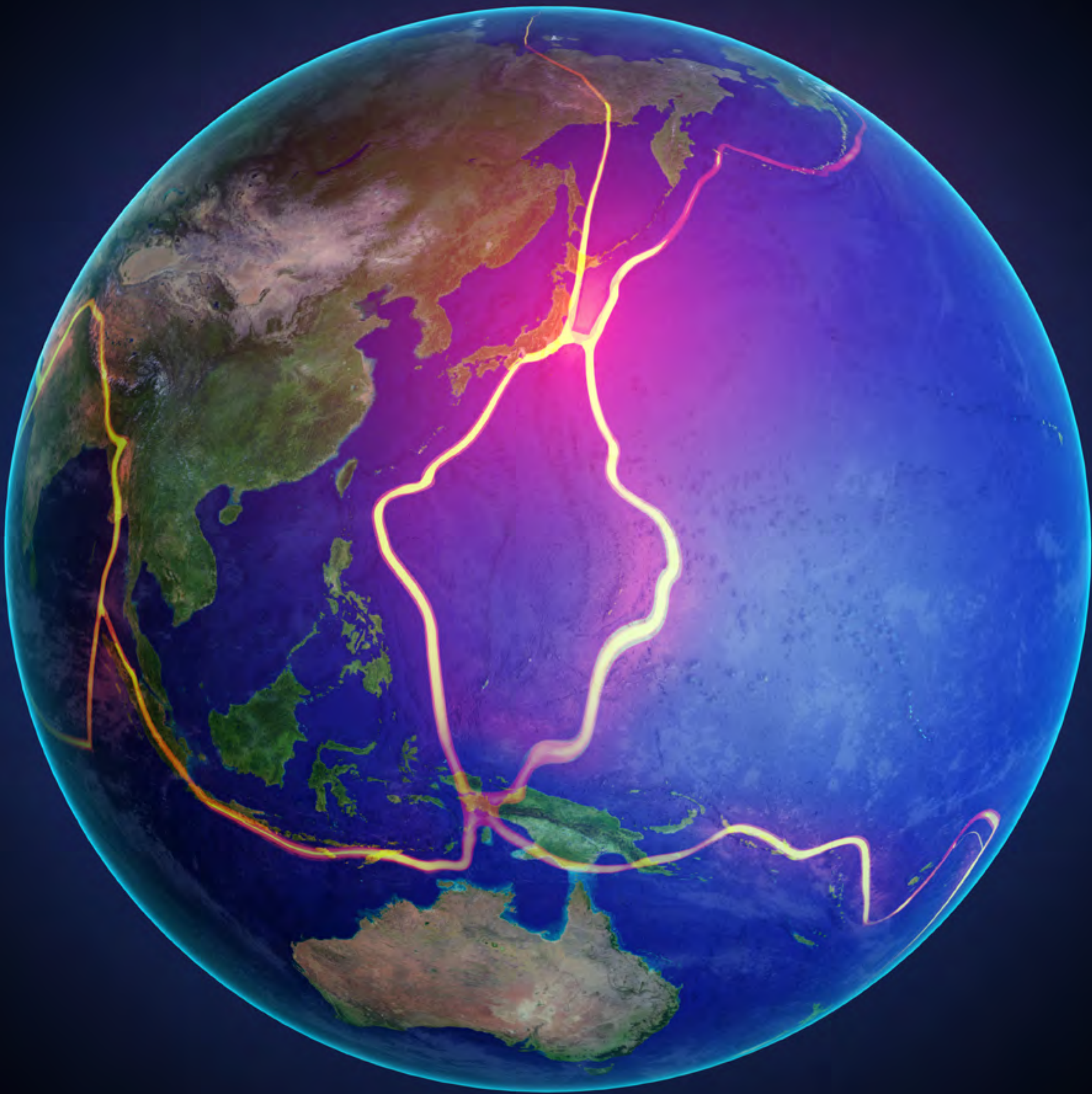


Earth Shattering Science

FUTURE MAKERS TEACHER RESOURCE

Future Makers

Future Makers is an innovative partnership between Queensland Museum Network and Shell's QGC business aiming to increase awareness and understanding of the value of science, technology, engineering and maths (STEM) education and skills in Queensland.

This partnership aims to engage and inspire people with the wonder of science, and increase the participation and performance of students in STEM-related subjects and careers — creating a highly capable workforce for the future.

QUEENSLAND MUSEUM NETWORK Queensland Government THE UNIVERSITY OF QUEENSLAND AUSTRALIA

This teacher resource is produced by Future Makers, a partnership between Queensland Museum Network and Shell's QGC business, with support from the Australian Research Council and other parties to ARC Linkage Project LP160101374: The University of Queensland, Australian Catholic University Limited and Queensland Department of Education.

Thank you to the University of Queensland School of Education for contributing to a number of the activities included in this workbook.

Contents

Workshop Overview

In this workshop, students use evidence collected by scientists at Queensland Museum to identify how the Earth has changed over time. They investigate how plate tectonics and the theory of continental drift can explain geological changes and why we sometimes find the remains of prehistoric animals in unexpected locations. The movement of plates can also result in the occurrence of natural disasters, which may damage built environments and cause loss of life. Students apply engineering skills and principles to design earthquake-resistant buildings that help mitigate these effects.

This workshop has been structured using the 5E's instruction model.

The following topics and concepts are explored in each aspect of the workshop:

ENGAGE	**Imagination Hats** Visualise the flora and fauna that lived in Australia millions of years ago.
EXPLORE **EXPLAIN**	**Exploring Continental Drift** Use fossils to recreate the southern supercontinent, Gondwana. • Explain why fossils provide evidence that the landmasses were once connected as a supercontinent. • Explain how the separation of the landmasses would have affected the flora and fauna. • Explain why Australia has so many unique plants and animals.
ELABORATE	**Modelling Convection Currents** Model convection currents and plate tectonics in a hands-on experiment. **Calculating the Movement of Australia** Calculate the movement of the Australian continent based on scientific data and explore the effects of this movement over time. **Puzzling Tectonic Plates** Use tectonic plates to construct a map of the Earth and identify the geological features and events that occur at different plate boundaries.
EXPLORE	**Tasty Tectonics** Model plate boundaries and the effects of tectonic plate movement using everyday materials.
EVALUATE	**Exploring Plate Boundaries: Monsters in the Mountains** Use visual literacy skills to infer the significance of a location and explain results using scientific understanding.
ENGAGE	**Introducing Dr Espen Knutsen, Vertebrate Palaeontologist** Learn about life as a vertebrate palaeontologist at Queensland Museum Network as Dr Espen Knutsen explains how Australia has changed over time, and the evidence for these changes.
ENGAGE **EXPLORE** **EXPLAIN** **ELABORATE** **EVALUATE**	**Earthquake-Resistant Building Challenge** • Investigate how buildings can be designed to withstand earthquakes. • Design and create a three story building capable of withstanding an earthquake. • Test and refine design to increase building strength, and present results to the class.

ENGAGE

Imagination Hats: Flora and Fauna of the Past

Teacher Resource

Ask students to view the image of a large prehistoric creature in a present day location. Provide students with time to silently observe the image, before facilitating a classroom discussion with the following questions:

- What is wrong with this picture? Why?
- Does this creature remind you of anything you have seen before? What was it? Where did you see it and when?
- What could this creature be? Why?
- Where could it have come from? Might it live in this location, or has it come from another location? If so, where?
- Is this creature real? Does it exist, or has it existed, before? How could we find out?

Reconstruction of Xenobrachyops allos in modern-day Chinchilla (left), Gladstone (right) and Brisbane (bottom).

EXPLORE - EXPLAIN

Exploring Continental Drift

Teacher Resource

Fossils, the preserved remains of ancient life, provide evidence for what the world was like in the distant past. In this activity, students use fossil evidence from Queensland Museum to recreate the southern supercontinent Gondwana and explore how the continents have moved over time.

Students analyse this information to:

1. Explain why fossils provide evidence that the landmasses were once connected as a supercontinent.
2. Explain how the separation of the landmasses would have affected the flora and fauna alive at this time.
3. Explain why Australia has so many unique plants and animals.

Curriculum Links

Science

YEAR 9

Science Understanding

The theory of plate tectonics explains global patterns of geological activity and continental movement (ACSSU180)

Science Inquiry Skills

Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS170)

Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data (ACSIS171)

Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS174)

Critically analyse the validity of information in primary and secondary sources and evaluate the approaches used to solve problems (ACSIS172)

Science as a Human Endeavour

Scientific understanding, including models and theories, is contestable and is refined over time through a process of review by the scientific community (ACSHE157)

General Capabilities

Critical and Creative Thinking

Inquiring – identifying, exploring and organising information and ideas

Exploring Continental Drift

Student Activity

Fossils, the preserved remains of ancient life, provide evidence for what the world was like in the distant past. In this activity you will use fossil evidence to investigate how scientists developed the theory of continental drift.

The geographic distribution of fossils around the world can help us understand species distribution and their evolution. However, early scientists had trouble explaining how some plant fossils like *Glossopteris* (see below) could be found in what is now tropical Queensland, as well as 7000 km away in Antarctica (and also in Africa and South America)!

The past distribution of plants, on what are now widely separated continents, was one piece of evidence that led to the development of the theory of continental drift by Alfred Wegener in 1912. This theory proposed that all continents had once been part of a giant landmass called Pangaea, which split into Laurasia in the north and Gondwana in the south. These landmasses continued to move and separate over time to form the continents as we know them today.

Fossilised Glossopteris leaves and the jointed stems of horsetails found in the Permian deposits of the Bowen Basin, Queensland. QMF58633, QM, Gary Cranitch.

Top: Reconstruction of Siderops kehli. QM, Vlad Konstantinov, Andrey Atuchin, Scott Hocknull.
Bottom: The fossilised remains of Siderops kehli which can be seen at the Queensland Museum, Brisbane. QMF7882, QM, Peter Waddington.

Temnospondyls, which include *Siderops* above, have been found on all Gondwanan landmasses. Scientists use fossils and our understanding of past and present environments to create reconstructions of these ancient amphibians. This particular Temnospondyl, *Siderops kehli*, was found near Taroom, Queensland. This specimen, and the others shown in this activity, can be seen in the *Lost Creatures* exhibition at Queensland Museum, Brisbane.

Fossils from *Glossopteris*, Temnospondyls, as well as *Dicroidium*, have been found in Australia and on other Gondwana landmasses. Learn more about these in *Table 1: Fossils that have been found on many different continents*, and then work through the activity - *Exploring Evidence of Continental Drift*.

THINK
If all continents were once joined together, what impact would this have had on flora and fauna?

Table 1: Fossils that have been found on many different continents.

