

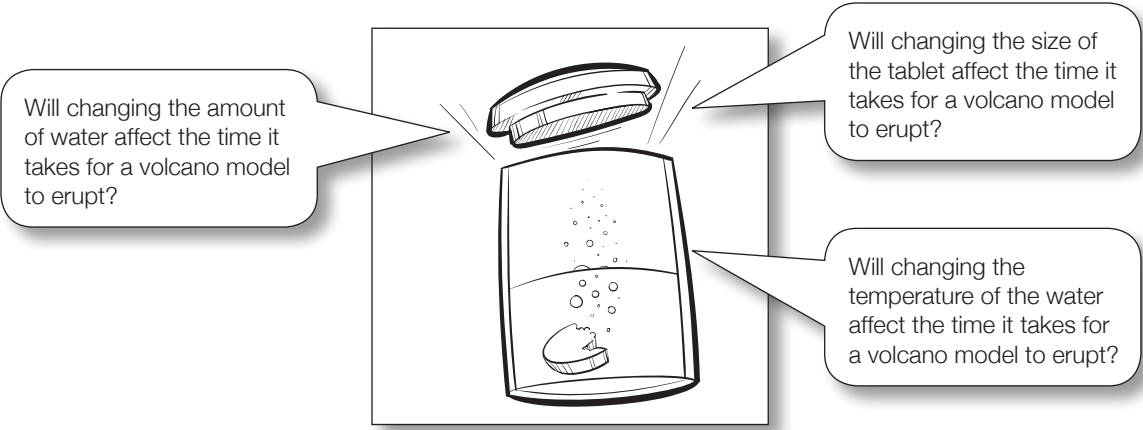
How to conduct a fair test

Introduction

Scientific investigations involve posing questions, testing predictions, planning and conducting tests, interpreting and representing evidence, drawing conclusions and communicating findings

Planning a fair test

In *Creators and destroyers*, students investigate things that affect the time it takes for a volcano model to erupt.



All scientific investigations involve *variables*. Variables are things that can be changed (independent), measured/observed (dependent) or kept the same (controlled) in an investigation. When planning an investigation, to make it a fair test, we need to identify the variables.

It is only by conducting a fair test that students can be sure that what they have changed in their investigation has affected what is being measured/observed.

‘**C**ows **M**oo **S**oftly’ is a useful scaffold to remind students how to plan a fair test:

- C**ows: **Change** one thing (independent variable)
- M**oo: **Measure/Observe** another thing (dependent variable)
- S**oftly: keep the other things (controlled variables) the **Same**.

To investigate things that affect the time it takes for a volcano model to erupt, students could:

CHANGE	The type of fizzy table	Independent variable
MEASURE/ OBSERVE	How long it takes to ‘erupt’	Dependent variable
KEEP THE SAME	The amount of water, the size of the tablet, the temperature of the water that the tablet is in	Controlled variables

Appendix 6

How to use a TWLH chart

Introduction

A learning tool commonly used in classrooms is the KWL chart. It is used to elicit students' prior **K**nowledge, determine questions students **W**ant to know answers to, and document what has been **L**earned.

Primary**Connections** has developed an adaptation called the **TWLH** chart.

T— 'What we **think** we know' is used to elicit students' background knowledge and document existing understanding and beliefs. It acknowledges that what we 'know' might not be the currently accepted scientific understanding

W— 'What we **want** to learn' encourages students to list questions for investigation. Further questions can be added as students develop their understanding.

L— 'What we **learned**' is introduced as students develop explanations for their observations. These become documented as 'claims'.

H— '**How** we know' or 'How we came to our conclusion' is used in conjunction with the third column and encourages students to record the evidence and reasoning that lead to their new claim, which is a key characteristic of science. This last question requires students to reflect on their investigations and learning, and to justify their claims.

