Planet Earth
Planet of Change

A resource book of ideas for teachers for National Science Week 2008

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Australian Science Teachers Association

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MINISTER'S FOREWORD

Now in its eleventh year, National Science Week gives Australians a chance to experience science first-hand. It aims to increase our understanding of how science, engineering, technology and innovation benefit society, the economy and the environment. With an estimated 700 events involving over 500,000 participants, National Science Week activities in 2008 will reach more regions and communities than ever before.

The Australian Science Teachers Association has made a wonderful contribution to National Science Week by producing *Planet Earth – Planet of Change,* a resource book for teachers full of ideas to make learning about science rewarding, exciting – and fun. The theme could not be more fitting in 2008, the International Year of Planet Earth.

Science and science education are critical to Australia's future. Science is one of the great enabling disciplines. A good science education can open doors to all sorts of interesting careers – and give young people the skills to make a real difference in the world.

Planet Earth – Planet of Change is a boon to teachers and a boon to science. Congratulations to ASTA on doing such a great job.

Kim Carr

Senator Kim Carr
Minister for Innovation, Industry, Science and Research
April 2008

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An Australian Government Initiative

ASTA acknowledges the support of the following organisations:

President's Message

The Australian Science Teachers Association (ASTA) is very pleased to bring you *Planet Earth – Planet of Change*, the 2008 National Science Week teacher resource book. This is the 24th in a series of annual National Science Week resource books published by ASTA since 1985, which have covered a wide range of science-related themes connected with their respective International Years. 2008 is the International Year of Planet Earth.

On behalf of ASTA I acknowledge the funding support of this project by the Australian Government through the Department of Innovation, Industry, Science and Research (DIISR). I also thank the many people who have contributed to the production of the book. This year there has been a special focus on producing a book that provides the background information science teachers need and a range of related science activities. I hope that you will enjoy this new layout, with its double-page topics and its focus on Australian case studies. It has been produced by educators for educators, and I am sure that you will find it a valuable resource.

It is also appropriate to acknowledge the eight ASTA member Science Teacher Associations and their state or territory National Science Week Representatives who support National Science Week in schools at the local level. Their efforts are also very much appreciated.

I hope that you will take the opportunity to participate in the unique national celebration that is National Science Week. Furthermore, I hope that you will find this publication most valuable in your promotion of Science within your school communities, and your efforts to enhance the scientific literacy of our future citizens.

Peter Turnbull
President, Australian Science Teachers Association

ASTA would like to acknowledge the following people for their valuable advice during the development of this book:
Dr Kate List, Shona Blewett and Fiona Wright, Geoscience Australia.

The authors would like to thank the following people and organisations for their help with the research, writing and review of this book:
Anna Davis (STANSW President), Curriculum Coordinator, Casimir Catholic College, NSW; Margaret Shepherd (STANSW Secretary), Administration Coordinator, Freeman Cathollic College, NSW; Anne Forbes (STANSW Councillor), Lecturer, Australian Catholic University, NSW; Jim Scott (STANSW Vice President), Lecturer & Science Education Consultant, University of Technology and University of Sydney, NSW; Frances Frend (STANSW Treasurer), Science Coordinator, Casimir Catholic College, NSW; Dr Peter Newcombe, Physics Teacher, Trinity Grammar School, NSW. The authors wish to acknowledge the input of the late Rosemary Hafner (STANSW President 2006-2007) into the initial tender and conceptual design of the project.

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Printer: Goanna Print, Canberra

Front Cover graphic design: Katharine Hagan, Geoscience Australia

Planet Earth – Planet of Change was produced during the International Year of Planet Earth, 2008

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Planet Earth – Planet of Change
ISBN: 0-9580663-6-1

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Questionnaire

National Science Week 2008 Resource Book

Planet Earth – Planet of Change

TEACHER FEEDBACK

Planet Earth – Planet of Change is an ASTA resource book of ideas for teachers for National Science Week 2008. The information you provide will help ASTA make improvements to future publications.

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ASTA MEMBER: YES/NO *(If yes which science teachers association)*

Please indicate your ratings

FEEDBACK CRITERIA

1. Overall response to the book	1	2	3	4	5	
A valuable resource						Of little value
Well presented						Poorly presented
Information sections were helpful						Not helpful
Supports an inquiry approach to student learning						Does not support an inquiry approach
Applicable beyond National Science Week 2008						Not applicable

2. Resource Book Content	1	2	3	4	5	
Good balance of activities – primary to secondary						Too targeted
Includes activities relevant to the class level I teach						Irrelevant to my students
Created student interest						Little interest created
Provided a springboard to other ideas and activities						No scope for creativity
Additional resource links were useful						Not useful
Appropriate methodology						Inappropriate methodology

3. What did you find most valuable about the book? ______________________

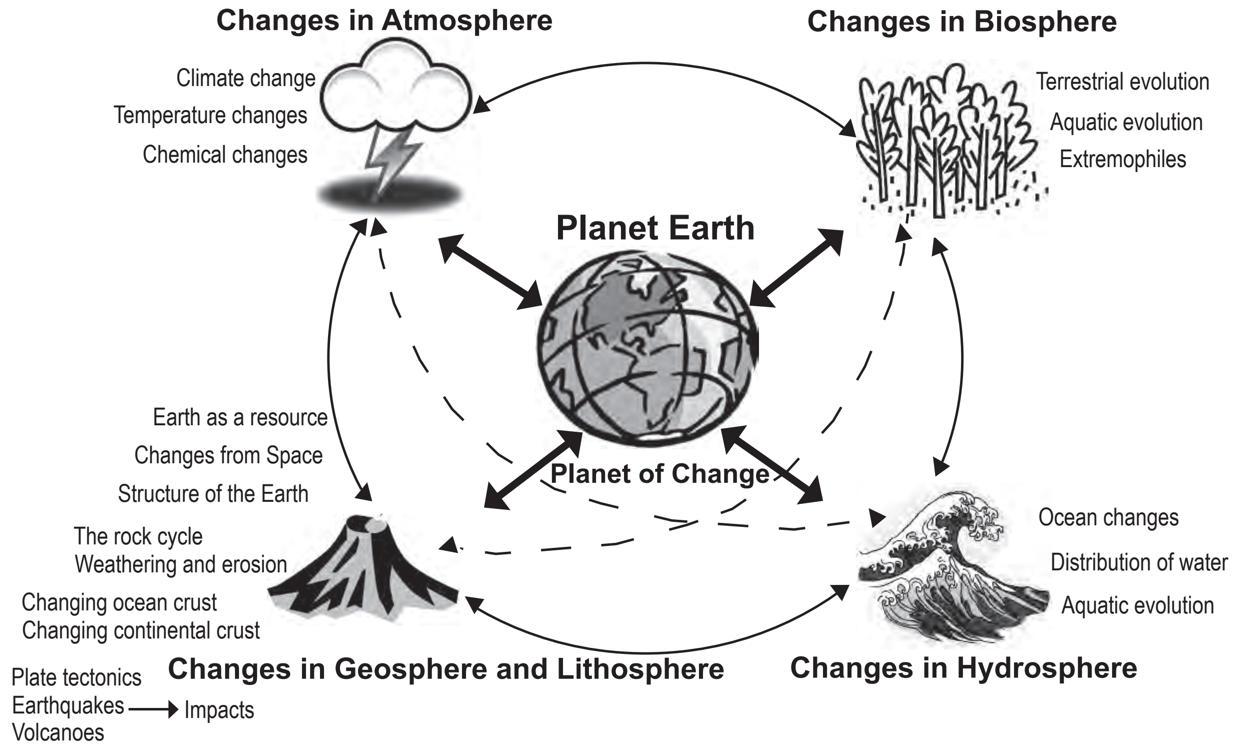
Why? ______________________

4. What did you find least valuable about the book? ______________________

Why? ______________________

INTRODUCTION

The booklet ***Planet Earth – Planet of Change*** has been designed to provide teachers with ideas about activities that can assist with developing conceptual understanding about the dynamic nature of the Earth, its structures and processes. Whilst many activities are hands-on investigations, others have been chosen to expand student experiences in extracting, processing and presenting information through electronic, audio-visual and oral media.



Interactions of the Earth's cycles

The diagram above has been used as the underpinning concept of this booklet's design. If students are to understand their home planet Earth, they need to focus on the interconnectivity of the parts that make up the planet:

- the atmosphere and its gases,
- the lithosphere with its various rock types,
- the hydrosphere with all water supplies,
- the biosphere which contains all living things,
- and the anthrosphere, that part of the Earth influenced by humans

Because Earth contains a number of interacting systems, a natural or human-caused change in one element of any system may impact on other elements of the planet. These impacts are used to demonstrate change and are included throughout the resource, which refers back, wherever possible, to the Australian context.

Understanding the cycles that interconnect and recycle the essential elements of each of the above parts is important if students are to understand our planet and the nature of the environments on it. The water cycle, the rock cycle, the carbon cycle and the nitrogen cycle all recycle Earth's finite resources.

This resource, with its geoscience focus, targets the rock cycle throughout the chapters in the book. It may be useful to download a larger diagram of this cycle from the ASTA website for display in the classroom during Science Week so that discussions and activities can be related to various steps in the rock cycle.

Humans now occupy almost every piece of land on Earth, and the places we occupy are shared with almost every other living thing. Our activities have impacted in some way on the lithosphere, hydrosphere, atmosphere, biosphere, and we are now even finding ways of reaching outer Space! Unfortunately many of our actions, although beneficial to us, often impact negatively on other species.

As students learn of the natural recycling processes and the limits of Earth resources, they will better understand the natural world and thus value moves to manage the environment in a sustainable way that benefits other life forms as well as humans in the future.

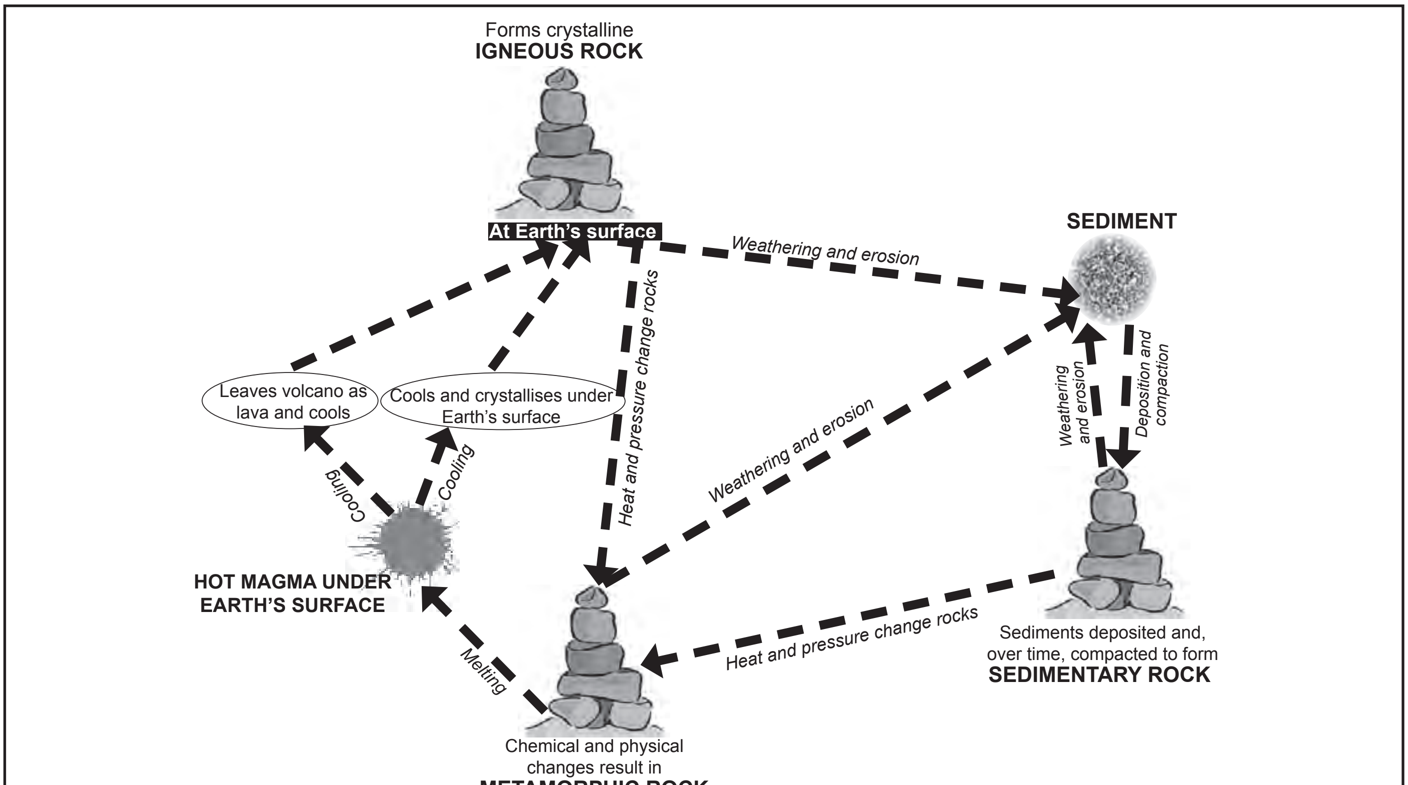
How this book is structured

Because of the length of time involved in geological processes, it is not necessarily apparent that the Earth is a place of constant change. The theme of change is woven through the descriptions and activities in the book to demonstrate the dynamic nature of the Earth and its systems.

The book has been divided into chapters based on changes:

1. that led to the formation of the Earth as it is now,
2. now occurring in the lithosphere,
3. now occurring in the atmosphere and hydrosphere,
4. in life on Earth and caused by life on Earth.

It is recognised that not all schools will have access to a wide range of geoscience resources and so the activities included



The Rock Cycle

in the book are varied to include presentations such as role plays, web quests and other activities based on the earth sciences as well as traditional hands-on investigations. This range is included to ensure that students in schools with limited resources may still engage in activities related to the theme of National Science Week. Whilst some activities are conceptually simple and easily achieved by most students, others will challenge students, to encourage further development of higher order skills including analysis and evaluation – important critical thinking skills.

Some activities have been specifically designed to allow for a 'celebration event' of National Science Week, but most could be included in appropriate work programs throughout the school year. In particular, many activities for students in the Lower Primary to Middle School range are interdisciplinary in their nature to increase their usefulness in that educational environment.

At the end of the book are two pages with additional information that may be useful. A 'Wall of Fame' has been constructed and, as a classroom activity, could be expanded to show the way in which scientific knowledge builds on past ideas. A list of further useful web links relating to each of the chapters has also been included to supplement those sites identified within the text of the chapters.

Organisation of Chapters

Each chapter includes the following features:

- an introductory page which provides background information on the subject of the chapter,
- a series of double-page spreads, each of which may be used independently of other pages,

Each double-page spread consists of:

A single page of information about the header topic. This single page is subdivided into:

- the background science knowledge and understandings relevant to the double page, and
- a case study based in the Australian context.

A page of teaching activities. This page generally provides activities across four groups:

- lower primary
- primary
- middle school
- senior secondary

Not all groups are catered for in every set of teaching activities. Teachers are encouraged to read across the activities for all groups for ideas that can be adapted to their own students' specific talents, interests and level of conceptual development.

Curriculum Guidelines

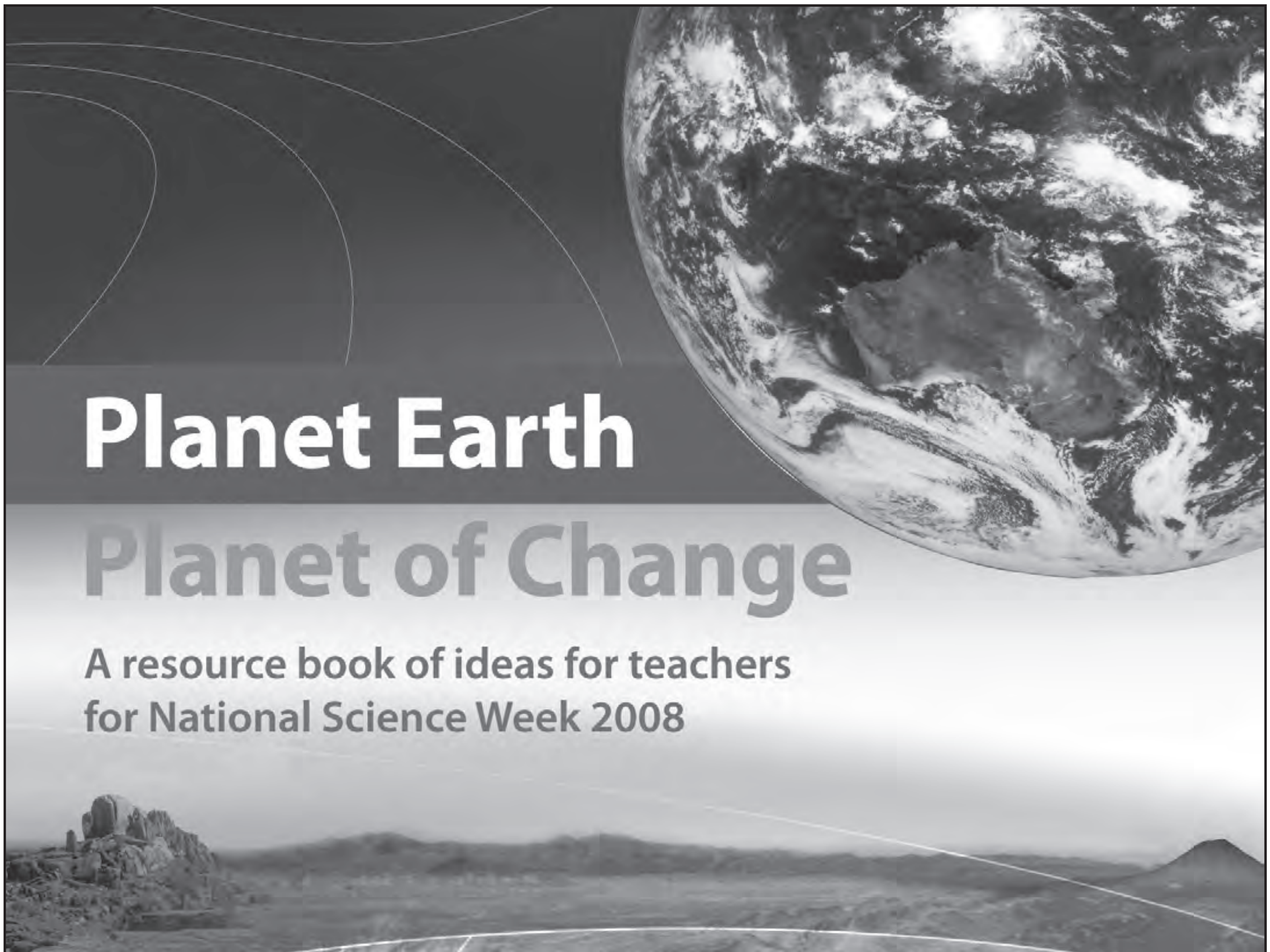
Whilst elements of the Earth Sciences are present in all state and territory curricula, it is not easy to find common threads that cover the scope of this topic for National Science Week. This document is, therefore, not prescriptive in its scope. Indeed many activities will take several lessons to complete and are envisaged as a once-off engaging event for students to demonstrate the excitement and wonder of Earth Science during National Science Week.

Teachers are encouraged to read through the book and identify one, perhaps two, activities which can be used within the context of current work programs and will demonstrate a 'touch' of *Planet Earth – Planet of Change* for their students.

Safety Awareness

All student experiments included in *Planet Earth – Planet of Change* have been designed to minimise hazards. However, there is no guarantee that a procedure will not cause injury. Teachers should test all activities before using them in class and consider the OH&S requirements within their state or territory. All necessary safety precautions should be outlined clearly to students. Students must be provided with all safety equipment necessary prior to the commencement of activities.

Happy Digging!



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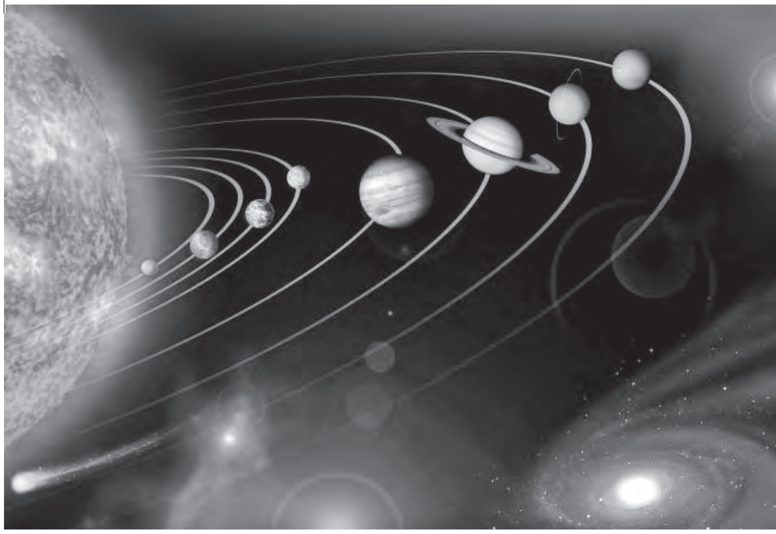


Courtesy of NASA/JPL - Caltech

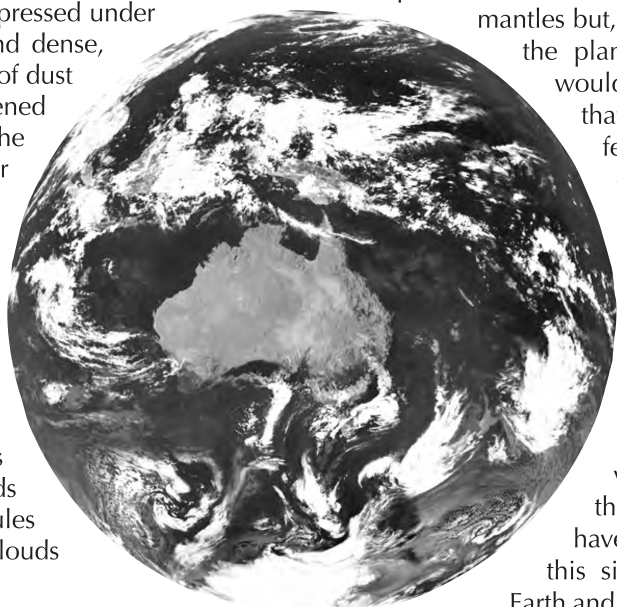
CHAPTER 1

Earth's turbulent past

Planet Earth is just a tiny part of an enormous, and constantly changing universe. The universe began 10–15 billion years ago with the 'Big Bang', a cosmic explosion that released all matter and energy that had been previously compacted into a single, inconceivably dense point.

Not only is the solar system in constant change but theories to explain the formation of the solar system have also changed.

An earlier theory explained that our solar system arose from a nebula that developed early in the formation of the Universe. This rotating cloud of gas would have been composed mainly of hydrogen and helium that formed after the Big Bang. Under the pull of gravity, matter began to accumulate in the centre of this cloud, and, compressed under its own weight, it became hot and dense, forming our early Sun. The cloud of dust and gas surrounding the Sun flattened into a disc, and grew hotter in the inner region where most matter accumulated.



However, new evidence leads astronomers to believe that the Solar System originated as a cloud of gas and dust in the spiral arms of the Milky Way galaxy. These immense clouds contain enough matter to form a thousand Suns. They sometimes break-up into smaller denser clouds in which more complex molecules such as methane can form. These clouds are called *molecular clouds*.

This most recent theory explains that a small molecular cloud became detached from the Milky Way galaxy about 4,600 million years ago by a supernova explosion. Gravitational attraction is a force of attraction, which exists between any two objects, even gas particles, in the universe. As this cloud of gas and particles cooled it began to collapse under its own gravitational attraction, forming a large rotating disc.

Within this disc, the Sun began to grow as gravitational attraction caused dust and other materials to collide and clump together. On the edges of the rotating disc, dust and other materials clumped into increasingly larger masses called *planetesimals*. Many planetesimals eventually broke apart during violent collisions. The largest planetesimals survived and continued to eventually grow into planets.

The resultant four inner planets – Mercury, Venus, Earth and Mars are relatively small and 'rocky', and are known as the terrestrial planets, while the outer planets – Jupiter, Saturn, Uranus and Neptune are much larger and are composed of large volumes of gaseous elements around a solid core.

Earth was initially an unsorted mixture of rocky debris. The above theory includes the suggestion that some of the planetesimals melted, forming iron cores and silicate mantles but, even so, as they clumped to form the planet, the developing planet Earth would have lacked the layered structure that exists today. Earth's distinguishing features such as the oceans, continents and atmosphere would not have existed.

Of the inner planets, Mercury is considered geologically dead. Venus and Mars do show signs of past geological activity but their crusts are now immobile. Earth remains the most geologically active. Earthquakes occur and volcanoes erupt somewhere on the planet every day. Scientists have searched for explanations for this significant difference between the Earth and the other rocky planets of the solar system.

DID YOU KNOW?

Earth is a beautiful blue and white ball when seen from space. The third planet from the Sun, it is the largest of the inner planets. Earth is the only planet known to support life and to have liquid water at the surface. However, Earth's beauty belies its turbulent past and the dynamic nature of its structure that still brings change on a daily basis.

