SCIENCE

Level

F	1	2	3	4	5	6	B6

Interactions and changes in Earth and space

Strand
Earth and Beyond

Key concepts
The Earth, solar system and universe are dynamic systems.
Events on Earth, in the solar system and in the universe occur on different scales of time and space.

Purpose

Activities in this module are designed to help students understand that there are interactions between systems on Earth and in the solar system and that these interactions occur in different scales of time and space. Students have opportunities to:

- design and perform investigations related to the formation and erosion of rocks on Earth;
- look for patterns and meanings in the interaction of the sun and Earth as they relate to day/night and seasons;
- construct and use models to simulate interactions between systems on Earth;
- formulate and elaborate ideas about the scale of time involved in changes on the Earth.

Overview of activities

The following table shows the activities in this module and the way in which these are organised in **introductory**, **developmental** and **culminating** phases.

Introductory ►	Developmental ►	Culminating
Is every day the same? Timelines	Day, night and seasons What if the Earth was moved? Lava mountains Cooling lava and magma Igneous rocks Erosion by streams Erosion by landslides Settling of sediments Sedimentary rocks Metamorphic rocks What is wind?	Earth on a different angle The rock cycle The dynamic Earth

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Core learning outcomes

This module focuses on the following core learning outcomes from the Years 1 to 10 Science Syllabus:

Earth and Beyond

3.1 Students identify and describe some interactions (including weathering and erosion) that occur within systems on Earth and beyond.

3.2 Students discuss regular and irregular events in time and space that occur on the Earth and in the sky.

4.1 Students recognise and analyse some interactions (including the weather) between systems of Earth and beyond.

4.2 Students collect information which illustrates that changes on Earth and in the solar system occur on different scales of time and space.

5.1 Students explain how present-day features and events can be used to make inferences about past events and changes in Earth and beyond.

5.2 Students infer from data that the events that occur on Earth and in the solar system can have effects at other times and in other places.

Core content

This module incorporates the following core content from the syllabus:

Earth and Beyond

The Earth as a system
- features — rock types, wind
- interactions between components — erosion, weathering

Changes on Earth and beyond
- rock cycle, weather, seasons, day/night

Scales of time
- human lifetime, geological time

Changes in Earth and beyond
- cyclical — day/night, seasons
- catastrophic — volcanic eruptions
- magma intrusions and extrusions, regional metamorphosis

Evidence of past events in present-day events and features
- rock types, patterns of erosion, sedimentation, composition of rocks

Assessment strategy

Suggestions for gathering information about student learning are provided in each of the activities in this module. Once sufficient information has been collected, judgments can be made about students' demonstrations of outcomes. Typical demonstrations of this module's intended outcomes are provided here to indicate the pattern of behaviour to look for when making judgments.

Earth and Beyond

3.1 Students identify and describe some interactions (including weathering and erosion) that occur within systems on Earth and beyond.

Students may:

- describe what happens to weathered material;
- describe some effects of erosion;
- identify the interactions between the sun and Earth that cause day and night;
- describe changes related to day/night and seasons;
- describe the structure of a volcano and what happens when it erupts;
- identify parts of the rock cycle.

Earth and Beyond

3.2 Students discuss regular and irregular events in time and space that occur on the Earth and in the sky.

Students may:

- discuss changes experienced from day to night;
- describe variations related to changes in the seasons;
- describe the flow of lava from a volcano;
- describe the effect of landslides;
- compare the area affected by a volcanic eruption and a cyclone;
- explain that the formation and erosion of rocks can take millions of years.

Earth and Beyond

4.1 Students recognise and analyse some interactions (including the weather) between systems of Earth and beyond.

Students may:

- analyse information gathered from simulations of erosion;
- make links between the structure of rocks and the conditions of their formation;
- construct and use models to clarify their ideas of interactions that cause day/night and seasons;
- explore and elaborate their ideas about interactions that give rise to storms.

Earth and Beyond

4.2 Students collect information which illustrates that changes on Earth and in the solar system occur on different scales of time and space.

Students may:

- gather information to answer their questions about changes in the atmosphere and the magnitude of those changes;
- create a timeline and sequence of events for the rock cycle;
- prepare scenarios related to the process of sedimentation;
- compare the scales of time in which different changes take place;
- apply ideas and concepts to predict the effects of changes.

Earth and Beyond

5.1 Students explain how present-day features and events can be used to make inferences about past events and changes in Earth and beyond.

Students may:

- make inferences about conditions in the past that gave rise to present-day distribution of rock types.

Earth and Beyond

5.2 Students infer from data that the events that occur on Earth and in the solar system can have effects at other times and in other places.

Students may:

- recognise that erosion and deposition may be separated significantly in time and space;
- infer from data that changes to the relationship between the sun and Earth could result in significant climatic change.

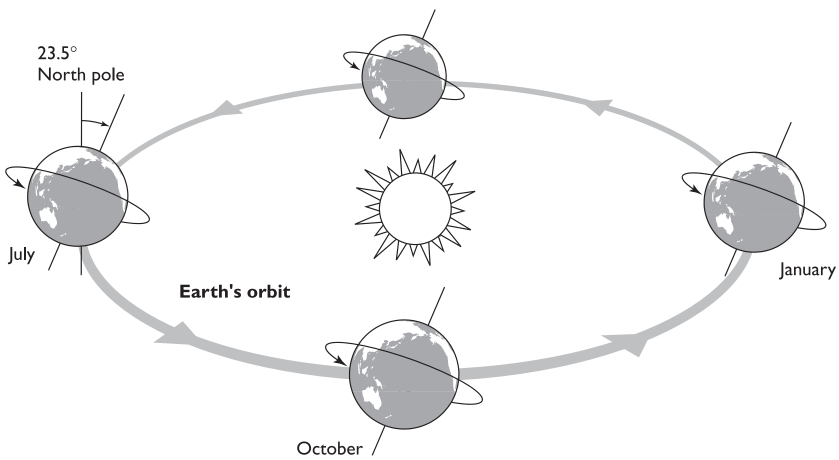
Background information

Current scientific conceptions

Day, night and seasons

The Earth is a sphere that spins like a ball-shaped top, making one complete rotation in one day. The imaginary axis around which the Earth rotates is currently tilted at an angle of approximately 23.5° from the vertical. As the Earth spins on its axis, it travels in an elliptical orbit around the sun, making one complete circuit around the sun in one year. Over time the length of the year has changed. The year 2000 actually included 365 days, 5 hours, 48 minutes and 45 seconds. To accommodate extra hours, minutes and seconds an extra day is added each fourth year. Thus, 2000 became a leap year with 366 days.

The Southern Hemisphere is angled towards the sun between about November and March. During this time, the Southern Hemisphere receives the sun's rays more directly and experiences spring, summer and autumn. Between about May and September, the Northern Hemisphere is angled towards the sun and has its spring, summer and autumn. When it is the middle of summer in the Southern Hemisphere, it is the middle of winter in the Northern Hemisphere.



As the Earth orbits around the sun, an observer on Earth sees the sun rise (appear above the horizon) and set (disappear below the horizon) in slightly different positions, and at slightly different times, each succeeding day. The table below shows how the sun's position in the sky varies throughout the year.

Southern Hemisphere				
Time of year	**Sun rises in**	**At midday, sun is directly over**	**Sun sets in**	**Day and night length**
Vernal equinox (21 Sept.*)	East	Equator	West	Day = night
Summer solstice (21 Dec.*)	South-east	Tropic of Capricorn, 23.5° S	South-west	Day > night
Autumnal equinox (21 March*)	East	Equator	West	Day = night
Winter solstice (21 June*)	North-east	Tropic of Cancer, 23.5° N	North-west	Day < night

*The actual date may vary from one year to the next because there is an extra day in each leap year.

The two **solstices** (the word means 'sun stands still') are the days on which the sun appears to stop its northward (or southward) progression and to start moving back towards the south (or north).

Equinoxes (meaning 'equal night', i.e. day and night are of equal length) occur twice a year when the sun is directly overhead at the equator. They are called the vernal (spring) equinox and the autumnal equinox.

The **equator** is the imaginary line around the middle of the Earth, that is, half way between the poles, dividing the Earth into Northern and Southern Hemispheres.

The Tropic of Cancer is an imaginary line of latitude 23.5° north of the equator. The sun is directly overhead at the Tropic of Cancer at noon on (or around) 21 June.

The Tropic of Capricorn is an imaginary line of latitude 23.5° south of the equator. The sun is directly overhead at the Tropic of Capricorn at noon on (or around) 21 December. The tropics mark the limits of the sun's apparent movement north and south of the equator.

Wind is moving air. The sun heats areas of land or water. The land or water re-radiates heat, causing the air above it to become warm. Warm air is less dense than cold air. The warm air rises, creating a region of relatively low pressure. Cooler, more dense air moves in from surrounding areas of relatively high pressure. This moving air is wind. The speed of the wind is determined by the difference in air pressure between the two places and the distance between them. Where there is a large pressure difference over a short distance, there will be strong winds.

The Beaufort scale is a way of describing wind speed. It uses qualitative rather than quantitative data.

Beaufort number	Type of wind	Speed (kph)	Description
0	Calm	<1	Smoke rises vertically.
1	Light	1–5	Smoke drifts.
2	Light breeze	6–11	Leaves rustle; wind felt on face.
3	Gentle breeze	12–19	Small twigs move.
4	Moderate breeze	20–29	Dust and loose paper move.
5	Fresh breeze	30–39	Small trees sway.
6	Strong breeze	40–50	Large branches sway. Umbrellas used with difficulty.
7	Near gale	51–61	Whole trees sway. Hard to walk against the wind.
8	Gale	62–74	Twigs break off trees. Hard to walk.
9	Strong gale	75–87	Slight damage to buildings — tiles blown off roof.
10	Storm	88–102	Trees uprooted. Considerable damage to buildings.
11	Violent storm	103–120	Widespread damage.
12 +	Hurricane	>120	Violent destruction over whole area.