As students reflect on their observations and understandings to complete the third and fourth columns, ideas recorded in the first column should be reconsidered and possibly confirmed, amended or discarded, depending on the investigation findings

Creators and destroyers TWLH chart

What we think we know	What we want to learn	What we learned (What are our claims?)	How we know (What is our evidence?)
Volcanoes are all over the world.	Where are volcanoes located?	Most volcanoes are located around the Ring of Fire.	We plotted secondary data of volcanic eruptions on a map each week.
→	→	→	

Appendix 7

How to facilitate evidence-based discussions

Introduction

Argumentation is at the heart of what scientists do; they pose questions, make claims, collect evidence, debate with other scientists and compare their ideas with others in the field

In the primary science classroom, argumentation is about students:

- articulating and communicating their thinking and understanding to others
- sharing information and insights
- presenting their ideas and evidence
- receiving feedback (and giving feedback to others)
- finding flaws in their own and others' reasoning
- reflecting on how their ideas have changed

It is through articulating, communicating and debating their ideas and arguments that students are able to develop a deep understanding of science content.

Establish norms

Introduce norms before starting a science discussion activity. For example:

- Listen when others speak.
- Ask questions of each other.
- Criticise ideas not people.
- Listen to and discuss all ideas before selecting one.

Question, Claim, Evidence and Reasoning

In science, arguments that make claims are supported by evidence. Sophisticated arguments follow the QCER process:

Q – What **question** are you trying to answer? For example, 'What variables affect the time it takes for a model volcano to erupt?'

C – The **claim**. For example, 'The size of the fizzy tablet affects the time it takes for a model volcano to erupt.'

E – The **evidence**. For example, 'A full tablet took 12 seconds to make the volcano model erupt and the half tablet took 28 seconds to make the volcano model to erupt.'

R – The **reasoning**. For example, 'The bigger tablet produced more fizz or gas, which caused the gas to build up more quickly and caused the volcano model to erupt earlier.'

Students need to be encouraged to move from making claims only, to citing evidence to support their claims. Older students develop full conclusions that include a claim, evidence and reasoning. This is an important characteristic of the nature of science and an aspect of scientific literacy. Using Science Question Starters (see next section) helps to promote evidence-based discussion in the classroom.

Science Question Starters

Science Question Starters can be used to model the way to discuss a claim and evidence for students. Teachers encourage team members to ask these questions of each other when preparing their claim and evidence. They might also be used by audience members when a team is presenting its results. See the PrimaryConnections 5Es video, *Elaborate*.

Science Question Starters

Question type	Question starter
Asking for evidence	I have a question about _____. What is your evidence to support your claim?
Agreeing	I agree with _____ because _____.
Disagreeing	I disagree with _____ because _____. One difference between my idea and yours is _____.
Questioning further	I wonder what would happen if _____? I have a question about _____. I wonder why _____? What caused _____? How would it be different if _____?
Clarifying	I'm not sure what you meant there. Could you explain your thinking to me again?

DISCUSSION SKILLS

- Listen when others speak.
- Ask questions of each other.
- Criticise ideas, not people.
- Listen to and discuss all ideas before selecting one.

Appendix 8

How to write questions for investigation

Introduction

Scientific inquiry and investigation are focused on and driven by questions. Some questions are open to scientific investigation, whereas others are not. Students often experience difficulty in developing their own questions for investigation.

This appendix explains the structure of questions and how they are related to variables in a scientific investigation. It describes an approach to developing questions for investigation and provides a guide for constructing investigable questions with your students.

Developing their own questions for investigation helps students to have ownership of their investigation and is an important component of scientific literacy.

The structure of questions for investigation

The way that a question is posed in a scientific investigation effects the type of investigation that is carried out and the way information is collected. Examples of different types of questions for investigation include:

- How does/do ...?
- What effect does ...
- Which type of ...?
- What happens to ...?

All science investigations involve variables. Variables are things that can be changed (independent), measured (dependent) or kept the same (controlled) in an investigation.

- The **independent variable** is the thing that is changed during the investigation.
- The **dependent variable** is the thing that is affected by the independent variable, and is measured or observed.
- **Controlled variables** are all the other things in an investigation that could change but are kept the same to make it a fair test.