Evolution of the Australian Continent

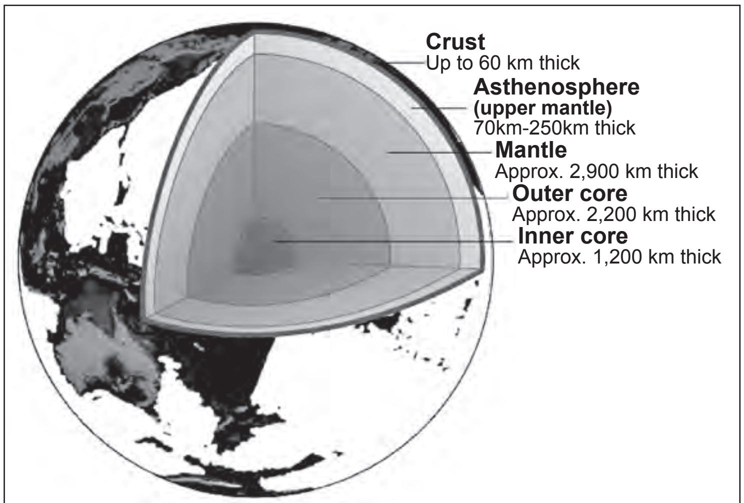
The Australian continent contains some of the oldest evidence of the geological history of planet Earth. The disjointed locations of this evidence challenge geologists to unravel the changing crustal patterns. Their discoveries demonstrate the dynamic nature of the Earth's structures.

The Science

Scientists think that about 4,440 million years ago (mya), the Earth collided with a Mars-sized body. The collision showered debris into space from both the Earth and the impacting body. The impact changed the spin axis of the Earth from vertical to a 23^{o} inclination and sped up its rotation. The Moon probably formed from the ejected debris. The energy of this collision would have caused the Earth to heat and melt, forming both an 'ocean' of molten rock hundreds of kilometres deep that covered the surface, and an interior 'soft' enough to allow its components to move around.

The molten rock then separated into layers according to density, with the densest materials sinking to the centre and the least dense materials moving to the surface. The Earth cooled and the outer layer solidified as heat radiated into space. This process of *differentiation* gave rise to a 'zoned' planet with three main layers:

- a hot, dense, metallic core,
- a highly viscous silicate mantle, and
- a thin, outermost, rigid crust.



Structure of the Earth

Continental growth occurred due to the flow of molten magma to the surface where it cooled forming a crust of solid rock.

At this time radioactive decay was about three times greater than it is today, and was another source of heat driving the differentiation process. The large amounts of heat released caused greater turbulence and faster convection currents than today within the Earth's mantle, leading to widespread volcanic eruptions on the Earth's surface. Planet Earth would have been a most inhospitable place.

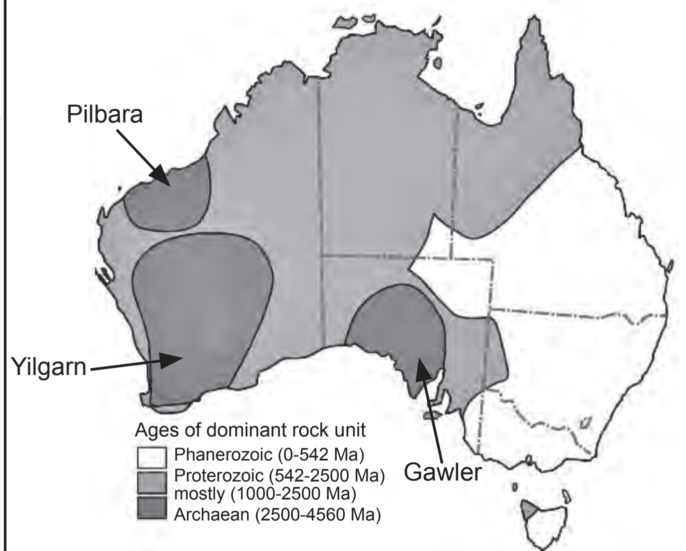
The oceans and atmosphere formed either from the water and gases that boiled off during heating and differentiation, or from comets (composed largely of H_2O and CO_2) bombarding Earth. The crust was then shaped by surface processes (wind, water and ice) as well as ongoing volcanic activity.

The Case Study

The evolution of the Australian continent

Australia is a collection of *cratons*, ancient igneous and metamorphic landmasses and sediments from former seas and oceans, now joined to form the continent we call Australia. 'Australia's' geographic location on the planet has altered many times since the original formation of the Earth's crust.

The word craton is used to define the extensive, flat, stable interiors of a continent. These ancient rocks underwent extensive geological activity but have been relatively stable for a very long time. The Pilbara and Yilgarn cratons in Western Australia and parts of the Gawler craton in South Australia were formed during the Archaean Era between 2,500 and 4,560 mya during a time of intense volcanic activity across the Earth's surface.



Source: adapted from Geoscience Australia poster GA10096.pdf

Rare sand grains found in the Jack Hills Metamorphics in the Yilgarn Craton in Western Australia and have been dated at 4,250 million years old making them the oldest known mineral grains in the world. At that time, northern, western, and central Australia belonged to different continents that were separated by oceans. They have survived the merging, deformations and splitting of continents and supercontinents for over 2,000 million years.

About 1,640 mya, a collision occurred between these three continents. This collision produced volcanoes that created the crust of Central Australia. Most of Central and Western Australia is now covered with 'younger' rock formed mostly between 1,000 and 2,500 mya.

From these beginnings, a long sequence of geological events added further landmass to the continent forming what is now Eastern Australia.

Teaching Activities

Primary

Model the solar system

Building a scale model of the solar system gives students some idea of the relative sizes of the Sun and the planets; it also gives them some idea of what the word 'space' really means when talking about the universe. Using a 500mm diameter beach ball for the Sun then to scale, Jupiter is 50mm (the size of a tennis ball), Earth and Venus are both beads about 4mm in diameter, and Mars and Venus are even smaller beads about 2mm in diameter.

Thread wire through each of the beads and tape them to separate paddle pop sticks. From the beach ball, have students set up the Solar System from Sun to Jupiter in a large field (you'll need nearly 300 metres of distance) using the calculated distances eg. Sun to Mercury is approx 20 metres, Mercury to Venus is 18 metres, Venus to Earth is 15 metres, Earth to Mars is 28 metres and Mars to Jupiter is approx 200 metres.

http://www.exploratorium.edu/ronh/solar_system/ is a useful site. It has a built-in calculator so that students can decide on the size of the scale model. Most students will be unfamiliar with the 'feet and inches' alternative for measurement – this will provide an opportunity to talk about different measurements used around the world.

This page then links with http://www.nineplanets.org/ which has information about each of the planets and photographic images from space flights. This site is suitable for middle to upper primary in reading level and content.

Middle School

Model the layered earth

Use different coloured modelling clays for students to build up a spherical model of the earth. Encourage older students to build the layers to scale. Some students will need assistance in developing a scale that is suitable to demonstrate the differences in thickness in the Earth's layers. If Plasticine or a similar material is used, the sphere can then be cut or opened up to demonstrate the layered structure of the earth.

Minerals from the Earth

Tectonic activity is the term used to describe any shifting of a planet's crust caused by changes deep under the crust. Such tectonic activity formed the Archaean cratons and blocks in Western Australia not long after the planet aggregated, cooled and differentiated. These ancient rocks contain rich mineral deposits that are mined to meet world demand for raw materials. Ask students to research the relationship between the location of the ancient blocks and the mines of economic importance to Australia.

Gold: http://www.austmus.gov.au/geoscience/earth/geological_ore.htm is a good place to start with its descriptions of gold deposits.

http://www.ga.gov.au/minerals/education/minerals_index.jsp has pages of basic information about gold.

Maps locating mineral deposits across Australia are available for download at http://www.ga.gov.au/map/index.jsp

Senior Secondary

Evidence for the layered structure of the Earth

Isaac Newton (1647–1727) calculated that the average density of the Earth is twice that of its surface rocks. From these calculations, he hypothesised that the Earth's interior must be composed of much denser material. He was correct! Since then, understanding of Earth's structure has increased significantly. Ask students to draw a time-line identifying further developments in knowledge of the Earth's structure. Ask them to identify/describe the advances in technology that have enabled these increased understandings. A good place to start is http://pubs.usgs.gov/gip/interior/

Science fiction takes a wrong turn

Journey to the Centre of the Earth is a classic 1864 science fiction novel written by Jules Verne. The story involves a professor who leads his nephew and hired guide down a volcano in Iceland to the 'centre of the Earth'. At the time of its writing there was little knowledge concerning the Earth's core. A film was made of this novel in 1959 and students may enjoy watching this 'epic' to identify all the incorrect or 'bad' science in the movie. Alternatively, set your students the task of finding another example of poor science in movies about the Earth's beginning or threats to the Earth from outer space. Ask them to prepare a short multi-media presentation to deliver to the class about a particular scene and the scientific inaccuracies in that scene.

So you want to be a geologist? How will I work?

Start by asking your students to draw a cartoon image of a geologist. Do the images have a person, probably male, wearing khaki work clothes and sturdy walking shoes, carrying a backpack with pick in hand, and tramping over distant mountains? Such an image reveals understanding of only a small part of the geologist's work. The sophisticated technology available to detect the previously undetectable has given geologists a very broad range of search options. http://wwww.ga.gov.au/education/minerals/minfact.html is an ideal place to start a research task that includes background geological information as well as descriptions of the tools available to the modern geologist.

The Moon

For the volume and mass of the Earth, the Moon is a relatively large satellite. Students could research ideas and theories, and the current evidence for them, of when and how the Moon came to be a satellite of the Earth. Students could consider limitations on our current ability to gather evidence and predict how this situation might change in the future.

All Age Groups

For the Science Week Celebratory Feast: An edible analogy for Earth's differentiation into a layered structure

Ingredients

4 eggs; 1 cup coconut; 1 cup sugar; ½ cup plain flour; 125g butter; 2 cups milk; 2 teaspoons vanilla.

Method

Cream the butter and sugar and then mix in all the other ingredients. You should have a really runny mixture! Pour the mixture into a well-oiled container such as a pie dish. Bake at 180^{o}C for about 1 hour or until the centre is firm. If all goes well, you will have a delicious 'crust' of coconut, a 'mantle' of egg custard and a denser 'core' of pastry at the bottom.

Changes from Space – Meteorites

Scientists refer to the first 600 million years after the formation of the planets as the Heavy Bombardment Period, when the planets continued to collide with and sweep up debris. These collisions resulted in pockmarked surfaces of the Moon, Mars, Mercury and other bodies in our solar system.

Evidence of such collisions and the changes caused are further indications of the changing face of planet Earth.

The Science

Collisions with space rocks

The vast spaces between the planets contain debris such as dust particles and small and large rocks that did not become incorporated into planets when they formed billions of years ago. Both the Earth and this debris travel at high speeds in orbits around the Sun—the Earth is travelling at an average speed of about 30 kilometres per second (km s^{-1}).

The Earth is constantly bombarded with this debris, most of which burns up in the atmosphere. However, the Earth does run the risk of colliding with a space rock that is large enough to hurtle into the ocean or onto a landmass.

A meteorite is a stony or metallic mass of matter that did not completely vaporise when it entered the Earth's atmosphere. The energy released by meteorites that formed impact craters on the Earth's surface has been calculated to range from the equivalent of about 1 million tonnes of TNT to tens of millions of tonnes of TNT.

Meteorite impacts can have significant and widespread effects, such as causing deformations of the Earth's crust or triggering environmental changes through the dust thrown up into the atmosphere. Simulations of impacts suggest that even a small object would cause global-scale pollution of the upper atmosphere with fine dust particles. Dust in the atmosphere would decrease incoming solar energy to the Earth's surface and result in cooling of the oceans and the atmosphere. This would lead to global and/or regional changes in ecological relationships and a crash in the overall populations of many species.

Some scientists think that impacts with space debris are the primary cause of the frequent mass extinction periods in the Earth's fossil record. These scientists have been able to link the age of fossil layers that show en masse deaths of marine organisms with the best-guess dates for the occurrence of impact craters.

Evidence also indicates that climate change was associated with the five known major mass extinction events on Earth. However, it is still uncertain whether or not meteorite impacts alone caused the changes. It is argued that the environmental changes caused by an impact would be of limited geographical extent, and that impacts may have simply enhanced global climate change that was already occurring.

Definitions

A **meteoroid** is the name given to a small body (10m or less in diameter) travelling through space.

If a meteoroid is pulled into a planet's or a satellite moon's gravitational field, it is then called a **meteor**.

Any solid body that survives a trip through the atmosphere and hits the Earth is called a **meteorite**.

The Case Study

Australian impact craters

There are at least 24 geological structures in Australia that are impact craters of meteorites ranging from a few metres to probably nearly 100 km in diameter. The impacts range in age from a few hundred thousand years ago to about 1,700 million years ago.

The Woodleigh crater was found on Woodleigh Station, east of Shark Bay in Western Australia. The crater may be as much as 120 km in diameter. The Woodleigh impact probably occurred approximately 360 million years ago and so the evidence for it is now buried under more recent sediments. It was detected in the late 1970s during a routine mineral drilling survey. A gravity survey in 1997 showed the area to have a higher than normal gravity readiness which suggested that the chemical composition of the area was different from that of its surroundings.

In 1999, investigation of the rocks found breccia and shocked quartz that could have only formed under the high-pressure conditions created by a meteorite impact. This pressure is estimated to have been 100 thousand times atmospheric pressure and up to 100 times greater than the pressures created during volcanic activity.

There was a mass extinction at about the same time as the Woodleigh impact. In this extinction, marine creatures, particularly ancient corals and invertebrates were affected. Palaeontologists estimate that 70% of species living at the time were lost. Similar impacts on other continents between 350 mya and 400 mya may coincide with the Woodleigh impact or indicate a period when the Earth was hit by several large meteorites, causing environmental changes around the globe.

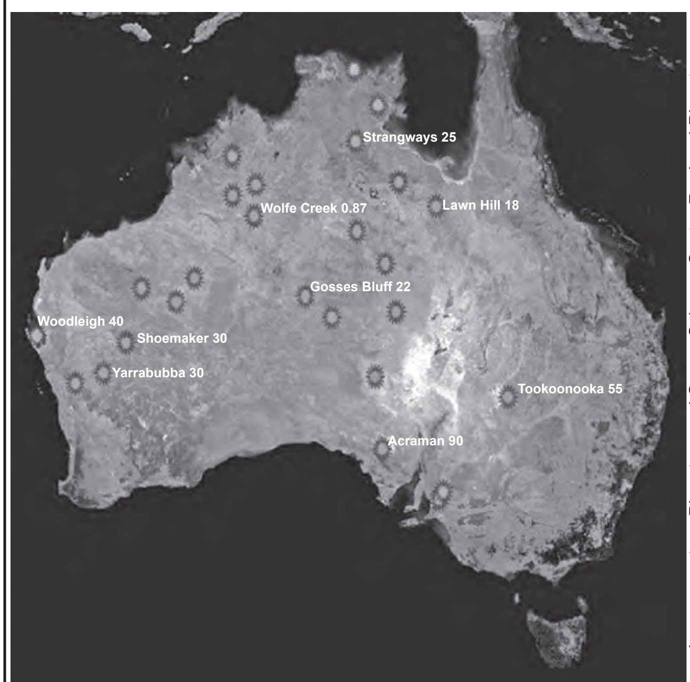


Image courtesy Planetary and Space Science Centre Regional Planetary Imagining Facility, Canada

A map of known Australian impact craters with some labelled with their diameters (in kilometres)

Teaching Activities

Lower Primary

Meteorite impacts

Students qualitatively investigate the differences between the energy of large and small objects, dropped from different heights.

Students fill a bucket with water and drop river pebbles or apples of, say, three different sizes into the bucket from the same height. Which object produces the (a) largest splash or (b) highest splash? They could drop one size of pebble from different heights and consider the same two variables, (a) and (b).

Primary

Craters 1

In small deep trays, such as baking trays, place a thick layer of flour. You might want to enhance the look of the trays by sprinkling a thin layer of cocoa or similar powder over the flour or sand.

Provide students with the following items in a takeaway container:

- a set of marbles (or steel balls) of different sizes
- tooth picks
- a fine point marker
- a ruler

Pre-test your setup by finding the maximum height at which the marbles or balls will not impact the bottom of the tray. Demonstrate the vertical dropping method to students. Discuss with them how to use a pair of toothpicks to estimate the diameter and depth of the 'crater'. Each student group could investigate at least one relationship, such as how the diameter and/or depth of the 'crater' depends on the:

- diameter of the dropped sphere (it might be best to give students this information)
- dropping height of the dropped sphere
- mass of the dropped sphere, if you have access to a low range kitchen scale in grams

Ask each group to present its results visually, report its findings to the class and explain them.

Alternatively, specify a depth or diameter for a 'crater' and ask each group to find the dropping height of the marble or ball which produces this 'crater' size.

http://www.tryscience.org/experiments/experiments_home.html
Website with offline and online investigations that are perfect for the primary school classroom. Click on the 'Space Sciences' card and then try the 'Comet Cratering' investigation.

http://www.questacon.edu.au/html/meteor_strike.html
Online learning object. What will happen if a meteor the size of a city approaches our planet Earth? Control the size of a meteor travelling towards Earth. Control the distance of the meteor from Earth. Control the meteor's angle of approach. Then see what happens!

Middle School

Craters 2

Read the Primary Craters 1 activity.

With Middle School students, it is best to use trays of moist sand. Make the sand just moist enough that it will form a persistent crater.

For this activity, it is best to use marbles or steel balls of four different diameters.

Students should be challenged to design an experiment in which they discover the relationship between crater depth and diameter and a key sphere variable, especially diameter or dropping height. The desired end product is a reliable line graph. Do crater diameter and depth follow the same, or different, relationships? This is a good opportunity to stress the need for repetitions of accurate experimental measurements.

Note that, as far as height is concerned, the release energy is proportional to the release height. Discuss the energy transformations that occur as a meteorite comes into the Earth's atmosphere and collides with the ground… (gravitational potential energy, kinetic energy, sound, heat energy…etc.)

Give students an image of all, or part of, the 'dark' side of the Moon. Choose an area where a number of craters overlie and underlie each other; e.g. http://www.lunarrepublic.com/atlas/index.shtml

Student groups could examine these images and discuss:

- the order in which the craters formed
- the relative sizes of the space rocks that caused each crater, based on diameter and apparent depth of the newer craters
- other variables that could affect the size and shape of a crater on the Moon

An interesting question for students to discuss or investigate is why the far or 'dark' side of the Moon is more cratered than the near side of the Moon. This should increase their understanding of the rotation of the Moon as it orbits the Earth.

All Age Groups

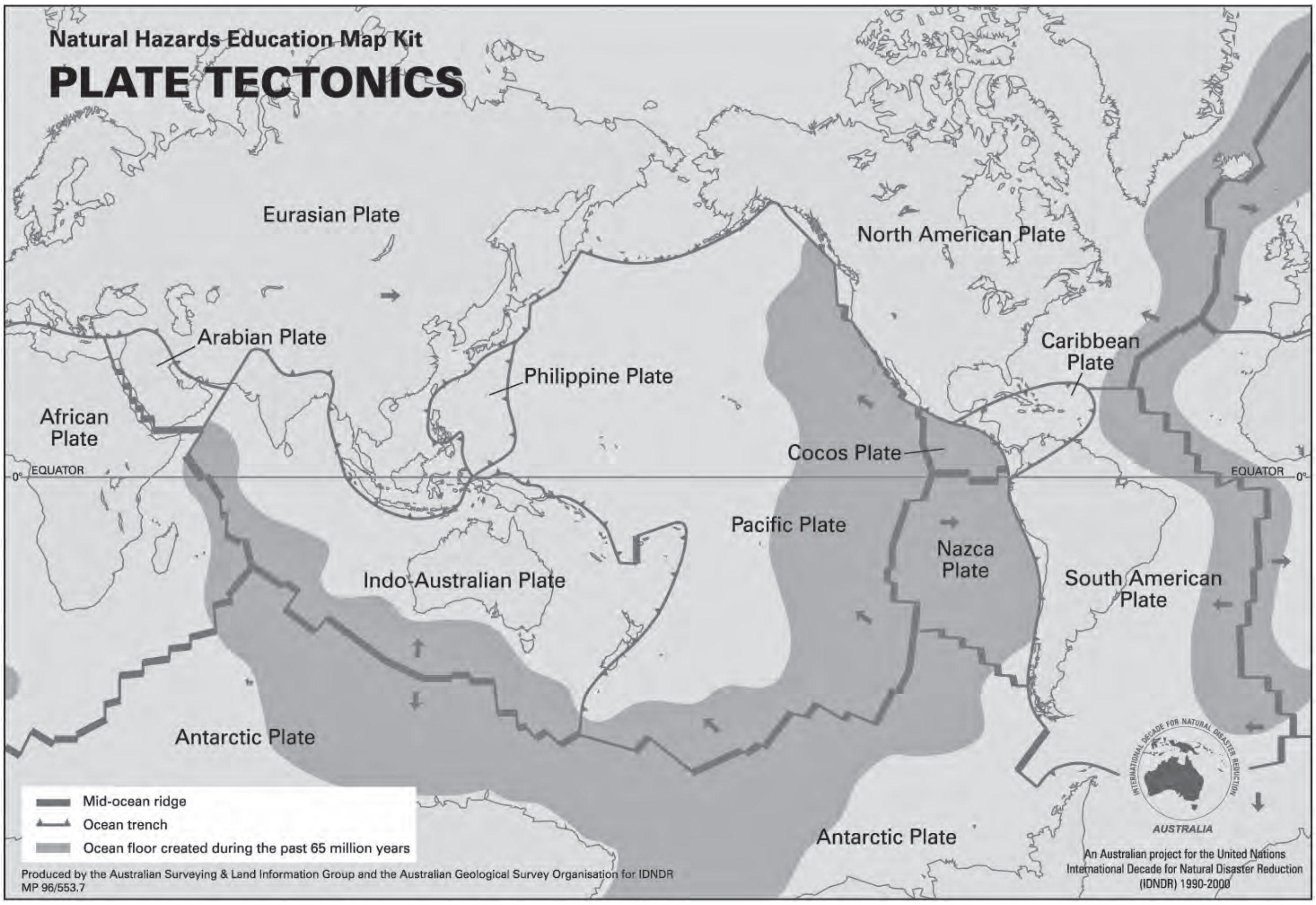
Science Week Celebratory Feast: Model Meteorites

http://dmns.org/main/minisites/spaceOdyssey/teachersGuide/grades48/pdf/edibleSpace.pdf US-based pdf file to download which uses various sweets as models for the different types of meteorites. This is readily adaptable to the Australian context and provides a background to take discussion about meteorites further with interested students. A similar activity is available at http://www.spacegrant.hawaii.edu/class_acts/EdibleRocksTe.html with recipes for model 'meteors'. http://www.spacegrant.hawaii.edu/class_acts/EdibleRocks.html has the student instruction page related to this exercise. These activities are useful in that they require students to use their observational and literacy skills to describe familiar objects in Earth science terms.

The Change Driver – Plate Tectonics

The theory of plate tectonics describes the surface of the Earth as a series of large rigid plates that move as distinct, independent units in different directions, riding on convection currents in the viscous upper layer of the mantle (asthenosphere). This theory revolutionised geoscience by providing an all-encompassing concept that explains many of the Earth's geological features and the changes that occur in these features.

The Science



Courtesy Geoscience Australia

Scientists mapping the shape of the sea floor discovered the Mid-Atlantic Ridge in the 1960s and were able to demonstrate that the two oceanic plates on either side of the ridge were moving apart. This was some of the defining final evidence that proved plate tectonics existed.

Since then, the boundaries of plates have been confirmed as the places where constant geological change occurs. Much of this change is sudden with most earthquakes, active volcanoes and their associated geological structures occurring on or near these boundaries.

At *divergent boundaries*, the plates spread apart and magma (molten rock) rises into the cracks to cool and form new crust. Most of these boundaries are found on ocean floors and are recognisable by the crack-like valleys at the crests of the mid ocean ridges that form. Present-day Iceland, with its active volcano, owes its existence to this spreading process, as it straddles the Mid-Atlantic Ridge (see photo, right).

Collisions between plates that are pushing together result in landforms that reflect the compressional situation. If one plate is denser, it will slide under the second plate, (*subduction zone*) subside and return to the upper mantle. The overriding plate buckles and forms volcanic mountains, such as the Andes mountain range, which is beside a deep ocean trench caused by the descent of the dense oceanic plate.

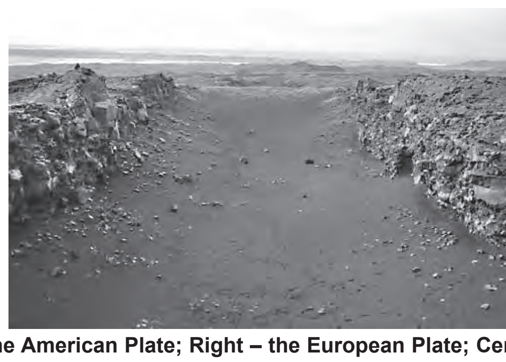


Photo courtesy Brigitte Antilla

Left – the American Plate; Right – the European Plate; Centre – the rift (Iceland) , approximately 6-7 metres wide

If both colliding plates have a similar density, the crust tends to buckle and push upwards or sideways creating mountain ranges. The buckling can give rise to folded mountains. An example is the collision of the Indian-Australian and Eurasian plates, which has given rise to the Himalayas and the Tibetan plateau.

If the plates are simply sliding past each other, the boundary is represented by a continuous crack (fault line). A famous example is the San Andreas Fault in California, where the Pacific plate slides past the North American plate in a north westerly direction. Sliding occurs in a stick-slip fashion so that earthquakes are common.

The Case Study

The continent of Australia is now in the middle of the giant Indian-Australian Plate. At each edge of the plate, geological activity is occurring but the Australian continent is relatively stable. Rocks in eastern Australia contain evidence that plate boundary activity took place in this region in the past in the form of ancient island arcs and ocean trenches.