Name	***Glossopteris***	***Dicroidium***	**Temnospondyls**
Picture	 *Glossopteris leaf.* *QMF58636, QM, Peter Waddington.*	 *Dicroidium dubium.* *GSQF329, QM, Rochelle Lawrence.*	*Right: Coprolites (fossilised faeces). QML78, QM, Peter Waddington.*   *Above: Reconstruction of Xenobrachyops allos.* *QM, Vlad Konstantinov, Andrey Atuchin, Scott Hocknull.*
Description	A tree up to 30 m in height, *Glossopteris*' tongue-shaped leaves could grow up to 1 m in length! The dominant vegetation in Gondwana during the Permian Period, this tree lived in swampy environments and had specially adapted aeration roots to survive the swamp (similar to mangroves). *Glossopteris* were deciduous, dropping their leaves during winter, which has resulted in many leaf deposits being found. This plant flourished 290-245 million years ago and has been found on every continent of Gondwana.	There were many species of *Dicroidium* and they can also be found on all of the Gondwana continents, particularly in the coal basins of south-eastern Queensland. These 'seed ferns' had leaves similar to those of modern ferns; however, instead of reproducing from spores (like ferns today) they had separate seed and pollen-bearing organs, which suggests closer links to flowering plants. *Dicroidium* grew in the warm temperatures of the Triassic 252-201 million years ago.	Temnospondyls, like *Xenobrachyops allos* (above) and *Siderops kehli* (page 6) resemble modern salamanders and newts in their body form and habit; however, these amphibians could grow up to 3 m long! Most lived in freshwater, although it seems that some also made the transition to life on land, returning only to the water to breed. Temnospondyls had sharp teeth and were likely ambush predators similar to crocodiles. They were very diverse throughout Gondwana, and fossils from the families of Lydekkerina, Rhytidosteidae and Brachyopidae (which includes *Xenobrachyops allos*) are shown on the map.

Exploring Evidence of Continental Drift

Objective

To understand how the Earth has changed over time, and to investigate how scientists developed the theory of continental drift using fossil evidence.

Materials

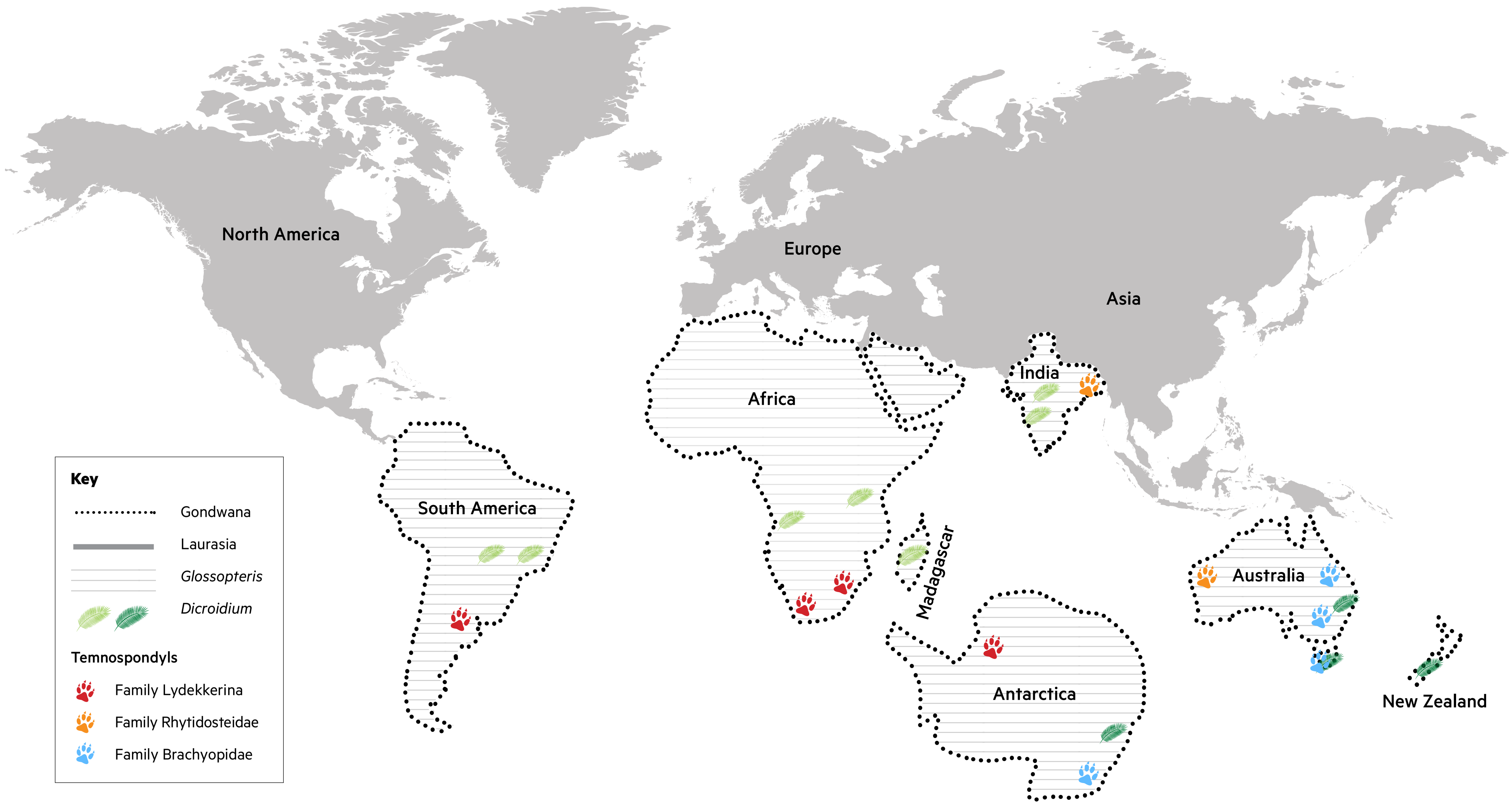
- A copy of *Recreating Gondwana: world map and fossil evidence of continental drift*.
- Scissors
- Glue

Activity

1. Recreate a map of Gondwana by following the instructions below.
    a. Using the dotted lines, cut around the landmasses on the map *Recreating Gondwana* (the dotted lines outline the landmasses that made up Gondwana).
    b. Fit the pieces together like a puzzle.
    c. Check to see if the landmasses are in the correct position by lining up areas where similar fossils are found.

Scientists can learn from imprint fossils as well. The temnospondyl footprint above was found in Albion, Brisbane. This amphibian was 3 m long – imagine that walking past your classroom window! UQF26279, QM, Peter Waddington.

Recreating Gondwana: World Map and Fossil Evidence for Continental Drift



Please note: This map contains select examples of thousands of fossils!

FUTURE MAKERS RECOMMENDS PRINTING THIS MAP IN A3

2. Explain why fossils provide evidence that the landmasses were once connected as a supercontinent. *Hint: You may want to think about climate, distance and how these organisms travel and reproduce.

3. Explain how the separation of the landmasses would have affected the flora and fauna.

4. The fossil evidence on your map does not always align precisely. Give possible reasons for this, and justify whether you have enough information to make a valid conclusion.

5. Fossil evidence is not the only evidence that supports continental drift. Research three more pieces of evidence that support the theory of continental drift.

STEM Careers in Real Life: Dr Andrew Rozefelds, Palaeobotanist

Dr Andrew Rozefelds is a palaeobotanist and the Head of Geosciences at the Queensland Museum. He has had the opportunity to work all around the world, including at the Smithsonian Museum of Natural History in Washington, USA, though his favourite objects to work on are fossilised plants from Queensland.

'Working in Australia it is evident that we know relatively little about the fossil record of this continent. There are new discoveries turning up all the time, and museums have played a key role in telling stories about our fossil heritage and the history of this continent. We are in an exciting phase of discovering new information about the geoheritage of the country, and while our continent has links to the other southern continents, the recent flora and fauna of our island continent evolved in relative isolation, so this is a uniquely Australian story.' – Dr Andrew Rozefelds

To learn more about Dr Andrew Rozefelds you can check out his profile on the Queensland Museum website.

Can you believe it? Dr Andrew Rozefelds has had five species named after him! A living spider Ixamatus rozefeldsi, a plant Boronia rozefeldsii, and three prehistoric species discovered from fossils! Queensland Museum.

ELABORATE

Modelling Convection Currents

Teacher Resource

Before starting the following activity, it is recommended that students draw and label a cross section of the Earth including the following labels: crust, mantel, core, ridge, divergent plate boundary, convergent plate boundary, convection current, movement.

The Earth is made of four layers: the inner and outer core, the mantle and the crust. The mantle is the largest layer. The top of the mantle near the crust is cooler than near the core. The temperature differential through the mantle causes convection currents, driving the gradual flow of the mantle. The flow from the convection currents also drives the movement of the tectonic plates!

Rheoscopic fluid highlights the currents in a liquid and can be used to model convection currents, similar to the Earth's mantle. It can be purchased from science suppliers; alternatively, you can find instructions for making a similar fluid online. Food dye can be added to the rheoscopic fluid to make it easier to observe these currents.

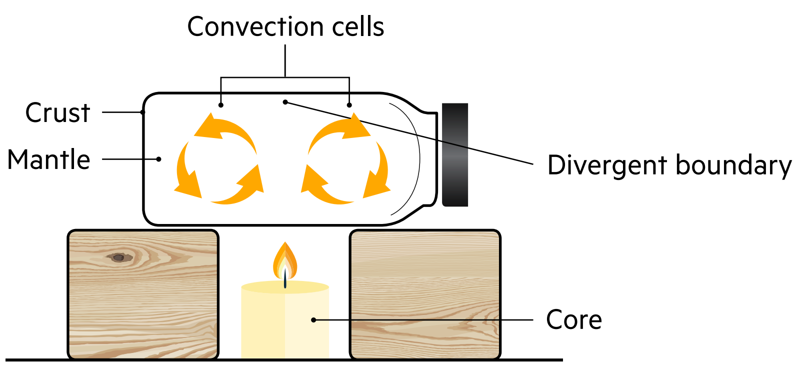
When a candle is used to heat the liquid, the particles in the liquid expand and the density decreases, causing the hotter liquid to move to the top of the bottle. This displaces the cooler liquid which sinks below, and is then heated continuing to drive the convection current.

In the following activity, students conduct an experiment and explain and analyse the experiment as a model for convection currents and plate tectonics.

After this activity you may wish explore visualisations of convection currents and continental drift. *Tectonics Investigator* on *Scootle* is a valuable interactive.

It can also be valuable for students to reflect on how their increased understanding of convection currents can help explain the world around them.

Rheoscopic fluid is useful for teaching heat transfer and particle theory, as well as modelling convection currents in the mantle and plate tectonics. The model represents the processes and materials as shown below.



How the model represents the process of continental drift (a possible response for Question 4).