An example of the way students can structure questions for investigation is:

What happens to _____ when we change _____?

(dependent variable) **(independent variable)**

The type of question for investigation in *Creators and destroyers* refers to two things (variables) and the relationship between them. For example, an investigation of the things (variables) that affect the time it takes for a model volcano to erupt might consider the amount of water or the size of the fizzy tablet. The question or investigation could be:

Q1: What happens to the time it takes for a model volcano to erupt when we change the amount of water?

In this question, **the time it takes for the model volcano to erupt** depends on **the amount of water**. **The amount of water** is the thing that is **changed** (independent variable) and **the time it takes for the model volcano to erupt** is the thing that is **measured or observed** (dependent variable).

Q2: What happens to the time it takes for a model volcano to erupt when we change the size of the tablet?

In this question, **the time it takes for the model volcano to erupt** depends on **the size of the tablet**. **The size of the tablet** is the thing that is **changed** (independent variable) and **the time it takes for the model volcano to erupt** is the thing that is **measured or observed** (dependent variable).

Developing questions for investigation

The process of developing questions for investigation is to:

- Provide a context and reason for investigating.
- Pose a general focus question in the form of:
‘What things might affect _____ (dependent variable)?’
For example, ‘What things might affect the time it takes for the model volcano to erupt?’
- Use questioning to elicit the things (independent variables) students think might affect the dependent variable (e.g. the amount of water)

Use questions to elicit the things that students can investigate, such as the size of the fizzy tablet and the amount and temperature of water. These are the things that could be changed (independent variables) that students predict will affect the thing that is measured or observed (dependent variable).

Each of the independent variables can be developed into a question for investigation.

- Use the scaffold ‘What happens to _____ when we change _____?’ to help students develop specific questions for their investigation.
For example, ‘What happens to the time it takes for the model volcano to erupt when we change the temperature of the water?’ or ‘What happens to the time it takes for the model volcano to erupt when we change the amount of water?’.

Ask students to review their question for investigation after they have conducted their investigation and collected and analysed their information.

Encouraging students to review their question will help them to understand the relationship between what was changed and what was measured in their investigation. It also helps students to see how the information they collected relates to their prediction.

Appendix 9

How to construct and use a graph

Introduction

A graph organises, represents and summarises information so that patterns and relationships can be identified. Understanding the conventions of constructing and using graphs is an important aspect of scientific literacy.

During a scientific investigation, observations and measurements are made and measurements are usually recorded in a table. Graphs can be used to organise the data to identify patterns, which help answer the research question and communicate findings from the investigation.

The Australian Curriculum: Mathematics Statistics and Probability ‘Data representation and interpretation’ content descriptions for Year 6 are:

- Interpret and compare a range of data displays, including side-by-side column graphs for two categorical variables.
- Interpret secondary data presented in digital media and elsewhere.

Once you have decided to construct a graph, two decisions need to be made:

- What type of graph? and
- Which variable goes on each axis of the graph?

What type of graph?

The type of graph used depends on the type of data to be represented. Many investigations explore the effect of changing one variable while another is measured or observed.

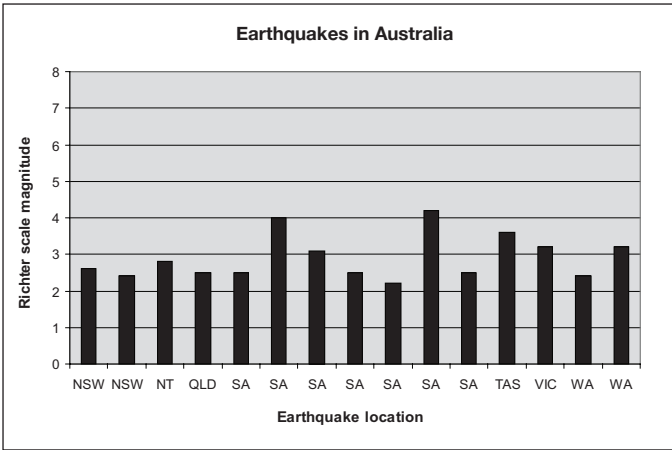
Column graph

When data for one of the variables are in **categories** (i.e. we use **words** to describe it; for example, earthquake location) a **column graph** is used. In *Earthquake explorers*, students analyse and compare secondary data. Students use their understanding of earthquakes to explain the patterns in the data. On the next page, graph A shows the magnitude of earthquakes in Australian States and Territories (**data in categories**) and is presented as a **column graph**.