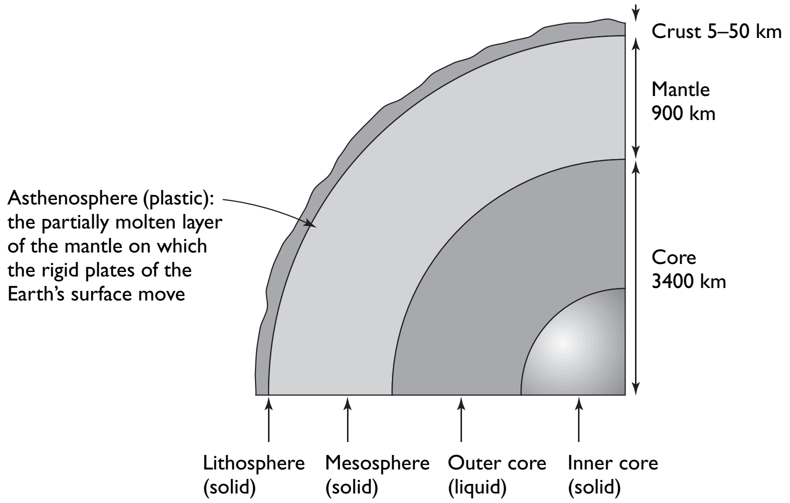
During the night, heat is lost from land more quickly than from water. In the early morning, the water is warm relative to the land. Air pressure over the water is, therefore, low relative to air pressure over the land. The movement of air (wind) is from the land to the sea — a land breeze.

During the day, the land heats up more quickly than water. Therefore, in the later part of the day, the air pressure above land will be low compared to the air pressure over water, and the movement of air will be from water to land — a sea breeze.

Tropical cyclones are areas of intense low pressure. They are created poleward of 5° north and south of the equator and where the sea temperature exceeds 27°C. Warm, moist air over the oceans rises rapidly and, as it rises, the air cools. Moisture in the air condensing to form clouds releases enormous amounts of energy. The rapidly rising air causes a drop in air pressure at the ground surface. Air converging in the area of low pressure is uplifted in a spiralling motion. This spiralling is clockwise in the Southern Hemisphere and anticlockwise in the Northern Hemisphere. The rate of air movement in the system increases as the energy of the system increases, and this causes the storm to form.

Formation of rocks

Interior source of Earth's heat: Radioactive decay of materials in the Earth's core raises the temperature in the centre of the Earth to over 6000°C. Heat from the centre moves via convection currents through the mantle to the junction between the upper mantle and the lower crust. This process provides some of the heat in these layers of the Earth. A major source of heat in the surface layers of the Earth comes from radioactive decay of materials in the crust (up to 40%) and in the upper mantle (up to 60%). In places, the temperature in the upper mantle is great enough to liquefy rocks. It is molten material from these areas that erupts from volcanoes.



Volcanoes: Deep within the upper layers of the Earth, molten rock and steam are at high pressures and temperatures. Where surface layers of the Earth are cracked or thin, this pressure is released as molten rock and gases escape to the surface and volcanoes form. Volcanic mountains are formed by the accumulation of erupted material. Volcanoes occur along fault lines and in areas where the Earth's tectonic plates are separating or colliding.

Lava is molten rock that reaches the surface of the Earth. When lava cools, it forms **extrusive igneous rock**. These rocks are fine grained because they were cooled quickly. Basalt is an extrusive igneous rock.

Molten rock beneath the surface of the Earth is known as magma. **Intrusive igneous rocks** are formed when magma solidifies deep beneath the Earth's surface. These rocks have more time to cool and so form larger crystals. Granite is the most common type of intrusive igneous rock.

Sedimentary rocks are grouped according to their composition and texture.

- Sedimentary rocks may be formed by compaction and cementing of sediments that have settled and consolidated over time through pressure, cementing agents or both. Sediment (for example, mud, sand, gravel and/or clay) is constantly brought into lakes and seas by rivers. These sediments settle on the bottom of the lakes and other bodies of water. Compaction of sediments occurs over time as the depth of deposited material increases. Over millions of years this sediment may be consolidated into a solid form known as sedimentary rock — for example, sandstone and mudstone.

- Chalk and coal are sedimentary rocks formed from living things or their remains.
- Halite (the mineral name for sodium chloride) and gypsum are sedimentary rocks formed when water evaporates, and dissolved minerals come out of solution and crystallise. These rocks are held together by tightly interlocking crystals.
- Limestone is a sedimentary rock that is derived either from the shells of marine organisms or as calcium carbonate precipitated out of solution in the oceans.

Metamorphic rocks are formed from previously existing rocks through the application of heat and/or pressure. This heat may be from magma or lava, or from large bodies of rock moving against each other. Metamorphic rocks are often formed near volcanoes. They are harder than their parent rocks and do not soak up water as readily. Metamorphic means 'transformed'. Marble and slate are examples of metamorphic rocks.

Weathering, erosion and deposition

Weathering is the general term for the processes by which rocks of the Earth's surface are broken down. **Erosion** occurs when an agent of erosion moves weathered material away from the parent rock. Wind, waves, streams or ice are all agents of erosion. Streams carry particles of rock, mud and sand; swifter moving streams carry more material than slower moving streams. When streams slow down, they can no longer carry heavy materials, so these are deposited. As streams slow down further, more material settles out of suspension and falls to the bottom since it becomes too heavy to be transported. Streams slow down greatly when they reach a larger body of water.

Melted water from the surface of glaciers seeps through cracks in the ice and into cracks in the rocks below. There the water freezes again, expands and causes the rocks to break apart. The resultant rock fragments become embedded in the bottom and sides of glaciers and abrade any surface over which they move.

Most wind erosion occurs in dry areas such as deserts. The wind dislodges and transports loose material from the land surface. This material abrades the surface of rocks over which the wind moves. The amount of abrasion occurring will depend on the speed of the wind, the size of the particles of material carried and the hardness of the rock being abraded.

Erosion of material on hill slopes is due mainly to mass movement. Mass movement is the displacement of soil and rock on slopes under the influence of gravity and without water being used as the transporting agent. Movement can be fast, as in the case of **landslides**, or slow as in the case of soil creep. Movement occurs when the forces holding the material in position are exceeded. Factors that can cause mass movement are undercutting, overloading due to water, and earthquakes or other tremors. How these factors affect material on a slope depends on the composition and texture of the material, the effect of water within the material, and how the material reacts to the imposed stresses.

A description of the process of weathering is included in the Level 3 module 'Interactions of systems on Earth and beyond'.

The **rock cycle** is a series of processes in which rocks continuously change from one type to another. The organisation of minerals within sedimentary and igneous rocks exposed to intense heat (especially in close proximity to magma) and pressure may change, and they become metamorphic rocks. Metamorphic rocks may be further changed under these conditions. If rocks are subjected to enough heat or pressure, they may melt completely and form new igneous rocks either by cooling within the Earth or by being ejected during volcanic activity. Weathering and the erosion of surface rocks eventually lead to the development of sedimentary rocks. Earth movement and erosion can lead to rocks previously buried in the ground being exposed and, therefore, subject to the forces of weathering and erosion.

Students' prior understandings

Students' prior understandings may differ from current scientific conceptions in a range of ways.

Day, night and seasons

Some students may think that:

- when it is day on one part of the Earth, it is day everywhere else on Earth at the same time;
- the cooler seasons happen when the fire in the sun dies down a little.

Formation of rocks

Some students may think that:

- lava comes from the centre of the Earth (lava is the name given to magma that has reached the surface of the Earth);
- lava is volcanic matter (but not understand that it is molten rock);
- all volcanoes are conical mountains;
- all mountains result from volcanic activity;
- rocks have always been 'there' as unchanging objects in the Earth;
- mountains have always been 'there' (though they may be aware that rocks 'fall off' mountains because of the action of landslides and avalanches).

Weathering, erosion and deposition

Some students may:

- be aware of some forms of erosion — for example, by water and wind — but not know what happens to the materials swept or washed away;
- think that eroded materials fall to the bottom of hills and stick to something else;
- think that rocks lying in water continue to soak up water, getting soft over time.

Teachers can help students refine their understanding by asking them to make analogies between classroom activities and larger-scale geological phenomena. They can encourage students to share many different scenarios on the changes of a rock through the rock cycle.

Terminology

Terms associated with interactions between systems of the Earth and beyond are essential to the activities in this module — for example:

Beaufort scale	magma	sedimentary rock
earthquakes	metamorphic rock	Southern Hemisphere
equator	Northern Hemisphere	Tropic of Cancer
erosion	pressure	Tropic of Capricorn
eruption	revolution of the Earth	tropical cyclone
igneous rock	rock cycle	volcano
landslide	rotation of the Earth	
lava	sediment	

Students may already be familiar with some of these terms and understand their meanings and use in scientific contexts. If so, the activities in this module will provide opportunities for them to evaluate current usage. If not, these activities will provide opportunities for students to develop their understandings.

School authority policies

Teachers need to be aware of school authority policies that may be relevant to this module.

Safety policies are of particular relevance to the activities that follow. It is essential that demonstrations and student activities are conducted according to procedures developed through appropriate risk assessments at the school.

In this module, teachers need to consider safety issues relating to:

- handling modelling materials, including chicken wire and craft knives;
- using Bunsen burners or candles, and heating substances;
- handling glass jars;
- safe movement in wet areas.