Eastern Australia was created from activities at plate boundaries in the last 500–200 million years. From 500 mya to 250 mya, the Tasman Fold Belt system that makes up the eastern third of the Australian continent was formed due to plate collisions. Sediment then accumulated between the continental edge existing at that time and the separated island arc, eventually filling the gap.

From 320 mya to 280 mya, eastern and central Australia experienced major tectonic activity, including mountain building, as evidenced in the Lachlan (south-eastern Australia) and New England Fold Belts (central and southern Queensland). Erosion of these mountains supplied sediment for basins that developed along Australia's eastern coastline such as the Sydney Basin. By 200 mya, thick stable continental crust had formed.

Volcanic activity has continued along the east coast for the last 60 million years, coinciding with the movement of the Indian-Australian plate northwards. The most recent eruption is believed to have been Mount Gambier in South Australia about 4,000 years ago.

Teaching Activities

Middle School

Where in the world is my town?
Use a modern Australian map in conjunction with the palaeographic atlas at http://www.ga.gov.au/multimedia/palaeo/html/palaeo.html to identify the location of your school. Students could then trace the changing landscape at that location through the last 500 million years. This activity could include a research investigation that considers the types of organisms that would have been found in the area at that time. Is there evidence of their existence in the rocks around the town? Perhaps the Science Week activity could include a 'Walk around town' to look at local rocks?

For added impact use the Australia through Time pdf at http://www.ga.gov.au/image_cache/GA10096.pdf so students can consider 'where in the world has my town been?'

Students may be able to conceptualise the extent of geological time if they construct a time line that compares the 'distance' between events in their own experience with the time 'distances' used in geology. Most middle-school students will need assistance with the selection of a suitable scale for this exercise. http://www.geology.wisc.edu/~museum/hughes/MakingTimeLine.pdf could be downloaded to assist this process. This time line could be used in association with tracking the 'town' in the exercise above.

What happens at plate boundaries?
http://volcano.und.edu/vwdocs/vwlessons/activities/p_number5.html uses simple materials to model the difference between divergent and convergent plate boundaries. Instructions are also provided to adjust the materials to model the differences in magnetic anomalies at ocean-ocean boundaries, ocean-continent boundaries and continent-continent boundaries.

http://msteacher.org/epubs/science/science1/science.aspx is well worth a visit for a range of activities about plate tectonics including links to activities and animations. For example, one link goes to an exercise that could become another Science Week feast if it is suitably changed to fit the Australian context. http://www.windows.ucar.edu/tour/link=/teacher_resources/teach_snacktectonics.html

Senior Secondary

History of ideas about the Earth's crust
Evidence of sea floor spreading, discovered in the 1960s, supported the theory of plate tectonics. Before this discovery, various theories abounded to explain the existence of volcanoes and earthquakes. As a Science Week project, students could research the history of ideas about the Earth and movement of the plates.

With help from a friendly drama teacher, perhaps they could assume roles to debate these ideas with their peers. This activity could be expanded into a role-play with individual students adopting the role of various scientists to argue their ideas.

Wegener's mechanism for crustal movement http://www.ucmp.berkeley.edu/geology/techist.html

Arthur Holmes and his ideas
http://mysite.du.edu/~jcalvert/geol/holmes.htm

Harry Hess and Robert Dietz
http://volcano.und.edu/vwdocs/vwlessons/plate_tectonics/part8.html

Expanding Earth (an alternative hypothesis to plate tectonics)
www.expanding-earth.org/

The impact of technology on the development of Earth Science ideas
'Technological advances and detailed studies of the ocean floor, both unavailable during Wegener's time, allowed Hess and Dietz to generate the new hypotheses' (about continental drift and plate tectonics). Improved technologies continue to assist earth scientists to refine their understandings about plate tectonics. Students could develop poster presentations for their class on the importance of various technologies to earth scientists.

The following sites are good starter references for students to begin web research:

Space technology
http://scign.jpl.nasa.gov/learn/; http://cddis.nasa.gov/926/slrtecto.html

Tracking and measurement of earthquake waves
http://www.sciam.com/article/cfm?articleID=006708F-9F7D-1C5E-B882809EC588ED9F

http://www.platetectonics.com/article.asp?a=74

http://www.platetectonics.com/article.asp?a=103&c=8

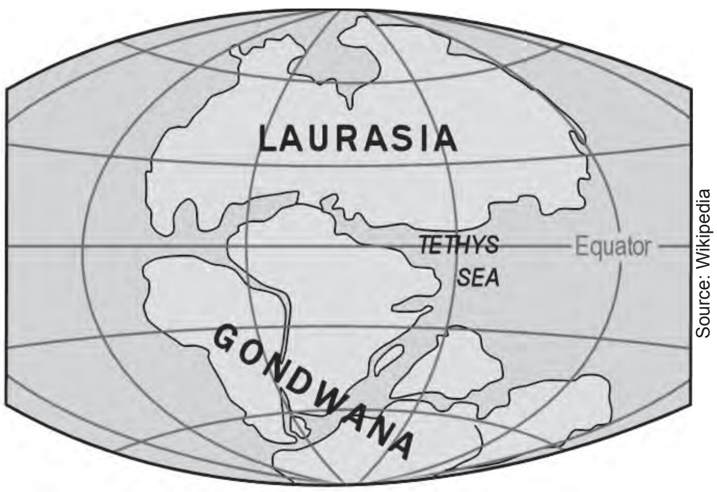
Continents on the Move

The concept of continental drift was first proposed in 1596 when Flemish geographer Abraham Ortelius commented on the jigsaw puzzle-fit of the African west coast with the South American east coast. During the 19th and 20th centuries, geologists began pointing out similarities in geological structures and rock ages along these two coastlines, and provided evidence for drift in the form of climatological and fossil data.

The Science

Continental drift became widely accepted by the scientific community in the 1960s with the development of plate tectonic theory (see page 12), which provided an explanation for a mechanism that made drift possible. If continents are embedded in moving plates, it follows that the continents must also be on the move. By studying rock assemblages, fossils, climate and magnetism, scientists have been able to piece together the movement of the continents over time – an incredible feat considering it all happened hundreds of millions of years ago!

About 750 mya, the continents were loosely combined in a super-continent known as Rodinia. Convection forces in the mantle began to drive the break up of this landmass, and the continents split and drifted around the globe until they reassembled about 260 mya to form another super-continent known as Pangaea. Then 200 mya, Pangaea split in half giving rise to Laurasia in the northern hemisphere and Gondwana in the southern hemisphere. These two landmasses continued to break apart and drift, eventually forming the continents that we are familiar with today. Their current arrangement is by no means permanent. If we could map the world in another 50 mya, it is likely to look very different from the way it does today!



The split and drift of the continents during the Triassic, 200 million years ago.

Gondwana: Great Southern Land

The break up of Gondwana began between 125 and 50 mya, and gave rise to Africa, South America, Antarctica, India, New Guinea and New Zealand plus assorted pieces now attached to other continents. Australia and Antarctica were the last of the continents to break apart, remaining joined until as recently as 45 mya. As Australia moved northwards and Antarctica south, a deep rift valley formed along the southern edge of Australia, developing into the Southern Ocean as it widened. This rifting created Tasmania, which was pulled from the mainland as Antarctica headed south.

After separation with Antarctica, Australia continued to head north where it collided with New Guinea and the Timor region, creating land bridges and initiating a subduction zone to the north of Papua New Guinea. Australia is presently located on the leading edge of the Indian-Australian plate, which continues to move northeast at a rate of 73mm per year.

Evidence for Drift: Biogeography

Biogeography, the study of the distribution of species in time and space, has been a useful tool for tracking the movement of the continents in the past. Many species have (or had) a curious distribution around the world that could only be explained in the context of continental drift.

A classic example is *Mesosaurus*, a late Paleozoic freshwater reptile that palaeontologists think was one of the first aquatic reptiles. It was a slightly built, four-legged animal and was about 45 cm long. *Mesosaurus* had long slim jaws that were lined with pointed, needle-thin teeth that interlocked with each other as the jaws closed. This would have formed a kind of cage or sieve-like structure that allowed the animal to take a mouthful of plankton or small fish and strain out the water before it swallowed its food.

Mesosaurus is represented by abundant, well–preserved specimens in both Brazil and West Africa. Possible explanations for this distribution are convergent evolution (i.e. similar species evolving in different parts of the world due to similar environmental conditions), or migration (i.e. the reptile crossing the Atlantic to populate the opposite coastline). Our knowledge of the Mid-Atlantic Ridge and seafloor spreading zones has allowed us to conclude that both these explanations are incorrect, and that the unusual distribution of Mesosaurus is because these two continents were joined at the time this animal was alive.

Definitions

A **convection current** is an internal circular current in a fluid such as air, water, or molten rock. The circulation is due to differences in temperature and occurs when a fluid is unevenly heated. Fluid particles with more energy spread out, thus becoming less dense and the opposite also applies. The warmer, less dense material rises (**upwelling**) and colder, denser material sinks (**downwelling**). This sequence produces a circular movement. Ocean currents, atmospheric currents and currents under the Earth's crust in the mantle are all formed by this process.

The Case Study

Australia may have had contact with other continents in the past, but since our split from Antarctica 45 mya we have been drifting in relative isolation. This isolation has allowed the Australian flora and fauna to evolve independently, giving our country one of the highest levels of endemism (species restricted to a particular geographic area) in the world. About 80% of our mammal species are endemic, and of the 900 eucalypt species found in Australia only about 13 occur naturally elsewhere.

The flora and fauna of joined landmasses tend to show similarities and a lower level of endemism due to the interchange of species. Australia and Papua New Guinea show similarities in their flora and fauna for this very reason; when these two countries collided, species migrated in both directions before a sea level rise cut off the land bridge and formed what is now the Torres Strait.

The Wollemi Pine

The Wollemi Pine (*Wollemia nobilis*) was first discovered in 1994 growing in a deep narrow canyon in Wollemi National Park, about 150km northwest of Sydney. The population consists of less than 40 individual trees, making it one of the rarest plants on Earth. This species is distinct from any other plant group that has existed in the last 65 million years, and is a representative of an evolutionary lineage thought to be long extinct. It belongs to the Araucariaceae – a plant family that is known from the fossil record to have dominated the landscape between 200 and 65 mya when Australia was part of Gondwana. At this time, the global climate was much warmer than the present day and Gondwana was covered in rainforest.

As the continents split apart and drifted, Australia became hotter and drier. The rainforests gave way to more drought-tolerant flowering trees and grasses and became restricted to moist and isolated locations (refugia) along the east coast. The word refugia is used to describe locations in which species have persisted while becoming extinct elsewhere.

The closest living relatives of the Wollemi Pine include the Hoop and Bunya Pines (Australia), Norfolk Island Pine, Kauri Pine (New Zealand), and Monkey-Puzzle Pine (Chile and Argentina). Today, these and other surviving members of the Araucaria are restricted to the South American and Southwest Asia-Western Pacific region – a distribution that supports the concept of a Gondwanan heritage. The Wollemi Pine is considered a true living fossil and has provided a unique glimpse into our environmental history.

Teaching Activities

Middle School

A 'fishing trip' through the ages

This activity will be fun for more able and adventurous students. Organise the students into small groups. Each group's task is to select a period of time in Earth's history, identify the position of 'Australia' in the world and research the conditions that Australia experienced as the continent drifted across the surface of the Earth at that time. Students are asked to go on a virtual 'fishing trip' and describe an animal they might have filmed if they went scuba diving, snorkelling or simply fishing at that time. Students then identify any problems that would have existed for their animal at the time, such as climate change, volcanic activity, predators and lack of food. As feedback to the class, allow students to select any medium such as a poster presentation, a 'TV News' item, PowerPoint display or a model/diorama to describe the animal they found and the conditions in which it lived.

http://www.pbs.org/wgbh/aso/tryit/tectonics/ Allow students some time to visit this site and watch each of the short animations about what happens at plate boundaries.

http://www.ucmp.berkeley.edu/geology/anim1.html has a simple animation that shows the drift of continents over time. Clicking on any time period will allow students to read about the conditions and animals that existed at the time. Whilst US-based, this site can be used in conjuction with http://www.lostkingdoms.com/ which covers Australia's lost kingdoms over time.

Senior Secondary

Web quest/Jigsaw activity: Discuss evidence that suggests crustal plates move over time.

This exercise is ideal for bringing together all the evidence for plate tectonics and continental drift.

Lesson 1: Students complete introductory activities that include:

(a) Familiarisation with the terms palaeontology, geophysics, geology, seismology and volcanology.
(b) Defining the terms 'plate tectonics' and 'theory of plate tectonics'. http://pubs.usgs.gov/publications/text/dynamic.html is a useful reference site.
(c) Viewing animations related to movement of continental plates. http://www.scotese.com/earth.htm contains a range of animations.
(d) Familiarisation with the process of a jigsaw activity. If the teacher or class is unfamiliar with this strategy http://www.jigsaw.org/steps.htm will explain the process used.

Students are then given an overview of the task and are placed into their HOME and EXPERT groups.

Lesson 2: Students work in their EXPERT group to access the sources and collect information on their particular area of research. Remind the students to use a geological glossary if they meet unfamiliar terms. http://geology.wr.usgs.gov/parks/misc/glossarya.html uses simple language.

Lesson 3: Students work in their EXPERT group to complete all allocated tasks. Teacher goes from group to group asking students to verbalise their understandings – so that they will be able to do this when they move to their HOME groups.

Lesson 4: Students work in their HOME groups to share information about the evidence that supports the Theory of Plate Tectonics. Teacher encourages students to orally identify, describe and explain how their evidence contributes to our understanding of Plate Tectonics.

Lesson 5: This is the lesson that brings this series of activities together and assesses the students' understanding of the evidence that supports Plate Tectonics. Students should be asked to try to answer the focus question individually (5–10 min), in home groups or as a class. Home group answers could be put on butcher's paper around the room, for students to move around and edit.

Web Quest Expert Groups

Expert Group 1: Evidence from the Geologists
Use the identified sources to complete the following tasks.

TASK 1: Ron Hackney is a PhD student in the Department of Geology and Geophysics at the University of Western Australia.

(a) Describe the role of a geologist and a geophysicist.
(b) Identify the qualifications that Ron has completed so far.
(c) Describe some of the research tasks that Ron has been involved with.

Source:

- Geologist/Geophysicist – an online interview with a geologist from Faces of Science, Uniserve Science http://science.uniserve.edu.au/faces/hackney/hackney.html

TASK 2: Geologists have made significant contributions to the Theory of Plate Tectonics.

For each of the sources below:
(a) Describe the evidence put forward.
(b) Plot relevant information on the map of Gondwana.
(c) Explain how this evidence supports the Theory of Plate Tectonics.

Sources:

- Continental Drift – Rock Sequences – from Volcano World http://volcano.und.nodak.edu/vwdocs/vwlessons/plate_tectonics/part4.html
- Continental Drift – Glaciation – from Volcano World http://volcano.und.nodak.edu/vwdocs/vwlessons/plate_tectonics/part5.html
- The Continent of Antarctica – Geology http://www.antarcticconnection.com/antarctic/science/geology.html

Expert Group 2: Evidence from the Geophysicists
Use the identified sources to complete the following tasks.

TASK 1: Amos Nur is a geophysicist working at Stanford University.

(a) Describe the role of a geophysicist
(b) Describe some of the research tasks that Amos has been involved in.
(c) Describe how geophysicists help archeologists.
(d) Describe Nur's collaboration with the Bar-Ilan University in Israel

Source:

- KiwiCareers – Geophysicist – from Career Service, NZ http://www.careers.co/nz/jobs/6a_phy/j26142a.htm
- Geotimes – Stories from the underground – Indiana Jones and the Dead Sea Scrolls http://www.geotimes.org/feb03/feature_stories.html
- Short biography of Amos Nur http://www.mssu.edu/seg-vm/bio_amos_nur.html

TASK 2: Geophysicists have made significant contributions to the Theory of Plate Tectonics.

For each of the sources below:
(a) Describe the evidence put forward.
(b) Explain how this evidence supports the Theory of Plate Tectonics.

Sources:

- Evolving Earth: Plate Tectonics – from University of Michigan Section on 'Ocean Floor' http://www.globalchange.umich.edu/globalchange1/current/lectures/evolving_earth/evolving_earth.html
- Developing the theory – from This Dynamic Earth, USGS http://pubs.usgs.gov/publications/text/developing.html
- In the news: Magnetic Reversal http://www.geomag.bgs.ac.uk/reversals.html
- Testing the Sea-Floor Spreading hypothesis http://volcano.und.nodak.edu/vwdocs/vwlessons/plate_tectonics/part9.html

Expert group 3: Evidence from the Palaeontologists
Use the identified sources to complete the following tasks.

TASK 1: Tom Rich is an Australian palaeontologist based in Victoria.

(a) Describe the role of a palaeontologist.
(b) Draw a timeline to indicate the major scientific events in Tom Rich's life.

Source:
- Luck and Persistence: a scientific career – career profile of a palaeontologist http://www.abc.net.au/science/slab/rich/story.htm

TASK 2: Palaeontologists have made significant contributions to the Theory of Plate Tectonics.

For each of the sources below:
(a) Describe the evidence put forward.
(b) Plot relevant information on the map of Gondwana.
(c) Explain how this evidence supports the Theory of Plate Tectonics.

Sources:
- Polar Dinosaurs in Australia? – from This Dynamic Earth, United States Geological Survey http://pubs.usgs.gov/publications/text/polar.html
- Lystrosaurus from Mt. Sirius – picture and brief text http://home.freeuk.com/gtlloyd/tam/palaeo.htm
- Reptiler – from Palaeontological Museum, University of Oslo http://www.toyen.uio.no/palmus/galleri/montre/english/162_883.htm
- Turning of the Fagus – about the Australian Beech from Scribbly Gum, Australian Broadcasting Corporation http://abc.net.au/science/scribblygum/April2000/default.htm
- Antarctic Garden – from Gardening Australia, ABC http://www.abc.net.au/gardening/stories/s131392.htm
- Introduction to the Glossopteridales – from University of Palaeontology, University of California, Berkeley http://www.ucmp.berkeley.edu/seedplants/pteridosperms/glossopterids
- Continental Drift – Fossils – from Volcano World http://volcano.und.nodak.edu/vwdocs/vwlessons/plate_tectonics/part3.html

Expert Group 4: Evidence from the Volcanologists and Seismologists
Use the identified sources to complete the following tasks.

TASK 1: Women and men in many different countries have been interviewed about their personal experiences in the field of volcanology.

(a) Describe some of the research tasks that these volcanologists have been involved in.
(b) Identify the qualifications that one of these volcanologists has completed
(c) Describe some of the precautions volcanologists take in their work.
(d) Describe what these volcanologists enjoy about their jobs.

Source:
- Interviews with Volcanologists http://volcano.und.edu/vwdocs/interview

TASK 2: Maya Tolstoy is a marine seismologist at the Lamont-Doherty Earth Observatory of Columbia University.

(a) What is a marine seismologist?
(b) Describe some of the research Maya has been involved in
(c) Describe the challenges Maya faces in her career (go to the hyperlink for 'interview' on the website listed below)

Source:
- Remarkable Careers in Oceanography — Maya Tolstoy http://www.womenoceanographers.org/ scroll down the right-hand-side index to click on Maya's story.

TASK 3: Volcanologists and seismologists have made significant contributions to the Theory of Plate Tectonics.

For each of the sources below:
(a) Describe the evidence put forward.
(b) Explain how this evidence supports the Theory of Plate Tectonics.

Sources:
- 'Ring of Fire', Plate Tectonics, Sea-Floor Spreading, Subduction Zones, 'Hot Spots' – from United States Geological Survey http://vulcan.wr.usgs.gov/Glossary/PlateTectonics/description_plate_tectonics.html
- Plate Tectonics, the Cause of Earthquakes — from Nevada Seismological Laboratory http://www.seismo.unr.edu/ftp/pub/louie/class/100/plate-tectonics.html
- Understanding plate motions — from United States Geological Survey http://pubs.usgs.gov/gip/dynamic/understanding.html

THE GEOLOGI SHORT FILM COMPETITION 2008

MAKE A FILM THAT ROCKS

geologi 08

All Australian secondary school students are invited to submit a short earth science film relating to one of three themes:

- Natural hazards
- Earth resources
- Deep earth

This competition will form part of Australia's Earth Science Week celebrations, assisting in raising awareness of the earth sciences in society.

The competition aligns with International Year of Planet Earth 2008 and is one of Australia's primary outreach programs contributing to this international initiative.

Registration closes on Tuesday 29 July 2008. All entries must be received by Friday 22 August 2008.

For your Geologi 08 Entry Pack or more information visit **www.ga.gov.au/about/event/geologi.jsp**

Geoscience Australia will host Geologi 08 as part of Earth Science Week 2008 celebrations being held from October 12 – 18.

Australian Government
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Make a film that rocks – visit **www.ga.gov.au/about/event/geologi.jsp** for more information

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Australian Government
Geoscience Australia

08-2786

Source: Geoscience Australia

CHAPTER 2

Earth's changing face

(The Geosphere and Lithosphere)

The surface of the Earth has an incredible diversity of landscapes, from rugged mountain ranges and rolling sand dune deserts to endless flat plains and coastal rock platforms. Volcanic activity, earthquakes, weathering and erosion are the main natural factors that change the surface of the Earth.

The landscape of early Earth was formed and shaped by tectonic forces that pushed and pulled at the molten crustal material as it cooled. Over the aeons, this tectonic activity has continued and still strongly influences the landscape today. A variety of landforms are created directly by volcanic and tectonic activity. For example, the shape of a volcanic mountain is determined by the relative amounts of ash and lava that are ejected from the volcano.

Image courtesy Matt Cole 2008

Ebor Falls, New England Ranges, NSW provide evidence of erosion by water

When continents collide, the layers of rocks at continental edges may experience folding. The 'waves' of rocks formed consist of alternating arched up warped folds and down warped folds. The mountains of eastern Australia are dominated by a number of such fold belts, the largest of which are the Lachlan and New England fold belts, that were formed over hundreds of millions of years by tectonic processes. The Lachlan Fold Belt covering much of NSW and Victoria is a 1,000km long and 700km wide belt of deformed marine sedimentary rocks, volcanic rocks and granites that are over 480 million years old.

However, brittle rocks near the Earth's surface may fracture when they are subjected to tectonic stress. If rock layers move on either side of a fracture (horizontally, vertically or obliquely) then the fracture is called a fault. The Great Rift Valley in Africa is one such example of a landform that was formed by faulting.

Over time, other surface processes interacted with and continue to interact with on-going tectonic activity and its products to produce geological formations that tell the story of Earth's changing face. Weathering, erosion and sedimentation are the main non-tectonic processes of change operating on the Earth's surface. These processes work on both short- and long-term time scales. For example, it took 300 million years of weathering to sculpt Uluru, whereas longshore drift can change the shape of beaches overnight.

The impact of interactions between atmospheric conditions, climate and tectonic activities are headlined regularly in the media for their catastrophic effects. For example, landslides commonly occur in connection with other major natural disasters such as earthquakes, volcanoes, wildfires, and floods.

DID YOU KNOW?

Mt Yasur in Vanuatu is one of the most active volcanoes in the world – it has erupted several times per hour for at least the last 800 years!

Yellowstone National Park in northwestern USA sits upon an enormous hotspot and is one of the world's largest super-volcanoes. It has erupted about 100 times in the last 16.5 million years. The last eruption 630,000 mya, left a crater 65km across and ejected ash over most of western USA plus parts of Canada and Mexico.

Yellowstone is due to erupt again and has the potential to be thousands of times more powerful than the Mount St Helens (USA) eruption of 1980 or the Krakatau (Indonesia) eruption of 1883.

Volcanoes

Volcanic eruptions provide graphic evidence that our planet is a dynamic structure with change occurring above and below its surface. Eruptions can cause rapid and sometimes catastrophic change. On any given day, there are about ten volcanoes worldwide that are actively erupting.

The Science

Volcanism is the process by which magma from the Earth's interior rises up through the crust, emerges onto the surface as lava and cools into hard volcanic rock. Volcanic eruptions occur when the pressure build-up is sufficient to push the magma to the surface. As the pressure is released, magma, lava, gases, ash and pieces of rock erupt from the volcano. A volcano is a hill or mountain that develops from the material erupted at the surface.

Approximately 80% of volcanoes are found at convergent boundaries, 15% at divergent boundaries, and the remaining 5% are located within plates and are attributable to 'hot spot' activity. Volcanoes are classified as active, dormant or extinct based on the frequency of eruption.

- Convergent zone volcanoes arise due to the melting of the lithosphere during subduction, which sends plumes of magma to the surface.
- Divergent zone volcanoes result from magma upwelling between the crack that forms between two plates that are pulling apart.
- Hot spot volcanoes arise from a jet of magma that rises from deep within the mantle and surfaces at a fixed point on the Earth's crust.

There are three indicators of an imminent volcanic eruption:

1. increased earthquakes in the area
2. increased ground deformation
3. changes in thermal activity – increased steam and volcanic gases, including carbon dioxide, sulfur dioxide, and hydrogen sulfide.

Volcanic activity has a significant impact on the Earth's surface and atmosphere. Erupted lava, ash and debris change the landscape. Soils derived from igneous rocks are usually high in plant nutrients and extremely fertile, and the gases released during eruptions, particularly CO_2, impact on atmospheric chemistry and climate.