Table A: Earthquake magnitude recorded in Australian States and Territories from October 2008 to November 2008.

Earthquake magnitude (Richter scale)	Australia
2.6	Australia (NSW)
2.4	Australia (NSW)
2.8	Australia (NT)
2.5	Australia (Qld)
2.5	Australia (SA)
4.0	Australia (SA)
3.1	Australia (SA)
2.5	Australia (SA)
2.2	Australia (SA)
4.2	Australia (SA)
2.5	Australia (SA)
3.6	Australia (Tas.)
3.2	Australia (Vic.)
2.4	Australia (WA)
3.2	Australia (WA)

Graph A: Earthquake magnitude recorded in Australian States and Territories from October 2008 to November 2008.



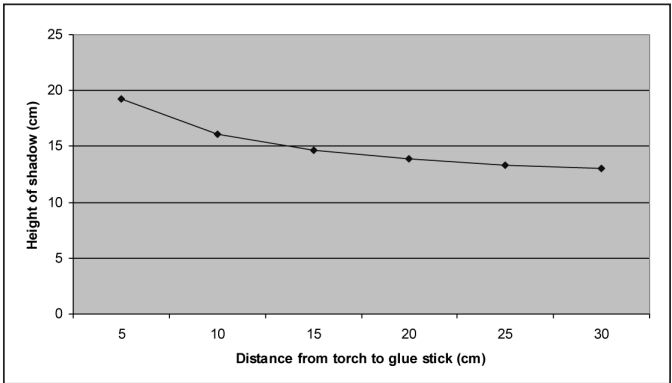
Line graph

When the data for both variables are **continuous** (i.e. we use **numbers** that can be recorded on a measurement scale, such as length in centimetres or mass in grams), a **line graph** is usually constructed. Graph B below shows how the results from an investigation of the effect of distance from a light source (**continuous data**) on the shadow height of an object (**continuous data**) have been constructed as a **line graph**.

Table B: The effect of distance from a torch on the shadow height of a glue stick.

Distance from torch to glue stick (cm)	Height of shadow (cm)
5	19.3
10	16.1
15	14.7
20	13.9
25	13.3
30	13.0

Graph B: The effect of distance from a torch on the shadow height of a glue stick.



Which variable goes on each axis?

It is conventional in science to plot the variable that has been changed on the horizontal axis (x-axis) and the variable that has been measured/observed on the vertical axis (y-axis) of the graph.

Graph titles and labels

Graphs have titles and each variable is labelled on the graph axes, including the units of measurement. The title of the graph is usually in the form of 'The effect of on variable on the other variable'; for example, 'The effect of distance from a torch on the shadow height of a glue stick' (graph B).

Steps in analysing and interpreting data

Step 1—Organise the data (e.g. construct a graph) so you can see patterns or the relationship between data for the variables (things that we change, measure/observe or keep the same).

Step 2—Identify and describe the pattern or relationship in the data.

Step 3—Explain the pattern or relationship using science concepts.

Questioning for analysis

Teachers use effective questioning to assist students to develop skills in interrogating and analysing data represented in graphs. Such as:

- What is the story of your graph?
- Do the data in your graph reveal any patterns?
- Is this what you expected? Why?
- Can you explain the pattern? Why did this happen?
- What do you think the pattern would be if you continued the line of the graph?
- How certain are you of your results?

Analysis

Analysis of graph B shows that the further the distance from the torch, the shorter the height of the glue stick's shadow. This is because as light travels in straight lines, the closer the object is to a light source, the more light it blocks out and therefore the bigger the shadow.