Support materials and references

Encyclopaedia Britannica 1983, *Science and Technology Illustrated*, Chicago.

Geophysical Institute, University of Alaska, Fairbanks. Available URL: http://www.gi.alaska.edu/ScienceForum/ASF13/1349.html (accessed November 2000).

Mitchell, M., Byrne, G., Ford, S. & Pain, P. 1995, *Investigate, Discover and Learn: A Laboratory Text Book for Students*, Dellasta, Vic.

Queensland Department of Education, Brisbane:
1982, *Primary Science Sourcebook: Activities for Teaching Science in Year 6*
1982, *Primary Science Sourcebook: Activities for Teaching Science in Year 7*

Queensland Department of Mines and Energy [follow links to student information]. Available URL: http://www.dme.qld.gov.au/ (accessed October 2000).

Thurman, R. 1997, *On the Spot Science and Technology: Level 4,* Addison Wesley Longman, Melbourne.

Walker, P. M. B. (ed.) 1991, *Chambers Science and Technology Dictionary*, W. & R. Chambers, Edinburgh.

Suppliers
Lauric acid can be purchased from suppliers listed under 'Laboratory equipment &/or supplies' in the Yellow Pages. Lauric acid can be purchased in 500 g containers.

ACTIVITY

Is every day the same?

Introductory

Focus

This activity provides opportunities for students to reflect on their understandings about the cause of day and night.

Materials

No particular materials are required.

Working scientifically

Time: 20 minutes

Clarifying and challenging
Clarifying ideas and concepts
Discussing thinking

▶ Students discuss their experiences and perceptions of day, night and seasonal changes. Discussion questions could include:

- What is meant by ‘day’?
- How long is a day?
- Is every day the same length as every other day of the year?
- What is meant by ‘night’?
- How long is a night?
- Is every night the same length as every other night of the year?
- Where is the sun during the day?
- Where is the sun during the night?
- What causes day and night?
- What is a season?
- How many seasons are there?
- How do the seasons differ from one another?

▶ Students compile a list of terms that are directly related to descriptions of day, night and seasons.

▶ In small groups, or independently, students develop concept maps (refer to initial in-service materials, p. 38) to present the terms and ideas discussed regarding day, night and seasonal changes.

Gathering information about student learning

Sources of information could include:

- students’ contributions to discussions;
- students’ drawings of, or contributions to, the concept map.

ACTIVITY

Timelines

Introductory

Focus

This activity provides opportunities for students to create analogies between their personal timelines, historical and geological timelines.

Materials

For each student:

- Resource Sheet 1, 'Timelines'

Teaching considerations

Students may require assistance to draw timelines to scale. The scale they use is not important. The scale they use for their personal timeline should be one that allows students to indicate important events in their lives. The historical timeline should be one into which the personal timeline can be easily inserted. For example, if the student is 10 years old, a line of 20 cm for the personal timeline would provide 2 cm per year for significant events. If the historical timeline that represents 200 years is 20 cm long, a student's personal timeline would occupy 1 cm of the historical timeline. Students will have greater difficulty conceptualising the geological timeline. Time since the formation of the Earth is thought to be approximately 4600 million years. If this were represented as a line 4.6 m long, the 200 years of the historical timeline would be represented by 0.005 mm of that line.

An alternative approach could be to start as before with the personal timeline being 20 cm long. Using the same scale, the historical timeline would be 400 cm long (4 m). The geological timeline would be 920 000 km long. This is more than twice the distance from here to the moon (which is 400 000 km from Earth) or about 230 000 trips to Perth in Western Australia (assuming Perth is 4000 km away).

Links to mathematics

Discussion of scales as a preliminary to, or part of, the drawing of timelines could be integrated with mathematics.

Working scientifically

Time: 15–30 minutes per timeline

Looking for patterns and meanings
Measuring
Constructing meaning
Creating analogies
Dealing in an orderly manner with the parts of a complex whole
Making comparisons
Constructing and using models
Discussing thinking

▶ Students and teachers discuss the concept of timelines and how they can be constructed. They discuss the nature of the events to be included in timelines.

▶ Students recall events to include on their personal timelines. They are encouraged to talk to their parents, carers or relatives to identify other significant occurrences and to clarify dates. Natural events (flood, cyclone) they may have experienced and which had a significant effect on their lives at the time could be included. The table shown overleaf is one way of recording information for the timeline.

Important events in my personal timeline

Event	Year
Day I was born	
I started walking	
My brother was born	

Resource Sheet 1

▶ Students construct personal timelines using the instructions on Resource Sheet 1. They share their timeline information in a small group or with the whole class. Students identify similarities and differences between events on their timelines.

▶ Students use the information and instructions provided on Resource Sheet 1 to complete the historical timeline and the geological timeline.

▶ Students discuss their perceptions of time. Discussion questions could include:

- What do you think of as a 'long time'?
- In your mind is 10 years a 'long time'?
- Describe how your perception of a 'long time' changes when a 10-year period is placed in the historical timeline.
- How would you describe the length of time represented in the historical timeline?
- Describe how your perception of a 'long time' or a 'very long time' changes when the historical timeline is compared with the geological timeline.

Gathering information about student learning

Sources of information could include:

- students' completed timelines;
- students' contributions to discussions.

ACTIVITY

Day, night and seasons

Developmental

Focus

This activity provides opportunities for students to explore the relationship between the tilt of the Earth's axis and the seasons.

Materials

For each pair of students:

- Resource Sheet 2, 'Day, night and seasons'
- materials listed on Resource Sheet 2

Teaching considerations

Simulations

Discuss with students how models or simulations can be used to explain complex ideas. Discuss also the limitations of the particular simulation being used and features of the simulation that may not correspond to the real situation. It is important that strategies used to explain or clarify one concept do not create misconceptions about others.

Practical points

Teachers should test the equipment and layout of this activity before the class undertakes it.

Those parts of this activity that rely on observation of light and shadow are best undertaken in a darkened room. If students are wearing light-coloured clothing and hold the balloon directly in front of themselves, some of the torchlight will be reflected off their clothing onto the unlit side of the balloon. To avoid this, advise students to hold the balloon to one side of their bodies or to hold it in front of a dark backdrop.

When summer in the Northern Hemisphere is being modelled and if the focus of the torch, and the distance between balloon and torch, are correct, the south polar region should be in virtual darkness during a full rotation of the balloon, while the north polar region is in 24-hour sunlight.

If the torch uses an incandescent filament globe and the beam of light is sufficiently powerful, students may be able to feel that the illuminated part of the balloon is warmer than the less-illuminated part. This may be especially useful for students with vision impairment.

Working scientifically

Exploring phenomena
Hypothesising
Suggesting
Constructing and using models
Explaining ideas and decisions

Resource Sheet 2

Time: 40 minutes

▶ Students discuss their ideas about the causes of the seasons. They make a list of the statements the class agrees on.

▶ Working in pairs, students follow the instructions on Resource Sheet 2 to model the effect of the tilt of the Earth's axis on relative lengths of daylight and darkness during different seasons.

▶ Students consolidate their understandings by drawing and annotating a diagram in their notebooks to show the patterns of interactions between the Earth and the sun.

▶ Students review the list of statements made earlier about the causes of the seasons. They revise the list based on their recent experiences.

Additional learning

▶ Students hypothesise what the climate and seasons are like in countries nearest the equator and report their ideas for class discussion. Library research could be undertaken to confirm the hypotheses.

Gathering information about student learning

Sources of information could include:

- students' responses to the questions;
- students' synthesis of observations;
- students' sentences or diagrams representing variations in daylight hours.

ACTIVITY

What if the Earth was moved?

Developmental

Focus

This activity provides opportunities for students to clarify their thinking about the cause of seasons.

Materials

For each group of students:

- Resource Sheet 3, 'Planetary data'

Teaching consideration

Period of rotation is the time it takes for a planet to turn on its own axis. The period of revolution is the time it takes for a planet to orbit the sun. Time is measured in Earth hours and days.

When the Earth is not being heated by the sun, heat is lost from it into the atmosphere. Heat is lost at a faster rate from land than it is from water. Some of the heat from the Earth is trapped within the atmosphere and this reduces the variation in temperature experienced between day and night. The length of the day will also influence the temperature of the Earth's surface. The longer the land is exposed to sunlight, the warmer the land will become. The longer the night, the more heat will be lost and the colder the land will become.

These ideas could be used as a focus for discussion. Discuss also the limitations of the modelling used in this activity. It is important that strategies used to explain or clarify one concept do not create misconceptions about another.

Working scientifically

Collecting information
Looking for patterns and meanings
Applying ideas and concepts
Generalising
Describing
Discussing thinking

Resource Sheet 3

Time: 60 minutes

▶ Students are asked the following question: 'What do you think would happen to the length of day/night and seasons if the planet Earth was moved to the position of another planet in the solar system and also rotated and revolved at rates characteristic of that planet?'

▶ In groups, students study the information provided in the table on Resource Sheet 3, 'Planetary data'.

▶ Students select two planets. They discuss the changes that would occur on Earth if Earth was moved to the position of these planets. Questions to guide discussion include:

- How will distance from the sun affect temperature and the amount of sunlight experienced?
- What effect would the period of rotation have on the length of day and night?
- How much variation in temperature would there be between day and night?
- What effect would the period of revolution have on the length of the seasons?
- How would the temperatures experienced in summer and winter compare with those currently experienced on Earth?

▶ Students present their ideas, and reasons for them, to the class.

▶ In the class group, students discuss the ideas presented and judge the credibility of the suggestions made.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' presentations.

ACTIVITY

Lava mountains

Developmental

Focus

This activity provides opportunities for students to explore the structure and formation of volcanoes.