Definitions

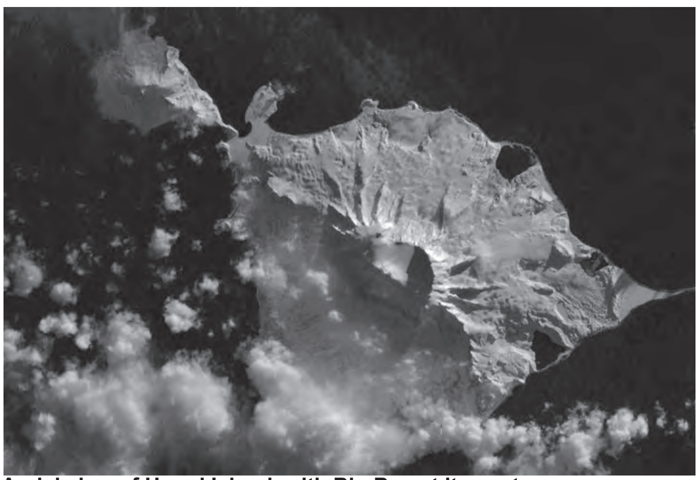
The **Lithosphere** is the relatively rigid crust and upper mantle of the Earth.
Magma is molten rock under the surface of the Earth.
Lava is molten rock extruding from a volcano.
An **extinct** volcano will never erupt again.
A volcano is considered **dormant** if it has not erupted for a long time but could again one day.
A volcano is **active** if it erupts lava, releases gas or shows seismic activity.
Seismic activity is characterised by vibrations that indicate activity within the Earth.
A **fault line** is a fracture in the Earth's crust along which a section of the crust has moved relative to another section, in response to forces of tension or compression as a result of tectonic movement.
Escarpment is a long steep slope at the edge of a plateau. An escarpment may indicate the presence of a fault line.

The Case Study

Although mainland Australia no longer has any spectacular active volcanoes, our east coast was once one of the most extensive volcanic regions in the world! Volcanism in Australia is attributable to intra-plate hot-spot activity, but unlike the Hawaiian, Society Islands and Yellowstone hot spots which produce a single chain of volcanoes, the hot spot beneath eastern Australia may come to the surface at any weak spot in the plate over a wider area.

Volcanic activity has occurred along the east coast for the last 60 million years, but all of Australia's mainland volcanoes are now considered extinct or dormant. The most recent eruption is thought to have been Mt Gambier in South Australia over 4,000 years ago.

There is only one remaining active volcano on Australian Territory, Big Ben, which is located on the sub-Antarctic Heard Island, more than 4,000 km south-west of Perth in the Southern Ocean.



Source: Wikipedia

Aerial view of Heard Island, with Big Ben at its centre.

Permanently covered in an icy glacier, Heard Island consists of two volcanic cones, Big Ben and Mt. Dixon, joined by a narrow isthmus. Big Ben is Australia's highest mountain, covering an area of 380 square kilometres (nearly the entire island) and rises to a height of 2,745 metres. Big Ben is located in the centre of the island and was last active in 2006. The middle of the 70m deep and 40m-50m wide crater still contains molten lava.

Isolated and remote, this wild, windswept island is home to dense populations of penguins, seals, and seabirds. In recognition of its abundant wildlife and vegetation, its intact ecosystems and unique geophysical attributes, Heard Island, together with the nearby McDonald Islands, was included on the World Heritage List in 1997. A Heard Island and McDonald Islands Marine Reserve was declared in October 2002.

Teaching Activities

Lower Primary

Model volcano – Using playdough

Recipe for cooked playdough in small quantities

2 cups water; 1 cup salt; 2 teaspoons tartaric acid; 2 cups plain flour; food colouring (optional); 1-2 tablespoons cooking oil.

Add the salt to water and bring to boil. Add the oil and colouring. Remove from heat and add the flour and tartaric acid. The mixture will go lumpy but allow it to cool then knead it until it is a smooth fine texture. Will keep for up to 3-4 weeks.

In the classroom:

- Decorate walls with images of volcanic mountains, volcanic plugs and crater lakes.
- Let the students help with kneading the cooled playdough.
- Ask the students to design, build and paint a model volcano or volcanic landform.
- An eruption can be simulated by filling the cavity at the top of the model with sodium bicarbonate (bicarb soda), and adding vinegar with red food colouring.

Follow-up:

- Discuss the differences between the simulated eruption and a real volcanic eruption.
- Discuss how the model could be adapted to simulate a 'pressure eruption' (burst a partially inflated balloon, wedged at the bottom of the 'crater' and then covered in sloppy, red jelly).
- Discuss why red colouring is used. This could lead into a discussion about observable changes in solid materials when heated – melting (butter, chocolate, ice), burning/combustion (paper, wood), colour changes at high temperatures in metals and rocks.
- Investigate the quantities of vinegar and bicarb soda needed to make an 'eruption' last for a specified time.

Primary

Watching a volcano erupt

Use audiovisual footage of actual volcanic eruptions as a tool to elicit language development. Find words to describe the movement of lava, sounds of explosions, colours of rocks, gas and lava erupting from the volcano and the feelings of people who may be affected by a volcanic eruption.

Use the exercise to guide and develop students' listening and note-taking skills during the AV presentation. Students can then use their notes to write a news report to accompany the footage. Alternatively, students could be encouraged to develop a narrative, placing themselves at the volcanic eruption and describing their experiences.

Discovering Pompeii

The following site has a 1.6Mb 11-page pdf file that includes letters by Pliny describing the explosion of Mt Vesuvius that buried Pompeii in 79AD. The resource includes ideas for classroom implementation, templates for a journal entry, and a map of Italy identifying Vesuvius and Pompeii. The US materials can be readily adapted for use in the Australian classroom.
http://vulcan.wr.usgs.gov/Outreach/Publications/GIP19/chapter_one_eruption.pdf

Follow up:

- Investigate the effects of heat energy on materials. http://www.eia.doe.gov/kids/energyfacts/sources/renewable/geothermal.html is a great site.
- Investigate the properties of different rocks.
  - o Preferably include pumice stone, with rocks from the school grounds for comparison.
  - o Compare colour, buoyancy, hardness, layering etc and link to formation and/or uses.
- Invite a 'minerals expert' into the classroom to speak with the students about gemstones/gold, fossils and/or resources, mining and energy.

Fact versus fiction

It may be interesting for older students to compare actual footage with fictional material in disaster movies such as 'Dante's Peak'.

Middle School

Living with volcanoes

As a Science Week project, students could develop a cartoon story with a volcanic explosion, where the characters address the following considerations.

Your character needs to:

- Explain how the early warning/monitoring devices/equipment work including the triangulation techniques.
- Outline any measures taken to prevent damage from volcanoes such as strengthening roofs to support the weight of ash deposits. http://volcanology.geol.ucsb.edu/hazards.htm
- Describe building protective structures, such as walls, to deflect lava flows away from places where people live. http://www.platetectonics.com/article.asp?a=15
- Discuss the impact poisonous gases released by the volcano may have on the quality of air and the effect on health of humans and other animals. Link with canaries in mines and how poisonous gases are a component of what is under the surface in various settings.
- Develop a disaster response plan in case a volcanic eruption occurs.

Whilst US-based, the following site has materials that may assist students in this task: http://vulcan.wr.usgs.gov/Outreach/Publications/GIP19/framework.html

Senior Secondary

Predicting volcanic activity

Technologies now exist to assist scientists in monitoring and predicting volcanic activity. Accurate prediction of imminent volcanic activity can save lives. Volcanic eruptions and gas emissions are hazardous to aircraft, as well as to people on the ground.

As a Science Week project, students could present examples of current technologies, the science behind them and explain how the data collected allows volcanologists to assess the volcano. Technologies can include laser range-finders and Global Positioning System (GPS) receivers to monitor ground deformation, seismic recordings, including radio-monitored seismic stations with real-time analysis of data using fast computers, satellite images using interferometry to highlight changes in elevation, tilt meters to detect any deformation and seismic tomography producing geological CT scans of the rock and magma deep below the surface.

Websites to assist:
http://www.ga.gov.au/urban/factsheets/risk_modelling.jsp for risk modelling
http://www.ga.gov.au/urban/factsheets/volcanoes_eruptions.jsp Prediction of volcanic activity: the challenge for geophysicists

Earthquakes

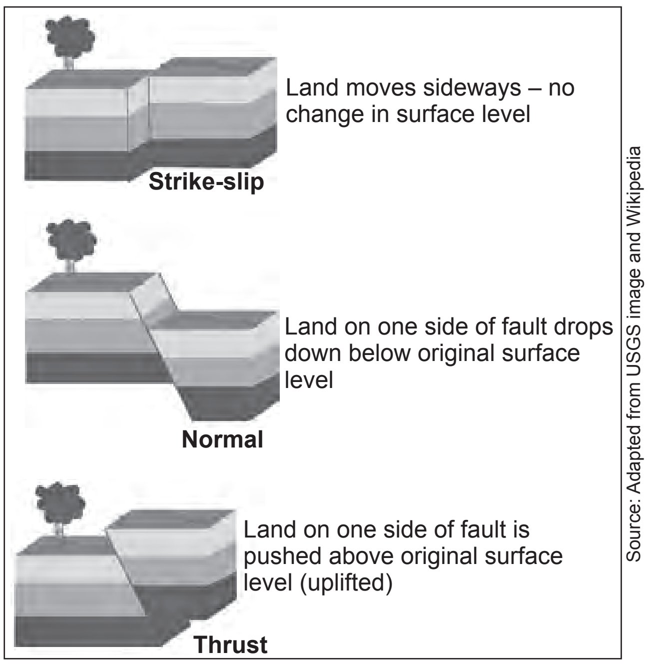
Although Australia is not located on a plate boundary, we still have earthquakes as a result of the stress that builds up from the Indian-Australian plate pushing northwards into the Pacific, Philippine and Eurasian plates. Adelaide has the highest earthquake hazard of any capital city in Australia, and is actually being slowly squeezed sideways by about 0.1mm/yr.

The Science

Fault lines

An earthquake is a shaking or vibration in the ground that occurs when rocks that are being deformed due to tectonic movement suddenly break along a fault line. The breakage results when two blocks of adjacent rock are pushed in opposite directions, and rather than sliding past each other smoothly, frictional forces lock them together causing the blocks to become deformed. Strain builds up over years and eventually the blocks will reach a point where frictional forces no longer hold them in place, and so the blocks suddenly slip. The blocks on either side of the fault may slip along their vertical axis (up or down), horizontal axis (sideways) or both. The fracture may range from centimetres to hundreds of kilometres long and several kilometres deep.

Many faults occur far from active plate boundaries but the largest effects are seen at plate edges. The movements at fault lines may be sudden, generating a severe earthquake. Commonly, however, movement is long term, cumulative, slow, and imperceptible, as in mountain masses that have risen by fault movement.



Fault Diagram

Measuring a quake

Earthquakes are measured in at least three ways:

1. Scientists use Global Positioning Systems (GPS) to monitor the movement of the Earth's crust, all over the world, between and during earthquakes. From these measurements, maps and models can be created to show how fast and in what direction the crust is moving due to both plate and fault movement.
2. At a local level, earthquake intensity can be described, in terms of degrees, by damage to the surface and the effects on humans eg. Mercali Scale of earthquake intensity.
3. The magnitude (size or extent) of the earthquake depends on wave amplitude and distance. One such magnitude scale is the Richter Scale. This magnitude scale is logarithmic, meaning each step in magnitude is exponentially greater than the last. For example, going from magnitude 6 to 7, the level of ground shaking goes up 10 times while the energy release goes up 32 times. The ground shaking at magnitude 8 is 100 times stronger than that of a magnitude 6 earthquake, and the energy release is 1,000 times stronger.

Earthquakes that occur on land can trigger avalanches, landslides or mudslides. An underwater earthquake may trigger a tsunami. Large earthquakes have the potential to devastate the human environment – the 9.3-magnitude earthquake that struck off the coast of Indonesia's Aceh Province on 26 December 2004 triggered a huge tsunami that devastated the Indonesian, Sri Lankan and Thai coastlines, killing hundreds of thousands of people.

The Case Study

Shaking up Oz

Whilst earthquake events in Australia may not be as numerous as those in other parts of the world, they do occur regularly and sometimes release immense amounts of energy. The Newcastle earthquake of 1989, with a magnitude of 5.6, resulted in the loss of thirteen lives and a damage bill estimated at A$4 billion.

Geologists are constantly monitoring earthquake activity across Australia, tracing the movement of known and active fault lines. For example, escarpments formed due to movements along faults dominate the landscape of the South Australian Mount Lofty Ranges. These fault scarps show evidence of young and continuing tectonic movement, identifying this as one of the most seismically-active regions of the Australian continent.

Some faults around Adelaide have moved slabs of the continent up to 30 metres in the last million years. Adelaide has the highest earthquake risk of any capital city in Australia, and is being slowly squeezed sideways by about 0.1mm/yr.

Other areas of intense mountain building have been around Victoria's Otway Ranges, Mornington Peninsula and the Strzeleckis. In some of these areas, uplift over the last 10 million years have thrust chunks of Australia upwards almost a kilometre. Tectonic movements have pushed the Otways 250 metres higher in the last three million years, and geologists believe that The Selwyn Fault has produced about six metres of uplift in the last 100,000 years.

Teaching Activities

Lower Primary

A jelly earthquake

http://www.fema.gov/kids/tastyeq.htm has a simple recipe and instructions for an investigation based on gelatine (or jelly) to model the way in which earthquake waves travel through the earth.

Primary

An earthquake at my place?

As a Science Week activity, students could be asked to:

- research the events that happen during an earthquake
- brainstorm the dangers that exist for humans during earthquakes. Consider answers to questions such as:
  - Do we stay inside or leave the building?
  - What is the safest room in a house if an earthquake hits?
  - What happens if the power lines come down? Do we have gas? What happens if the pipe breaks?
  - How can we protect ourselves in an earthquake?
  - How can we be earthquake ready?
- prepare a poster that gives advice on how to behave safely during an earthquake.

http://www.fema.gov/kids/quake.htm is a good place to start with internet research. This site has a wealth of information over a wide range of earthquake-related topics and is well worth a visit.

http://www.disastercenter.com/guide/earth.html is a good US-based site that deals with earthquake preparedness and the damage caused by earthquakes.

Middle School

Tracking earthquakes

For Science Week, students could focus on the theme 'The Restless Earth' by tracking/identifying current earthquake activity around the world. Allocate students to various continents, oceans and/or countries.

By compiling and sharing their data on a map of the world, the clustering of earthquakes around the edges of tectonic plates will quickly become apparent. Earthquakes clustered in other zones could then lead to discussion about the potential changes occurring in those regions.

http://www.ga.gov.au/bin/listQuakes is a good place to start as recent earthquakes are listed with details of their location, depth, latitude and longitude. This provides a useful entry point for learning about latitude and longitude.

Measuring earthquakes

Seismometers are instruments that measure and record motions of the ground, including earthquake waves. Simple seismometers and seismographs can be built from common materials. Students can be given the task of researching the structure of the instrument and constructing a working model.

Webquest about earthquakes

http://www.eduref.org/Virtual/Lessons/Science/Geology/GLG0035.html introduces a US-based webquest. All the activities are internet-based and the information includes a grading rubric for the final task. http://www.scde.k12.tn.us/chms/jaz/equakes.htm contains the activities and is the address where students should begin. The webquest is well designed but will require some prior knowledge of earthquake causes. At the time of writing, all links within the page were operational.

More ideas

The internet has plenty of ideas for activities on earthquakes. http://earthquake.usgs.gov/learning/kids/sciencefair.php is a good place to start with a list of earthquake related projects that would be suitable for a Science Week event.

What about running a 'design and make' competition to build a structure that withstands earthquakes? At the beginning of the week decide on the testing criteria for the structures and then have students design, make and test the structures by the end of the week.

Senior Secondary

Why is the depth of an earthquake recorded?

Read the suggested exercise for middle school students headed 'Tracking earthquakes'. This exercise could be expanded for senior students by requiring that the depth of each earthquake is also recorded. If this exercise is plotted on a large world map, the significance of depth can be identified. The deeper earthquakes occur in subduction zones where the ocean floor is diving under the continental crust. http://volcano.und.edu/vwdocs/vwlessons/plate_tectonics/part8.html begins a series of simple explanations of this process.

http://volcano.und.edu/vwdocs/vwlessons/plate_tectonics/part10.html explains the process further.

Earthquake resistant building standards

The Newcastle earthquake killed 13 people, injured another 160 and left a damage bill of over $4 billion. All this resulted from a few seconds of ground shaking. It has been stated that this damage could have been avoided with the application of earthquake engineering principles. See http://www.ga.gov.au/image_cache/GA10000.pdf for a full report. Ask students to research and summarise the impact of earthquakes on buildings, then design, construct and test a simple model building that might withstand the impact of an earthquake.

How many earthquakes does it take to make a mountain?

http://scign.jpl.nasa.gov/learn/eqact1.htm has a great exercise for senior students with some knowledge of faulting and Year 10 trigonometry. It is based on the Californian fault system but would be interesting for able senior students as it demonstrates a role of mathematics within the Earth Sciences.

Detecting earthquakes (or kids jumping on your desks)

Most physics departments have an electronic *Long Scale Galvanometer* (LSG) lying around and this activity provides an interesting use for it. Connect the LSG to an air-cored solenoid. Suspend a bar magnet on a spring and clamp the spring so that the magnet is just in the solenoid. Drop things onto the bench. What happens? Some questions for the students: What piece of scientific equipment have we made? Could we determine direction or just intensity from our equipment? How sensitive is the equipment? What else could we detect (for example, slamming doors, air movement)? *Warning: this experiment may cause some students to organise jumping competitions in the room to create quakes.*

Weathering and Erosion

The Earth has an incredible diversity of landscapes. In Australia we have mountain ranges, sand dune and gibber deserts, flat inland plains, coastal rock platforms, sandy beaches, floodplains and many more. Weathering, erosion and sedimentation are important agents of geological change operating on the Earth's surface, and are responsible for creating many of the unique geological features that we see today.

The Science

Shaping the Earth

Weathering is the process where rocks are broken down at the Earth's surface by physical or chemical means.

Chemical weathering results from chemical reactions between the minerals in rocks and air, water and living things, and predominates in humid environments where water is abundant and biological activity is high.

Physical weathering is the mechanical breakdown of rocks as a result of stress regimes imposed by environmental factors and predominates in dry conditions such as in arid or alpine environments. Some types of physical weathering include frost wedging, mineral crystallisation, thermal expansion and contraction, sandblasting, wetting and drying and organic activity (e.g. growth of a plant through a crack in the rock).

Erosion is the process where weathered materials are transported either downhill or downstream by means of wind, water, or ice, with the help of gravity.

Sedimentation is the process whereby transported materials are laid down as layers of sediment on the ocean floor or in low-lying areas on land. Weathering, erosion and sedimentation work in different combinations depending upon the topography, elevation and relief of the land.

Landscape types

Landscapes can be classified broadly as either *erosional* or *depositional* based on whether erosion or sedimentation is the dominant process. *Erosional* landscapes tend to be areas that are uphill, upstream or at high elevations, whereas *depositional* landscapes are usually the reverse of this. Features of erosional landscapes include mountains and hills, plateaus, river valleys, fjords, rock platforms, blowholes and stacks. Features of depositional landscapes include alluvial fans, submarine fans, deltas, floodplains, sedimentary basins, sand dunes, barrier islands, and pocket beaches.

The Case Study

Willandra Lakes

The Willandra Lakes system lies within the Murray Basin in southwestern NSW. It comprises 19 interconnected relict (remnants) lake basins, which vary in surface area from 600 to 35,000 hectares and cover a combined area of about 240,000 hectares.

The Willandra Lakes system is a depositional environment where streams transported sediment from the upper reaches of the catchment and deposited it in the lakes. The lakes were formed over a period of two million years and were fed by streams flowing from the Eastern Highlands to the Murray River. The lakes were full about 50,000 years ago, but, from about 30,000 years ago, the climate became increasingly arid and they began to dry. By 15,000 years ago they had completely dried up.

What is now left is a unique geological record of sediment deposition in the Willandra Lakes region over the last 50,000 years. The sediments comprise three main layers that were deposited at different stages of the lakes' history and provide a geological record of climatic change in the area.

The earliest bottom-layer sediments are more than 50,000 years old, and above this are the clays, sands and soils that were deposited when the lake was full. The top layer consists largely of wind-blown clay particles heaped up on the dunes during periods of fluctuating water levels, before the lakes finally dried up.

The Willandra Lakes area is also culturally significant due to archeological discoveries that testify to occupation of the region by Aboriginal people for at least the last 50,000 years. These include the largest known collection of Pleistocene human footprints in the world, various human-made artifacts and the 40,000-year-old remains of 'Mungo Man'. The 26,000-year-old cremated remains of 'Mungo Lady' found in the area place Lake Mungo as the oldest cremation site in the world.

The region was placed on the World Heritage List in 1981 in recognition of its outstanding natural and cultural values.

Willandra Lakes Region. Courtesy: Mark Mohell and the Department of the Environment and Heritage

Teaching Activities

Lower Primary

What happens when it rains?
Find colour pictures of rivers in flood – the water will be brown with sediment washed off the land. Where did the 'brown' come from? Students can see how this can happen. Get them to build small 'hills' of soil and gently pour water over their hill. What happens?

http://www.bright.net/~double/erode.htm Students may like to see this page where a child reports on his experiment with a dirt mound!

What happens when the rivers drop their soil into the ocean?
Give each group of students a transparent jar (glass) with a lid, some water and a small amount of garden soil. Let them add the soil to the water in the jar, screw the lid on and then give the mixture a good shake. Now they should let the container stand for as long as possible. Students will be able to see the larger bits of rock fall quickly and the rest of the sediments fall in layers.

http://www.uq.edu.au/ School Science Lessons/year2.html#2.38 has some similar lessons described for Year 2 students in more detail.

Primary

Weathering rocks – beware a noisy lesson!
Gather some rocks that break easily – each group of students will need 5 or 6 pieces of rock. Each group will also need a large plastic container with a tight-fitting lid.

Ask the students to feel the rocks and describe their shapes. They then place the rocks in the tin, put the lid on tightly and shake! Take the lid off! What has happened? This can lead to a discussion about what happens to rocks caught in fast-flowing rivers and streams. What happens to rocks hit by waves? Where do all the 'bits' end up?

http://www.uq.edu.au/ School Science Lessons/year4.html#4.32 has further ideas for weathering rocks and making rocks.

http://qldscienceteachers.tripod.com/junior/expt/geology erosion.html if you have access to a freezer, this page details an investigation to demonstrate the effect of ice on rock. It also has a simple investigation to demonstrate the effect of acid on rock.

Middle School

Changing landmarks – Any chance of change in your district?
The Twelve Apostles, off the Victorian coast, have become the Eleven Apostles! This famous feature formed over time from the weathering of rock along the coastline by wave action. Parts of the strata were more resistant to weathering, and stacks came to form as a result. Continuous wave action proved too much for one of the 'apostles' however, which collapsed in 2005.

'Famous Landmark Gone in 60 Seconds' (*The Australian* 4 July 2005) www.news.com.au/story/0,10117,15811265-2,00.html describes the event. Use this story as an introduction to the processes of erosion by waves. Students living in coastal regions could search for similar possible events in their region.

Students may be able to track the impacts of weathering and erosion on local landmarks by visiting the local historical society museum. Old photographs are a great way to identify changes in landscapes. Ask students to check out the background when group photos were taken!

http://qldscienceteachers.tripod.com/junior/expt/geology erosion.html has a simple practical exercise to demonstrate the weathering effect of acid on rock. This could be expanded into a longer investigation into the origins of 'acid' in nature and research from secondary sources into the impacts of acid rain on old monuments and heritage buildings in Europe.

Senior Secondary

Weathering the cemetery
To do this exercise effectively, students will need to have a fundamental grasp of the differences between igneous, sedimentary and metamorphic rocks. The exercise will be more successful if they are able to recognise the most common rocks used for tombstones, such as sandstone, limestone, marble and granite.

Tombstones are ideal for studying weathering rates as they are constructed from rock and are dated. Organise the students into groups and ask them to find tombstones of varying ages. Get them to consider the following questions.

1. What type(s) of rocks are used for tombstones? Suggest reasons for these choices.
2. Describe the evidence for weathering on the tombstones Are there any differences in:
   a. The speed of weathering of the tombstones?
   b. The types of changes observed in the various rocks used?
3. Is there any evidence that the location of the tombstone influences the rate of weathering? For example, do tombstones facing north seem to weather faster than tombstones facing south?
4. Is there evidence of weathering caused by living things such as lichen? If there are areas of the cemetery where the grass is longer, is there any evidence of weathering caused by long grass?
5. Does the oldest part of the cemetery have the most weathered tombstones?

Sedimentation impacts
http://vulcan.wr.usgs.gov/Glossary/Sediment/framework.html has a comprehensive list of hyperlinks relating to the problems of unusual sediment in rivers surrounding Mt St Helen's after the eruption. A search of this site could be used as the introduction to a discussion about the impact of unusual geological events on biodiversity and ecosystems.

The life cycle of a mountain
http://www.math.montana.edu/~nmp/materials/ess/mountain environments/intermediate/cycle int.html This page is called 'immediate on-line lessons' and is designed to move students through the life-cycle of mountain ranges. The lessons make the assumption that students have learned about plate tectonics and know where the mountains came from.

Safety: Appropriate risk assessment is required for some of the activities on this page as some have serious safety issues.

Advertorial

Australian Government

Australian Fisheries Management Authority

The Australian Fisheries Management Authority (AFMA) is the Government department responsible for the management of Australian fisheries. It is AFMA's job to make sure that the oceans around Australia are not over-fished so that the fishing industry has fish to catch and the public has fish to eat.

AFMA also plays a role in reducing by-catch and regulating the fishing industry.

What is a fishery?

A fishery is an area of the ocean which has been identified as being a good spot to find certain types of fish. Australia is surrounded by 21 different fisheries. The rules for fishers are made as consistent as possible, but some rules apply only to individual fisheries.