Appendix 10

Creators and destroyers equipment list

EQUIPMENT ITEM	QUANTITIES	LESSON							
		SESSION	1	2	2	3	3	4	5
Equipment and materials									
fizzy tablet (eg. Be occa™)	1 per class								
fizzy tablets (eg. Be occa™)	3 per class								
ideas map	per class								
materials to create information products on volcanoes	per class								
measuring cup, small	1 per team								
plastic cups with 1/4 cup of flour in each	3 per team								
container with a pop-on lid (e.g. a plastic film canister with lid)	1 per class								
container with a pop-on lid (e.g. a plastic film canister with lid)	1 per team								
plate, plastic smooth	3 per team								
poster or model of volcano	1 per team								
red food colouring <i>optional</i>	per team								
ruler	1 per team								
safety glasses	1 pair per class								
safety glasses	1 pair per team								
self-adhesive dots	1 box per class								
self-adhesive notes	per class								
set of cards with names of hazards	1 per class								
spoon, plastic	1 per team								
stopwatch	1 per team								
stopwatch	1 per class								
tablespoon	1 per team								
Weekly Volcanic Activity Report	per class								
water	per team								
world map, large with latitude and longitude lines	1 per class								

EQUIPMENT ITEM	QUANTITIES	LESSON		1	2	2	3	3	4	5	6	6	7	7	8
		SESSION			1	2	1	2			1	2	1	2	
Resource sheets															
'Volcanoes investigation planner' (RS1) 'Volcanoes investigation planner' (RS1), enlarged 'An eyewitness story' (RS2) 'An eyewitness story' (RS2), enlarged 'A volcano' (RS3) 'A volcano' (RS3), enlarged 'Lava investigation planner' (RS4) 'Lava investigation planner' (RS4), enlarged 'Natural hazards' (RS5) 'Natural hazards' (RS5), enlarged 'Volcanoes investigation record' (RS6) 'Volcanoes investigation record' (RS6), enlarged	1 per student					●							●	●	
	1 per class				●								●	●	
	1 per student				●										
	1 per class				●										
	3 per team					●						●	●	●	●
	1 per class					●								●	●
	3 per team							●							
	1 per class							●							
	1 per student								●						
	1 per class									●					
Teaching tools															
class science journal student science journal word wall TWLH chart team roles chart team skills chart role wristbands or badges	1 per class					●		●	●	●	●	●	●	●	●
	1 per student					●		●	●	●	●	●	●	●	●
	1 per class					●		●	●	●	●	●	●	●	●
	1 per class					●		●	●	●	●	●	●	●	●
	1 per class								●	●	●	●	●	●	●
	1 per class							●	●	●	●	●	●	●	●
	1 set per team									●	●	●	●	●	●
Multimedia															
Digital camera optional								●							
Multimedia resources on volcanoes Factual texts or videos on the interior of volcanoes Factual texts or videos showing lava flows optional Factual videos about different volcano types optional Factual texts or videos on the benefits of living near a volcano Factual texts or videos on different natural hazards optional Factual texts or videos on the risks of living near a volcano Factual texts or videos on volcanoes as creators or destroyers Factual texts or videos on Earth's interior World map showing tectonic plates optional	per class									●					
	per class						●								
	per class						●								
	per class							●							
	per class								●						
	per class									●					
	per class											●			
	per class												●		
	per class													●	
	per class														●