Materials

For the class:

- video of volcano erupting

For each group of students:

- Resource Sheet 4, 'Making a volcano'
- materials listed on Resource Sheet 4

Teaching considerations

Concept

Vinegar and baking soda (bicarbonate of soda) react together to produce carbon dioxide gas. The gas bubbles through the vinegar causing a froth that will pour out of any open container. When used in the simulation of a volcano, the froth represents the lava flowing out from the vent of the volcano and pouring down the sides of the mountain.

Placing the lid on the bottle, but keeping it unscrewed, could simulate a volcano with a rock plugging the vent. Making a small hole in the lid and screwing it tightly onto the bottle could represent a very small vent.

Simulation

Discuss with students how models or simulations can be used to explain complex ideas. Discuss also the limitations of the particular model being used and features of the model that may not correspond to the real situation. It is important that strategies used to explain or clarify one concept do not create misconceptions about others.

Practical point

Pictures of volcanoes may be obtained from library resources, other reference materials, or from the Internet.

Safety

Inform students about safe handling procedures for using chicken wire.

Working scientifically

Time: Part 1, an extended period of time; Part 2, 30 minutes

Designing and performing experiments
Exploring phenomena
Handling materials
Making observations
Predicting
Applying ideas and concepts

Part 1

▶ Students watch a video showing a volcano erupting.

▶ In the class group, students brainstorm words and ideas they associate with volcanoes. The words and ideas are then sorted into groups such as:

- the structure of a volcano;
- the effect of a volcanic eruption.

Constructing and using models
Exploring and elaborating ideas
Summarising and reporting

▶ Students create a concept map, or an annotated drawing of a volcano, to illustrate the relationship between the words and ideas on the list related to the structure of the volcano.

▶ Students use resources (books, a video, the Internet) to check their concept map or drawings and make any necessary changes. They use the ideas gathered here as a guide when constructing the volcano.

Resource Sheet 4

▶ Students work in groups to design and construct a model volcano. Resource Sheet 4 and pictures of real volcanoes in their surrounding terrain could be used as a guide.

Part 2

▶ Students watch a demonstration showing what happens in a beaker or glass jar when vinegar is added to baking soda. They predict what will happen when this reaction occurs inside their model volcano. Questions to guide their thinking could include:

- Will the 'lava' shoot or spurt out of the volcano or will it flow out of the vent?
- How will the surface of the volcano affect the way the lava flows over it?
- What would happen to anything on the mountainside or in the pathway of the lava?
- What do you think will happen to the lava when it reaches the base of the volcano?

▶ Students test their ideas and report back to the class.

▶ Students discuss their responses to each of these questions:

- What would happen if there were a rock plug at the top of the volcano?
- What would happen if there were only a small vent from which the lava could escape?
- What would happen if there were additional vents or cracks in the side of the mountain?

▶ Students then design and perform investigations to test their ideas.

▶ Students report their observations to the class. They discuss the effects that the different types of eruptions would have on the shape of the mountain produced.

▶ In their notebooks, students write down the ideas they tested, the observations made and any interesting comments or ideas that arose in the discussion.

▶ As a class, students discuss how realistic their model volcanoes were. Students could be asked to compare:

- the rate of the eruption;
- the force behind the eruption;
- the characteristics of lava and those of the froth.

▶ Students are also asked to identify aspects of a volcano erupting that could not be included in the simulation. Some of the factors not able to be included are the buildup in pressure preceding an eruption; the power of an explosive eruption; and the burning by the lava as it flows down the mountain side.

Additional learning

▶ Students research the long-term and short-term effects of well-known volcanic eruptions on surrounding land areas and life. Good examples are the Mt Vesuvius eruption of AD 79; the Krakatoa eruption of 1883; Mount St Helens, 1980; and the volcanic island of Maui. Part of this research could include an investigation into ancient beliefs surrounding volcanoes.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' concept maps or annotated diagrams;
- students' use of resource materials;
- students' hypotheses and designs of investigations;
- students' observations made during the simulations;
- students' comparisons of the simulations and real eruptions.

ACTIVITY

Cooling lava and magma

Developmental

Focus

This activity provides opportunities for students to investigate, through simulation, the behaviour of magma and lava as they make their way to the surface of the Earth.

Materials

For each group of students:

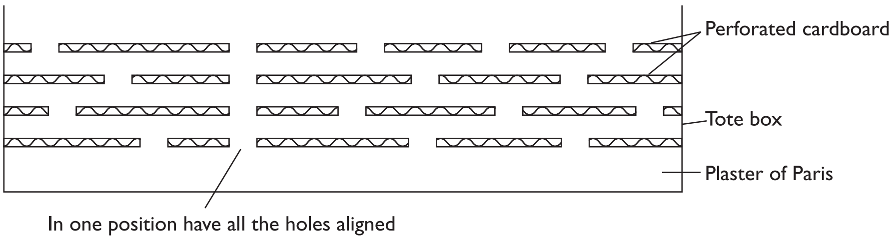
- rectangular large deep dishes (e.g. baking trays or tote boxes)
- 4 pieces of thick, heavy cardboard (e.g. from packing boxes) to fit the dish
- craft knife
- plaster of Paris, mixed to the consistency of heavy cream

Teaching considerations

Concept

Magma is molten material under the Earth's surface. When it reaches the surface, it is called lava.

In the model in this activity, plaster of Paris is used to represent magma. The sheets of cardboard represent the layers of rock; spaces between the sheets of cardboard and the holes in the cardboard represent weaknesses and fissures in the rocks. The magma is able to intrude into these spaces and cool, forming intrusions or intrusive igneous rocks. In the model, the position where all the holes in the cardboard are aligned represents the vent of a volcano where the magma comes straight to the surface of the Earth. See the diagram below.



Discuss with students how models or simulations can be used to explain complex ideas. Discuss also the limitations of the particular model being used and features of the model that may not correspond to the real situation. It is important that strategies used to explain or clarify one concept do not create misconceptions about others.

Practical point

This activity may be carried out as a classroom demonstration if plaster of Paris is difficult to obtain.

Safety

Inform students about safe practices for handling and using craft knives — for example:

- Cut on mats or thick wads of newspaper.
- Carry the knives in sheaths or with the blades fully retracted.

Working scientifically

Time: 20 minutes

Exploring phenomena
Making observations
Creating analogies
Constructing and using models
Discussing thinking
Using scientific terminology

▶ Students cut a number of holes in four sheets of cardboard, making sure that one set of holes is directly aligned, but the other holes are in different places in each sheet. Refer to the diagram in 'Teaching considerations'.

▶ Students place a 5 cm layer of plaster of Paris in the dish and then add the four sheets of cardboard. The students push down on the cardboard sheets by the edges until the plaster of Paris begins to come out the holes in the top sheet of cardboard. They then put the dishes aside until the surface layer of the plaster of Paris is stiff, but not hard. In places where the plaster of Paris is very thin, it will be dry.

▶ In small groups, students discuss their observations. Discussion points could include:

- Compare the way the plaster of Paris came out of the hole that was continuous through all layers of cardboard and the way it came out of the holes that were offset.
- Compare the shape of the 'mound' of plaster of Paris over the holes in these two positions.
- In which positions has the plaster of Paris dried most quickly?
- Compare the degree to which the plaster has dried in the following positions:
  - on the surface where there is a thin layer of plaster of Paris;
  - on the surface where there is a thick layer of plaster of Paris;
  - under the surface layer of cardboard where the plaster of Paris is forming a thin layer;
  - at the bottom of the container.

▶ The teacher discusses with students the relevance of this activity to the cooling and solidification of molten material associated with a volcano. Questions to guide discussion could include:

- Where would you expect the lava to cool most quickly and most slowly?
- Where do you think the material could stay molten?
- Apart from exposure to air, what factors in the environment could cause the molten rock to cool and solidify? (for example, contact with cooler rocks; contact with water)

▶ Students draw an annotated picture of the simulation. On one side of the diagram the annotations should:

- name the parts of the simulation (for example, 'cardboard with holes in it');
- indicate where the plaster of Paris dried quickly, slowly or not at all.

On the other side of the diagram the annotations should:

- name the parts of the Earth represented by the parts of the simulation (for example, 'layers of rock');
- indicate where molten magma or lava would cool quickly, slowly or not at all.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' descriptions of observations made;
- students' annotated diagrams.

ACTIVITY

Igneous rocks

Developmental

Focus

This activity provides opportunities for students to develop an understanding of the formation of different igneous rocks.

Materials

- lauric acid (a wax)

For each group of students:

- samples of granite, basalt, obsidian and pumice
- magnifying glass or hand lens
- small jar with a screw-top lid
- saucer
- 50 mL and 250 mL beakers

Teaching considerations

Concept

Granite is an intrusive igneous rock formed by slowly cooling underground. It has large crystals which can be seen as the different-coloured 'speckles' in the rock.

Basalt is an extrusive igneous rock. It is formed when lava reaches the surface of the Earth and is cooled quickly. The crystals in basalt are very small.

Obsidian is formed when lava solidifies so quickly that minerals or crystals are not able to develop. Instead it forms an amorphous solid or glass.

Pumice is formed when lava solidifies so rapidly that large quantities of volcanic gas are trapped within it as minute bubbles. The gas has since escaped and been replaced by air. This makes the rock buoyant enough to float.

Practical point

Lauric acid is a flaky, crystalline solid that melts at 44°C. The lauric acid will take some time to cool. Part 1 of this activity could be undertaken on one day and Part 2 on the following day.

Safety

Inform students of safe practices for heating materials. While lauric acid is non-corrosive, care should be taken not to get it on the skin.