The rules (or 'regulations') depend on the type of fish species in the fishery and the type of equipment and methods people use for catching fish.

What is over-fishing?

Over fishing is where lots of people try to catch a large amount of the same type of fish it can lead to over-fishing. To stop this from happening, AFMA limits how much of that type of fish is allowed to be caught. The amount you are allowed to catch is called your 'quota'.

Fishers can buy quota which then allows them to catch a certain amount of fish. If they catch more than they are allowed, they may receive a fine or they may be convicted in court.

What is by-catch?

By-catch is where 'non-target' species are taken while fishing, many of which are not intentionally caught, including endangered species. Animals that are accidentally caught are returned to the sea and fishermen generally do everything they can to save the lives of the animals if they can.

In AFMA-managed fisheries ALL interactions with endangered species during commercial fishing operations MUST be reported to AFMA.

Through its management of Australia's fisheries, AFMA helps to build a sustainable ocean ecosystem. This will allow the oceans around Australia to be more resistant to other changes.

AFMA

Source: Fanny Schertzer

CHAPTER 3

Earth's blankets

(The Atmosphere and Hydrosphere)

An insulative blanket wraps around planet Earth. This blanket of air and water flows, shifts and changes as it moves around the Earth and is an obvious indicator of planet Earth as a planet of change. The gaseous atmosphere and the liquid hydrosphere have an enormous impact on the Earth's changing surface and the living things that inhabit the Earth.

The Earth's atmosphere was initially generated by volcanic outgassing (the release of gases tothe atmosphere from hot, molten rock during volcanic activity) from the mantle a little over 4,000 million years ago. The gases that comprised the early atmosphere and were released by volcanoes in the past are presumed to be the same as those released today. The early atmospheric gases would have included predominantly water vapour and carbon dioxide, with lesser amounts of nitrogen and gases of sulphur. Volcanic gases contain little oxygen in its molecular forms, O^2 (normal diatomic oxygen) or O^3 (ozone), uncombined with other elements so the early atmosphere is believed to have had low concentrations of oxygen.

Earth is the only planet in the Solar System with a hydrosphere. This is a relatively thin film of water on the surface of the solid Earth with some extensions into the atmosphere and the lithosphere (rock layers).

As the Earth's layered structure formed when the molten denser minerals moved to the central core, the less dense minerals containing water remained near the surface. The hydrosphere then developed from outgassing during volcanic activity. As the Earth's surface cooled, there would have been constant torrential rains that began the process of weathering and erosion. Eventually the Earth's surface cooled sufficiently for this water to condense and settle into lower areas of the crust to form the oceans. By 3,800 million years ago, an atmosphere and a hydrosphere had formed, and the same surface chemical processes that caused weathering then, still exist today.

More than 97% of the Earth's total water is salty and fills the oceans. Where is the other 3%? Rivers and lakes account for about 0.02%, ice caps and glaciers store about 2.2% and the rocks of the lithosphere contain about 0.6% in small cracks and pore spaces. The atmosphere holds about 0.0001% either as vapour or in clouds.

The salts in the oceans come from both the weathering of surface rocks, with the weathered products carried by rivers to the oceans and from hot, ocean floor eruptions which release salts into the water above.

The oceans are more salty now than in the past due to these processes and due to the evaporation of freshwater into clouds. This evaporation concentrates the salts even more.

The early atmosphere and hydrosphere contained little free oxygen because most of it was combined with other elements. It appears that oxygen began to enter the atmosphere with the evolution of photosynthesis about 3.5 billion years ago. Evidence for this exists in the form of fossilized bacteria in rocks in Canada, stromatolites (a product of photosynthesis by cyanobacteria) in Western Australia (see page 38), and abundant oxidised banded iron formations in Precambrian sediments. Oxygen levels must have continued to rise throughout history, as evidenced by the appearance of large, active terrestrial organisms that need high concentrations of oxygen. The present-day atmosphere is composed of mainly nitrogen (78.1%), oxygen (20.9%) and argon (0.93%). Carbon dioxide has a concentration of only 0.03%.

The current debate over increasing carbon dioxide (CO_2) levels is taking place in the context of uncertainty over historical levels of CO_2. There is evidence for wide fluctuations in CO_2 over geological time.

DID YOU KNOW?

The Earth is a dynamic but closed system. A change in any one part of the system will affect other parts of the system. There is no loss or gain of matter from Earth, this matter is moved around. As well as the very long slow geologic cycles involved in plate tectonics, there are three main cycles: the rock cycle, the water cycle, and the atmospheric cycle which take place more quickly. Additionally, there are cycles such as those in the atmospheric and ocean currents, which can greatly affect the weather. The oceans and the atmosphere are two tightly coupled components of the global climate system – the exchange of water vapour and heat between the oceans and the atmosphere leads to condensation, cloud formation, precipitation, as well as energy transfer that drives the weather systems.

Oceans

Approximately 95.96% (or 1.40 billion km^3) of the water on the Earth's surface is found in the oceans. For much of human history (at least the last 100,000 years), oceans have covered about 71% of the surface of the Earth. Only one quarter of the world is dry land! The world's oceans are currently divided into five major oceans; the Atlantic, Pacific, Indian, Arctic and Southern. The oceans provide a diversity of habitat types for marine organisms, and play a major role in the regulation of climate.

The Science

Convection currents

The world's large-scale ocean currents are driven by two major forces; global wind patterns and thermohaline circulation.

In general, westerly winds in the mid-latitudes and easterly winds in the tropics drive large, closed-circulation patterns in the major ocean basins.

Ocean currents play a significant role in the regulation of regional climates. One example of this is the Gulf Stream, a limb of the Atlantic Ocean gyre, which delivers equatorial heat to the North Atlantic, warming the region by as much as 5°C and significantly tempering average winter temperatures. The Eastern Australian Current operates in a similar manner, flowing southwards from the Coral Sea.

Chemistry

Seawater can be thought of as a soup that contains most elements and compounds on Earth. These come from rivers, fallout from the atmosphere, coastal erosion and deep-sea hydrothermal vents. Biological processes may affect or conversely, be controlled by, the levels of chemicals in ocean water.

Salinity, dissolved oxygen and nutrient levels affect the distribution and abundance of marine ecosystems.

- Salinity is the measure of the total amount of dissolved salts present in the ocean and can vary from place to place.
- Dissolved oxygen is important for respiration by marine organisms, and is affected by factors such as temperature (colder water can hold more oxygen), respiration rates, production by photosynthetic plants and bacteria, oxidation of detritus, other biochemical reactions, and upwelling and downwelling.
- The availability of nutrients, particularly nitrogen, phosphorus and silicon, can determine the extent of phytoplankton growth in oceans.

Biodiversity

The marine environment is complex, dynamic and variable, boasting a diversity of habitat types, and supporting a variety of organisms from the simple (algae) to the elaborate (whales). The diversity of living things tends to be greatest on the shelves at edges of continents because of nutrient runoff from the land and high light availability in shallow waters. Coastal marine environments include beaches, intertidal rocky shores and flats, estuaries and coastal lagoons, mangroves and salt marshes, coral reefs, seagrass meadows and kelp forests. Ecosystems in the open ocean and deep sea tend to be much more specialised due to lower levels of plant growth.

The Case Study

Australian Fisheries

Australia is an island nation with almost 60,000km of coastline and the third largest fishing zone in the world, but surprisingly we are not a major fishing nation and our annual production is only 0.2% of the world total. The main reason for this is low biological productivity of our coastal waters. Australia lacks the major upwellings of other southern continents, which result in high nutrient levels and rich fishery production.

Australian marine environments contain some 3,000 species of fish and an equal number of crustacean and mollusc species; 10% of these are harvested commercially. Fishery biologists must have a good understanding of the biology and population dynamics of the fish stock to provide advice to fishery managers that enables sustainable resource use.

The Orange Roughy provides a good example of the need to manage fisheries sustainably. The fishery was discovered in the early 1990s and initial catches were extremely high. What fishery managers did not realise at the time was that the species was very long-lived (maximum age is up to 150 years!) and slow to mature and reproduce (sexual maturity is only reached after 20–30 years). The fish were being harvested at a much faster rate than they could reproduce, reducing some schools to less than 10% of their original size.

The Orange Roughy is now managed under a conservation program.

Definitions

Global wind patterns: The Equator receives the Sun's rays most directly. Here, air is heated and rises, leaving low pressure areas behind. Moving to about thirty degrees north (eg. Shanghai, China) and south of the equator (eg. Grafton, NSW), the warm air from the equator begins to cool and sink. Between thirty degrees latitude and the equator, most of the cooling, sinking air moves back to the equator, while the rest flows towards the poles.

Gyre refers to any large swirling vortex. It is used to describe the large, closed-circulation patterns in wind and ocean currents. Gyres circulate anticlockwise in the southern hemisphere and clockwise in the northern hemisphere.

Thermohaline circulation: The global density-driven circulation of the oceans. The term is derived from *thermo-* for heat and *-haline* for salt, which together determine the density of sea water. Hotter water can hold more dissolved salt but cooler water is more dense. Water heated near the Equator travels on the surface of the ocean into cold high latitudes where it becomes cooler. As it cools, it becomes denser and sinks. More warm surface water flows in to take its place, cools, sinks, and the pattern continues. In contrast to wind-driven currents, the thermohaline circulation is not confined to surface waters but is a churning of the world's oceans, from top to bottom.

Phytoplankton: Microscopic plants at the base of the aquatic food chain, providing an essential resource for all aquatic life.

Teaching Activities

Lower Primary

Life in the oceans
Use a large map of the world to show the locations of the oceans, with coloured stickers to identify areas where oceans are warm and cold.

Create collages or mobiles of the plants and animals of warm and cold oceans.

http://www.enchantedlearning.com/coloring/oceanlife.shtml has a series of images that will be useful for this activity. Closer to home, http://www.classroom.antarctica.gov.au has some excellent information resources.

Primary

Modelling heat transfer and convection currents
You will need:

Transparent plastic tray
Four polystyrene cups
Cold water
Container of hot water
Food colouring

1. Turn the four polystyrene cups upside down and rest the tray on them. Make sure there is room to slide the container of hot water under the tray.
2. Pour the cold water into the tray and let it stand until it stops moving.
3. Add a couple of drops of food colouring to the centre of the tray of water. If you use a straw, you can get the food colouring to rest on the bottom.
4. Slide in the container of hot water.

The food colouring should show the path of the water in the tray as it heats up and moves around. The increase in temperature in the middle of the tray could also be measured with a thermometer.

Save the Orange Roughy
Run a 'Save the Orange Roughy' campaign. Research aspects of the Orange Roughy such as its anatomy, life cycle, habitat and place in the food chain in its natural ecosystem. Students explain why the Orange Roughy needs protecting.

Middle School

Estimating the percentage of the Earth covered by ocean
Toss an inflatable world globe around the room. As students catch it, record and tally if their right index finger landed on water or land. Calculate the percentage of the total for water after 'x' throws, or 'x' minutes and use this to estimate the percentage of Earth's surface covered by ocean. This exercise can be linked to reliability in investigations, as the more throws measured, the more reliable the data is likely to be.

Save the Orange Roughy – see Primary activity
This activity could be extended for older students by including the following features in the campaign:

- factual information on the decline in population,
- causes for the decline in population.
- research on statistics if available
- use of appropriate graphs to support the classification of the Orange Roughy as a threatened species.

Based on graphs, ask students to predict the amount of time left before the fish becomes extinct, unless practices change.

Research the food webs that the Orange Roughy is a part.

Complete a consequence chart for the over-fishing of the Orange Roughy and one for its conservation.

Modelling the water cycle and ocean currents
Use the following solar still activity to model the water cycle. Note that it is really important that the water in the solar still is salty.

http://www.solaqua.com/solstilbas.html

https://www.streamwatch.org.au/streamwatch/resources/file/eb8f8943f355899/2135%20StreamsAlive@150dpi.pdf (go to page 31)

For a more detailed set of observations and activities related to convection currents in the ocean go to http://www.ridge2000.org/seas/downloads/curriculum/seas_unit3_activity3.pdf

Senior Secondary

The chemistry of water
Use data loggers to investigate dissolved oxygen in warm and cold water.

Test the effect of various concentrations of fertiliser on algal growth. This investigation can be linked to run-off of nutrients into the ocean.

To consider the impacts of acidic chemicals on plant growth, see http://www.powernaturally.org/programs/pdfs_docs/20_Acid_Rain.doc

A 16-page booklet of information about investigations on algae is available at http://sbcdata.lternet.edu/external/Outreach/AB_virtualtour/SBCLTER_AB_virtualTour_Algae_Experiments.pdf

Investigate changes in dissolved oxygen levels as plants photosynthesise and respire. Place a water plant such as *Elodea sp.* in a test tube with water, add a couple of drops of bromothymol blue and invert it into a large beaker of water. Leave to stand in a well-lit spot. Changing oxygen concentrations will be demonstrated by the change in colour of the indicator. Oxygen will also collect as a gas at the top of the test tube.

DID YOU KNOW?

When scientists first started capturing Anglerfish (a deep ocean species) they noticed all the specimens were female and were baffled by the absence of males. They also noticed that all the specimens had 'parasites' attached to them, which they later realised were the male of the species! The male is significantly smaller than the female and has evolved into a permanent parasite to overcome the problem of finding a mate in the vast abyss of the deep sea. The young male latches onto the female with its sharp teeth and over time physically fuses with her – their skin and bloodstreams become connected and the male loses its eyes and all its internal organs except for the testes. The male effectively becomes a sperm-sac on the female – the ultimate mascot for feminism!

Source: http://arthursclipart.tripod.com/marine.htm

Freshwater

Freshwater is the term used to describe those bodies of water in the world that contain low concentrations of dissolved salts. Of the 1.46 billion km^3 of water on the planet only 4.04% is fresh! It is found in glaciers and polar ice (2.97%), groundwater (1.05%), lakes and rivers (0.009%), and in the biosphere (1×10^{-4} %). If all the water on Earth was in a 600ml water bottle, only 24ml (a mouthful) would be fresh, with just 0.05ml (a quarter of a drop) being available to humans for drinking!

The Science

A scarce resource

Freshwater is our most precious resource. Although the human biological requirement for water is only about one litre per day, we use closer to about 50 litres per day per person when cooking, washing, agriculture and industrial use is taken into account. Humans are not the only ones that rely on it – many other species also need it for drinking, reproduction or to live in!

Our terrestrial ecosystems are all dependent on reliable supplies of clean freshwater in liquid form but the freshwater component of the hydrosphere is dynamic and changeable. Lakes can freeze over in winter, glaciers and icecaps shrink and expand with the seasons, and droughts can reduce groundwater flows.

Over longer timescales, global glacial cycles can impact significantly on the nature of freshwater resources by affecting the amount of water locked in ice caps.

Australia is the second driest continent in the world. All of Australia, barring the north and east coasts and the south western corner, is classified as arid or semi-arid. This means that the annual rainfall is less than 500 mm.

Water chemistry

The chemicals dissolved in freshwater vary significantly. Igneous rocks generally weather to release a broader range of minerals than sedimentary rocks. As a consequence, freshwater bodies near igneous rocks will be richer in dissolved minerals. Freshwater bodies may collect run-off from the ecosystem habitats and contain minerals from the decomposition of organic materials including excreta. In addition, the frequency and quantity of rainfall will determine the concentration of minerals in bodies of still water when high evaporation rates are likely.

Effects of changing water supplies

As Australia experiences extreme cycles of climatic change, living things that rely on freshwater supplies need to survive dramatic changes in water quality and quantity.

Australia's low rainfall and high evaporation result in the lowest river discharge rate in the world. Australian rivers tend to be small, relatively shallow, and slow-moving, making them vulnerable to algal blooms.

In arid and semi-arid ecosystems, plant growth is controlled by how much water is available rather than by sunlight or nutrient availability. Rainfall is erratic and water availability to plants and animals is therefore highly unpredictable, creating what is known as an ephemeral environment. Species living in these ecosystems must have adaptations that either allow them to reproduce rapidly when water becomes available (e.g. desert wildflowers) or withstand long periods without water (e.g. the deep-rooted, groundwater-reliant River Red Gum – *Eucalyptus camaldulensis*). Some animal species can avoid drought altogether by migrating.

The Case Study

Lake Pinaroo

Lake Pinaroo is an 800 ha wetland system located in Sturt National Park in the far north-west corner of NSW, about 24km south east of Cameron Corner. It has been listed as a RAMSAR site (Wetland of International Importance) since 1996 in recognition of its outstanding ecological values.

The lake is the largest terminal basin found in far north-western NSW, and when full it supports a huge number and diversity of waterbirds, including migratory and threatened species. Lake Pinaroo is located in an arid climate zone, receiving on average only 229mm of rain each year and only filling when the adjacent Frome Swamp overflows during intense local rainfall events. The water depth in the lake can vary from 0-2m and once the lake fills it can take up to six years to dry out.

Over the last 30 years, Lake Pinaroo has filled and dried out three times. Floods filled the lake between 1974-81 and 1984-90, and more recently in 2000-02. It has remained dry since 2002. This system exemplifies the ephemeral nature of outback Australian freshwater resources – during dry periods the area may appear devoid of life and even unrecognisable as a wetland, but after heavy rains it becomes a critical habitat for hundreds of species.

Definitions

The **discharge rate of a river** is the volume of water transported by it in a certain amount of time – usually measured in cubic metres per second (m^3/s).

Algae is a general term for plants that grow in water; it includes both single celled and multi-celled water plants.

Algal bloom is a sudden increase in numbers of algae in a waterway. Algal blooms occur when there are excessive amounts of nutrients entering waterways as run-off from the land. They can affect water quality adversely and some algae may cause harmful changes to local water chemistry. The algae themselves can also be toxic to livestock if ingested.

An **ephemeral environment** has transitory episodes of activity with each episode lasting a short time. An ephemeral ecosystem is characterised by living things that have short life cycles of a few days or weeks, are migratory or can survive long periods without water.

A **species** is a basic unit of biological classification. It can be described as a group of related organisms having common characteristics and capable of interbreeding to produce live offspring.

A **terminal basin** is a basin that receives drainage or overflow from a river or swamp. Terminal basins form important wetlands for waterbird breeding and habitat.

Teaching Activities

Lower Primary

Plants and animals of freshwater
Draw up a poster that models a body of freshwater such as a dam, creek or river. Use cut-out pictures of freshwater plants and animals and get the students to glue the pictures where the animals would be found.

http://www.amonline.net.au/wild_kids/freshwater/index.htm is an easy place to start.

Primary

Freshwater project
Have your students prepare a presentation about a freshwater body (e.g. creek, lake or a wetland) near their home or school. The presentation may be in the form of a drawing, story, poster, play, or model. Ask them to answer such questions as:

- Where does the water come from? (Introduce the term 'catchment' to describe the area that 'catches' the water for it to run into the water body.)
- Are there potential sources of pollution in the catchment?
- Where does the water end up?
- Is it a kind of 'terminal basin' or does it feed into a creek, river or dam?
- Does the water look clean? Would you drink it?'

Encourage the students to consider the water body as a habitat for living things. Some lead questions could include:

- How many different water habitats does the water body provide? In the water? On the banks?
- What species live there?'

http://www.uq.edu.au/_School_Science_Lessons/year5.html#5.41 has some good questions to promote student appreciation of the need to keep waterways clean.

Middle School

Animal adaptations to freshwater availability in Australia
Have students conduct a research project on a native arid or semi-arid native species and its adaptations for survival.

http://www.amonline.net.au/wild_kids/arid_zone.cfm is an easy place to start. The site shows sites within the arid zone and their inhabitants.

Draw a freshwater catchment
Ask students to create a poster of a freshwater catchment system. They will need to identify what type of catchment it is (e.g. dry inland, coastal, tropical wetland), the components of the catchment from its upper to lower reaches, the links between different components of the catchment (e.g. groundwater, recharging streams), the different types of land uses within the catchment (e.g. farming, residential, forestry), any disturbances to the water regime and their impact.

Streamwatch
Streamwatch is a NSW-based school and community education and action program that raises awareness of the natural environment through testing water quality in local rivers and streams. For more information, contact Streamwatch at streamteam@sydneywater.com.au.

Senior Secondary

Ask your students to do a media search on the incidents below, or similar ones across Australia. Having collected the evidence for both sides of the argument, ask them to debate the statement 'If land owners volunteer land to be included in a RAMSAR site, they have the right to change their minds and use the land for agriculture'.

From http://www.abc.net.au/lateline/content/2007/s1929254.htm 'In what could be one of Australia's worst cases of illegal land clearing, a huge stretch of the Gwydir wetlands in north-western NSW has been flattened. It's a vital habitat for native water birds and has been bulldozed into the ground. Environmentalists fear it will take decades for the wetlands to recover…. a local farmer has bulldozed up to 750 hectares of the surrounding vegetation.'

And from http://www.environment.nsw.gov.au/wetlands/GwydirWetlandsGinghamAndLowerGwydirBigLeatherWatercourses.htm 'The Gwydir wetlands are around 60 km west of Moree in the north west of NSW. Four wetlands make up the RAMSAR site. They are all in the larger Gwydir wetland system. The RAMSAR site is a mixture of freehold and perpetual leasehold lands, managed by private landholders. This is the first time that landholders have voluntarily nominated their private wetlands as RAMSAR sites. The wetlands cover 823 hectares.'

Rising water table
Salt is a natural part of the environment, found in rocks and groundwater. Salt becomes a problem when excessive amounts are drawn up into the soil profile or flushed into river systems. Groundwater levels can rise as land is cleared and irrigated. As groundwater moves up through the soils the water evaporates into the air leaving salt behind. Most plants will die if there is too much salt in the soil and the land may become barren and infertile.

This activity demonstrates how salt moves up through the soil profile to the surface. Materials: small tray (or bowl), warm water, teaspoon, table salt, nail (about 3mm diameter), plastic cups and various soil types (e.g. sand, silt and clay).

Pour water into a tray to a depth of 1cm, add half a teaspoon of salt and stir to dissolve. Continue adding salt until no more will dissolve. Using the nail, make a small hole in the bottom of a plastic cup. Add one type of soil to the cup to a height of about 4cm. Stand the cup in the tray of salt water. Check the cup each day until all the water has been drawn up and evaporated. This could take a couple of weeks. Repeat steps 3 to 6 for the other soil types. What is happening?

Over time the salt water will be drawn up through the soil surface due to capillary action. Once the water reaches the surface of the soil it evaporates, leaving behind salt crystals.

http://www.csiro.au/resources/ps201.html has information about salinity and links to further investigations.

Water wars?
Discuss the threat of 'water wars' in the future. Where are they likely to occur? Which countries are rich or poor in terms of their water resources? Are water wars already happening? The following article could get students thinking:

US and Global Water Wars Loom (www.livescience.com/environment/070417_ap_gw_water.html).

Global Climate

Physical features of the Southern Hemisphere predominantly determine Australia's climate. However, the circulation of global ocean currents with some intermixing of Northern and Southern Hemisphere atmospheric circulations can impact on the Australian climate and cause changes. For this reason, it is worthwhile investigating the broader picture of global climate.

The Science

The climate system

Global climate is defined by long-term variations in weather across the world. The climatic system is interactive and consists of five major components; the atmosphere, hydrosphere, cryosphere, land surface and biosphere. It is influenced by external forcing mechanisms, the most important of which is the Sun.

The Sun

According to evidence and theories, three main changes in the Sun's luminous output influence the energy received by Earth. They are fluctuations in energy output over time, increases in energy output as the Sun ages, its core becomes denser (by 10-20% every billion years), and it increases in radius, and the 11-year (approx) sunspot cycle caused by changes in the Sun's magnetism.

The Earth orbits around the Sun and its distance from the Sun varies with gravitational effects. At the same time, the Earth is spinning on its axis, with 'wobbles' in its spin. These variations affect the intensity of radiation at different latitudes.

Seasonal changes

As the Earth's axis is tilted, the angle at which the Sun's rays hit the Earth varies throughout the year. The Sun is higher in summer when the Earth's axis points towards the Sun and more energy hits each square centimetre of the ground. The days are also longer so the Sun has more time to heat the Earth. The Sun is lower in winter when the Earth's axis points away from the Sun, the energy is diffused, the days are shorter and less heat can be absorbed.

Measuring variations in solar output

One of the most sensitive methods of measuring past solar energy output is the amount of the minor isotope carbon-14 (^{14}C) in tree rings. The link is that when the Sun's magnetic activity is lower, its power output is reduced and the solar winds are weaker. This increases the flow rate of cosmic rays into the Earth's atmosphere. High energy cosmic ray particles can convert carbon-12 (^{12}C) to carbon-14 (^{14}C).

One tree ring is laid down in a tree's trunk each year. The relative amounts of ^{12}C and ^{14}C in tree rings are used as historic measures of the annual absolute average energy output of the Sun. This method can be used to measure changes in solar power of as little as 0.1%. Similar measurements can be done of the oxygen-16/oxygen-18 ($^{16}O/^{18}O$) ratio in the carbonate salts of sea shells.

The atmosphere

The atmosphere is the most unstable and rapidly changing part of the climatic system, and its chemical composition is of vital importance. A number of trace gases present in the atmosphere, such as carbon dioxide, methane, nitrous oxide, and ozone, are major controllers of climate due to their ability to absorb and emit infrared radiation, potentially raising the temperature near the Earth's surface. They are known as 'greenhouse gases' for this reason.

There is concern that the recent increases in atmospheric carbon dioxide (CO_2) due to human activities will enhance the greenhouse effect, and trigger global climate change, with potentially disastrous consequences for humans. Prior to the burning of fossil fuels by humans, volcanoes and wildfires were the primary source of greenhouse gases.