Appendix 11

Creator and destroyers unit overview

	SCIENCE OUTCOMES*	LITERACY OUTCOMES*	LESSON SUMMARY	ASSESSMENT OPPORTUNITIES
	Students will be able to represent their current understanding as they:	Students will be able to:	Students:	
ENGAGE	Lesson 1 Pompeii and Vesuvius <ul style="list-style-type: none"> describe the effects of volcanic eruptions list ideas on how volcanoes are both 'creators' and 'destroyers' list what they know about the formation of volcanoes express ideas on where volcanoes are located. 	<ul style="list-style-type: none"> use analytical images such as tables, T-chart and maps to display information participate in and contribute to discussions, sharing information, experiences and opinions. 	<ul style="list-style-type: none"> observe an animation of the effects of the eruption of Mount Vesuvius create a T-chart on volcanoes as 'creators' and 'destroyers'. 	Diagnostic assessment <ul style="list-style-type: none"> Science journal entries Class discussions TWLH contributions T-chart
EXPLORE	Lesson 2 Eruptions! <ul style="list-style-type: none"> identify key features of volcanic eruptions compare the reliability of different sources of evidence. 	<ul style="list-style-type: none"> select, navigate and read factual texts to source information on a selected volcano use comprehension strategies to analyse and compare information between two texts on a volcanic eruption participate in and contribute to discussions, developing and supporting arguments. 	Session 1 Two recounts <ul style="list-style-type: none"> watch a video and read an eyewitness account of the events of the eruption of Mount Vesuvius begin planning a secondary data investigation into the location of volcanoes. Session 2 Ready to research <ul style="list-style-type: none"> begin researching a well-known volcano. 	Formative assessment <ul style="list-style-type: none"> Science journal entries Class discussions TWLH contributions Summaries 'Volcanoes investigation planner' (Resource sheet 1)

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EXPLORE		SCIENCE OUTCOMES*	LITERACY OUTCOMES*	LESSON SUMMARY	ASSESSMENT OPPORTUNITIES
		Students will be able to:	Students will be able to:	Students:	
Lesson 3 Lava creations		<ul style="list-style-type: none"> identify the internal features of a volcano compare the behaviour of liquids with different viscosities plan and conduct a fair test relate the viscosity of lava to the shape of a volcano. 	<ul style="list-style-type: none"> draw a cross-section to represent ideas about the interior of a volcano use scientific vocabulary to describe the interior of a volcano participate in and contribute to discussions, sharing and evaluating. 	<p>Session 1 Inside my volcano</p> <ul style="list-style-type: none"> create a cross-section of the interior of their volcano. <p>Session 2 Varying viscosity</p> <ul style="list-style-type: none"> plan and conduct an investigation into whether the viscosity of a volcano's lava affects its shape relate their findings to the shape of the volcano they are investigating. 	<p>Formative assessment</p> <ul style="list-style-type: none"> science journal entries class discussions TWLH contributions cross-section 'Lava investigation planner' (Resource sheet 4)
Lesson 4 Living on the edge		<ul style="list-style-type: none"> discuss the difference between a dormant and extinct volcano identify the benefits of living near a volcano discuss the effects of other natural events on Earth's surface. 	<ul style="list-style-type: none"> interpret and analyse information from a factual text create an ideas map participate in and contribute to discussions share and evaluate information and ideas. 	<ul style="list-style-type: none"> create an ideas map about benefits of living near a volcano read factual texts compare living near a volcano with other natural hazards. 	<p>Formative assessment</p> <ul style="list-style-type: none"> science journal entries class discussions TWLH contributions 'Natural hazards' (Resource sheet 5)

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	SCIENCE OUTCOMES*	LITERACY OUTCOMES*	LESSON SUMMARY	ASSESSMENT OPPORTUNITIES
	Students will be able to:	Students will be able to:	Students:	
EXPLORE	Lesson 5 Popping tops (Optional) <ul style="list-style-type: none">• discuss the risks of living near a volcano• identify the signs that a volcano might erupt• investigate a simplified model of a volcanic eruption.	<ul style="list-style-type: none">• make and record observations• engage in discussion to compare ideas.	<ul style="list-style-type: none">• watch a video on the risks of living near a volcano• use a film canister to explore predicting an ‘eruption’• discuss the difficulty of predicting volcanic eruptions.	Formative assessment <ul style="list-style-type: none">• science journal entries• class discussions• TWLH contributions
EXPLAIN	Lesson 6 Creator or destroyers? <ul style="list-style-type: none">• explain what Earth’s interior looks like and where magma comes from• explain why volcanoes are considered as both creators and destroyers.	<ul style="list-style-type: none">• update ideas on volcanoes in a T-chart• participate in and contribute to discussions, and clarifying ideas.	Session 1 Pros and cons <ul style="list-style-type: none">• draw a cross-section of Earth’s interior• view a video and update their cross-section. Session 2 Deep down <ul style="list-style-type: none">• review and update their T-chart from Lesson 1• view a video on volcanoes as ‘creators’ and ‘destroyers’.	Formative assessment <ul style="list-style-type: none">• science journal entries• class discussions• TWLH contributions• cross-sections• revised T-charts