Working scientifically

Time: Part 1, 25 minutes; Part 2, 15 minutes

Exploring phenomena
Handling materials
Looking for patterns and meanings
Making and judging observations
Constructing meaning
Generalising
Discussing thinking

Part 1

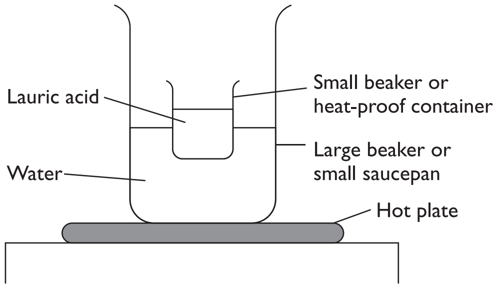
▶ Students discuss the differences they recognise between rocks.

In pairs or small groups, students feel the texture of the rock samples provided and use a magnifying glass or hand lens to observe them. They describe each of the rocks in terms of the size of its crystals.

- Which of the rocks had the largest (or smallest) crystals?
- Suggest why there are no crystals observable in obsidian.
- Describe the structure of pumice and suggest how it was formed.

INTERACTIONS AND CHANGES IN EARTH AND SPACE • UPPER PRIMARY

▶ Students investigate the effects of fast and slow cooling on lauric acid as an analogy for cooling of lava. They set up a water bath as shown in the diagram and place a small beaker containing lauric acid in the water bath. When the lauric acid is melted, they remove the small beaker from the water bath. Some of the lauric acid is poured into a saucer where it will be able to cool quickly; some is poured into a small jar with a screw-top lid, which is immediately wrapped in insulating material to slow down the rate at which the contents cool. The remaining lauric acid is left to cool in the small beaker.



▶ After about 15 minutes, students observe the lauric acid in the three situations and note whether it has solidified or is still liquid.

Part 2

▶ Next day students use a magnifying glass or hand lens to observe the three samples of lauric acid. Students decide whether or not they can see crystals and compare the size of the crystals resulting from the different treatments. Students write a statement describing the relationship between cooling rate and crystal size.

▶ Students use the information about crystal size to discuss how and where the rocks they studied earlier were formed. Discussion questions could include:

- Which rocks do you think formed underground and which formed on the surface?
- Place the rocks in order of the one formed by most rapid cooling and solidification to the one formed most slowly.

▶ Students draw a picture of a volcano to illustrate where the different rock types could have formed.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' interpretations of observations of rock samples;
- students' use of information from the simulation;
- students' illustrations showing where the rock types form.

ACTIVITY

Erosion by streams

Developmental

Focus

This activity provides opportunities for students to investigate the effects of erosion caused by streams and to relate this to changes in mountains over time.

Materials

For the class:

- soil
- garden hose (with outlet)

Materials for each group's investigation, which could include:

- PVC piping cut to form a trough (or a piece of guttering)
- aluminium foil
- cardboard sheet
- garden hose (with outlet)
- sand (coarse and fine mixed)
- small stones
- soil
- two water containers
- water

Teaching considerations

Previous learning

It is expected that students will know the difference between weathering and erosion and will be aware of some forms of weathering and causes of erosion. If the students do not demonstrate these understandings during the first part of the activity, it may be necessary to revisit these ideas.

A suggested approach

One way of comparing the effects of fast and slow flowing water on erosion is described here. Fold a long piece of cardboard (about 2 m) to form a V-shaped trough and then line it with an unbroken length of aluminium foil. (Alternatively a piece of PVC downpipe cut in half lengthwise could be used as a trough.) One end of the trough is raised about 25 cm above the level of the other end. A water container is placed at the outfall end of the trough, and the top end is filled with a mixture of coarse and fine sand (small stones could also be included). A hose is used to pour water on the sand mixture at the top of the trough and the result is observed. The rate of water flowing through the hose can be changed to represent fast and slow moving rivers or streams.

The faster the water is flowing, the more energy it has and, therefore, the larger the particles it is able to move.

Safety

Inform students of safe practices when using water and moving in wet areas.

Working scientifically

Time: 60 minutes

Designing and performing investigations

Engaging with problems

► Students discuss their responses to the following questions.

- Have the mountains and hills we see today always looked the same?
- What do you think could have caused the mountains to change?

Exploring phenomena
Applying ideas and concepts
Generalising
Preparing scenarios
Discussing thinking
Exploring and elaborating ideas
Using scientific terminology

▶ In small groups, students list all the ways they know or think that mountains and hills can be worn down. They then form larger groups and compare their ideas. Students then combine all the group lists to form a class list. This list is displayed for further additions or corrections.

▶ As a class, students make a large pile of dirt in the school grounds, compacting the soil tightly. They make a 3 cm groove down one side of the hill and observe what happens when water from a hose is allowed to run slowly down the groove and off the hill. Students discuss their observations. Stimuli for discussion could include:

- Describe any changes in the appearance of the hill.
- What is happening to the groove created for the stream?
- What evidence is there that erosion has taken place?
- What happens to the soil?
- Describe the water that runs off the hill.
- What makes the water look like that?
- Where is the soil deposited and why is it deposited there?
- Compare the rate at which the water is moving when soil is being eroded and when it is being deposited.

▶ Students predict whether slow-moving or fast-moving water is a more effective agent of erosion. They discuss ways of designing an investigation to test their predictions. Students perform the investigation and present their results.

▶ Students prepare explanations of how streams and rivers erode the land and suggest scenarios of what might happen to a rock in or near a stream in different conditions or situations — for example:

- after flooding rains;
- the first rain after a long period of drought;
- on the outside of a bend in a river;
- on the inside of a bend in a river;
- in the middle of a fast-flowing stream with a rocky bottom.

▶ Students discuss the questions:

- Is erosion a slow process or a fast process?
- How does the rate of weathering compare with the rate of erosion?
- How long do you think it would take for a mountain to be worn away?

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' designs and reports of their investigations;
- students' explanations of how streams erode the land;
- students' scenarios;
- students' comparisons of weathering and erosion.

ACTIVITY

Erosion by landslides

Developmental

Focus

This activity provides opportunities for students to investigate the effects of erosion caused by landslides and to relate this to the erosion of mountains over time.

Students model erosion due to gravity and water.

Materials

For each group of students:

- fine, dry sand (about 1L)
- 1 large sheet of paper (e.g. A3)
- gravel (about 1L)
- protractor
- ruler

For the class:

- soil
- garden hose (with outlet)

Teaching considerations

These activities could take place outside, in a place sheltered from the wind.

Students may need assistance to measure the piles of sand accurately.

Simulation

Discuss with students how models or simulations can be used to explain complex ideas. Discuss also the limitations of the particular model being used and features of the model that may not correspond to the real situation. It is important that strategies used to explain or clarify one concept do not create misconceptions about others.

Safety

Inform students of safe practices when using water and moving in wet areas.

Working scientifically

Designing and performing investigations
Handling materials
Measuring
Constructing meaning
Creating analogies
Drawing conclusions
Formulating and elaborating ideas
Preparing scenarios

Time: 90 minutes

▶ Students discuss their ideas of landslides. Questions to guide discussion could include:

- What is a landslide?
- Where do landslides occur?
- When do landslides occur?
- Why do landslides occur?

▶ Students draw a picture or a concept map to represent their ideas about landslides and their causes.

Clarifying ideas and concepts

Creating presentations

▶ Students place the large sheet of paper on a clear flat space outside, protected from wind movement. They then slowly pour the fine, dry sand onto the sheet to form a small hill. Students observe what happens as they continue to pour more sand on top of the hill. Guiding questions might include:

- Did all the sand stay on top of the hill?
- What happened to the sand as it was added to the hill?

▶ Students design methods to measure the height and steepness of the pile of sand accurately. They use their methods and record their results. A table similar to the one shown below could be used to record results for this and the next part of the activity.

Material used	Sand	Gravel
Height of hill (centimetres)		
Angle of slope (degrees)		
When part of the hill was cut away……		

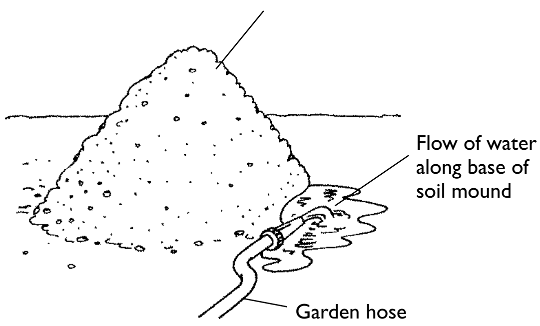
▶ Students carefully cut away a part of the sand pile and observe what happens. They record their observations.

▶ Students repeat the investigation using gravel.

▶ In small groups, students compare the observations and measurements of the height and steepness of the piles of sand and gravel. They suggest reasons for the two piles having different slopes. As a class, students share their observations and discuss the suggestions they have made.

▶ Students predict what will happen when water undercuts the bottom of a hill.

▶ Students test their prediction by building a mound of soil approximately 50 cm high in the school grounds. Using a garden hose, students run a small stream of water along the edge of the mound of soil so that some soil is washed away. The flow of water from the hose needs to be kept at the bottom of the mound. Students describe what happens to the soil on top of the pile. They record their observations.



▶ As a class group, students share their observations and give explanations for what they observed. They discuss:

- what a landslide is and what might cause one;
- how the landslide they created using a mound of dirt could compare with natural landslides;
- how landslides might gradually wear away a mountain or hill.

▶ Students revisit the concept maps they made at the beginning of the activity and make adjustments to reflect their current understandings.

▶ Students suggest scenarios for what might happen to a rock caught in, or located near, a landslide.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' participation in the investigations;
- students' recordings and interpretations of results;
- students' explanations of landslides and their causes;
- students' concept maps;
- students' scenarios.