Curriculum Links

Science

YEAR 5

Science Understanding

Solids, liquids and gases have different observable properties and behave in different ways (ACSSU077)

YEAR 8

Science Understanding

Energy appears in different forms, including movement (kinetic energy), heat and potential energy, and energy transformations and transfers cause change within systems (ACSSU155

YEAR 9

Science Understanding

The theory of plate tectonics explains global patterns of geological activity and continental movement (ACSSU180)

Energy transfer through different mediums can be explained using wave and particle models (ACSSU182)

Science Inquiry Skills

Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS170)

Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data (ACSIS171)

Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS174)

Science as a Human Endeavour

Scientific understanding, including models and theories, is contestable and is refined over time through a process of review by the scientific community (ACSHE157)

General Capabilities

Critical and Creative Thinking

Inquiring – identifying, exploring and organising information and ideas

Analysing, synthesising and evaluating reasoning and procedures

Modelling Convection Currents

Student Activity

Aim

To observe a model of convection currents, and understand how convection currents link to the movement of tectonic plates.

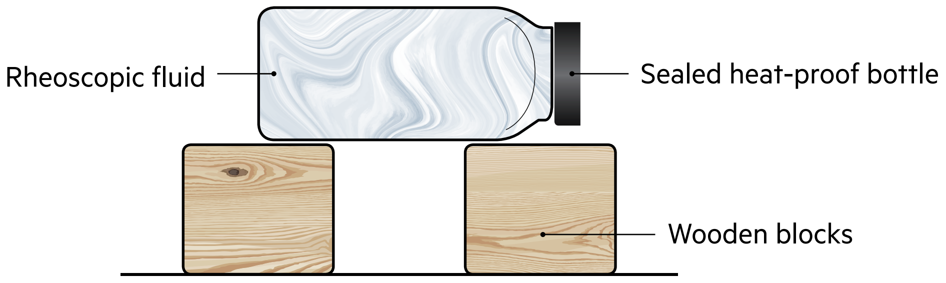
Materials

- Rheoscopic convection fluid
- Sealed heat-proof bottle
- Tea light candle
- Matches
- Wooden blocks
- Blu tack/plasticine

Method

1. Complete the K (what I know) and W (what I want to know) parts of the KWL chart (page 17).

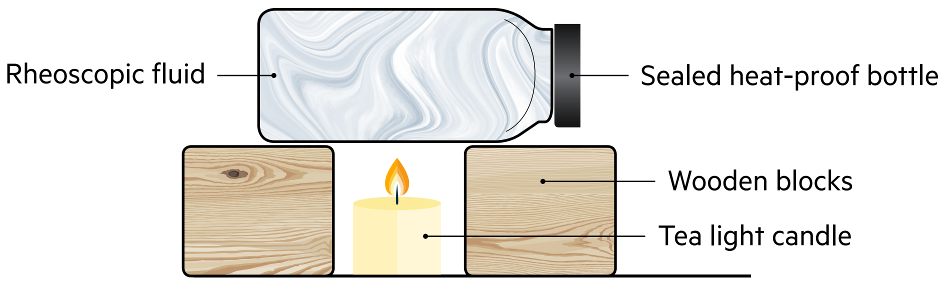
2. Set up materials as shown in the diagram below. Use blu tack to secure bottle to wooden blocks.



Material set-up.

3. While the bottle is stationary, observe current flow in the rheoscopic fluid for 1 minute. Record observations in results table on page 17.

4. Place a tea light candle under the heat-proof bottle (see below). Observe current flow in the rheoscopic fluid for 3 minutes. Record observations and complete the questions below.



Using heat to model convection currents.

Questions

1. Before your experiment, complete the K and W sections of the KWL chart below.

Table: KWL chart on convection currents.

What I **K**now about convection currents:	What I **W**ant to know about convection currents:	What I **L**earned about convection currents and how tectonic plates move:

2. During the experiment record your observations:

Table: Observations of results

Observations without heat source	Observations with heat source

3. Compare fluid movement without a heat source to fluid movement with a heat source. Why do you think these differences occurred?

4. This experiment can model plate tectonics. Draw a scientific diagram of material setup with the heat source and use arrows to show the fluid movement. Add the following labels to the diagram to show how the model represents continental drift:

convection current	crust	mantle	core	divergent plate boundary	ridge

5. Explain how this experiment represents the convection currents that occur within the Earth and the movement of tectonic plates.

6. Discuss similarities and differences between this model and tectonic plate movement.

7. How could you improve this model?

8. What did you learn? Complete the L section of the KWL chart.

ELABORATE

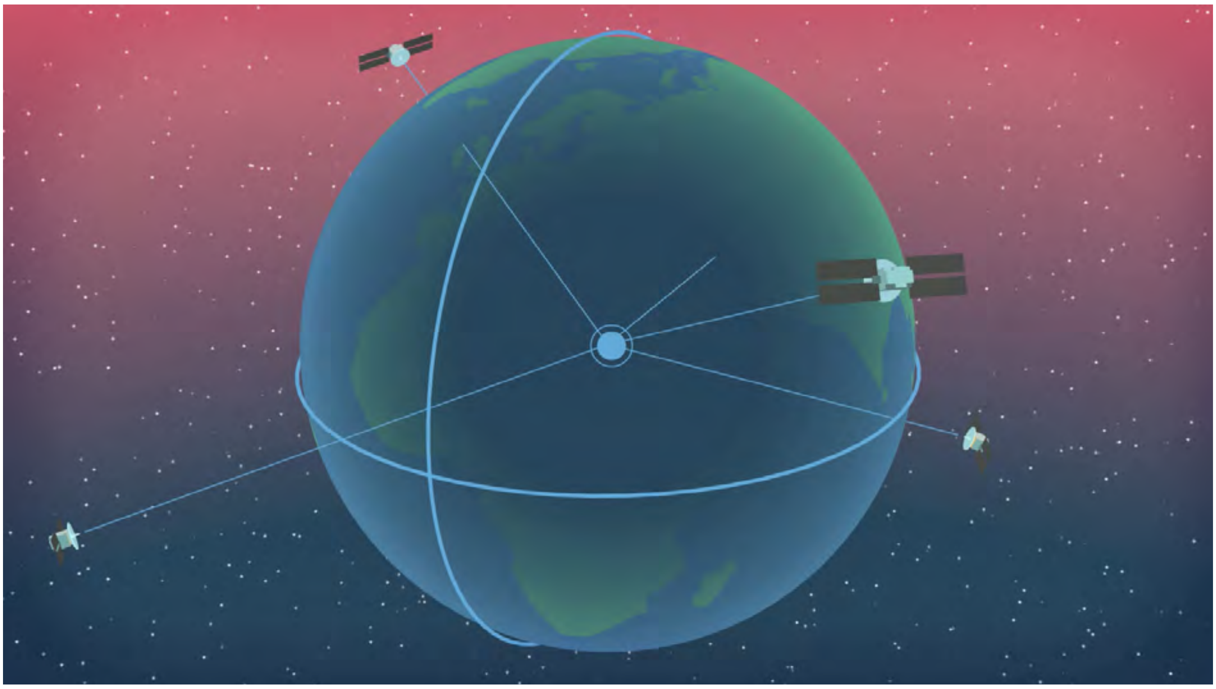
Calculating the Movement of Australia

Teacher Resource

It is important to note that the tectonic plates are in a continuous state of movement, and this movement, resulting from the flow of convention currents, impacts the surface of the Earth. This movement also impacts how we engage with the world around us using technologies.

For example, the Indo-Australian plate moves north at about seven centimetres per year. In 2016, Australia's position had to be reviewed and recalibrated as the country had moved 1.5 metres away from our GPS location on maps due to continental drift. This accuracy is not so much of a problem when using Google Maps on your phone; however, it can cause huge problems for technology that requires positional accuracy to function properly, such as self-driving cars. 1.5 metres could be the difference between being on the road and crashing into a tree!

In this activity, students will watch the video *Modernising Australia's Datum* to explain why the position of Australia was recalibrated in 2016. They will then calculate how far Australia will move between now and 2085. You could extend learning by asking students to calculate how long it will take for Australia to move certain distances.



Modernising Australia's Datum, ICSM ANZLIC Committee on Surveying and Mapping, Small Island Studios.

Curriculum Links

Science

YEAR 9

Science Understanding

The theory of plate tectonics explains global patterns of geological activity and continental movement (ACSSU180)

Humanities and Social Sciences

YEAR 6

Geography: Knowledge and Understanding

The geographical diversity of the Asia region and the location of its major countries in relation to Australia (describing the location of places in countries of the Asia region in absolute terms using latitude and longitude) (ACHASSK138)

General Capabilities

Numeracy

Estimating and calculating with whole numbers

Using measurement

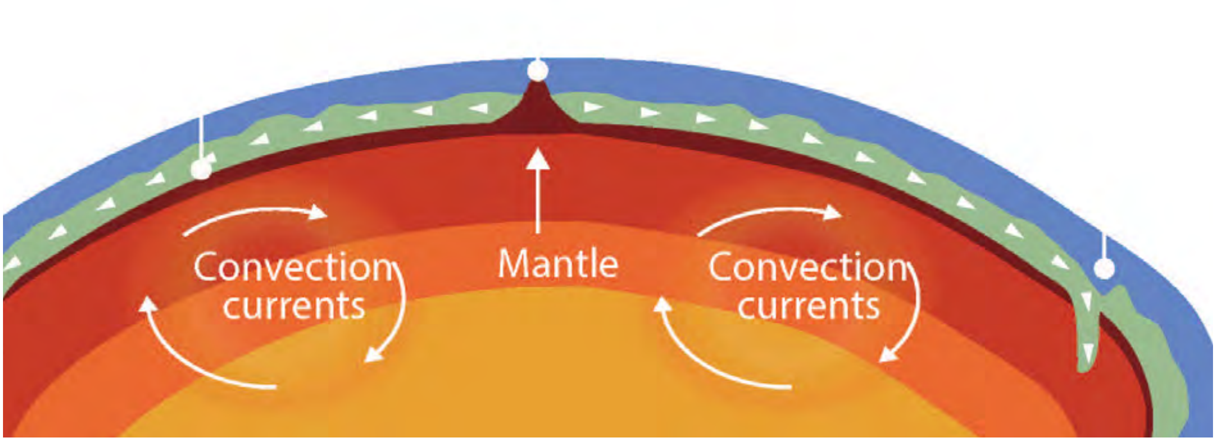
Using spatial reasoning

Calculating the Movement of Australia

Student Activity

From the highest mountain to the deepest trench, the theory of plate tectonics explains the features of the Earth, along with much of the geological activity we experience such as earthquakes and volcanoes.

The Earth's crust is divided into many plates that move around on top of the mantle. Convection currents caused by heat contained within the Earth drive the movement of these plates.



Slow moving convection currents within the mantle contribute to tectonic activity. Image: QM, Angelina Martinez

The tectonic plates are in a continuous state of movement, and this movement, resulting from the flow of convention currents, impacts the surface of the Earth.