Global climate history

Global climate has fluctuated greatly in the past and it is thought that this is strongly related to CO_2 levels in the atmosphere. Evidence of past climate change comes from the geological record, fossilised plants and pollen, ice cores and tree rings. Evidence suggests that the Earth has gone through numerous glacial-interglacial cycles (at least eight in the last 1 million years), has twice been completely covered in ice (periods referred to as 'Snowball Earth'), and has experienced at least three major global warming events, as well as many minor fluctuations.

Climate change usually occurs slowly over millions of years, but can occur suddenly and rapidly. This is known as 'abrupt climate change', and occurs when the climate system is forced to cross a threshold, triggering a transition to a new state. For example, palaeoclimatic records from the last 10,000 years show rapid cold reversals interrupting warming periods, and abrupt regional changes in extreme weather event regimes (e.g. hurricanes, droughts and floods). Global climate change is often associated with mass extinction events – the five mass extinctions that have occurred on Earth all coincided with periods of global cooling or warming.

The Case Study

Evidence of past climate change

During the last two million years, there has been a major Ice Age across planet Earth. As the continents have not moved much in this time, it appears that the amount of energy from the Sun has been an important factor in the overall Earth climate.

In the Southern Hemisphere, temperatures during the last Ice Age were about 5ºC lower than now. When the Ice Age was at its coldest, the central highlands of Tasmania were covered by an ice cap with glaciers carving out the mountains. The effects of these glaciers can still be seen in Tasmania.

The effects were more subtle in mainland Australia. Perennial ice was limited to the high ridges of the Kosciuszko area where snow and ice extended 700 – 1,000 metres below the present snowline.

As there was more water locked up in ice, sea-levels dropped, there were changes to rainfall, average temperature and water availability. These caused changes to the flora and fauna of Australia and to the patterns of inland lakes and sand dunes.

As the Ice Age ended, and the temperatures increased, the glaciers melted and sea levels rose. This rising sea level flooded the land bridge between Tasmania and mainland Australia so that Tasmania and its inhabitants, including the Tasmanian Aboriginal people, were isolated from the mainland.

Teaching Activities

Lower Primary

Radiant heat from an object
Heat energy can travel through matter by conduction, it can be carried through matter where particles can move by convection, and it can travel through space by radiation. The sun's heat reaches us by radiation.

Students could qualitatively investigate the relationship between distance and energy from a source of heat and light.

Use a rubber band or string to tie some chicken wire or similar across the end of the light shade of an incandescent desk lamp, so that students cannot accidentally touch the globe.

Ask them to move their hands closer to and further away from the globe, testing how hot the hand feels at different distances. Ask them to describe and explain their findings and relate this to what would happen if the Earth were nearer to the Sun.

Primary

Investigate what happens to warm and cold air in the classroom. Link this to weather patterns and how it would create moving air/wind cyclical movements.
http://ezinearticles.com/?Why-Does-Cold-Air-Fall-and-Warm-Air-Rise?&id=302338
Some great weather experiments that look at convection currents in water and air.
http://www.hometrainingtools.com/articles/weather-experiments-project.html

Middle School

Tasmanian mountains
http://www.vnc.qld.edu.au/enviro/flinders/f-p-tmf.htm 'The island of Tasmania has a large proportion of its area made up of rugged mountainous and plateau landscapes, in addition to its coastal landscapes. From virtually anywhere along the coast it is possible to see hills or mountains, especially when looking towards the island's central mass. Glaciation has carved some interesting features on the plateau surface and escarpments.'

This page lays out information about the Tasmanian glaciation landforms in simple language and has a separate page with suggested student activities for further research, oral reporting and classroom discussion. It also parallels the landform theme with a historical theme, leaving scope for a glaciation-based history role-play on Matthew Flinders' trip around Tasmania.

Trends and cycles in the Sun's energy output
Students can examine historical records of the energy output of the Sun and identify any trends or cycles.
http://ircamera.as.arizona.edu/NatSci102/lectures/climate.htm

http://science.msfc.nasa.gov/ssl/pad/solar/images/ssn_yearly.jpg

Senior Secondary

Effect of power output on temperature
Set up an investigation in which students test the effect of the power output of a light source on temperature. Groups will need a 12-volt globe of about 25-50 W maximum power; connected to a power pack; an ammeter and a voltmeter; a styrofoam sphere, or a ball, to represent the Earth and a retort stand, boss head, clamp and thermometer

Set the sphere and the light globe a suitable distance apart (e.g. 10-20 cm). Clamp the thermometer so that it directly faces the light globe, with its bulb at the equator of the sphere. Students then measure the steady maximum temperature at the surface of the sphere for each of the 2, 4, 6, 8, 10 and 12-volt settings of the power pack. They should also measure the current in amps through the globe and the voltage across the globe. Note that globe power = current × voltage.

Each student group could measure one setting, or each group could perform all six measurements.

Students can then graph their six data points of temperature versus output power and comment on the experimental relationship.

The experiment can be extended to model the effect of Earth's atmosphere on surface temperature. For example, place a square of cellophane or an OHT in front of the sphere, repeat the six measurements and compare data.

A further extension is to gather data for the heating of bodies of water. Suspend the light globes a set distance above six identical trays of water (e.g. takeaway containers). Leave the experiments overnight at the six different power pack voltage settings. Use magnetic stirrers if six of these are available. Next day, after thorough mixing, record the temperature in each water sample. Students can again compare temperature with power output and the water temperatures with those for the spheres.

Climate change in Australia
Predictions for future climate change in Australia are a hot topic and there are plenty of resources on the web to assist any debate about:

- Is climate change occurring?
- If climate change is occurring, what is the cause of this change?

This topic could engender lively classroom debate but needs to be backed by solid scientific evidence.

The issues are:

- Are we simply experiencing a natural cycle that has been part of Earth's climate change patterns over the eons?
- What is the impact of sunspot activity, as it is known that these cycles can also influence climate change?
- What is the human impact on climate? Are increased carbon dioxide levels sufficient to cause climate change?

A place to start is http://www.bom.gov.au/climate/change/ which has a series of links to current information such as rainfall patterns, and projections for managing future climate change.

http://www.bom.gov.au/lam/climate/levelthree/climch/climch.htm is a link from this site which focuses on climate education. It is has a number of useful links with further information on climate change. These links could make the basis of a jig-saw activity focusing on 'Evidence for Climate Change – Past, Present and Future'.

Weather

Weather is the fluctuating state of the atmosphere, characterised by the temperature, wind, precipitation, clouds and other weather elements. It is variable in space and time and impossible to predict accurately much more than a week in advance!

The Science

Climate types

Climate describes the average of weather variations across a region over a long period of time, and is affected by factors such as latitude, distance to the sea, vegetation, altitude, winds, aspect and topography. Climatic conditions are also variable with time, e.g. seasonally (summer/winter), annually (varying rainfall each summer), or over longer time scales (El Niño/La Niña cycles). Five main types of climate are recognised based on temperature and precipitation characteristics. The major characteristics of each are described in the table below.

Climate Type	Temperature	Precipitation	Cloud Cover	Difference Summer/Winter Daylight Hrs	Examples
Tropical	High	High	Variable	Little	Brazil, Papua New Guinea
Dry (Arid and semi-arid)	Cold night, hot days	Low	Little	Little	Inland Australia
Temperate	Warm-hot summer, cool-cold winter	Medium-high	Variable	Large	Mediterranean countries, SW Australia
Continental	Cool-warm summer, cold winter	Medium - Low	Variable	Large	Central and Eastern Europe and Russia
Polar	Very cold	Low	Little	Very long/constant in summer, very short/none in winter	Antarctica

Australia is unique in having several climatic zones; temperate along the south-eastern and south-western coasts, tropical in Cape York, Arnhem Land and the Kimberly, and dry throughout the remaining interior.

Extreme weather events

Extreme weather events are phenomena that exhibit wide deviations from the typical conditions. They are naturally occurring but usually rare and impossible to predict. Examples include droughts, floods, storms, cyclones and tornadoes, ocean and coastal surges, heatwaves and cold snaps.

Extreme weather events are a source of disruption to the physical environment. Droughts can cause rivers and lakes to dry up, vegetation to die off, and wildfires to be more frequent. Flooding is a fairly common occurrence but floods can also be rare and extreme weather events.

Storms impact on land-based water by recharging rivers, lakes and groundwater, expanding or modifying watercourse boundaries, and causing floods. Cyclones and tornados can strip soil and vegetation, damage coral reefs, and cause large swells that erode coastal landforms.

Changes to regional climatic regimes can influence extreme weather event frequency and intensity. Some scientists believe that the increase in extreme events such as hurricanes and tornadoes over the last 15-20 years is attributable to anthropogenic (caused by human impact) climate change.

The Case Study

El Niño

The Australian climate is strongly influenced by the El Niño Southern Oscillation (ENSO). El Niño refers to the extensive warming of the central and eastern Pacific that leads to a major shift in weather patterns across the Pacific. El Niño events occur every 2-7 years and bring dry conditions to Australia (particularly eastern Australia) and flooding rains to coastal South America. A strong El Niño, such as the one that occurred in 1982-3, also brought dry conditions to Indonesia and was felt as far away as India where the monsoonal rains failed.

The opposite of El Niño is La Niña, which occurs when the central and eastern Pacific are much cooler than usual, bringing widespread rain and flooding to Australia. Due to the unpredictable nature of the ENSO, Australia's climate (especially inland) is characterised by high variability, particularly with respect to water availability.

The early outback farmers and graziers who were used to Europe's predictable climate had trouble adapting to the Australian climate. Many had the good fortune of arriving during wet La Niña years, but made the mistake of assuming the prevailing conditions were the norm and established farming practices that were not sustainable during the inevitable drought years that followed.

It took many years before scientists unravelled the mystery behind Australia's climate variability. In fact it was not until the 1980s, after the extremely strong El Niño of 1982-3, that they began to understand the ENSO system and realise that Australia's droughts were just a small part of a Pacific-wide phenomenon.

Teaching Activities

Lower Primary

Playing with puddles

Do a playground inspection on a rainy day and watch as puddles form in different places. How are the puddles similar? How are they different? Which puddles are the biggest? Ask the students why some puddles are bigger. When it stops raining, draw a line around the edge of different puddles. Return every hour or so, observe and discuss what is happening. If the puddles are getting smaller, draw another line around the edge each time you check them. Do all the puddles disappear at the same rate? Discuss possible reasons for this with the students.

Cloud watching

Cloud watching is a very simple and readily available example of the Earth as a planet of change! Talk about how clouds are formed (water evaporates from the earth and condenses into small droplets) and what happens when clouds touch the earth (fog).

Have the students go outside and lie down on the oval facing upwards (preferably on a cloudy day!). Ask them to look at the sky carefully and describe what they see. Are there clouds in the sky? What do they notice about them? Are they high or low in the sky? What colour are they? Their shape and texture? Ask the students to draw the different types of clouds they see.

http://www.rcn27.dial.pipex.com/cloudsrus/cloudwatch.html is a good place to find descriptions of the various clouds, with images. This page also describes the weather that may accompany these clouds.

Primary

Wondering about the weather

Brainstorm and list words associated with the weather. Watch a television weather report and collect more words and any interesting symbols. What do the words and symbols mean? Do they fit into any particular groups or themes? Create a weather mural to record the words and symbols.

Recording chart and weather forecasting

Ask the students to create a weather chart, recording daily weather observations such as relative cloud cover, temperature, rainfall and wind direction over one week. Have students make a prediction (forecast) for the Saturday. Bring in the newspaper weather readings for the weekend and see who was the best 'weatherperson'.

Using clouds to predict weather

Read the lower primary activity on cloud watching. Students could be asked to identify the different cloud structures and predict the weather that might come from them.

http://www.canteach.ca/elementary/earthspace3.html has a very simple lesson outline on clouds.

Middle School

Weather presenter game

Download a meteorological map from www.bom.gov.au that shows the location of high and low pressure systems around Australia. Have students present the weather for different parts of the country after studying the map and deciding what the weather is likely to be based on the presence of low or high-pressure systems. Air has higher pressure when it is colder and more dense. Warm, lighter air rises and has lower pressure. Have students predict and then research how large bodies of warm and cold air behave when they meet.

Natural disasters

Researching natural disaster case studies on the web is a great way for students to become familiar with the science behind the events. Many of the case studies students will find are contemporary, and often involve contentious, science-based problems, which make the classroom science relevant. Have students research a natural disaster using the internet and prepare a summary of the event covering details such as the location of the disaster, impact on the natural environment, human impact, cause of the disaster, disaster prevention and mitigation, event frequency in that area, and any other relevant details. Present the research as a short essay, a poster, presentation, or classroom debate.

Make your own thermometer

This is an easy exercise for students to try at home.

Fill a plastic 2L soft drink bottle with water, adding a few drops of bright food colouring. Wrap Plasticine around a clear drinking straw, taking care not to squash it, and put the straw into the bottle, using the Plasticine to hold it in place and seal. The bottom ¼ of the straw should be in the water. Describe what happens if the bottle is stood upright in a bowl of hot water and a bowl of icy water.

Discuss their observations with the students and negotiate an explanation for what is happening. The bowl of hot water will heat the water in the bottle, causing it to expand and move up the straw. When the water in the bottle is chilled, it will contract and move back down the straw.

Senior Secondary

Compare climates of different countries

Download from the internet a week of weather data for several different cities in the world (over the same time period). Try to pick at least one city from each of the major climatic zones, e.g. tropical, dry, temperate, continental and polar. A map showing world climatic zones can be downloaded from http://www.mapsofworld.com/world-maps/world-climate-map.html

Ask students to plot data for temperature, rainfall, humidity, cloud cover, and any other variables, create a separate graph for each weather variable so that it can be compared across cities, and suggest an explanation for the differences between the cities. Consider latitude, distance to the coast, regional topography, daylight hours, altitude, and hemisphere.

The same activity can be carried out for the capital cities of Australia. A map showing Australian climatic zones can be downloaded from www.bom.gov.au/climate/environ/travel/map.shtml.

Another exercise on world climates is available at http://www.nationalgeographic.com/xpeditions/activities/08/climates.html

Cloud appreciation

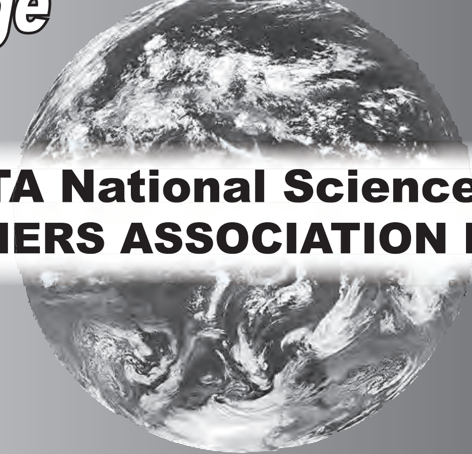
Clouds are a readily available example of the constant changes occurring on planet Earth. Run a competition for the best cloud photo! http://www.cloudappreciationsociety.org/ has some fun ideas.

School Theme

PLANET EARTH – Planet of Change

national **science week 08**

sat 16 – sun 24 august
www.scienceweek.info.au



ASTA National Science Week
SCIENCE TEACHERS ASSOCIATION REPRESENTATIVES

In each state and territory there is a representative from the local Science Teacher's Association to assist school, teacher and student participation in National Science Week. To find out about National Science Week in schools – programs, activities, school grants and assistance – contact your state/territory representative.

Science Educators' Association of the Australian Capital Territory (SEA*ACT)
Helen Shead • helen.shead@ed.act.edu.au • 02 6205 5599

Science Teachers' Association of New South Wales (STANSW)
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Science Teachers' Association of the Northern Territory (STANT)
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Science Teachers' Association of Queensland (STAQ)
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Science Teachers' Association of Tasmania (STAT)
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South Australian Science Teachers Association (SASTA)
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Science Teachers' Association of Western Australia (STAWA)
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National Science Week SCHOOLS KIT

- **A copy is sent to every school in Australia in May 2008**
- **Includes a FREE copy of the ASTA National Science Week Teacher Resource Book, 'Planet Earth – Planet of Change'**
- **School grant application form**

Additional Resource Books are available to purchase from the ASTA office @ $12 members, $15 non-members (+ postage & handling)

ASTA members of 2008 receive a FREE copy of the Resource Book 'Planet Earth – Planet of Change' through their state/territory Science Teachers Association. Check your membership.

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NATIONAL SCIENCE WEEK

An Australian Government Initiative

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CHAPTER 4

Life and its impacts

(The Biosphere and Anthrosphere)

Life first appeared about 4.4 billion years ago in the form of single-celled blue-green algae that theoretically evolved in anoxic (lacking oxygen) tidal pools, hot springs or near hydrothermal vents in the oceans' depths. These tiny organisms, with the help of evolution, gave rise to all the species that have ever existed on Earth, including humans.

The theory of evolution provides a unifying, logical explanation for the diversity of life. Evolution is the change in the inherited characteristics of a population over generations.

Adaptation describes any feature or characteristic that is beneficial in terms of survival and reproduction and that becomes most common over generations in a population of living things, while those that are harmful become more rare. Species have been able to adapt and change over time in so many different ways that they are now found in almost every imaginable environment on the planet. For example, hundreds of previously unknown organisms have recently been discovered during a recent major survey of New Zealand's cold, deep, Antarctic seas. Huge sea snails, jellyfish with tentacles up to four metres long and starfish the size of large food platters were among some of the species found.

The accumulation of differences in characteristics over successive generations leads to *speciation*, or the emergence of new species. A *species* is generally defined as a group of organisms capable of interbreeding and producing fertile offspring.

For every species that is present on Earth today, there are hundreds more that have succumbed to extinction due to an inability to survive the changing conditions. Fossils give tantalising glimpses of the changing nature of life on Earth, and also provide information about the predecessors of current living things.

The rate of evolution is dependent upon both how fast a species can reproduce and the rate of change to the environment in which it lives. Scientists have actually been able to observe evolution in action by experimenting with rapidly reproducing and short-lived species such as the *E. coli* bacterium, flies and house mice. Another example is the selective breeding of plants and animals by humans, which has given rise to different varieties of fruit, vegetables, and dogs.

Biodiversity is the term used to describe the variety of life on Earth, usually at three levels of organisation: genetic, species and ecosystem. Many people, including scientists, have concerns about the potential loss of much of the Earth's biodiversity through human impact and looming climate change. The concern is based around the increasingly rapid change in ecosystems caused by a soaring human population and an increased need for resources. An ecosystem that has a high biodiversity of organisms is more able to withstand environmental changes because there are many interactions at play instead of only a few. Thus an invading 'wheat pest' in a wheat field ecosystem would cause devastation, but in a woodland ecosystem would have minimal impact.

However, as humans continue to use the Earth's resources, increasing attempts are being made to rectify and avoid further damage to biodiversity through more careful extraction and utilisation of those resources considered to be essential for human survival on this planet.

DID YOU KNOW?

The term extremophile is used to describe those species that live in extreme environments. It was first coined in 1965 when biologists discovered two species of bacteria living in the hot springs of Yellowstone National Park. *Sulpholobus acidocaldarius* and *Thermophilus aquaticus* have amazingly made their home in acidic, sulphur-choked waters where the temperature can reach nearly 100° C!

The more researchers look, the more micro-organisms they discover that can survive in the harshest and strangest of environments. Microscopic life has been found:

- in the freezing Arctic and Antarctic waters
- in volcanic vents on land
- on the ocean floor
- in deserts
- in hot volcanic vents in the deep ocean
- in rock, deep inside the Earth
- in chemical environments such as strong acids, alkalis and salt solutions that would be lethal to most life forms
- in highly radioactive environments, such as on the control rods of nuclear power plants.

The changing nature of life on Earth

The biosphere, that part of the Earth populated by living organisms, has also changed over the history of the Earth. The biosphere's distribution has altered and its inhabitants have evolved significantly over time. However, the earliest life forms and their descendents give insight into the evolutionary patterns and processes that have led to life as it exists on Earth today.

The Science

Life on Earth in one calendar year

If the entire history of Earth was condensed into just one year, this is what it would look like:

Calendar	Event
1 Jan	Formation of the Earth
20 Feb	Period of heavy bombardment of Earth by asteroids ends
1 March	First life appears
10 April	Stromatolites formed
15 June	Photosynthesis evolves
22 July	Atmosphere becomes oxygenated (from 0.0001 to 21%)
1 Oct	Appearance of multicellular organisms
25 Oct	Appearance of complex life forms, macro-fossils
20 Nov	Appearance of vertebrates
7 Dec	Dominance of reptiles, continents assembled in Pangaea
15 Dec	Appearance of dinosaurs and first birds
25 Dec	KT asteroid – major extinction event (Goodbye dinosaurs!)
31 Dec (3pm)	Hominids appear
31 Dec (11pm)	Rise of *Homo sapiens* (humans as we know them)
31 Dec (11:58:45pm)	End of the last Ice Age
31 Dec (11:59pm)	Development of agriculture
31 Dec (11:59:59pm)	Industrial Revolution
31 Dec (11:59:59.99pm)	First human leaves Earth for space

A comprehensive table, Australia through Time, charts the history of Australia from a geological perspective. It includes the evolution of life, palaeogeography, sea level, climate change and major mineral deposits from an Australian perspective. This table is available for download at http://www.ga.gov.au/education/facts/timescale/aust.html

Source: Wikipedia

Stromatolites growing in Hamelin Pool Marine Nature Reserve, Shark Bay, Western Australia.

The Case Study

Cane toads and snakes

Adaptation, extinction and speciation are not just things that happened in the past; they are still occurring. Species have to adapt to influences such as climate, food availability and competition with other species, but these days most are faced with the additional pressure of the environmental changes caused by human activity. It is evident that modification of the natural environment (e.g. clearing vegetation for farmland, building cities, damming and diverting water flows, and introducing exotic species) has already led to changes in Australia's flora and fauna.

One such example of evolution in action is the change in the lengths of two species of snake, the Red-bellied Black Snake and Green Tree Snake, in response to cane toads. A post-graduate researcher at the University of Sydney has found that that since the introduction of cane toads about 70 years ago to control a pest (cane beetles) of sugar cane, these snakes, which are sensitive to the toad's poison, have become longer by about 3-5%.

As the length of a snake increases, the size of the head decreases in relation to the body. The researchers suggest that this adaptation may have occurred in response to cane toads because a big snake with a small head is the best possible size and shape for surviving a 'toad meal'. The biggest toad that the snake can eat is quite small in comparison to the size of its body. Consequently, such snakes may still eat cane toads but they cannot swallow a larger toad with enough poison to kill them.

The researchers suggest that this effect may help to ensure the survival of the species. Their belief is supported by the fact that species of snakes that are more tolerant of the toad poison have not shown similar increases in body length.

DID YOU KNOW?

A stromatolite is a layered rock that has been built by microscopic organisms. Stromatolites are built by a community of micro-organisms that forms mats and secrete mucus that traps sedimentary grains, cementing them into layers. The community consists of some primitive bacteria (cyanobacteria) that can carry out photosynthesis, as well as underlying layers of other species of bacteria, which do not need light.

Because the upper part of the mat requires sunlight for photosynthesis, the mat migrates upwards, leaving the layers below that are seen in both modern and ancient stromatolites. Before 1954, stromatolites were known only as ancient and puzzling fossils. The discovery of living stromatolites forming in the Hamelin Pool at Shark Bay in Western Australia was extremely important in allowing scientists to learn more about the history of life on Earth.

Teaching Activities

Primary

Welcome to the biosphere
This activity will introduce younger students to the idea that soil forms part of the biosphere, and contains living things (or the spores/eggs/larvae of living things).

Collect some small plastic or glass containers with lids that fit well (such as takeaway food containers). Use large raw potatoes and slice them thinly, giving each group one or two slices that will lie flat on the bottom of the plastic container. Ask the students to sprinkle a small amount of soil on each potato slice. Place the lids on the containers firmly without disturbing the slices and seal the lids. For a fair test, a second set of slices can be set up in the same conditions but without any soil. Put the sealed containers in a dark place and allow the students to inspect them each day (without opening the lids). Within a short while, fungal colonies will appear on the potatoes. Ask the students to identify any differences between the samples with and without soil.

This exercise can be extended by collecting soil from different places and heating or microwaving some soil samples to destroy living cells.

Safety: Ensure that the containers remain sealed and dispose of them and their contents without opening.

Middle School

X-Men amongst us?
Watch the first 10 minutes of 'X-Men'. Discuss the science behind the movie. Did they get it right? Could evolution occur like this? Is it possible that X-Men could evolve in real life? Why or why not?

The importance of community
Stromatolites are built by a community of micro-organisms. If one part of the community dies, the whole stromatolite structure cannot be built. Investigation of the stromatolite community reveals the importance of its food chains and food webs. http://www.enchantedlearning.com/subjects/foodchain/ is a US site with useful background information on food chains and webs.

1. **Food chains and food webs**
   - Ask students to research the names and pictures of plants, animals, insects and macroinvertebrates (large animals without backbones) found in the local area.
   - Ask the students to think about what the animals might eat, what eats them, and ask them to place them in order from the base of the food chain to the top. If pictures are available, they could be strung together to make food chain mobiles of varying lengths.
   - Discuss with students the habitat requirements of each organism and how it links with other organisms. Simple food chains can be laid out on a large piece of paper and lines drawn between them to indicate the connections. The end result will show a 'web' of connections.
   - Removing organisms such as plants and insects from the lower levels of the food web will show that many other organisms will go hungry or homeless without them. This will help students to understand the importance of maintaining biodiversity within an area.
2. **Unusual communities**
   Use the stromatolite example as a springboard for students to discuss or research other unusual living communities such as:
   - *Coral reef*
     http://www.exmouthdiving.com.au/english/ningaloo.htm is a place to start for the Ningaloo Reef.
     http://www.reefed.edu.au/ for information on the Great Barrier Reef.
   - *Hydrothermal vent*
     http://science.uniserve.edu.au/school/quests/hydroventwq.html has a great webquest on 'Black Smokers' – deep ocean vents.
   - *Hot spring*
     http://www.theguardians.com/Microbiology/gm_mbm04.htm deals with micro-organisms that live under extreme conditions. Links will allow students to investigate the communities dependent on these extremophiles.
     http://landresources.montana.edu/FIBR/Ward/intro.htm has a language level better suited to more able/older students.