ACTIVITY

Settling of sediments

Developmental

Focus

This activity provides opportunities for students to investigate the settling of sediments in water and the formation of sedimentary rocks.

Materials

For each group of students:

- large jar with lid that seals
- 1/4 cup each of fine sand, coarse sand and gravel
- Resource Sheet 5, 'Sedimentation'
- 1 slice each of white and brown bread
- several heavy books or other flat, heavy objects

Teaching considerations

Safety

If glass jars are used, warn students that the glass may break if the jar is shaken too vigorously.

Working scientifically

Exploring phenomena
Looking for patterns and meanings
Constructing meaning
Inferring from data
Making comparisons
Creating diagrams
Discussing thinking
Explaining ideas
Using scientific terminology

Time: 40 minutes

▶ Students brainstorm what they think happens to rocks and weathered materials that are carried away in streams and rivers. Each student records an idea as a statement. The class discusses these ideas. Students modify their statements based on what they have heard in discussion. The statements are then displayed to be revisited at the end of the activity.

▶ Students suggest materials that might be eroded by running water and could, therefore, be found in streams and rivers. Groups of three or four students are given about 1/4 cup each of fine sand, coarse sand and gravel. They observe the three materials and discuss the relative size of the particles. They predict which material would be carried most easily by running water and which one would settle out of the water most quickly. Students record their predictions.

▶ To test their predictions, students place all ingredients in the jar, add about 1 1/2 cups of water and secure the lid. They shake the mixture well and then place the jar on the bench, leaving the contents to settle. They observe the materials as they settle out of the water as it stops moving. Observation and discussion questions could include:

- Which particles dropped to the bottom first?
- Which particles dropped to the bottom last?
- Why do you think the particles fell in that order?

Students infer which substance was the heaviest, through to the lightest. Students return to their predictions and note any changes they need to make.

▶ Students discuss the ways in which the simulation using sand and gravel in a jar of water was similar to sediments being carried in a river. They also identify ways in which the simulation was different from the natural situation.

Resource Sheet 5

▶ Students examine the picture and read the scenario on Resource Sheet 5. They draw a diagram to show what they think will happen in the lake over a long period of time as the rivers carry eroded material into it. As students create their diagram, they think of answers to the questions:

- What happens to the rocks and rock materials (for example, sand, gravel, soil) that are carried by the river into the lake?
- If sediments were dumped into the lake year after year, what would happen?
- What differences might exist now between sediments dumped into the lake this year compared with sediments dumped 10 years ago? What about 100 years, 1000 years or 10 000 years ago?

▶ To simulate the layers of sediment at the bottom of the lake, students place one slice each of white and brown bread on top of each other and wrap them in waxed paper as if they were a sandwich. They place the wrapped bread on a flat desk top and place three or four heavy books on top of them. Students predict what will happen to the bread after one hour. They test their predictions and record and share their findings.

As a class, students discuss how the results of this simulation relate to changes in the sediments on the lake bottom as more and more material is added to the top.

▶ Students revisit the statements they made at the beginning of the activity. They modify the statements, add new ones or remove ones they no longer think are appropriate.

Additional learning

▶ Students investigate the deposition of sediment where a local stream enters a pond, or a fast-moving river enters a slower-moving river. They trace the course of the river to find the origin of the sediment.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' original statements and subsequent modifications of them;
- students' diagrams of the lake.

ACTIVITY

Sedimentary rocks

Developmental

Focus

This activity provides opportunities for students to observe sedimentary rocks and how they are made.

Materials

For each group of students:

- gravel
- magnifying glass or hand lens
- plastic containers (to use as moulds)
- plaster of Paris
- sample of sandstone, conglomerate and mudstone
- sand
- silt

Working scientifically

Time: 30 minutes

Handling materials
Applying ideas and concepts
Creating analogies
Clarifying ideas and concepts

▶ Students handle the specimens of sandstone, conglomerate and mudstone. They use a hand lens to observe them closely. Students write a description of each of the rocks focusing on the size of the particles in the rock.

▶ Students suggest the conditions that may have led to material of these sizes being carried by rivers and streams and then being deposited.

▶ Students access library or Internet resources to find out what conditions are required for sediments to turn into rock.

▶ In groups of two or three, students discuss ways of making their own sedimentary rock. Using their ideas, they make the rocks.

▶ Students tell the class the type of rock they made (sandstone, mudstone or conglomerate). They discuss the process they used and how successful they think it was.

Gathering information about student learning

Sources of information could include:

- students' observations of the rocks;
- students' contributions to discussions;
- the process students used for making the rocks and their evaluations of it.

ACTIVITY

Metamorphic rocks

Developmental

Focus

This activity provides opportunities for students to investigate the formation and properties of rocks before and after they have been changed by the application of heat, or pressure, or both.

Materials

- samples of labelled metamorphic rocks and their parent rocks (see below)

For the teacher:

- Resource Sheet 6, 'Exploring changes in rocks caused by heat and pressure'

Teaching considerations

Metamorphic rocks and their parent rocks

Students' previous experiences of the words 'metamorphic' and 'metamorphosis' will probably be associated with life cycles of amphibians and insects. These life cycles include a change in form of the organism. When students use these terms associated with rocks, they again mean a change in form. In this situation, heat and pressure cause the change in form. The source of heat is the naturally occurring heat in the Earth, including that associated with volcanoes. The source of pressure may be new sediments being deposited on existing layers, or it may come from movements within the Earth's crust.

Metamorphic rocks and their parent rocks

Metamorphic rocks	Changed from
Slate	Shale
Schist	Shale
Marble	Limestone, dolomite
Quartzite	Sandstone
Gneiss	Shale, conglomerate, granite

Resource Sheet 6

Half the class could investigate the changes caused by heat and the other half the changes caused by pressure. Resource Sheet 6 provides suggestions for activities. Investigation of the effects of heat will need to be carried out over a couple of sessions to allow time for the clay to be fired. Clay left to dry naturally has characteristics similar to sedimentary rock. If no kiln is available, the clay slabs could be fired by placing them on some pieces of broken glass or pottery in an unglazed pottery pot over a propane torch or Bunsen burner flame.

Working scientifically

Time: 60 minutes

Designing and performing investigations
Handling materials
Making and judging observations
Examining and evaluating
Making comparisons
Suggesting
Discussing thinking
Summarising and reporting

▶ Students discuss the term 'metamorphic' and what is meant by that term.

▶ Students brainstorm situations where rocks could be changed and the conditions that would cause the changes. They discuss the ideas raised in the brainstorm. Discussion questions could include:

- What types of changes to matter have you explored in other science activities?
- Which of these changes caused a new substance to be formed?
- What conditions cause chemical changes to take place?
- Where in the Earth might rocks be exposed to heat intense enough to cause a chemical change?
- What other extreme forces are acting in the Earth that could cause rocks to change?

▶ Students suggest ways that changes caused by heat and/or pressure could be explored. They design and perform investigations based on their suggestions. Students discuss the best way of reporting their findings to the class and then prepare and present their reports.

▶ Students discuss ways in which the simulation in their investigation is different from the real process of metamorphosis of rocks.

▶ Students compare some samples of labelled metamorphic rocks with their parent rocks by testing for hardness and the ability to soak up water. They record and share their observations.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' designs of the investigations;
- students' records of their results and reports on these to the class;
- students' comparisons of metamorphic rocks and the parent rocks.

ACTIVITY

What is wind?

Developmental

Focus

This activity provides opportunities for students to explore and elaborate their ideas about changes in the atmosphere.

Materials

- library and electronic resource materials

Teaching considerations

Questions students might ask include:

- What causes wind?
- How is wind speed measured?
- Why is the wind stronger in some places than others?
- Where does wind come from?
- Why does wind stop?
- Why are some places windier than other places?
- How hard can wind blow?
- Why does the wind blow from the land to the sea in the morning and the other way in the afternoon?

Working scientifically

Accessing resources
Collecting information
Exploring phenomena
Formulating questions
Clarifying ideas and concepts
Creating presentations
Exploring and elaborating ideas

Time: 40 minutes

▶ Through discussion, students clarify and challenge their ideas about the nature and causes of wind. They develop an agreed definition of wind. They formulate questions to guide their exploration of the phenomenon of wind.

▶ In groups of two or three, students access resources to find answers to their questions. They present their answers to the class.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions and formulation of questions;
- students' answers to research questions;
- students' presentations.

ACTIVITY

Earth on a different angle

Culminating

Focus

This activity provides opportunities for students to create scenarios related to changes in the tilt of the Earth.

Materials

For each pair of students:

- balloons
- marker pens
- a thick book or similar object
- torches

For the teacher:

- Resource Sheet 2, 'Day, night and seasons'

Teaching considerations

Practical points

Teachers should test the equipment and layout of this activity before the class undertakes it.

The process students follow is the same as for the activity 'Day, night and seasons' (Resource Sheet 2); however, the detail is different. Instead of holding the balloon at an angle of 23.5° to simulate the tilt of the Earth's axis, students hold it vertically for one trial and at an angle of 50° for the second trial.

Those parts of this activity that rely on observation of light and shadow are best undertaken in a darkened room. If students are wearing light-coloured clothing, and hold the balloon directly in front of themselves, some of the torchlight will be reflected off their clothing onto the unlit side of the balloon. To avoid this, advise students to hold the balloon to one side of their bodies, or to hold it in front of a dark backdrop.

If the torch uses an incandescent filament globe and the beam of light is sufficiently powerful, students may be able to feel that the illuminated part of the balloon is warmer than the less-illuminated part. This may be especially useful for students with vision impairment.