For example, the Indo-Australian plate, one of the fastest moving plates, moves north at about seven centimetres per year. Due to this movement, scientists believe that in 200,000 years we could have another supercontinent as the Indo-Australian plate crashes into the Eurasian Plate. Austraeurasia anyone?

This movement also impacts how we engage with the world around us. Watch *Modernising Australia's Datum* to investigate how people are using technologies to address the effects of continental drift.

Questions

1. In 2016 Australia's position had to be recalibrated. Watch *Modernising Australia's Datum* then explain why recalibration was required.

2. Is there anything that puzzles you after watching the video, or is there anything else you would like to know about modernising Australia's datum?

3. How will you find the answers to your questions?

4. Australia moves north at about 7 centimetres per year. Use the information to calculate how far Australia will move between now and 2085.

5. If Australia continues to move the same speed and distance, how far will Australia have moved in 10 000 years? Draw this on a map.

ELABORATE

Puzzling Tectonic Plates

Teacher Resource

Students solve a puzzle using tectonic plates to construct a map of the Earth, and use this map to identify the geological features and events that occur at different plate boundaries.

Puzzle pieces may be laminated and re-used, and whiteboard markers can then be used to mark the geological features and events. This could be set as a research activity in groups. You can find many great simulations/visual representations of the earthquakes and volcanoes that have occurred around the world on the web.

Curriculum Links

Science

YEAR 6

Science Understanding

Sudden geological changes and extreme weather events can affect Earth's surface (ACSSU096)

Science Inquiry Skills

Compare data with predictions and use as evidence in developing explanations (ACSIS221)

Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal texts (ACSIS110)

Science as a Human Endeavour

Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena and reflects historical and cultural contributions (ACSHE098)

Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE100)

YEAR 9

Science Understanding

The theory of plate tectonics explains global patterns of geological activity and continental movement (ACSSU180)

Science Inquiry Skills

Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS170)

Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS174)

Science as a Human Endeavour

Scientific understanding, including models and theories, is contestable and is refined over time through a process of review by the scientific community (ACSHE157)

General Capabilities

Numeracy

Using spatial reasoning

Critical and Creative Thinking

Inquiring – identifying, exploring and organising information and ideas

Analysing, synthesising and evaluating reasoning and procedures

Puzzling Tectonic Plates

Student Activity

The boundaries between the plates are where most geological activity occurs, either when the plates push together (convergent plate boundaries), move apart (divergent plate boundaries) or slide past one another (transform boundaries).

In this task you will construct a map of the Earth using the tectonic plates. You will then do some research to determine the type of plate boundary, and the geological features and events that occur along each boundary.

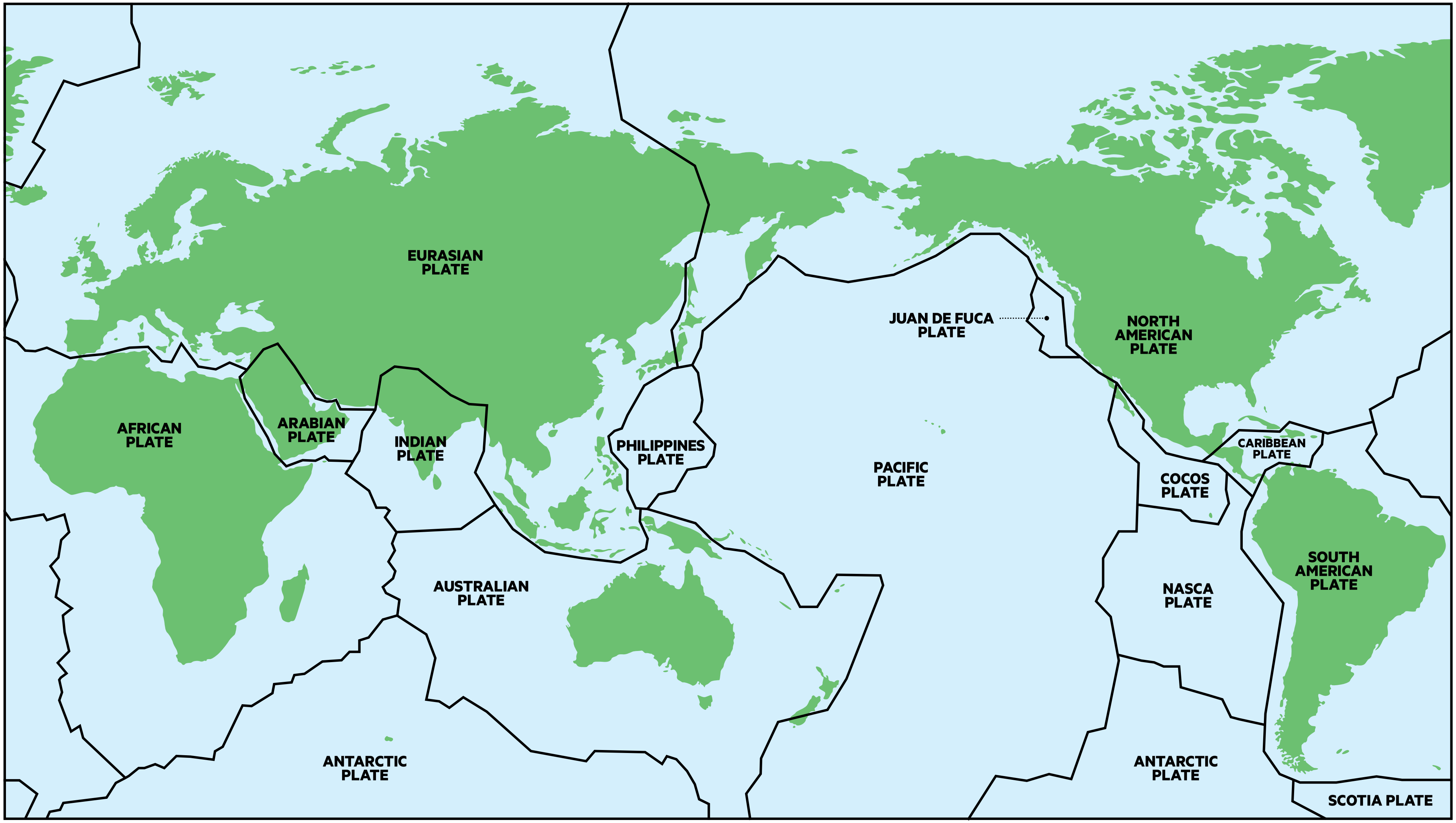
Materials

- A copy of *Our Earth's Tectonic Plates*
- Scissors
- Glue
- Highlighters
- Coloured pens

Method

1. Use the tectonic plates to construct a map of the Earth. Then add features to show the geological features and events that occur at the boundary, and predict if the plate boundary is convergent, divergent or transform.
   a. Cut out the tectonic plates and glue them in the correct order to construct a map of Earth.
   b. Draw in the major mountain ranges and/or trenches. Remember to include a key.
   c. Highlight where the most earthquakes occur. Use a different colour to highlight where the most volcanoes occur.
   d. Use the geological features and activity on your map to predict whether each tectonic plate boundary is a convergent, divergent or transform boundary.

Our Earth's Tectonic Plates



EXPLORE

Exploring Plate Boundaries: Tasty Tectonics

Teacher Resource

There are many ways to model plate boundaries using everyday materials. Mars bars are great models because the layers of the Mars bar can represent the layers of the Earth, and highlight the geological features that occur at plate boundaries. You may want to model this activity for the students. Check your school policy around food and student allergies before providing Mars bars, and ensure the activity is conducted in a food safe area.

Curriculum Links

Science

YEAR 6

Science Understanding

Sudden geological changes and extreme weather events can affect Earth's surface (ACSSU096)

Science Inquiry Skills

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 (ACSIS107)

Compare data with predictions and use as evidence in developing explanations (ACSIS221)

Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal texts (ACSIS110)

Science as a Human Endeavour

Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena and reflects historical and cultural contributions (ACSHE098)

Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE100)

YEAR 9

Science Understanding

The theory of plate tectonics explains global patterns of geological activity and continental movement (ACSSU180)

Science Inquiry Skills

Plan, select and use appropriate investigation types, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods (ACSIS165)

Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS170)

Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS174)

Science as a Human Endeavour

Scientific understanding, including models and theories, is contestable and is refined over time through a process of review by the scientific community (ACSHE157)

General Capabilities

Literacy

Comprehending texts through listening, reading and viewing

Understand how visual elements create knowledge

Critical and Creative Thinking

Inquiring – identifying, exploring and organising information and ideas

Analysing, synthesising and evaluating reasoning and procedures

Exploring Plate Boundaries: Tasty Tectonics

Student Activity

Geological features and activity such as mountains, earthquakes and volcanoes mainly occur along tectonic plate boundaries. In this activity you will investigate how the movement of tectonic plates can affect the Earth's surface.

Aim

To model how geological features form as a result of moving tectonic plates.

Materials

- 1 x treat-sized Mars bar per person
- 6 x plastic butter knives to share around the class

Method

1. Thoroughly wash your hands.
2. Unwrap the Mars bar.
3. Use the plastic butter knife to cut a straight line through the chocolate and top caramel layer of the Mars bar, without cutting through the nougat (see dotted line in the figure below).
4. With the Mars bar facing up, push the ends of the Mars bar together, 'squishing' the Mars bar. What happens to the chocolate on top? What does this represent? Record results in the Plate Boundary Table on the following page.
5. Using two hands hold either end of the Mars bar with your thumb and index finger and gently pull the ends of the Mars bar away from each other (the Mars bar should stretch, not break into two). What do you observe? What does this represent? Record results and observations.
6. Repeat steps 4 – 5 a couple of times, looking at how the movement affects the chocolate and caramel.
7. Consider how you might model a transform boundary. Include your answer in the Plate Boundary Table.
8. Use your model to answer the remaining questions in the Plate Boundary Table.

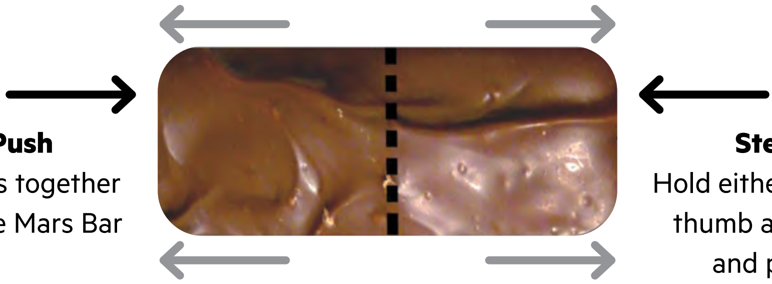
THINK

Which part of the Mars bar represents the following:

- Earths crust
- Mantle and magma
- Fault line/tectonic plate boundary

Step 1 Cut
Cut through the chocolate and caramel (not nougat)

Step 2 Push
Push the ends together
'squishing' the Mars Bar

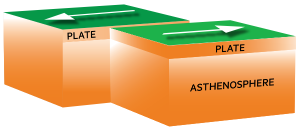


Step 3 Pull
Hold either end between
thumb and forefinger
and pull gently

Tasty Tectonics

Modelling and comparing plate boundaries

Use your understanding from the Mars bar activity to complete the table below. You may need to conduct further research to complete this task.