Senior Secondary

The great cane toad debacle
Biological control is the use of natural enemies to suppress or control a pest or weed. Cane toads were introduced to Queensland from South America in 1935, in an unsuccessful attempt to control cane beetles, a pest of the sugar cane industry. Unfortunately, it was a mistake that has resulted in the spread of an even greater pest across Australia.

The use of the cane toad as a case study for the impact of an introduced species on an indigenous population is useful as it allows students to appreciate the need for specialised knowledge of any animal or plant introduced into Australia, the purpose of quarantine, the impact on the ecosystems invaded by the cane toad and the usually slow nature of evolution in selecting adaptations to survive new environmental hazards

http://www.amonline.net.au/herpetology/faq/cane_toad.htm has information on the cane toad and is a good starting point for understanding the biology and impact of the animal.

Ben Phillips, University of Sydney – outline of research into the effect of cane toads on snakes. www.bio.usyd.edu.au/Shinelab/staff/ben/ben.html

Cane toads exert a pressure on snakes to adapt to survive www.abc.net.au/science/news/stories/s1250708.htm

Researchers welcome evolution of cane toad's predator www.abc.net.au/news/newsitems/200412/s1270907/htm

Fauna survey
This could be developed into an individual or group research investigation on local biodiversity for entry into your State's Science Teachers Association Awards:

Carry out a fauna survey of the school or area.
- How many different types of birds, mammals, reptiles, and amphibians and fish (if there is a creek or other water body nearby) can be found?
- Use binoculars to spot birds.
- Spotlighting or searching for scats is a good way to detect nocturnal or secretive fauna.
- Listen for bats and nocturnal birds at night.
- Record the frog calls from nearby creeks, rivers or lakes, and identify them using a frog call ID CD.
- If your school is close to a beach investigate and record its fauna.
- How diverse is your school or area?

Fossils – Evidence of life on Earth

Fossils represent direct evidence that life on Earth has changed. Scientists are able to describe both the organisms that lived in past times and the environment in which they lived by their body structures. For example, diet can be identified in animals with teeth. Terrestrial fossils in the Australian context are excellent examples of change in life forms over time.

The Science

Fossils are remnants of past life. They provide evidence of changing life forms as well as evidence of similarities between present and past life forms.

Fossilisation is always a rare event and even more so in the terrestrial environment. The process must be rapid so the body is buried quickly and preserved intact. Decay may still remove the soft tissue, so it is more often the hard parts that are fossilised. Examples of potential fossilisation events include occasions when an animal falls into a crack or cave, is swept away by a flood, drowns and sinks to the bottom of a lake, swamp or bog, or is buried in a cool volcanic ash shower.

Unaltered remains are the best and rarest terrestrial fossils. Examples include frozen carcasses in permafrost, animal and plant material trapped in amber (tree sap), mummified remains in hot, dry conditions and animals trapped in tar pits. Unaltered remains include the soft tissues of the organism and many still have hair, skin colour, and an intact last meal.

Trace fossils include evidence left behind by the organism, rather than the organism itself. Examples include footprints, scats, leaf imprints and burrows.

Carbon films (or carbonisation) are thin films of carbon in layers of sandstone or shale. Plant material is the most common tissue to be preserved in this manner.

Permineralisation occurs when buried hard remains such as bones, teeth, and shells are flooded with ground water containing rock-forming minerals. These minerals fill any holes or gaps in the hard parts, and with time and pressure the minerals solidify to form the fossil. Petrified wood is a result of this process.

Dissolution and replacement occur when the original minerals of bone or shell are dissolved and replaced with rock-forming minerals. Examples include coral and shell fossils.

Dating fossils – two methods

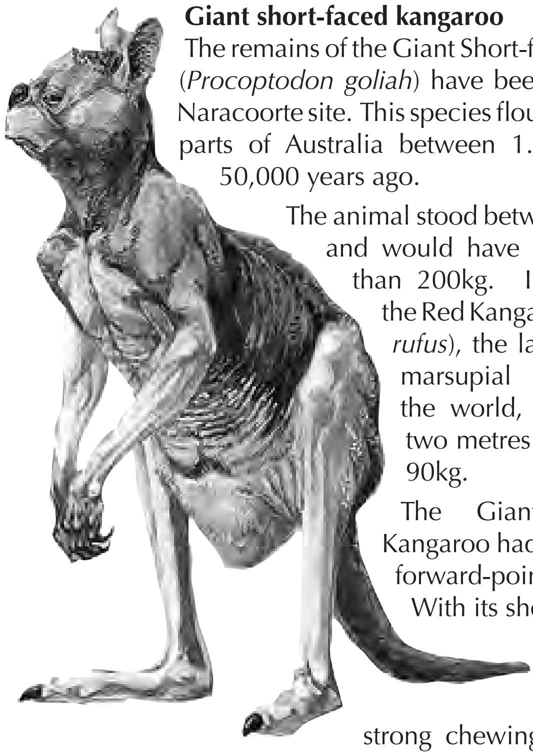
The sediments that bury fossils are deposited in horizontal layers with newer layers formed on top of the older layers. This order allows their relative ages (and the fossils in them) to be determined. Deeper rocks containing fossils are older than those found above them.

Radioactive elements decay at known rates. By comparing the amount of original radioactive element with the amount of its decay product in an igneous rock sample, physicists are able to provide an age for the rock. This process cannot be used directly on fossils but can be used to give a time-range for a fossil by testing igneous rocks above and/or below the fossil.

The Case Study

The Naracoorte Fossil Assemblage

The limestone underlying the Naracoorte region of South Australia contains an extensive system of caves. In 1969, speleologist Grant Gartrell and palaeontologist Rod Wells discovered the largest, most diverse and best-preserved Pleistocene vertebrate fossil assemblage in Australia. The site, located in the Cathedral Cave at Naracoorte, is now known as the 'Fossil Chamber'. The animals appear to have dropped through a natural pitfall trap between 280,000 and 160,000 years ago. The fossils indicate that at the time the fauna assemblage of the region was dominated by large herbivores, and suggests that the landscape was covered with grassy open forest or woodland. Both extinct (no longer existing) and extant (still living) species are represented in the fossils.



Giant short-faced kangaroo

The remains of the Giant Short-faced Kangaroo (*Procoptodon goliah*) have been found at the Naracoorte site. This species flourished in many parts of Australia between 1.6 million and 50,000 years ago.

The animal stood between 2-3m high and would have weighed more than 200kg. In comparison, the Red Kangaroo (*Macropus rufus*), the largest surviving marsupial anywhere in the world, can be up to two metres tall and weigh 90kg.

The Giant Short-faced Kangaroo had a flat face and forward-pointing eyes. With its short face and deep skull it would have had very strong chewing muscles and was probably able to eat the very tough leaves and stems of taller shrubs and small trees.

Unlike modern kangaroos, extinct Sthenurine kangaroos, such as the Giant Short-faced Kangaroo, were able to reach above their heads. On each hind foot it had a single large toe, and each paw on its forelimbs had two extra-long fingers with large claws. These adaptations enabled them to reach up to leaves more than three metres above the ground by balancing on their toes whilst propped up by their tail.

Image source: ABC Library Sales

Teaching Activities

Lower Primary

Make a fossil

You will need Plasticine, cardboard, paper clips, cling wrap, Plaster of Paris, water, containers, stirrers and leaves and/or shells. Flatten the Plasticine into a disc shape, and put a cardboard collar around it. Press a leaf with enough interesting detail on it, or a shell, into the Plasticine, using a layer of cling wrap to stop adhesion. Remove leaf or shell. Mix plaster of paris to a pouring, creamy consistency, and pour into cardboard collar over Plasticine. Wait for it to set and remove. Real fossils form in a similar way, with impressions in mud being filled with later deposits of mud.

http://www.csiro.au/resources/ps1tk.html instructions for making 'fossils' and other plaster casts.

Primary

Australian giants

Younger children have usually heard about dinosaurs but have they heard about the giant creatures that lived in Australia many thousands of years ago? Making scaled representations of the animals, using chalk on the playground, or paper cut-outs, allows students to compare the actual sizes of extinct Australian megafauna with animals living today.

http://www.bbc.co.uk/sn/prehistoric_life/dinosaurs/makingfossils/index.shtml excellent series of animations about fossil formation.

Name	Length	Height	Weight	Special features
Wombat	1.0 m	45cm	25–40 kg	Wombat burrows may consist of 30 m or more of tunnels.
Red Kangaroo	2.3m with tail	1.5m–2m	90kg	The largest mammal to hop on hind legs
Tasmanian Devil	50cm – 60cm	30cm	12kg maximum	Largest living marsupial carnivore; became extinct on mainland Australia about 600 years ago
Giant Short-faced Kangaroo	4.5m with tail	2m – 3m	230kg	Extinct – the biggest kangaroo ever?
Marsupial lion	1.5m	75cm	130kg	Extinct - the largest meat-eating mammal to live in Australia, and one of the largest marsupial carnivores in the world
Giant wombat	2.0m	1.0m	200 kg	Extinct for more than 10,000 years – could it burrow?
Diprotodon	3.0m	2.0.	2 tonnes	Extinct - the largest marsupial was the size of a rhinoceros.

Middle School

The Australian scene – life from the past

The Giant Short-faced Kangaroo lived in Australia in the Pleistocene epoch (1.6 million–10,000 years ago). It shared the continent with a variety of other animals, some of which still exist whilst others have long been extinct. As a Science Week project, students can gather information, design and make a scaled diorama to represent the fauna of Australia at any one time, and create a time line of their chosen period. The task could focus on one epoch, such as the Pleistocene, or groups within the class could be allocated different epochs, with a view to tracing the changing life forms in Australia over time. Information can be gathered via a web and book search and should include: size of the animal, appearance and special features, diet, places in Australia where its fossil remains have been found, and how long ago it became extinct. Students will develop skills in accessing web sites, extracting, tabulating, collating and summarising information, and designing and making scale models.

http://www.ga.gov.au/education/facts/timescale/aust.html a useful downloadable time line.

http://www.lostkingdoms.com/facts/ lists fauna from the Cretaceous to the Holocene, with hyperlinks to brief notes about each species.

http://www.museum.vic.gov.au/prehistoric/mammals/australia.html Pleistocene megafauna.

http://www.parks.sa.gov.au/naracoorte.wonambi/animals/index.htm extinct and extant fossil animals found in the caves at Naracoorte.

http://www.museum.wa.gov.au/AncientNullabourmegafauna.asp Nullarbor Caves megafauna.

Wildlife of Gondwana: Dinosaurs and Other Vertebrates from the Ancient Supercontinent (Life of the Past) *1999 Vickers-Rich, Rich ISBN-13: 978-0253336439*

Australia's Lost World: Prehistoric Animals of Riversleigh 2001 Archer, Hand, Godthelp ISBN-13: 978-0253339140

Senior Secondary

Extinction of Australia's megafauna

Extensive fossil evidence from sites such as Riversleigh, Naracoorte and the Nullarbor caves indicates that megafauna played a significant part in the food chain of Australian ecosystems in the recent geologic past. With increased concern about global warming, students will benefit from examination of the impact of climate change on past life forms.

The reason for the disappearance of this megafauna during the late Pleistocene continues to be one of science's hotly debated topics. For example, Tim Flannery in his book *The Future Eaters,* contentiously linked the disappearance of the megafauna with human settlement. Use the items below to stimulate research and debate:

http://www.abc.net.au/science/news/stories/2007/1832750.htm 'Marsupial lion reignites megafauna debate'

http://www.abc.net.au/rn/inconversation/stories/2007/1876587.htm Robin Williams talks to John Long, one of the palaeontologists involved in the Nullarbor research.

http://science.uniserve.edu.au/school/quests/mgfauna.html a web quest on the topic.

Resources from the Earth

Australians are dependent on the minerals industry to supply the raw materials for many of the requirements for everyday life. All of these minerals come from the Earth's crust. Whilst most will be aware of the current Western Australian mining boom, each state of Australia is extracting minerals from the Earth's crust that help to provide Australians with the lifestyle they enjoy.

The Science

Natural resources are considered renewable if they can be replenished or reproduced easily. Non-renewable resources are those that are formed over very long periods and can not be replenished rapidly.

Minerals are the building blocks of rocks. They can be composed of single elements, such as gold or diamond, or compounds such as quartz or sapphire. Rocks may be composed of one mineral but are usually mixtures of minerals. The Earth's mineral resources are non-renewable and can be categorised into three groups:

- Metallic minerals
- Non-metallic minerals
- Energy resources - coal, oil, gas

Our manufacturing and construction industries depend on these resources to produce and transport their products to the consumers – that is us.

Whilst the Earth's supply of minerals is finite, humans continue to extract and change vast amounts for a wide range of uses. Where recycling is possible and occurring, the predicted shortfalls in non-renewable resources can be postponed.

Metallic minerals
Gold, silver and platinum are found in their pure form as *native metals*. Most metals are found in minerals as compounds. When there is a sufficiently high percentage of the desired metal present in a mineral, the mineral is called an *ore*.

Minerals are concentrated into ore bodies by the processes that shape the Earth's crust. For example, when magma cools slowly to form igneous rock, crystals may sink to the bottom of the liquid magma to form a layer within the rock. The ores of nickel, chromium and platinum often form in this way.

Many metals that occur in very small quantities in the original magma may be concentrated into the last of the liquid left as the magma cools. This liquid seeps into cracks in surrounding rocks to form mineral-rich *veins*. Metals such as gold, copper silver, lead and zinc are deposited this way.

Weathering and erosion can also concentrate ores by depositing the heavier minerals in streambeds or on beaches. Tin, titanium, gold and zirconium are mined from such deposits.

The top layers of rock and soil are severely weathered in these conditions and minerals, which dissolve in water, are easily washed away, leaving behind only the most insoluble minerals such as aluminium and iron oxides, clay and quartz, with small quantities of other minerals.

Non-metallic minerals
These minerals are mined for a wide range of uses including construction materials, production of fertilisers and chemicals, and metal extraction processes.

The extraction of all of these minerals during the mining processes involves changes to the surface features of the Earth and can significantly impact on the environment both in the region where mining is occurring and in areas where waste products are dumped or stored.

The 21st century is witnessing an important change in attitude to mining processes, with all new and most existing operations required to ensure that their long-term impact on the local environment is as non-damaging as possible. Whilst humans continue to desire the wealth of products, goods and services that they currently enjoy, mining must continue.

The Case Study – Manganese Nodules

Manganese nodules were first discovered on the ocean floor in 1803 and are particularly common in the Pacific where they are estimated to cover 30–50% of the sea floor in water depths of 4,000 to 6,000 metres. These nodules are potentially valuable not only because of the gradual depletion of high-grade deposits of manganese on land but also because they are rich in other minerals. Manganese nodule deposits are estimated to be in the trillions of tons worldwide.

The nodules are dark brown-black in colour, slightly flattened rough spheres, 5–10cm in diameter and are made up of manganese oxide (MnO_2) and iron oxide (Fe_2O_3), with average contents of 30% manganese and 20% iron. They also contain more valuable elements such as copper, nickel and cobalt.

The nodules are formed from the precipitation and then deposition of the above metal oxides from seawater. In cross-section the nodules show concentric layers, or growth, rings around a core – like tree rings. The growth rate of the nodules is very slow – nodules in the Pacific Ocean are estimated to be two to three million years old.

The Australian scene
Manganese nodule fields are common on the ocean floor both south and west of Australia. They have been reported on the continental margin south and west of Tasmania and in the Tasman Sea south east of Sydney.

A rich manganese nodule field lies in the Cape Leeuwin region of south-west Australia with about 900,000 square kilometres of closely-packed nodules, mostly in international waters. Weather conditions would make recovery of these nodules very difficult as water depths in the area vary from 4,300 metres to 5,300 metres. At this stage, deep-sea nodule deposits containing copper, nickel, cobalt and manganese are regarded as long-term resources.

Teaching Activities

Lower Primary

Modelling – searching for iron
To give students an idea of how geologists find important ferrous minerals, hide some magnets around the playground.
Equipment: magnets and compasses.

Give each group a compass and demonstrate how the compass behaves near a magnet. Ask them to find some 'minerals' in the playground.

This activity could be set in the context of the K-4 readers supplied by the Minerals Council (see Primary Section).

Materials and manufacturing
Students examine the properties, limitations, and durability of a variety of materials and then evaluate which of them would be most suitable for building a model house. The lesson sequence is based on the tale of the Three Little Pigs. For full details go to http://www.sciencenetlinks.com/lessons.cfm?Grade=K-2+&BechmarkID=8&DocID=16

Primary

Stories about mining
K-4 Readers are a set of five attractively illustrated booklets for younger students. They encourage literacy, while at the same time exposing students to aspects of the Australian minerals industry. The titles are: *Finding Minerals, A Mine, Mine Machines, When We Mine* and *Mine to Metal*.

A set of these readers can be obtained by filling in an order form at http://www.minerals.org.au/_data/assets/file/0010/8947/K-4OrderWeb.doc

Middle School

Mining strategies – hands-on activities to demonstrate the concepts
Ore can be extracted by open-cut mining or by selectively mining through the ore body. The following activity demonstrates the effectiveness of recovery of the ore and the potential impact on the environment.

Equipment: at least two chocolate chip cookies per group (the chocolate chips represent the valuable ore); a probe or pointed object such as a long nail.

With open-cut mining, the 'cookie' will be completely broken up. How much of the ore can be retrieved? What has happened to the surrounding rock?

With selective underground mining, the rock will be drilled to retrieve the ore. Students will need to chip away at the cookie to release the 'ore'. How much ore is retrieved? What happened to the surrounding rock?

http://www.minerals.org.au/primary/primary/primary_resources/minerals_downunder/environmental_management has a jigsaw matrix activity that can be used to stimulate discussion on the environmental issues associated with various mining strategies. Information on the accompanying booklet is available at http://www.minerals.org.au/primary/primary/primary_resources/minerals_downunder

The NSW Minerals Council website is also worth a visit for a range of activities, including virtual tours of mining sites: http://www.nswmin.com.au/campus

For example, 'The Cadia Hill Cake' is a three-page downloadable file with instructions on cooking a rock cake and using it to model mining and extraction processes:

http://www.nswmin.com.au/education/minerals_classroom/virtual_tours/cadia_one/media/pdf/primary-lesson_rocky_cake.pdf

The *Down to Earth* CD
Use the section on 'Metals Matter' to demonstrate to students the broad range of uses of metals in the home, the costs involved and the origins of these metals. The commodity calculator has a number of challenges to encourage students to think about the importance of metals (including their mining and recycling) for society.

Voyage to the Bottom of the Sea
There are some excellent websites with direct reporting mechanisms on deep sea exploration expeditions. See http://www.divediscover.whoi.edu/edu/index.html

This website makes a great starting point for discussion on 'What happens to marine life if we mine the ocean floor?' http://environment.newscientist.com/channel/earth/deep-sea/dn9967

Senior Secondary

The *Down to Earth* CD – see 'Middle School' above for some notes on this CD which could also be effectively used at the upper secondary level.

Oresome Froth
http://www.minerals.org.au/primary/secondary/secondary_resources/oresome_froth2 Oresome Froth provides secondary science students with an authentic industry context for self-directed learning in applied chemistry. Instructions on this page accompany a 3.5 Mb file which is free to download and provides an interesting tutorial on the mining and extraction of metals using froth flotation. Well worth a visit!

http://www.minerals.org.au/victoriaeducation/teacher_services/lesson_plans/froth_flotation has a classroom exercise that can be used to model the process of froth flotation.

The chemistry of mineral extraction
Review the broad spectrum of physical and chemical extraction processes used to extract and purify the large quantity of metallic and non-metallic resources utilised by humans.

http://www.minerals.org.au/primary/primary/primary_resources/rockfiles has basic information on ten key metals and the ores from which they are extracted. The physical and chemical extraction processes are described without use of chemical equations and without any specific chemistry. A useful starting point for independent research projects on aspects of the extraction of a metal from its ore and its subsequent use.

The oceans – the next frontier?
Read the *Voyage to the Bottom of the Sea* activity for Middle School. This could be expanded upon for older students.

The Geoscience Australia page http://www.ga.gov.au/minerals/exploration/offshore/ is a good place to start student research on the wealth of minerals available from the ocean floor. It even has an offshore minerals map available for download.

As a Science Week project, ask students to use this map and others available on the Geoscience Australia site to research the currently mined and available mineral deposits on land. As a group activity, allocate each group a different mineral resource to research and report back to the class on its current uses and availability and future land and ocean reserves.

Changing human resource use – recipes for the future

***A natural resource** is something that is economically valued by humans and is derived from the environment. Many are essential to our survival while others are used to satisfy our wants. Some non-renewable resources are becoming depleted and renewable resources degraded. Humans are now faced with the challenge of finding alternative resources to replace those that we have traditionally used and managing them in a more sustainable manner.*

The Science

Human natural resource use

Humans have always exploited natural resources, but current technology allows us to exploit more resources more quickly. Minerals are extracted from rocks for a multitude of uses. Oil, coal and gas (fossil fuels) are extracted for their stores of chemical energy that can be transformed into heat energy by combustion. In coal fired power stations this heat energy is then used to heat water to form steam that is then used to turn (movement energy) a turbine in a generator that then produces electrical energy. Humans eat animals from the sea, sky and land, drink water from lakes and rivers, and harvest plants for food, medicine, clothing and building materials.

Resource availability has not been a problem for humans in the past, but as the global population increases (6.6 billion people and counting) we are beginning to see a critical need for sustainable resource management.

Alternatives

One of the biggest resource issues facing humans in the near future is our energy – as in electrical energy – supply. Almost all of the energy generated in the world comes from non-renewable sources – 37% from oil, 23% from gas, 25% from coal and 6% from nuclear.

Renewable sources currently account for only about 9% of global energy consumption. Australia is the biggest producer of coal in the world, and as a result we generate about 84% of our power from coal. Current coal reserves are estimated to last for another 200 years, and oil and natural gas for another 50-65 years.

When these run out, Australians will have to increase the proportion of electrical energy generated from renewable resources such as hydroelectric, solar, wind, biomass, biofuels and geothermal energy. Many countries have already adopted sustainable technologies on a large scale, (eg. Denmark currently produces 20% of its electricity using wind power and is aiming to increase this figure to 50% by 2025).

The concept of sustainable resource management is also being applied to other primary industries in Australia. For example, there is pressure on the forestry industry to harvest timber from native plantations (eg. eucalypt) rather than from old-growth forests or exotic plantations (eg. pine). More native species that are better suited to the arid Australian environment (eg. macadamia, wattle, bush tomato) are being used in agriculture. Understanding of sustainable fishery management has improved and aquaculture is now used to produce much of our seafood.

Case Study One

Geothermal Energy

Geothermal energy has the potential to be the major energy alternative to fossil fuels. It is energy generated from heat stored beneath the surface of the Earth. When water flows over subterranean hot rocks, hot water and steam are created and escape to the Earth's surface – mud pools, hot springs and geysers are examples of this. The steam can be used to power generators and produce electricity.

The two main types of geothermal energy are hydrothermal (hot spring water) and hot rock (large hot underground rock). Electrical energy is transformed from the heat energy in hot rock by pumping water into the ground which is then heated and extracted as steam and then used to turn a turbine and generator.

The first geothermal energy projects in Australia are currently underway in Birdsville in QLD and the Cooper Basin in SA. The Birdsville power station runs on hydrothermal (hot spring) power and produces enough electricity to meet all the town's needs during night and winter (additional energy sources are required for peak periods in summer).

The Coopers Basin power station is the first trial hot rock project in Australia and runs off a large body of granite nearly 4km below the surface. This body of granite has a temperature of about 250ºC and is the hottest near-surface, non-volcanic rock ever discovered.

Case Study Two

Alternative food sources

Australia is trying to find ways to make renewable resources, such as food production, more sustainable. Environmental problems associated with farming hard-hoofed animals such as sheep and cattle in Australia include soil degradation, vegetation changes and increased carbon emissions from their digestive wastes.

A way to overcome this problem is to farm or harvest native animals that are already adapted to the Australian environment. Kangaroos have been harvested commercially for over 30 years now and provide an example of a sustainable food production system.

Kangaroos must be harvested from the wild, as they cannot be farmed by traditional methods because they are highly susceptible to stress. National Parks authorities survey kangaroo populations annually to work out a sustainable quota for the number that can be taken in that year. Kangaroo harvesters must be licensed by the government and be trained in laws controlling kangaroo harvesting, meat hygiene and animal welfare. The harvested kangaroos are generally in good health and carry few of the diseases that domestic animals do.

Other native animals, such as emus and crocodiles, are also taking the place of lamb and beef on our dinner tables .

Teaching Activities

Primary

What resources do you use?

- Ask students to make a list of items that they use in one day. Make sure they include such wastes as food wrappers, bus tickets, even fruit peelings, as well as the more obvious materials such as books, pencils etc. that they use each day in school.
- Get the students to draw up a table and sort the items they have listed into groups such as plastic, paper, plant, animal, mineral etc.
- Discuss the origins of the items they use – perhaps as a jigsaw activity where expert groups research the raw resources/materials used to make each of the resources.
- Introduce the terms 'renewable' and 'non-renewable' and ask the students to sort the resources they use into the two categories, based on the research of the expert groups.