Resources for additional learning

Access information about the effect of the tilt of the Earth's axis using 'tilt of the Earth's axis' or 'Milankovitch cycles,' to search the Internet. One website that may be useful is http://www.gi.alaska.edu/ScienceForum/ASF13/1349.html (accessed November 2000).

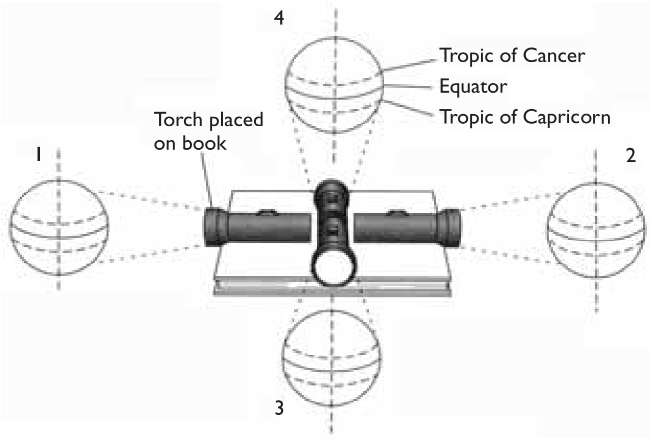
Working scientifically

Time: 40 minutes

Exploring phenomena
Hypothesising
Applying ideas and concepts
Suggesting
Constructing and using models
Explaining ideas and decisions

► Students review their ideas of the changes that took place as the Earth revolved around the sun. Questions to guide their thinking could include:

- At what angle is the axis of the Earth tilted?
- Where is the sun overhead when it is summer in the Southern Hemisphere?
- Compare the hours of daylight and hours of darkness during summer.
- When it is winter in the Southern Hemisphere, where is the sun overhead?
- In winter how do the hours of daylight and darkness compare?



Position 1 — light overhead at Tropic of Cancer
Position 2 — light overhead at Tropic of Capricorn
Positions 3 & 4 — light overhead at the equator

► Students blow up a balloon and draw on it features such as the north and south poles, Tropics of Cancer and Capricorn, and the equator. A rough map of the positions of the continents, or the names only, could be added to improve the balloon as a model of the Earth.

► Students hold the balloon Earth vertically (with a 0° tilt of the axis) in position 1 in the diagram. They note where the sun is overhead. They rotate the 'Earth' on its axis and compare the length of daylight and darkness. They record their observations in a table like the one below.

Table of daylight related to position of sun

Tilt of axis	Position	Where the sun is overhead	Comparison of daylight and darkness	
			Prediction	Observation
0°	1			
	2			
	3			
	4			
50°	1			
	2			
	3			
	4			

INTERACTIONS AND CHANGES IN EARTH AND SPACE • UPPER PRIMARY

Students predict what will happen when the 'Earth' is moved into positions 2, 3 and 4. They test their ideas and record their observations.

▶ As a class, students discuss their observations and the effect a change in the tilt of the Earth's axis would have. Stimuli for discussion could include:

- What would happen to the seasons if the Earth's axis were vertical?
- Describe what the climate would be like in Queensland and compare it with the present climate.
- What do you think would happen at the north and south poles?

▶ In small groups, students discuss their ideas of what changes would occur if the Earth's axis were tilted at 50°. They make their predictions and test them. Using their observations, students prepare a description of the conditions in Queensland and compare them to conditions in Tasmania. They discuss the relative amounts of daylight and darkness, and temperatures in summer and winter. The information could be presented as a travel brochure, annotated diagram or a story, 'The day the world tilted'.

Additional learning

▶ Students consider the long-term effects on ice caps of either scenario (0° or 50° tilt), and the implications for people living in high latitudes, for example, Tasmania, the south island of New Zealand, southern Argentina and Chile, northern Canada, Greenland, Scandinavian countries, Russia.

▶ Students access resources to find out whether the tilt of the Earth's axis has been different in the past and, if so, what effects this had on world climate.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions of relative positions of the sun and day length in a normal situation;
- students' predictions, observations and discussions relating to alternative scenarios;
- students' presentations.

ACTIVITY

The rock cycle

Culminating

Focus

This activity provides opportunities for students to consolidate their thinking about the formation and erosion of rocks over time.

Materials

No particular materials are required.

Working scientifically

Time: 60 minutes

Applying ideas and concepts
Creating analogies
Generalising
Making comparisons
Clarifying ideas and concepts
Constructing and using models
Creating presentations
Using scientific terminology

▶ Students reflect on their knowledge of rock formation and draw a diagram of the rock cycle representing the relationship between igneous, metamorphic and sedimentary rocks.

▶ Students reflect on their understanding of the processes of weathering and erosion. They add these processes to the diagram showing where they would occur.

▶ Students discuss their ideas of the relative time involved in the various stages of their diagram. They also discuss the relative times required for weathering and erosion to take place. Students use their ideas and either:

- add to their diagram an indication of the relative time for each part of the diagram and the processes involved; or
- draw a timeline showing the relative length of time for each part of the rock cycle.

▶ Students discuss different ways of presenting a life story of a rock as it changes through the rock cycle. The environment in which it is found and the processes acting on the rock should be included in the presentation. Students complete the presentation.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' diagrams;
- students' presentations.

ACTIVITY

The dynamic Earth

Culminating

Focus

This activity provides opportunities for students to reflect on the ways in which the Earth is shown to be dynamic and to consider the different scales of time and space over which this change occurs.

Materials

No particular materials are required.

Teaching considerations

The activities in this module explore many aspects of the dynamic Earth. Examples are day and night, seasons, erosion, rock formation, sedimentation, landslides, and volcanic eruptions. The list the students produce could include examples they know from sources other than the activities in this module.

Working scientifically

Time: 30 minutes

Applying ideas and concepts
Inferring from data
Synthesising
Creating presentations
Discussing thinking

▶ Students brainstorm a list of the ways in which the Earth is shown to be dynamic. They discuss ways in which the dynamism varies — for example, the time over which the change occurs, whether it is cyclical or not, the area affected by the changes, or whether the events are catastrophic or not.

▶ Students place the events on their list in order from slowest to fastest. They discuss ways of representing this information diagrammatically to show the relative rates of change.

▶ Students place the events on their list in order of magnitude, that is, starting with the area that is most affected by the changes. They present this comparison diagrammatically.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' representations of rate and scale of change.

Timelines

Resource Sheet 1

Use the following information to create timelines.

Personal timeline

Draw a line across a sheet of paper to represent your life so far. Mark off 2 cm for every year you have been alive — for example, if you are 10 years old, draw the line 20 cm long.

Name the spaces with the appropriate year, starting with the year of your birth on the left-hand side and the current year on the right-hand side. Position the information you have collected about events in your life along this scale.

Historical timeline

On a piece of paper (it could be the same piece of paper as your personal timeline) draw a line. Mark it off in centimetres with each centimetre representing 10 years. Label the marks with the relevant year.

Complete the last column of the table and the relevant information for your personal timeline; then position the information from the table at the appropriate point along the timeline.

A historical timeline since 1783

Event	Year(s)	Distance along the line (mm)
First recorded flight in a hot-air balloon	1783	0
First bicycle	1811	
First steam locomotive used to carry passengers	1814	
The Queensland colony separates from NSW	1859	
Telephone invented by Graham Bell	1865	
X-rays discovered	1895	
World War I	1914–1918	
First stick-on bandages	1921	
World War II	1939–1945	
First human-made satellite — Sputnik	1957	
First person in space	1961	
First landing by man on the moon	1969	
Hubble space telescope launched	1990	
Sydney Olympic games	2000	
My personal timeline		

(continued)

Timelines (*continued*)

Geological timeline

The time since the Earth was formed is thought to be 4600 million years. If you made a timeline 4.6 m long, what would your scale mean?

Calculation of scale

Number of years	Distance on the timeline
1000 million	1 metre
100 million	10 centimetres
10 million	1 centimetre
1 million	1 millimetre

Join pieces of butcher's paper together until you have a piece of paper 4.6 m long. Draw a line along the paper and mark it off in 10 cm sections. Name these marks. The first mark, on the left-hand end of the line, will be 4600. The mark on the right-hand end will be zero. The numbers are in descending order because the timeline is representing time in the past. Somewhere on the paper you will need to represent the scale — each 10 cm represents 100 million years.

Complete the last column of the table and the relevant information for the historical timeline; then position the information from the table at the appropriate point along the timeline.

A geological timeline

Event	Million years ago	Distance along the line (mm)
Earth formed	4600	4600
First plants	3000	
First trace fossils of animals with many cells	1000	
First fish	500	
First plants on land	450	
First animals with backbones on land	400	
Many reptiles	290	
Dinosaurs	250	
First flowering plants	150	
First humans	1.6	
Historical timeline		

Day, night and seasons

R2 Resource Sheet 2

Each pair of students will need:

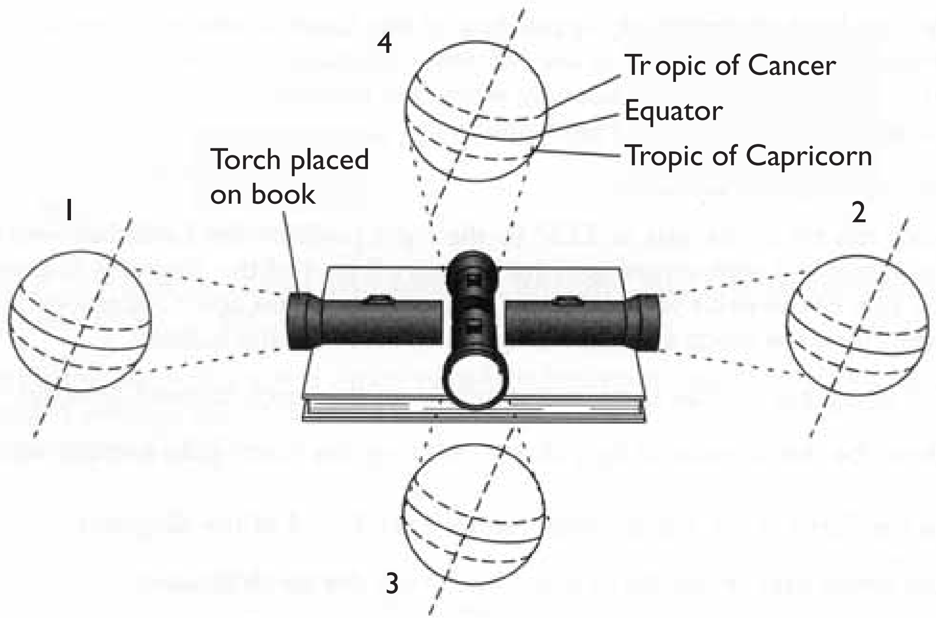
- balloon
- marker pen
- thick book or similar object
- torch

Day and night

1. Blow up a balloon and draw on it features such as the equator and north and south poles. A rough map showing the positions of the continents could also be included. Alternatively, write the names of the continents in the correct relative positions.