	Transform boundary	______ **boundary**	______ **boundary**
Model	A transform boundary can be shown using the Mars bar model by : ______	Pulling the Mars bar apart represents a ______ plate boundary.	Pushing the Mars bar together represents a ______ plate boundary.
Diagram of plate movement			
Movement	At transform plate boundaries, plates slide past each other in opposite directions, or in the same direction but at different speeds.		
Effect of movement	As the plates slide past each other, they can get stuck, creating a build-up of stress. When the friction is eventually overcome, the plates slip past in a sudden movement, creating seismic waves which result in earthquakes. Places where these slips occur are called faults.		
Common geological features	• Minimal, as crust is not created or destroyed • Fault lines – where slips occur • Linear valleys where the rocks have been ground away due to plate movement		
Common geological events	Earthquakes		
Examples	Alpine Fault, New Zealand; San Andres fault, USA.		

EXPLORE

Monsters in the Mountains: Visual Literacy

Teacher Resource

In this activity students will use their visual literacy skills to infer the significance of a location. Students explore evidence and transform their existing understanding of plate tectonics and continental drift to explain how fossils of tropical marine reptiles came to be found in mountains in the Arctic Circle.

This activity can be used to assess student understanding at the end of a topic, or modified to engage students before learning about plate tectonics and continental drift.

Curriculum Links

Science

YEAR 6

Science Understanding

Sudden geological changes and extreme weather events can affect Earth's surface (ACSSU096)

Science Inquiry Skills

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 (ACSIS107)

Compare data with predictions and use as evidence in developing explanations (ACSIS221)

Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal texts (ACSIS110)

Science as a Human Endeavour

Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena and reflects historical and cultural contributions (ACSHE098)

Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE100)

YEAR 9

Science Understanding

The theory of plate tectonics explains global patterns of geological activity and continental movement (ACSSU180)

Science Inquiry Skills

Plan, select and use appropriate investigation types, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods (ACSIS165)

Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS170)

Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS174)

Science as a Human Endeavour

People use scientific knowledge to evaluate whether they accept claims, explanations or predictions, and advances in science can affect people's lives, including generating new career opportunities (ACSHE160)

General Capabilities

Literacy

Comprehending texts through listening, reading and viewing

Understand how visual elements create knowledge

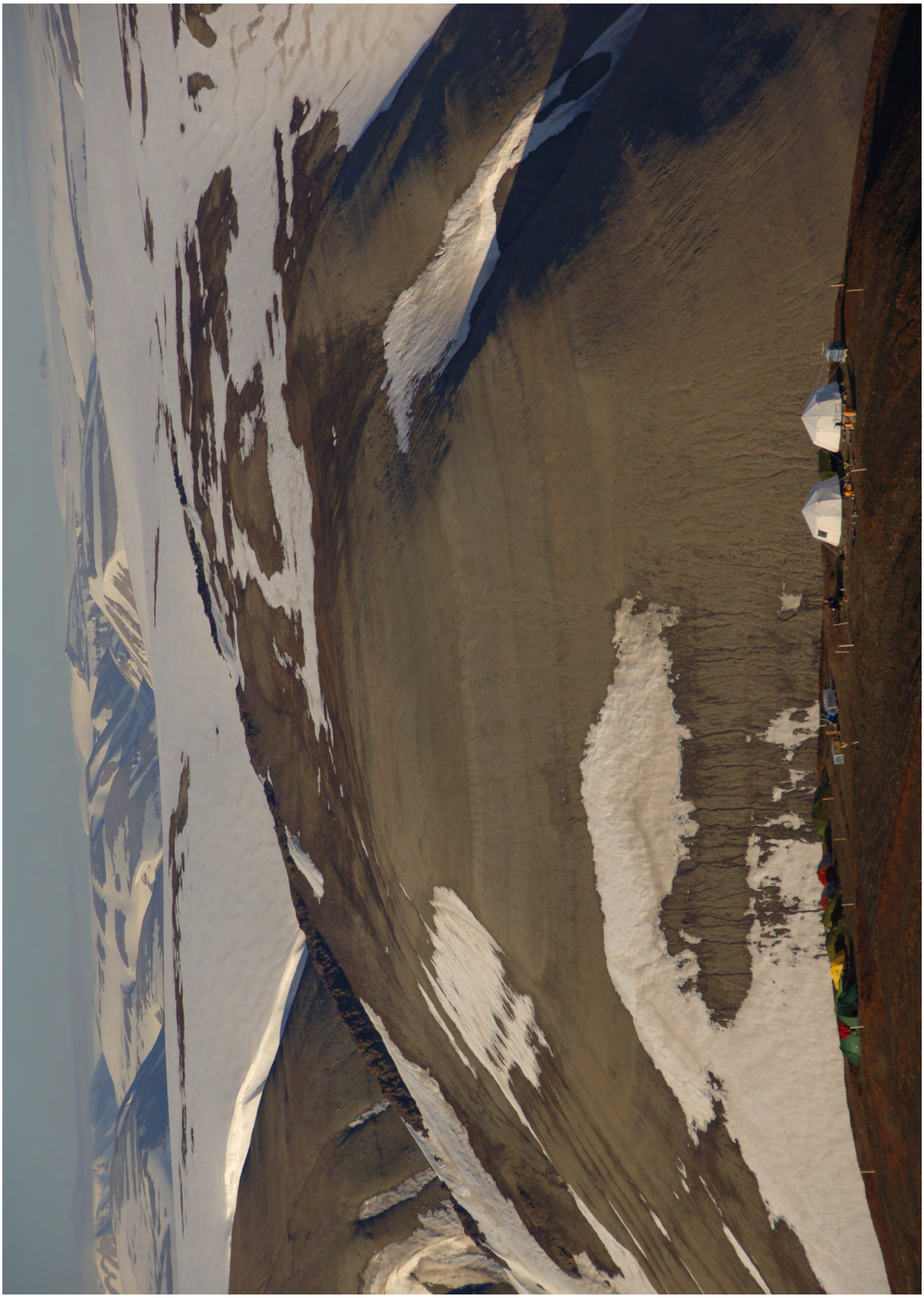
Critical and Creative Thinking

Inquiring – identifying, exploring and organising information and ideas

Analysing, synthesising and evaluating reasoning and procedures

Visual Literacy

Student Activity



Look closely, what can you infer from a picture? What is it? Jørn Hurum / NHM / UiO

Visual Literacy: Group Discussion

Use the Visual Literacy photograph to answer the questions below. Remember to justify your answers.

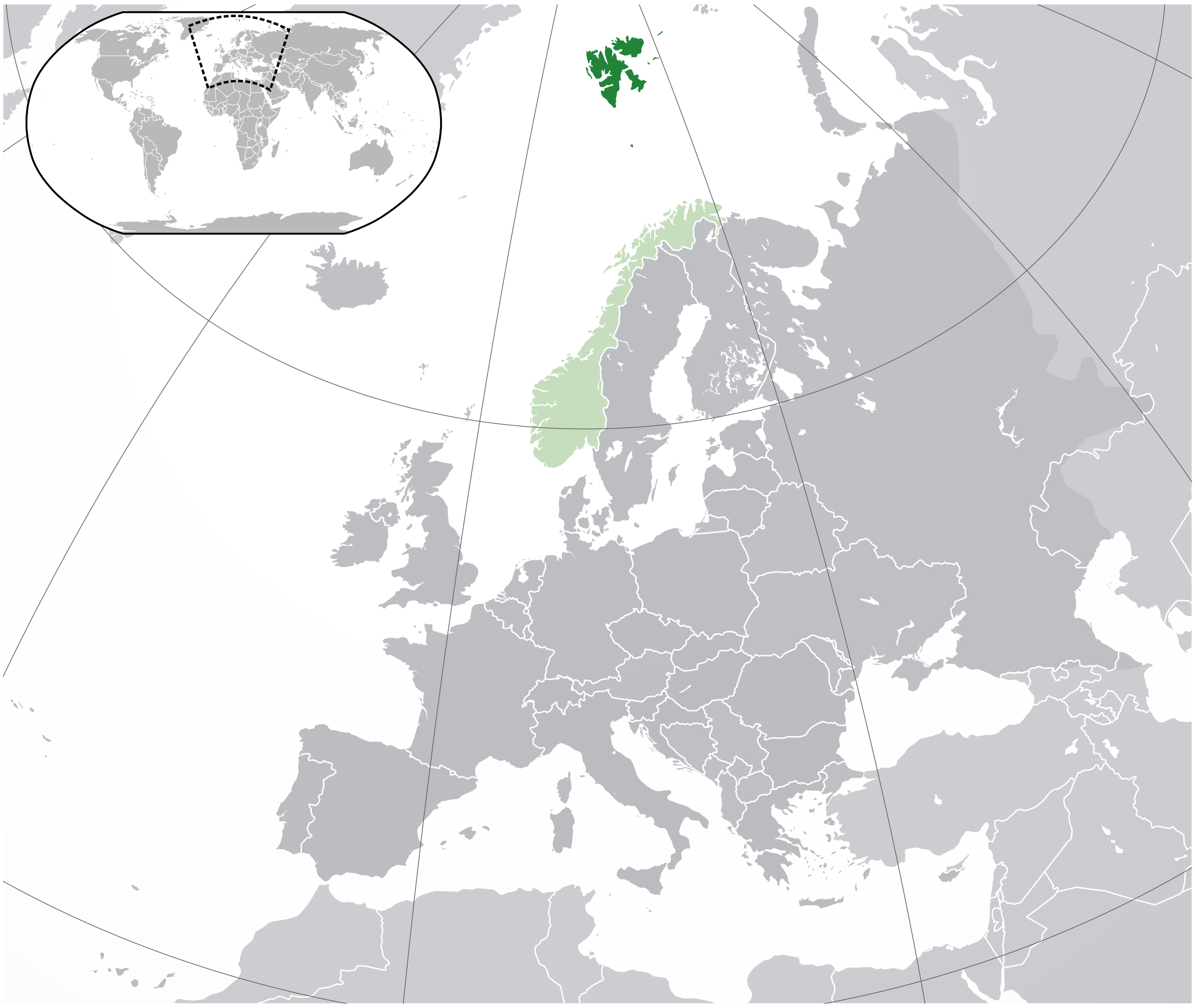
1. Describe what you see in the picture.