A discussion question could be 'What can you change so that you use more renewable resources?'

This could be expanded into a discussion about what resources are likely to become scarce in the near future, and what could be used to replace them.

http://www.urbanext.uiuc.edu/world/nres.html information and a related activity on mineral resource use.

Middle School

Bush tucker

Bush tucker is the name given to edible native Australian plants and animals. The Australian Aborigines survived on the native species for thousands of years, but it has come to comprise only a small proportion of the Australian modern day diet. Over the last couple of decades however, there has been increasing interest in bush tucker and more native foods have been appearing in supermarkets and on dinner tables.

Plants widely used in the bush food industry include Illawarra Plum (*Podocarpus elatus*), Davidsons Plum (*Aracaria bidwillii*), finger lime (*Citrus australis*), lemon aspen (*Acronychia acidula*), pepper berries (*Tasmannia* sp.), bush tomato (*Solanum centrale*) and Warrigal greens (*Tetragonia tetragonoides*). Native animal species farmed or harvested for meat include kangaroos, emus and crocodiles.

Ask students to investigate the types of plants and animals used as bush tucker, traditional cooking methods, bush tucker nutrition, issues associated with eating native species, and identification of foods in our diet that we could substitute with native species.

Why not start a bush foods garden at your school or have a bush food feast for your Science Week festivity?

Where did my dinner come from?

Ask students to take a snapshot of a meal so they can understand the energy required to put it on the table. This will be quite complicated and will require some discussion about the ways in which fossil fuels are used. Ask such questions as:

- Record what you have for dinner tonight
- Look at the labels on food packaging and find out where all the ingredients came from. Was your dinner grown in Australia or overseas?
- Did your dinner require a lot of energy to produce? Did it take a lot of fossil fuels to grow? Did the meal include processed food? Estimate the amount of energy used. Estimate the amount of energy used to transport the food. Estimate the amount of energy used to cook the food.
- What could you change about your dinner so that less fossil fuel is used?

http://www.sbs.utexas.edu/resource/onlinetext/Definitions/resources.htm discussion on human use of natural resources

Senior Secondary

Research a case study

Find a recent article from a newspaper that deals with an issue relating to human use of a natural resource.

Two examples are:

http://www.smh.com.au/news/environment/human-greed-takes-lions-share-of-solar-energy/2007/07/02/1183351126304.html

http://www.theaustralian.news.com.au/story/0,25197,23375772-643,00.html

Ask students to present a summary of the article in the form of a short essay or class presentation with lead questions such as what type of natural resource is identified in the article?; Is the resource use sustainable?; What are the environmental, social and economic issues associated with using this resource?; Discuss any other relevant issues such as strategies for changing human attitudes towards sustainable use of resources.

Where will the people go?

Global population was three billion in 1960, six billion in 1999, and is expected to reach nine billion or more by 2050 with the extra growth almost all in the less developed world. According to the United Nations Population Fund, Australia will have a population of 27.9 million in 2050. So a very small percentage of the world's population lives in Australia!

In Australia, the average population density is 2.3 people per square kilometre. However, 86% of the population is concentrated in a small section in the south-east of the continent (on 7 million hectares of land – 0.9% of Australia). Why is this so?

By the year 2045, it is estimated that Australia's population (assuming immigration continues at its present rate) will increase to 32 million. This means that the equivalent of two more Sydneys AND two more Melbournes would have to be built.

Provide each student with a map of Australia indicating the major cities and climatic zones (showing rainfall most importantly), and get them to mark in the Great Dividing Range, forested areas, deserts, productive agricultural areas and any other important features. They should note that only 10% of Australia is arable (suitable for growing crops).

Ask your students where they would build the 'new' Sydney and Melbourne so that residents would have a comparable quality of life (this isn't a far-out question as they will be faced with this during their lives).

Ask your students to consider water supply, sewerage facilities, roads, housing needs and commercial centres.

Now consider the impact of population growth on already severely overpopulated countries such as India, China, Mexico or Japan.

Older students might like to read such discussion starters as the article at http://www.manningclark.org.au/papers/aspire.htm *Our Population, Our Future What Sort of Country Do We Aspire To Be?*

Wall of Fame

Charles Keeling (1928-2005)
An American scientist who began recording atmospheric carbon dioxide concentrations in 1958 at an observatory on top of the Mauna Loa volcano in Hawaii.

Carl Sagan (1934-1996)
American astronomer and astrochemist who pioneered exobiology (the study of the origin, distribution and evolution of life) and promoted the search for extraterrestrial intelligence. He helped to solve the mysteries of the environmental conditions on Venus, Mars and Titan.

Steven Hawkings (1942 -)
British theoretical physicist who showed that Einstein's General Theory of Relativity implied space and time would have a beginning in the Big Bang and an end in black holes.

Harry Hess (1906-1969)
American geologist who discovered in 1960, with the help of Robert Dietz, the Mid-Atlantic ridge and the phenomenon known as seafloor spreading.

James Lovelock (1919-)
English climate scientist and environmentalist who developed the Gaia hypothesis, which describes the Earth as a single organism whose equilibrium is regulated by its living components.

Clair Patterson (1922-1995)
An American geochemist who developed the uranium-lead dating method that finally allowed the true age of the Earth to be calculated.

Arthur Holmes (1890-1965)
British geologist who pioneered the use of radiometric dating in calculating the age of the Earth. In 1946 he estimated the Earth was at least 3 billion years old when all previous estimates were no older than 100 million years.

Edwin Hubble (1889-1953)
American astronomer who revolutionised our understanding of the size and structure of the universe. He proved the existence of galaxies other than our own (the Milky Way), and through studying the speed at which galaxies move away from each other, discovered that the universe expands uniformly.

Alfred Wegener (1880-1930)
German geophysicist and climatologist who first proposed plate tectonic theory, continental drift and the notion that the continents had once been assembled in a super-continent he referred to as Pangaea.

Albert Einstein (1879-1955)
German theoretical physicist who made many important contributions to physics, of which he is best known for his theory of relativity. His work had important implications for astronomy and cosmology.

Mary Anning (1799-1847)
Anning is commonly referred to as the 'greatest fossilist ever known'. A devoted collector of fossils all her life, she discovered the first complete ichthyosaur skeleton at age 12, first ever plesiosaur skeleton at 14, and first ever complete pterosaur skeleton at 21.

David Edgeworth (1858-1934)
Sydney University's Professor of Geology from 1890-1924, David led the first successful attempt to climb the active Antarctic volcano, Mt Erebus and then made a four-month journey to reach the South Magnetic Pole.

Charles Darwin (1809-1882)
English naturalist who developed the concept of evolution and proposed that all species on Earth have evolved over time from one or more common ancestors through the process of natural selection.

Henry Cavendish (1731-1810)
In 1797 Cavendish, an English chemist and physicist first produced an accurate value for the gravitational constant (Newton's Law of Universal Gravitation) allowing him to determine the mass of the Earth.

Georges Cuvier (1773-1838)
Cuvier was a French naturalist and zoologist instrumental in establishing the fields of comparative anatomy and palaeontology by comparing living animals with fossils and is well known for proving extinction as a fact.

Gideon Mantell (1790-1852)
English geologist, palaeontologist and obstetrician credited with discovering the first dinosaur fossil (an Iguanodon).

Isaac Newton (1643-1727)
English physicist, mathematician and astronomer generally regarded as the most influential scientific intellect of all time. He defined the three laws of motion and universal gravitation which had a huge impact on theoretical astronomy.

James Hutton (1726-1797)
A Scottish farmer and naturalist known as the founder of geology. He believed that the history of the Earth could be understood through the study of geological processes such as erosion, sedimentation and volcanism.

Abraham Ortelius (1527-1598)
A Belgium cartographer and geographer recognised for creating the first modern world atlas in 1564.

A Science Week Activity: expand on this wall of fame to include modern Australian Earth Scientists

USEFUL WEBSITES

General Geoscience

Geoscience Australia
http://www.ga.gov.au/education/ From this page you can link to Geoscience Australia Education Resources, which list a range of 3-D models to download and cut out, along with the regional seafloor and land topography map displayed in the Education Centre. The education page also links to:

Fabulous facts about Australia including *Australia through time*, dimensions of Australia, landform information such as the longest river, highest mountain, islands and deserts.
http://www.ga.gov.au/education/facts/

Factsheets – natural hazards and minerals
http://www.ga.gov.au/education/factsheets/index.jsp

U.S. Geological Survey – Education
http://education.usgs.gov/ Lots to explore here including an electronic version of *This dynamic Earth: the story of plate tectonics* (1996) at http://pubs.usgs.gov/gip/dynamic/dynamic.html

This Dynamic Planet map (earthquakes, volcanoes and plate tectonics plus impact crater locations) has a new 2006 edition available from http://pubs.usgs.gov/imap/2800/ Click through to the Smithsonian Institute and you can download individual sections of the map.

Minerals Council of Australia – Education
http://www.minerals.org.au/primary is well worth a visit as there are many downloadable resources of interest at the primary, secondary and tertiary levels. The CD, which has been provided to secondary schools, can also be downloaded from this site as a series of 3-4Mb files.

NASA
http://www.nasa.gov/audience/foreducators/index.html is a must-visit site for extra assistance for educators – podcasts, lessons, graded exercises from pre-school to tertiary in the geosciences and life sciences.

http://kids.earth.nasa.gov/ A wealth of educational materials for primary and lower secondary students along with teachers guides to assist.

Australian Bureau of Meteorology
http://www.bom.gov.au/lam/ has resources for special purposes, including many for teachers and students.

Chapter 1 – some selected sites

KidsAstronomy.com http://www.kidsastronomy.com/

National Geographic Virtual Solar System
http://www.nationalgeographic.com/solarsystem/

Museum Victoria, Melbourne Planetarium
http://www.museum.vic.gov.au/planetarium/

Australian Museum, Geoscience: The Earth
http://www.amonline.net.au/geoscience/earth/solar.htm

Global maps showing the positions and shapes of the continents starting from 540 million years ago.
http://www.scotese.com/earth.htm

http://www.unb.ca/passc/ImpactDatabase/austr.html has data and links for worldwide impact craters and links to Google maps, including 26 Australian craters

Model of Sea-Floor Spreading Teachers Guide
www.ucmp.berkeley.edu/fosrec/Metzger3.html

Continents on the Move
http://www.pbs.org/wgbh/nova/ice/continents/

Plate Tectonics www.platetectonics.com

Chapter 2 – some selected sites

Volcano World (US) http://volcano.und.edu/ extensive site with well-written material about volcanoes, plate tectonics and earthquakes.

Oz Volcanoes http://science.uniserve.edu.au/school/quests/ozvolcanoes.html

Hawaii Centre for Volcanology
http://www.soest.hawaii.edu/GG/hcv.html

Global Volcanism Program, Smithsonian Institute
www.volcano.si.edu

Big Ben: The Fire Beneath the Ice (Australian Antarctic Magazine, Spring 2001) www.aad.gov.au/Asset/Mag_spring01/science04_05.pdf

Geohazards International http://geohaz.org/

Willandra Lakes Region (DEC) www.environment.gov.au/heritage/publications/pubs/world-heritage-willandra.pdf

Chapter 3 – some selected sites

CSIRO Marine and Atmospheric Research www.cmar.csiro.au/

Department of Agriculture, Fisheries and Forestry (Australian Government) http://www.daff.gov.au/fisheries

Sturt National Park (National Parks & Wildlife Service)
www.nationalparks.nsw.gov.au/parks.nsf/parkContent/N0032?OpenDocument&PartKey=N0032&Type=Xo

Wetland Information (NSW Dept of Natural Resources) www.dnr.nsw.gov.au/water/wetlands.shtml

The RAMSAR Convention on Wetlands www.ramsar.org

Groundwater Dependant Ecosystems (Australian Government)
www.connectedwater.gov.au/framework/ground_dependant_ecosystems.html

Wild Kids: Freshwater (Australian Museum Online)
www.amonline.net.au/wild_kids/freshwater.cfm

Stromatolites, Macquarie University
http://pilbara.mq.edu.au/wiki/Stromatolites

Chapter 4 — some selected sites

The Naracoorte fossil assemblage
http://www.samuseum.sa.gov.au/ Use the journal search on Naracoorte to obtain further information about the Naracoorte fossil assemblage. Example: trssa_v124_p091p104

CSIRO Science experiments http://www.csiro.au/resources/ps1tk.html instructions for making 'fossils' and other plaster casts.

Animations about fossil formation http://www.bbc.co.uk/sn/prehistoric_life/dinosaurs/making_fossils/makingfossils/index.shtml

Australian Museum http://www.lostkingdoms.ccom/facts lists reptiles, birds and mammals from the Cretaceous period to the Holocene epoch with hyperlinks to brief notes about each one.

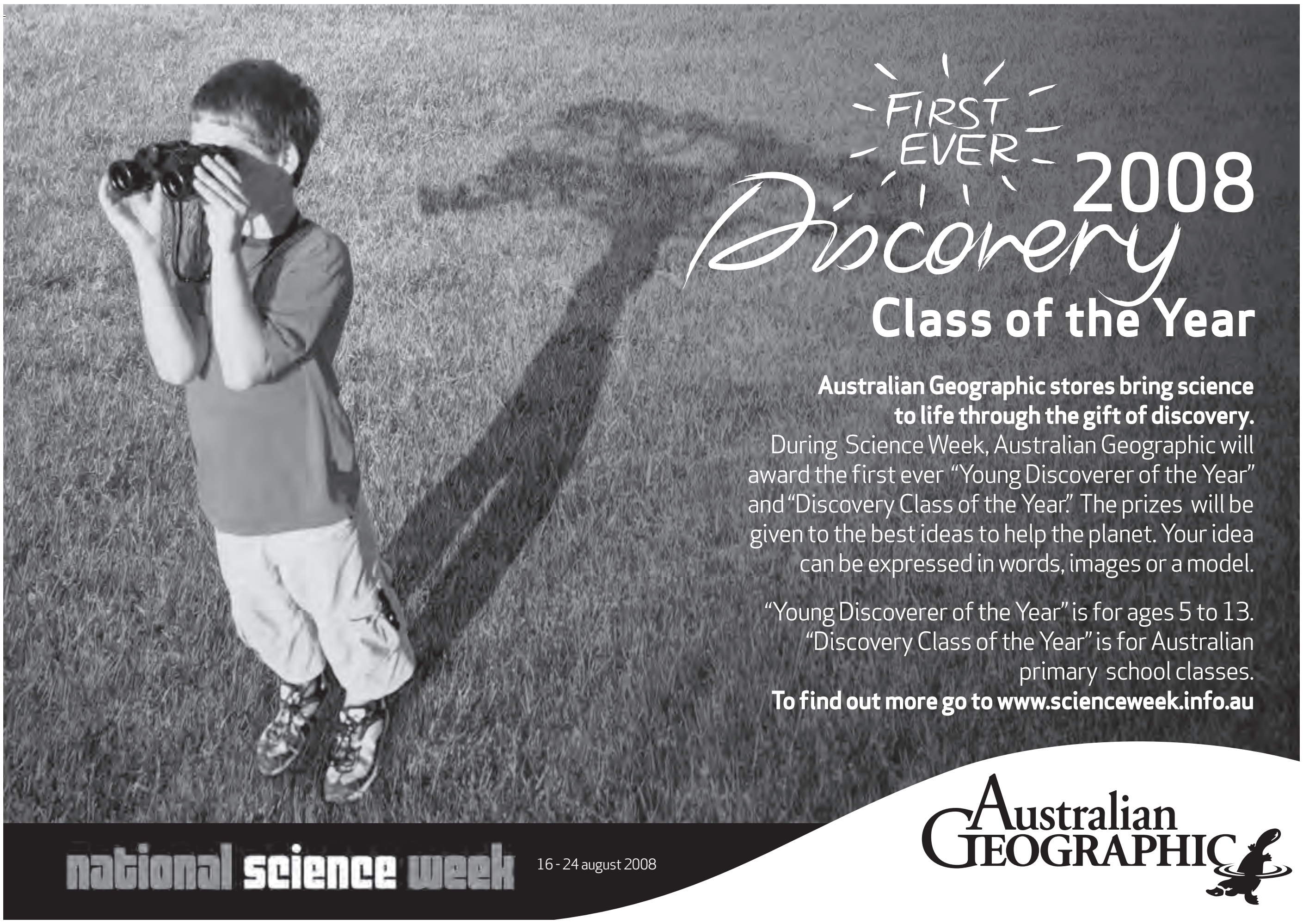
Kangaroo Industry Association of Australia
www.kangaroo-industry.asn.au/

Birdsville Geothermal Power Station (QLD EPA)
www.epa.qld.gov.au/publications/p00834aa.pdf/Birdsville_geothermal_power_station.pdf

CSIRO Sustainable Ecosystems www.cse.csiro.au/

Energy Australia: Renewable Energy (EnergyKidz)
www.energy.com.au/energy/ea.nsf/Content/Kids+Renewable+energy

Ecological Footprint Calculator (World Wildlife Fund)
http://footprint.wwf.org.uk/



Did National Science Week inspire your students? Then keep that inspiration alive!

CSIRO's CREST program can help you continue National Science Week's Planet Earth theme, allowing students to create their own investigation or product.

CREST provides structured support for open-ended investigations in science and technology for students and teachers, with a range of levels, extensive support materials and PD.

CREST is also a great framework for creating science competition entries for local STA competitions, and the national BHP Billiton Science Awards.

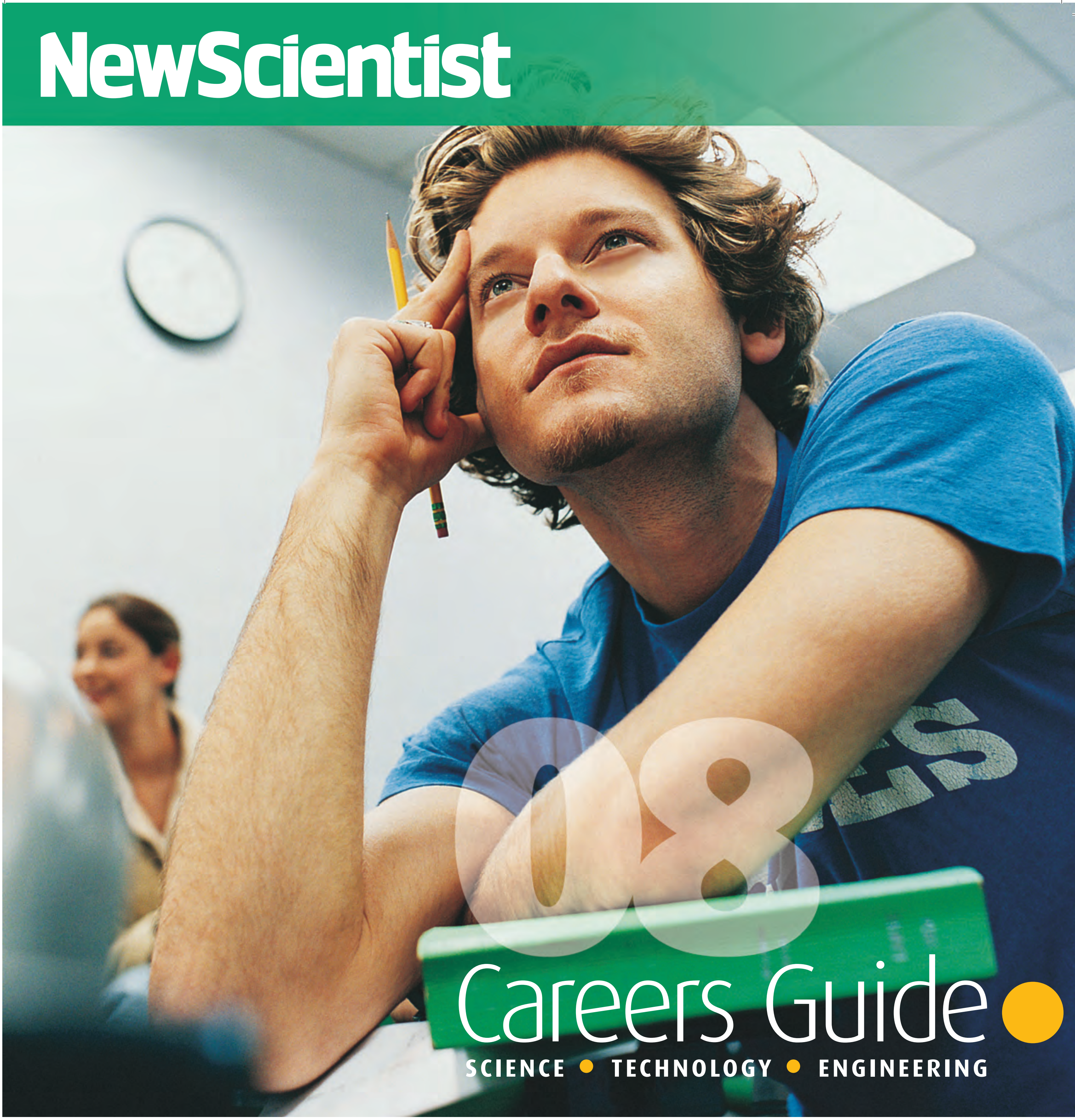
CREST AWARDS

CSIRO

CREST projects are as broad as your students' imaginations. Here are some past Earth-themed projects to get you going:

- *Ants and weather: can ants be used to predict the weather?*
- *Biodegradable plant containers containing plant nutrients*
- *Comparing composts in arid areas*
- *Conquering salinity – which Australian native grass is best suited?*
- *Do pollutants in the air affect efficiency of solar panels?*
- *Reducing water erosion in flood conditions*

More information: 1800 626 646 or www.csiro.au/crest



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- Where the jobs will be in 5 years time
- Comprehensive salary reports
- The skills and attributes employers look for

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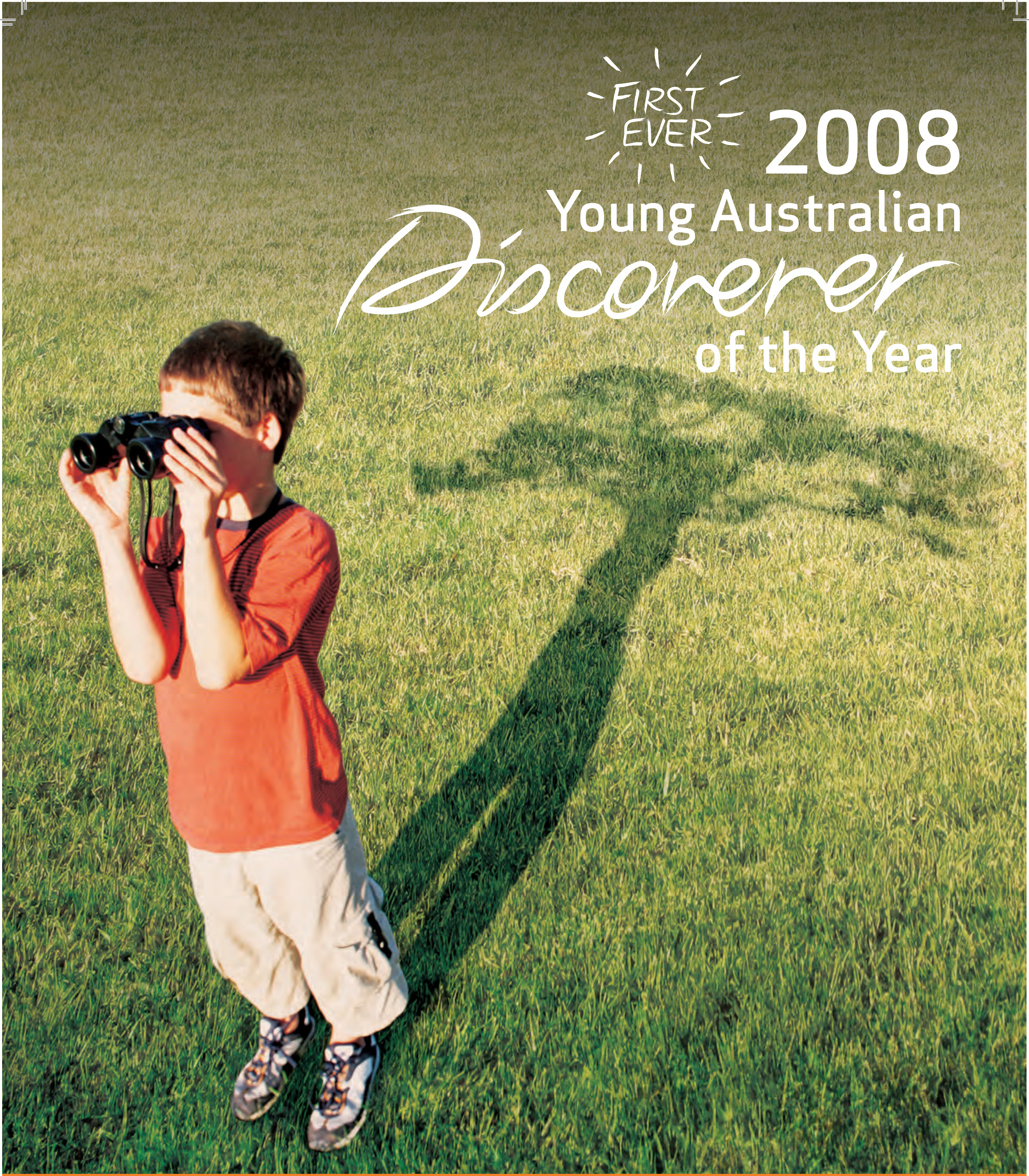

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Your idea can be expressed in words, images or a model.

"Young Discoverer of the Year" is for ages 5 to 13.
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national science week 16 - 24 august 2008