2. Hold the balloon, turning it slowly around its vertical axis from west (your right) to east (your left), while your partner aims the beam of light from the torch onto the balloon 'Earth'. Note how the light from the 'sun' falls on the rotating 'Earth' so that, while any one part of the globe is lit (day), the side of the 'Earth' that is opposite the 'sun' is unlit (night). This demonstrates that day and night occur simultaneously on different parts of the Earth.

3. Change places and exchange roles.



Position 1 — light overhead at Tropic of Cancer
Position 2 — light overhead at Tropic of Capricorn
Positions 3 & 4 — light overhead at the equator

(continued)

Day, night and seasons (*continued*)

Seasons: summer and winter

- Place the torch close to the edge of the book on which it is resting and turn it to shine to the left (refer to part 1 of the diagram). Tilt the vertical axis of the 'Earth' balloon to the right (23.5°), and position the balloon in the torch beam so that the 'Northern Hemisphere' (upper side of balloon) is inclined towards the torch. The focus of the torch should be on the Tropic of Cancer. Turn the Earth on its axis to demonstrate day and night.
  - Watch what happens at the south pole as the balloon Earth is rotated.
  - Watch what happens at the north pole at the same time.
  - Where is the sun overhead?
- Turn the torch so that the beam is aimed to the right. Tilt the balloon to the right (this direction of tilt never changes) and place it in the beam of light (part 2 of the diagram). Now the balloon is angled away from the torch so that the Tropic of Capricorn is the focus. Turn the Earth on its axis and make your observations.
  - Watch what happens at the south pole as the balloon Earth is rotated.
  - Watch what happens at the north pole at the same time.
  - Where is the sun overhead?
- So far you have represented the position of the Earth at two positions of its orbit — firstly, when it is summer in the Northern Hemisphere and winter in the Southern Hemisphere and, secondly, when it is summer in the Southern Hemisphere and winter in the Northern Hemisphere.

Seasons: spring and autumn

- Keeping the tilt of the axis at 23.5° to the right, position the Earth half way between the summer and winter positions (either part 3 or 4 of the diagram). Depending on which side of the orbit you place the Earth, this position could represent spring or autumn. Turn the torch so that the light is focused on the balloon.
  - On which part of the Earth is the light from the torch focused directly?
  - Describe the amount of light that is reaching the north pole and the south pole.
- Place the Earth in the last position (either part 3 or 4 of the diagram).
  - On which part of the Earth is the light from the torch focused directly?
  - Describe the amount of light that is reaching the north pole and the south pole.
- Write a sentence or two as a synthesis of the observations you have made about the four seasons. Alternatively, you could draw pictures showing the parts of the Earth that receive light (or most light) at the different times of the year.

(continued)

Day, night and seasons (*continued*)

Seasons: the whole picture

- Mark two towns on the Earth. You could name these towns or just call them A and B. Town A is in the Northern Hemisphere, about half way between the equator and the north pole. Town B is in the Southern Hemisphere, about half way between the equator and the south pole.

- Return the Earth and the torch to position 1 in the diagram. Turn the Earth on its axis to represent one period of 24 hours (a day).
  - Concentrate on town A. Was town A in darkness for more time or less time than it was in the light? What season was town A experiencing at the time?
  - Concentrate on town B. Was town B in darkness for more time or less time than it was in the light? What season was town B experiencing at the time?
  - What conclusions can you draw about the length of daylight in a place in summer compared to winter?

- Place the Earth in position 2 (of the diagram) and repeat the last set of observations. Do these observations support your idea?

- Place the Earth in positions 3 and 4. Compare the length of daylight and darkness at the two towns in spring and autumn.

- Write a sentence that describes the changes in length of daylight through one cycle of the seasons — that is, one year.

- Use your knowledge of the relative positions of the Earth and sun at different times of the year to explain why:
  - winter is cooler than summer
  - winter in Hobart is colder than winter in Brisbane. (July average temperature — Brisbane 13.5°C–18°C, Hobart 4.5°C–9°C)
  - the temperature in Darwin varies very little between summer and winter. (January average temperature is in the range 27°C–31.5°C. July average temperature 22.5°C–27°C)

Planetary data

R3 Resource Sheet 3

Planet	Period of rotation (Earth time)		Period of revolution (Earth time)	
Mercury	1416.0 hours	(59 days)	88 days	
Venus	5832.0 hours	(243 days)	224.7 days	
Earth	24.0 hours		365 days	
Mars	24.5 hours		687 days	
Jupiter	9.9 hours		4 343.5 days	11.9 years
Saturn	10.2 hours		10 767.5 days	29.5 years
Uranus	17.0 hours		30 660 days	84 years
Neptune	16.0 hours		60 152 days	164.8 years
Pluto	153.6 hours	(6.4 days)	929 910.5 days	2547.7 years

Planet	Distance from the sun (km)	Distance from the sun (AU)
Mercury	58 000 000	0.39
Venus	108 000 000	0.72
Earth	149 500 000	1.00
Mars	228 000 000	1.50
Jupiter	778 000 000	6.20
Saturn	1 430 000 000	9.50
Uranus	2 900 000 000	19.20
Neptune	4 400 000 000	30.00
Pluto	5 800 000 000	39.40

AU = astronomical unit

One astronomical unit is the average distance from the Earth to the sun.

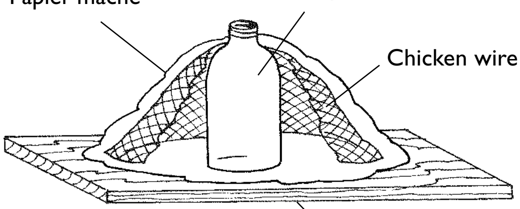
Making a volcano

You will need:

- chicken wire
- clear adhesive tape
- glue
- paper strips
- pictures of volcanoes showing a variety of shapes and sizes
- sheets of newspaper
- small plastic bottle (300 mL) with a screw-top lid
- water and flour mix
- waterproof paint (earth and grass colours) (optional)
- wooden base, maximum 30 cm square

1. Secure the plastic bottle to the base board.
2. Wrap chicken wire around the bottle, shaping it like a volcano. Chicken wire has sharp edges. Handle it very carefully to avoid injury.

   Screwed-up newspaper may be used to make the shape of the volcano more realistic.



3. Cover chicken wire (and newspaper) with paper strips dipped in a mixture of flour and water (papier-mâché). Leave the opening at the top of the screw-top bottle free from chicken wire and papier-mâché.
4. When the papier-mâché is dry, you could paint the volcano to make it look realistic.

Sedimentation

R5 Resource Sheet 5

This scene is in an area where there is very heavy summer rain. Farmers in the area have cleared most of the trees. Gullies, caused by erosion and landslips, are common in surrounding areas.

Exploring changes in rocks caused by heat and pressure

These activities will help students to model the effects of heat and pressure on materials.

Exploring changes in rocks caused by heat

- Students make two slabs of moist clay about 5 x 3 x 2 cm. They predict how they would compare if one were heated in a kiln and the other left to dry in the air and record their comparison. Questions to guide their thinking could include:
  - Would one slab of clay be softer than the other?
  - Would one slab of clay scratch more easily?
  - Would one slab of clay soak up more water than the other?
- One of the clay slabs is fired in the kiln. The other is left to dry in the air.
- Groups of two or three students design and perform investigations to compare the characteristics of clay that has been fired in a kiln with clay that has been left to dry naturally. (Refer to 'Teaching considerations', p. 35, if no kiln is available.)
- Students record their observations in a table and discuss their findings as a group.

Exploring changes in rocks caused by pressure

- Students make two piles each with two slices of bread placed between two sheets of greaseproof paper. Students predict what would happen if pressure were applied to the bread. Questions to guide their thinking could include:
  - How would the thickness of the layers compare?
  - Would one sample of bread be softer than the other?
  - Would one sample of bread crumble more easily than the other?
  - Would one sample of bread soak up more water than the other?
  - Would the two slices of bread be able to be separated easily?
- Groups of two or three students design and perform investigations to compare the characteristics of samples of bread that have had pressure applied to them and bread that has not. Pressure could be applied using a rolling pin, or the bread could be placed under a pile of heavy books for one or two days.
- Students record their observations in a table and discuss their findings as a group.

Acknowledgments

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This sourcebook module should be read in conjunction with the following Queensland School Curriculum Council materials:

Years 1 to 10 Science Syllabus

Years 1 to 10 Science Sourcebook: Guidelines

Science Initial In-service Materials

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