2. Explain where the picture may have been taken.

3. Make an inference: there are people conducting scientific work in this location. What might they be doing?

4. What types of living things might you find in this environment?

5. What types of fossils might you find in this environment?



Geographic location of Svalbard shown in dark green.

Visual Literacy: The Image Revealed

The freezing mountains seen in the photograph on page 28 are in Svalbard, a mountainous island archipelago in the Arctic Circle (map above). This area reaches 4˚C to 6˚C in the summer, and is well below freezing in the winter. Svalbard is so close to the poles that during the winter it is dark all day long. This remote area has a population of approximately 2500 people, and an equal number of polar bears!

This photograph shows the field base 'Camp of the Crows', where palaeontologists stay while excavating fossils in Svalbard. One of the scientists on this expedition was Dr Espen Knutsen (page 31), who currently works with the Queensland Museum Network.

What fossils are found in Svalbard? Read below to find out!

STEM Careers in Real Life:

Dr Epsen Knutsen, Palaeontologist

Dr Espen Knutsen is the Senior Curator of Palaeontology with the Queensland Museum Network. He is a vertebrate palaeontologist and has spent the past 12 years conducting fieldwork in Australia, the Netherlands, the Arctic and the USA. During this time he has described five new species of Jurassic marine reptiles!

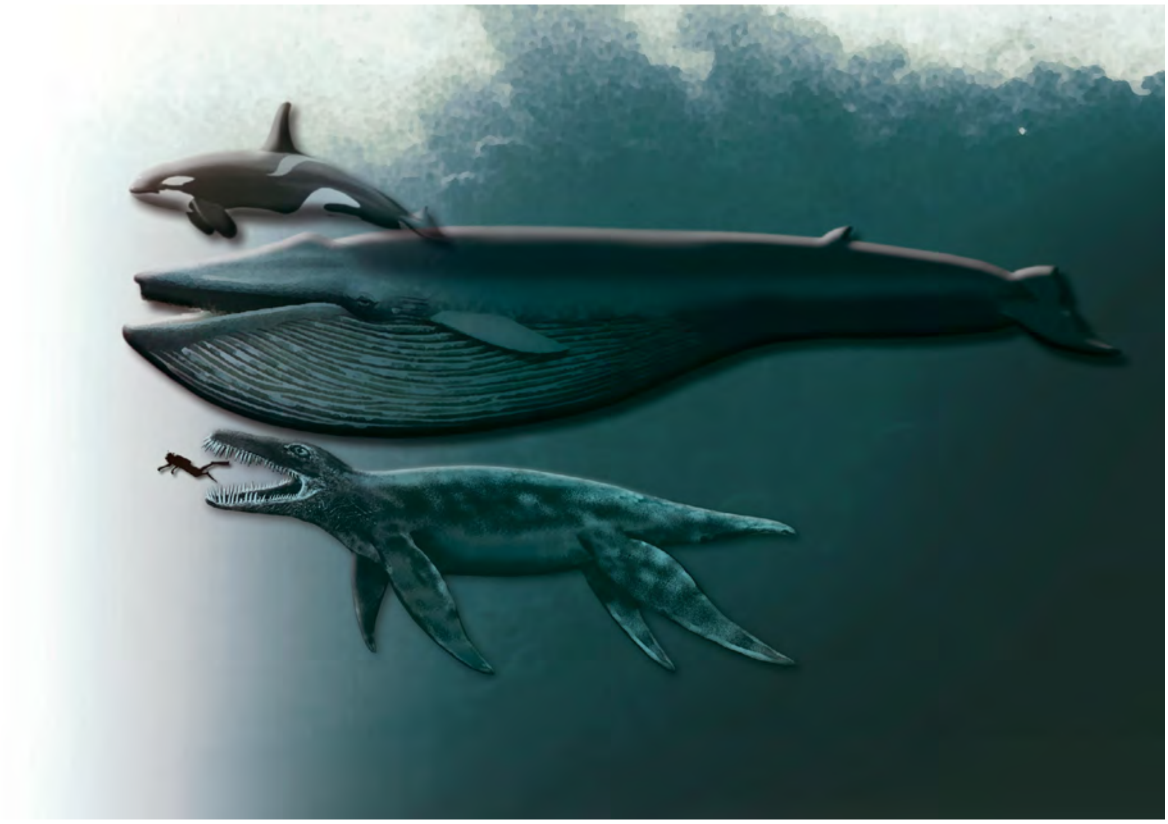
His most famous discovery was that of the pliosaur from Svalbard. This huge aquatic carnivore is estimated to have been 15 m long and 45,000 kg in weight. Teeth from the pliosaur were 30 cm in length (the size of a ruler!) and the skull measured a whopping 2.5 m. Dr Espen Knutsen's discovery was featured in two TV documentaries - *Predator X* (History Channel/BBC) and *Death of a Sea Monster* (National Geographic).

Dr Espen Knutsen working in Svalbard.

Svalbard is incredibly rich in marine reptile fossils. Over 40 individuals have been found, predominately ichthyosaurs, pliosaurs and long necked plesiosaurs. These marine reptiles lived in warm, shallow seas during the Jurassic Period.

Svalbard is also a remote and cold region which poses extra challenges for scientists conducting field work. Digs can only occur in the summer when temperatures are above freezing, and during this time the sun never sets. All people and equipment (including food for the length of the stay) are dropped in via helicopter, and extra precautions need to be taken due to the high number of polar bears in the region. While in the field, scientists look for exposed fossilised material, and when located, they mark the site for excavation. When it is time to excavate the site tonnes of material is removed by hand resulting in a very big hole!

Once fossils are exposed they are photographed in their location to help palaeontologists reconstruct them later. Fossils are then covered in wet toilet paper, plaster and iron to help hold them together in transit (page 34). Due to the high amount of freeze-thaw weathering, fossils from this area are very delicate, and take a lot of glue to put back together.



Size comparison - Killer whale, Blue whale, Pliosaur ("The Monster" or "Predator X") and human diver. You would not have wanted to run into this animal while swimming! Tor Sponga, Bergens Tidende.

Dr Espen Knutsen is now based at the Museum of Tropical Queensland in Townsville, working to increase our understanding of Jurassic fauna in Australia. He works on projects with many volunteers and students from James Cook University, discovering and collecting new marine reptiles and dinosaurs from around Australia.

To learn more about life as a palaeontologist you can watch the videos of Dr Espen Knutsen on Queensland Museum Network Learning Resources.

Polar bear warning. The high number of polar bears add an extra health and safety concern for scientists and volunteers. Trip wires around the camp are attached to flares to scare off polar bears that may wander too close (and alert anyone sleeping in the tents).

Everyone must have access to protective equipment at all times, and food tents are separated from the sleeping tents, shown in the visual literacy photograph of 'Camp of the Crows' (food tents are in white and sleeping tents are green).

6. Did you predict marine reptiles would be found in the Arctic mountains? Research and compare the ecosystem of Svalbard today, to that of the Jurassic period, including the environment, climate and fauna.

7. Predict how fossils from these Jurassic marine reptiles came to be buried in the mountains of Svalbard, a place with snow and polar bears.

Ichthyosaur fossil found in Queensland. This specimen from the Queensland Museum is Platypterygius australis, which grew over five metres in length. It had a streamlined body to reduce drag while moving through the water, and, like most ichthyosaurs, it had enormous eyes, among the largest recorded for any animal. Image: QM

Additional Activity

You are a scientist working with Dr Espen Knutsen on a fossil dig site. Record a journal entry from a day in the field, including your favourite parts.

Dr Espen Knutsen (third from left) and the team working together to excavate fossils in Svalbard. Fossils are covered in a plaster jacket before being taken back to the lab. Image: Jørn Hurum / NHM / UiO

EXPLAIN

Introducing Dr Espen Knutsen

Teacher Resource

Scientists are regular people, like you and me, who have questions that they want to answer. Many of these scientists work at the Queensland Museum Network. Students watch the STEM video of Dr Espen Knutsen, a vertebrate palaeontologist at Queensland Museum, as he explains how Australia has changed over time and the evidence for these changes.

Dr Espen Knutsen at work at Queensland Museum.

Curriculum Links

Science

YEAR 6

Science as a Human Endeavour

Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena and reflects historical and cultural contributions (ACSHE098)

Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE100)

YEAR 9

Science Understanding

The theory of plate tectonics explains global patterns of geological activity and continental movement (ACSSU180)

Science as a Human Endeavour

Scientific understanding, including models and theories, is contestable and is refined over time through a process of review by the scientific community (ACSHE157)

Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries (ACSHE158)

People use scientific knowledge to evaluate whether they accept claims, explanations or predictions, and advances in science can affect people's lives, including generating new career opportunities (ACSHE160)

Values and needs of contemporary society can influence the focus of scientific research (ACSHE228)

Earthquake-Resistant Building Challenge

Teacher Resource

Students are the engineers tasked with designing and building a three story building that can resist large earthquakes. They will follow the design-thinking framework to investigate the problem, design an earthquake-resistant building, create and test the building, and then refine their designs to withstand the maximum acoustic waves.

Designing a cross-disciplinary STEM task

Based on your schools STEM agenda, the Earthquake-Resistant Building Challenge can be incorporated into a lesson or two, or modified to become a cross-disciplinary project-based unit. A cross-disciplinary task will integrate the Australian Curriculum subjects of Science, Technologies and Mathematics to solve the problem – how do we design buildings to resist earthquakes? See suggestions for developing a cross-disciplinary task on page 38.

Creating a shake table

Shake tables can simulate earthquakes; therefore, they are effective for testing model buildings. There are many different types of shake tables that you can make depending on resources and time. All of these shake tables are effective in testing building strength, and digital technologies can be used to measure the intensity of the earthquake simulation. You may find shake table designs online or students could design and build their own shake tables.

A phone or tablet can be used to measure the size of the earthquake. The phone or tablet should be secured to the shake table. There are many apps to measure the intensity of the earthquake including *Vibration Meter* (Gamma Play, Android) or *Vibration Meter* (Smart Tools, Android) and *Vibration Meter, Seismograph, Seismometer* (ExaMobile S.A., iOS).