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ELABORATE				
	SCIENCE OUTCOMES*	LITERACY OUTCOMES*	LESSON SUMMARY	ASSESSMENT OPPORTUNITIES
	Students will be able to:	Students will be able to:	Students:	
Lesson 7 Where on Earth?	<ul style="list-style-type: none">analyse secondary data to identify the area of the location of most of Earth's volcanoesconduct research into why volcanoes are located along the edges of tectonic plates.	<ul style="list-style-type: none">read and interpret different texts from different sourcespresent and analyse information in tables, maps or graphs.	<p>Session 1 Dissecting data</p> <ul style="list-style-type: none">represent and analyse secondary data to identify the location of currently active volcanoesconduct research into explanations of why volcanoes are located where they are. <p>Session 2 Claims and evidence</p> <ul style="list-style-type: none">present team's claims and evidence about where the majority of volcanoes are locatedpresent research about explanations of why volcanoes are located where they are.	<p>Summative assessment of Science Inquiry Skills</p> <ul style="list-style-type: none">science journal entriesclass discussionsTWLH contributions'Volcanoes investigation record' (Resource sheet 6)oral presentations

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	SCIENCE OUTCOMES*	LITERACY OUTCOMES*	LESSON SUMMARY	ASSESSMENT OPPORTUNITIES
	Students will be able to:	Students will be able to:	Students:	
EVALUATE Lesson 8 Volcanoes on show	<ul style="list-style-type: none"> explain how a selected volcano was formed explain changes that occurred in the landscape due to the volcanic eruption. 	<ul style="list-style-type: none"> plan, draft and publish informative texts, including images and digital resources appropriate to purpose and audience plan and deliver an oral presentation on selected volcano contribute to discussions about their learning journey. 	<ul style="list-style-type: none"> create and/or present information about their researched volcano review and reflect on their learning during the unit. 	Summative assessment Science Understanding <ul style="list-style-type: none"> science journal entries class discussions TWLH contributions oral presentation 'A volcano' (Resource sheet 3) Information product

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PrimaryConnections Units

Year	Biological sciences	Chemical sciences	Earth and space sciences	Physical sciences
F	<i>Staying alive</i>	<i>That's my hat!</i>	<i>Weather in my world</i>	<i>On the move</i>
	<i>Growing well</i>	<i>What's it made of?</i>		
1	<i>Schoolyard safari</i>	<i>Bend it! Stretch it!</i>	<i>Changes all around</i>	<i>Look! Listen!</i>
	<i>Dinosaurs and more</i>	<i>Spot the difference</i>	<i>Up, down and all around</i>	
2	<i>Watch it grow!</i>	<i>All mixed up</i>	<i>Water works</i>	<i>Machine makers</i>
				<i>Push-pull</i>
3	<i>Feathers, fur or leaves?</i>	<i>Melting moments</i>	<i>Night and day</i>	<i>Heating up</i>
4	<i>Friends or foes?</i>	<i>Material world</i>	<i>Beneath our feet</i>	<i>Magnetic moves</i>
	<i>Among the gum trees</i>	<i>Package it better</i>		<i>Smooth moves</i>
5	<i>Desert survivors</i>	<i>What's the matter?</i>	<i>Earth's place in space</i>	<i>Light shows</i>
6	<i>Marvellous micro-organisms</i>	<i>Change detectives</i>	<i>Creators and destroyers</i>	<i>Circuits and switches</i>
	<i>Rising salt</i>		<i>Earthquake explorers</i>	<i>Essential energy</i>