Curriculum Links

Science

YEAR 6

Science Understanding

Sudden geological changes and extreme weather events can affect Earth's surface (ACSSU096)

Science Inquiry Skills

Identify, plan and apply the elements of scientific investigations to answer questions and solve problems using equipment and materials safely and identifying potential risks (ACSIS103)

Decide variables to be changed and measured in fair tests, and observe measure and record data with accuracy using digital technologies as appropriate (ACSIS104)

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 (ACSIS107)

Reflect on and suggest improvements to scientific investigations (ACSIS108)

Compare data with predictions and use as evidence in developing explanations (ACSIS221)

Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal texts (ACSIS110)

Science as a Human Endeavour

Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena and reflects historical and cultural contributions (ACSHE098)

Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE100)

YEAR 9

Science Understanding

The theory of plate tectonics explains global patterns of geological activity and continental movement (ACSSU180)

Science Inquiry Skills

Plan, select and use appropriate investigation types, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods (ACSIS165)

Select and use appropriate equipment, including digital technologies, to collect and record data systematically and accurately (ACSIS166)

Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS170)

Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS174)

Science as a Human Endeavour

People use scientific knowledge to evaluate whether they accept claims, explanations or predictions, and advances in science can affect people's lives, including generating new career opportunities (ACSHE160)

Values and needs of contemporary society can influence the focus of scientific research (ACSHE228)

Design and Technologies

YEAR 5 AND 6

Design and Technologies: Knowledge and Understanding

Investigate characteristics and properties of a range of materials, systems, components, tools and equipment and evaluate the impact of their use (ACTDEK023)

Design and Technologies: Process and Production Skills

Critique needs or opportunities for designing, and investigate materials, components, tools, equipment and processes to achieve intended designed solutions (ACTDEP024)

Generate, develop and communicate design ideas and processes for audiences using appropriate technical terms and graphical representation techniques (ACTDEP025)

Select appropriate materials, components, tools, equipment and techniques and apply safe procedures to make designed solutions (ACTDEP026)

Negotiate criteria for success that include sustainability to evaluate design ideas, processes and solutions (ACTDEP027)

Develop project plans that include consideration of resources when making designed solutions individually and collaboratively (ACTDEP028)

YEAR 9 AND 10

Design and Technologies: Knowledge and Understanding

Critically analyse factors, including social, ethical and sustainability considerations, that impact on designed solutions

for global preferred futures and the complex design and production processes involved (ACTDEK040)

Explain how products, services and environments evolve with consideration of preferred futures and the impact of emerging technologies on design decisions (ACTDEK041)

Investigate and make judgments on how the characteristics and properties of materials are combined with force, motion and energy to create engineered solutions (ACTDEK043)

Design and Technologies: Process and Production Skills

Critique needs or opportunities to develop design briefs and investigate and select an increasingly sophisticated range

of materials, systems, components, tools and equipment to develop design ideas (ACTDEP048)

Develop, modify and communicate design ideas by applying design thinking, creativity, innovation and enterprise skills of increasing sophistication (ACTDEP049)

Work flexibly to effectively and safely test, select, justify and use appropriate technologies and processes to make designed solutions (ACTDEP050)

Evaluate design ideas, processes and solutions against comprehensive criteria for success recognising the need for sustainability (ACTDEP051)

Develop project plans using digital technologies to plan and manage projects individually and collaboratively taking into consideration time, cost, risk and production processes (ACTDEP052)

Curriculum Links

General Capabilities

Numeracy

Using spatial reasoning

Critical and Creative Thinking

Inquiring – identifying, exploring and organising information and ideas

Generating ideas, possibilities and actions

Analysing, synthesising and evaluating reasoning and procedures

Personal and Social Capability

Social management

ICT Capability

Investigating with ICT

Creating with ICT

Communicating with ICT

Managing and operating ICT

Earthquake-Resistant Building Challenge

Suggestions for developing a cross-disciplinary STEM task

YEAR 6 MATHEMATICS

Number and Algebra

- Calculate the scale of the building. According to the Australian building code, ceilings must be 2.4m above the floor. You could measure the ceiling height of the classroom or have students investigate this as part of their design to help students calculate the scale of their building. Once they have calculated the scale, students map out a to-scale plan of one floor. They could use a measuring tape on the oval to complete this task. Students should consider the following during this time:
  Is this an appropriate size for a building? Do you need to rethink the scale? Students can also covert measurements to decimals, fractions and percentages.
- Provide students with a budget and specify costs for materials. You may wish to use the table below.

Item	Cost per Item	Number of Items	Total Cost
		GRAND TOTAL	

If providing students with a budget, you could choose to have ‘sales’ on some materials e.g. 10%, 20% or 50% off. You could include other discounts such as ‘buy two get one free’ to encourage the development of financial literacy skills while also teaching Year 6 Number and Algebra.

Curriculum Links

Select and apply efficient mental and written strategies and appropriate digital technologies to solve problems involving all four operations with whole numbers *(ACMNA123)*

Find a simple fraction of a quantity where the result is a whole number, with and without digital technologies *(ACMNA127)*

Add and subtract decimals, with and without digital technologies, and use estimation and rounding to check the reasonableness of answers *(ACMNA128)*

Multiply decimals by whole numbers and perform divisions by non-zero whole numbers where the results are terminating decimals, with and without digital technologies *(ACMNA129)*

Make connections between equivalent fractions, decimals and percentages *(ACMNA131)*

Investigate and calculate percentage discounts of 10%, 25% and 50% on sale items, with and without digital technologies *(ACMNA132)*

Measurement and Geometry

- Convert between units of lengths while designing and constructing the building, and recognise the equivalence of lengths used in construction.
- Calculate the floor or wall area of scale models and life-sized buildings. Such calculations could be used to identify the quantity of carpet needed to cover the floor area. Students could also calculate the volume of the room.
- Construct prisms and pyramids to create their building and then test the strength of these designs.
- Calculate the angles in their construction and label these angles on design plans. Students may use this information to inform the inclusion of any wall bracings used to increase the strength of the building.
- Design the building using digital technologies which have the ability to rotate, reflect and translate buildings. This movement could possibly be used to enhance design features.

Curriculum Links

Connect decimal representations to the metric system *(ACMMG135)*

Construct simple prisms and pyramids *(ACMMG140)*

Convert between common metric units of length, mass and capacity *(ACMMG136)*

Solve problems involving the comparison of lengths and areas using appropriate units *(ACMMG137)*

Investigate combinations of translations, reflections and rotations, with and without the use of digital technologies *(ACMMG142)*

Investigate, with and without digital technologies, angles on a straight line, angles at a point and vertically opposite angles. Use results to find unknown angles *(ACMMG141)*

Statistics and Probability

- Test the building's design and measure how often the building is damaged in earthquakes at different intensities. Describe the probability the building will be damaged in future earthquakes of various intensities. Students may present this information, along with building design proposals, to the class. They may then participate in a class debate to identify which building has the best design. This replicates real-world practice, in which engineers present different designs to their team and the best design selected for construction.
- Data collected on building destruction at different earthquake intensities could be presented using various data displays, including comparisons to other buildings, for instance, the intensity of the earthquake the building can withstand. These data displays should be incorporated into the final proposal.
- Digital technologies can be used to measure earthquake intensities, save and convert collected data into data displays. Alternatively, students could convert the data into data displays using software such as Excel. Students can use this data to analyse the earthquake.
- Real-world data from past earthquakes can be compared to the student-collected data from their shake table tests. For example, students could investigate: Was the shake table earthquake more or less intense than the Christchurch earthquake? Would you building have withstood the Christchurch earthquake? Explain your answer.

Curriculum Links

Describe probabilities using fractions, decimals and percentages *(ACMSP144)*

Interpret and compare a range of data displays, including side-by-side column graphs for two categorical variables *(ACMSP147)*

Interpret secondary data presented in digital media and elsewhere *(ACMSP148)*

YEAR 9 MATHEMATICS

Number and Algebra

- According to the Australian building code, ceilings must be 2.4m above the floor. You could measure the ceiling height of the classroom or have students investigate this as part of their design to help students calculate the scale of their building. They could also investigate the proportions using wooden lengths or floor plans.
- Provide students with a 'loan' to construct the building and specify costs for materials. Students will then to calculate the interest that is charged on their loan and investigate how much they need to rent or sell rooms for to make a profit.

Curriculum Links

Solve problems involving direct proportion. Explore the relationship between graphs and equations corresponding to simple rate problems *(ACMNA208)*

Solve problems involving simple interest *(ACMNA211)*

Measurement and Geometry

Calculate the surface area and/or volume of model buildings and real buildings, such as the classroom.

Curriculum Links

Calculate areas of composite shapes *(ACMMG216)*

Calculate the surface area and volume of cylinders and solve related problems *(ACMMG217)*

Solve problems involving the surface area and volume of right prisms *(ACMMG218)*

Solve problems using ratio and scale factors in similar figures *(ACMMG221)*

Statistics and Probability

- Calculate the frequency of building failure at different earthquake intensities. Numerical data can be collected by identifying angle of torsion after a specified time on the shake table, while categorical data can be collected by identifying if the building has or has not been destroyed.

Curriculum Links

Calculate relative frequencies from given or collected data to estimate probabilities of events involving 'and' or 'or' *(ACMSP226)*

Identify everyday questions and issues involving at least one numerical and at least one categorical variable, and collect data directly and from secondary sources *(ACMSP228)*

YEAR 5-6 DIGITAL TECHNOLOGIES

Digital Technologies Processes and Production Skills

- Use devices to measure earthquake intensity data, and export or insert this data into a spreadsheet. Students can then validate the data, display the data in graph form and use the data to answer a range of questions.
- Compare the historical collection of data by seismometers to student data collection using devices. Students could also create a DIY seismometer and compare collected results, user experience and sustainability to the data collected via Apps on their devices.
- Create a website for the building design proposal, following ethical, social and technical protocols agreed on by the team. You may wish to assign a role for each member of the team.

Curriculum Links

Acquire, store and validate different types of data, and use a range of software to interpret and visualise data to create information *(ACTDIP016)*

Explain how student solutions and existing information systems are sustainable and meet current and future local community needs *(ACTDIP021)*

Plan, create and communicate ideas and information, including collaboratively online, applying agreed ethical, social and technical protocols *(ACTDIP022)*

YEAR 9-10 DIGITAL TECHNOLOGIES

Digital Technologies Processes and Production Skills

- Collect earthquake intensity and building strength data using multiple strategies, and identify the strengths and weakness of each method. This could include a comparison of multiple Apps and physical seismographs, including any DIY seismometers constructed by students.
- Store and display data as visual representations for improved user experience and understanding.

Curriculum Links

Develop techniques for acquiring, storing and validating quantitative and qualitative data from a range of sources, considering privacy and security requirements *(ACTDIP036)*

Analyse and visualise data to create information and address complex problems, and model processes, entities and their relationships using structured data *(ACTDIP037)*

YEAR 5-6 DESIGN AND TECHNOLOGIES

Design and Technologies Knowledge and Understanding

- Students must test different designs, and create a strong building within a set budget. You could give different materials different values so students must consider the cost and properties of materials. When students test their buildings they will notice the advantages and disadvantages of different materials and modify their buildings to according to their observations. Students can also investigate different building locations, and discuss environmental factors that they would need to consider in their building design or investigate the best location for their building. For example, is an area likely to receive large earthquakes, snowfall or flooding? Does a building need to be able to withstand earthquakes if it is in an area of low seismic activity such as Australia?
- Analyse how professionals collect seismographic information, and how scientists are working to improve data collection, storage and understanding. Investigate how seismic measurement systems can also be used to alert populations and emergency services about earthquakes and tsunamis due to seismic activity. Students could also investigate important considerations for disaster management, what disaster management information must be considered for future planning, and identify how disaster management and communication could be improved.
- Students could test and evaluate a range of materials used for beams, struts, bracing and adhesives.

Curriculum Links

Examine how people in design and technologies occupations address competing considerations, including sustainability in the design of products, services, and environments for current and future use *(ACTDEK019)*

Investigate characteristics and properties of a range of materials, systems, components, tools and equipment and evaluate the impact of their use *(ACTDEK023)*

Design and Technologies Processes and Production Skills

- Critique needs of buildings in different geographical areas, and design, create and test buildings for these locations.
- Create a building design proposal justifying why the building design is the best and present the proposal to the class.
- Create and test buildings following proper safety protocols, and select materials which will allow buildings to support mass and withstand an earthquake with an intensity of 9 on the Mercalli scale.
- Students test and refine their designs until their buildings meet the success criteria of withstanding an earthquake of 9 on the Mercalli scale.
- Students develop a project plan for their model, and a project proposal explaining why their design is the best and should be chosen when constructing a full-size building.

Curriculum Links

Critique needs or opportunities for designing, and investigate materials, components, tools, equipment and processes to achieve intended designed solutions *(ACTDEP024)*

Generate, develop and communicate design ideas and processes for audiences using appropriate technical terms and graphical representation techniques *(ACTDEP025)*

Select appropriate materials, components, tools, equipment and techniques and apply safe procedures to make designed solutions *(ACTDEP026)*

Negotiate criteria for success that include sustainability to evaluate design ideas, processes and solutions *(ACTDEP027)*

Develop project plans that include consideration of resources when making designed solutions individually and collaboratively *(ACTDEP028)*

YEAR 9-10 DESIGN AND TECHNOLOGIES

Design and Technologies Knowledge and Understanding

- Students analyse earthquake case studies, investigating why some areas experience more damage than others. Students could also investigate the relationship between socio-economic status and earthquake casualties, and explore what could be done to decrease casualties. They could also evaluate and propose strategies for improved disaster response and management.
- Students explain how strategies for earthquake resistance have evolved over time, why changes and advances in technology occur at different rates in different areas, and how emerging technologies and design decisions allow newer buildings to resist larger earthquakes
- Investigate and make judgments on how the characteristics and properties of materials and building design are combined with force, motion and energy to create buildings that can withstand larger earthquakes.

Curriculum Links

Critically analyse factors, including social, ethical and sustainability considerations, that impact on designed solutions for global preferred futures and the complex design and production processes involved *(ACTDEK040)*

Explain how products, services and environments evolve with consideration of preferred futures and the impact of emerging technologies on design decisions *(ACTDEK041)*

Investigate and make judgments on how the characteristics and properties of materials are combined with force, motion and energy to create engineered solutions *(ACTDEK043)*

Design and Technologies Processes and Production Skills

- Students critique the needs of different areas based on geographical and environmental conditions, and create a building that best meets needs of the community. Students investigate different methods to increase earthquake resistance in buildings, and incorporate these strategies when designing their own buildings.
- Students develop, modify and communicate building design ideas by applying design thinking, creativity, innovation and enterprise skills of increasing sophistication to create and present a building that meets the brief, and justify why their building should be chosen for the full-scale build.
- Students choose, assess and modify building materials and designs based on testing results, and respond flexibly to collected data.
- Students evaluate building design ideas, processes and solutions against comprehensive criteria for success, recognising the need for sustainability. This could include designing a building that: is three stories and at least 30 cm high; can support at least 100 grams; and, can withstand earthquakes up to 9 on the Mercalli Scale. Students could also be required to work within a budget.
- Use software to plan and manage the project. Students could use a Gantt chart to plot progress and timelines, and manage budget in Excel.

Curriculum Links

Critique needs or opportunities to develop design briefs and investigate and select an increasingly sophisticated range of materials, systems, components, tools and equipment to develop design ideas *(ACTDEP048)*

Develop, modify and communicate design ideas by applying design thinking, creativity, innovation and enterprise skills of increasing sophistication *(ACTDEP049)*

Work flexibly to effectively and safely test, select, justify and use appropriate technologies and processes to make designed solutions *(ACTDEP050)*

Evaluate design ideas, processes and solutions against comprehensive criteria for success recognising the need for sustainability *(ACTDEP051)*

Develop project plans using digital technologies to plan and manage projects individually and collaboratively taking into consideration time, cost, risk and production processes *(ACTDEP052)*

Earthquake-Resistant Building Challenge

Suggestions for variables

Independent variable suggestions:

- Effect of building shape on angle of torsion from origin
- Effect of vertical/horizontal mass distribution on number of damage points
- Effect of building shape on number of damage points
- Effect of vertical mass distribution on time to building failure
  (for example, one building could have an open-ground carpark underneath)
- Beam material (for example, do stronger beams result in fewer damage points?)
- Column materials (for example, do more flexible columns result in fewer damage points?)
- Incorporation of cross bracing (for example, does cross bracing reduce the number damage points?)
- The use of a seismic damper (for example, does the use of dampers reduce number of damage points?)
- The use of a base isolation device (for example, do base isolators reduce the number damage points?)
- Soil type (for example, do rocky soils results in less movement compared to sandy soils?)
- Foundation material (for example, does a wooden foundation reduce the number damage points?)

Dependent variable suggestions:

- Angle of torsion from origin
- Movement distance from origin
- Magnitude of building failure
- Intensity of building failure
- Time to building failure
- Distribution of damage
- Number of damage points

Earthquake-Resistant Building Challenge

Student Activity

Imagine…

You are sitting at the table on a computer when suddenly you feel a jolt and the whole house starts to shake. There is a really loud noise, like 30 trains are driving right through your house. You leap under the table and have to hold onto the table legs to stop it from bouncing away. Your computer crashes onto the ground and you see a bookshelf fall nearby. A minute later the shaking stops. You stand up and walk outside. Some buildings have big cracks in them. There are people who have been injured and small children are crying. You see a building that has been completely destroyed.

Later you hear that people were killed when that building was destroyed. Experts are saying that if the building was designed to be more earthquake-resistant it may not have fallen to the ground. They say on the news, 'Earthquakes don't kill people. Buildings do.'

You decide that you are going to work on designing and building earthquake safe buildings so less people are hurt in the future.

Task:

It is ten years later and you are an engineer. You have been tasked with designing and building your first three story building.

You must:

- **Investigate** how buildings can be designed to withstand earthquakes. You should include background information on earthquakes and features that increase the strength of buildings during earthquakes.
- **Design** a three story building that can resist earthquakes up to an intensity of nine on the Mercalli Scale. Your building should also be cost effective and come within the specified budget.
- **Create** a prototype of your building out of balsa wood, masking tape and paper (or other materials provided by your teacher).
- **Test** your prototype on the shake table to simulate a real earthquake. The building will also need to support weights of at least 100 grams.
- **Refine** the building design and construction to increase the strength.
- **Collaborate** in teams of two or three.
- **Evaluate** continuously to create a building that meets the brief. You may also be required to evaluate social interactions to effectively work in a team.

Continue to design, create, test and refine the building to resist earthquakes up to nine on the Mercalli scale (and bigger!).

1. Investigate and Design

Before constructing your building, you must write a proposal to explain the design of the building and get approval from your manager (in this case, your teacher). A proposal should include:

- [ ] Background information on earthquakes and earthquake resistant buildings
- [ ] Labelled sketch or digital representation of building
- [ ] Justification for design
- [ ] Calculated scale of the building (building ceiling heights are usually 2.4 m)
- [ ] Materials required
- [ ] Predicted cost of proposed design based on materials

Once your proposed design has been approved, you can create your building prototype.

2. Create

Create your three story building using the materials provided. Record any modifications required as you build. You may want to test that each floor of building can hold the required weights, and continually test the strength of the building.

Your building should also include a strong foundation that can be attached to the shake table.

3. Test

Attach your building to the shake table. A phone or tablet can be used to measure the size of the earthquake. The phone or tablet should also be secured to the shake table. There are many apps to measure the magnitude of the earthquake including Vibration Meter (Gamma Play, Android) or Vibration Meter (Smart Tools, Android) and Vibration Meter, Seismograph, Seismometer (ExaMobile S.A., iOS).

Place 100 grams of weight on your building and start shaking gently. Increase the magnitude of the earthquake and continue to shake. If you observe any building faults you may want to stop shaking and refine your design to increase the building strength in an earthquake. Once you reach a magnitude of nine, continue to shake for one minute. Record your observations. Record the maximum earthquake that your building will withstand.

4. Refine

Based on your observations, modify your building design to increase its strength, and then re-test it on the shake table. You may want to investigate other strategies to help your building resist earthquakes. Continue to create a building that can resist earthquakes to at least a magnitude of nine on the Mercalli Scale.

Appendix 1: Additional Resources

STEM Learning Resources

Specific resources relevant to Earth Shattering Science and/or plate tectonics can be found online at Queensland Museum Learning Resources, including:

STEM Video: Plate Tectonics, Dr Espen Knutsen
Explore how scientists use fossil evidence to explain global patterns of geological activity and continental movement. This video is presented by Dr Espen Knutsen, Senior Curator of Palaeontology at Museum of Tropical Queensland.

STEM Careers: Dr Espen Knutsen, Palaeontologist
Dr Espen Knutsen is a Senior Curator of Palaeontology at Museum of Tropical Queensland. In this video, Espen discusses his work as a vertebrate palaeologist, as well as how and why he decided to enter this profession.

Plate Tectonics Part 1: Exploring Continental Drift
Use fossil evidence from these prehistoric giants and other ancient life to identify how the continents have moved through time, and use this fossil evidence to recreate a map of Gondwana.

Plate Tectonics Part 2: Tectonic Plates and Australia
Australia has moved over time, and is still moving! Work as a scientist to predict how the movement of the Australian plate would have influenced flora and fauna, and calculate the current movement of Australia as we drift north. Use an understanding of the continents and spatial awareness to solve a tectonic plate puzzle, and identify the geological features and events found at plate boundaries.

Plate Tectonics Part 3: Exploring Plate Boundaries
Monsters in the mountains, how did they get there? Use mini Mars bars to examine the features and events that occur at plate boundaries, and discover how fossils can end up in unexpected places.

Exploring Volcanoes
Evidence of past volcanoes can be seen all over the world, including Australia. In this resource students model two different volcanoes, and explore how and why volcanoes affect Earth's surface, the environment and human populations.

Queensland Museum Loans Kits

Active Earth
Investigate major geological events such as earthquakes, volcanic eruptions and tsunamis.

Queensland Museum Publications

In Search of Ancient Queensland
In Search of Ancient Queensland charts the complex evolution of life over the past 250 million years, and explores the geological events and dramatic environmental change that have shaped modern Queensland.