OutOfThisWorld: Investigating Space

Celebrating the 20th publication of ASTA's resource book for teachers.

free
copy to schools

Australian Science Teachers Association

A resource book of ideas for National Science Week 2004

Science for 8 to 14 year olds at ABC Science Online

Why Is it So?

Professor Julius Sumner Miller's TV series inspired a generation of Australians to think about and enjoy science. Now you can view original episodes of Why is it So? on Broadband at ABC Science Online.
abc.net.au/science/features/whyisitso

The ExperiMentals

In the spirit of Professor Julius, comes The ExperiMentals. For Surfing Scientist Ruben Meerman and 'Bunsen' Bernie Hobbs, no experiment is too big, crazy or inexpensive! They tackle everything from outer space to dating tricks and the kitchen sink - exploding, demystifying and explaining along the way.
abc.net.au/science/experimentals
(Broadband video is available through dial-up and other internet connections – you just need Windows Media Player or Real Player which are available free online.)

The Surfing Scientist

Ruben Meerman is the Surfing Scientist. His action-packed school shows have fascinated thousands of children in Qld and now he's bringing his liquid nitrogen, bananas and balloons to other parts of Australia along with this accompanying website. The Surfing Scientist teachers' lesson plans are designed for primary teachers - and high school teachers can use the demonstrations and conundrums to enrich lessons and add some fun.
abc.net.au/science/surfingscientist

THE HON PETER McGAURAN MP

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FOREWORD

This year the Australian Science Teachers' Association is celebrating 20 years of involvement in what has grown, due in large measure to ASTA's commitment, to become National Science Week. ASTA was the principal organisation involved in establishing what was then known as "Australian Science in Schools Week" in 1984. On the occasion of the twentieth anniversary of what is now a major national event with widespread community participation, I would like to acknowledge ASTA's unwavering support for National Science Week and, indeed, its commitment to assisting science teachers and the teaching of science in schools.

This 20th Anniversary edition of the Resource Book has a proud history, a similar edition addressing ASTA's schools theme for National Science Week having been produced every year since 1984.

Previous editions have provided materials on topics such as *Animal, Vegetable, Mineral* (1993), *Exploring Biodiversity* (2001) and *Investigating Freshwater* (2003). I am confident the Resource Books have proven to be a lasting source of inspiration for teachers over the years.

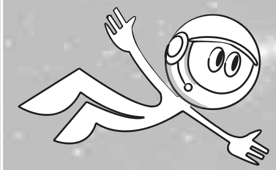
I am therefore delighted to launch this 20th anniversary edition of the Resource Book, which explores the theme *Out of this World: Investigating Space*. It has been developed by an outstanding team of space science educators and contains a wealth of up to date material designed to assist teachers in engaging students in work on space related activities, challenges and projects. I am delighted also that, for the first time in 2004, this Resource Book is being distributed to every school in Australia.

I encourage teachers to use the Resource Book not only in planning for your school's participation in National Science Week 2004, but also in planning science activities throughout the year.

Peter McGauran
Australian Minister for Science

May 2004

Out of this World: Investigating Space



Out of this World: Investigating Space is an ASTA resource book of ideas for teachers for National Science Week 2004. The information you provide will help ASTA make improvements to future publications.

TEACHER FEEDBACK QUESTIONNAIRE

YOUR NAME	YEAR LEVEL YOU TEACH
YOUR SCHOOL NAME	YEAR LEVELS CATERED FOR AT YOUR SCHOOL
SCHOOLS ADDRESS	
SCHOOL PHONE NUMBER	SCHOOL FAX NUMBER
SCHOOL EMAIL ADDRESS	

Please indicate your ratings

FEEDBACK CRITERIA – *Out of this World: Investigating Space*						
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 2004 ←						→ Not applicable
2. Resource Book Content	**1**	**2**	**3**	**4**	**5**	
Too complex ←						→ Too simple
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. Number of students who were involved in activities from this resource book ....

....

4. What did you find most valuable about the book? ....

Why? ....

....

5. What did you find least valuable about the book? ....

Why? ....

....

6. Any other comments about *Out of this World: Investigating Space* or suggestions for how it could be improved?

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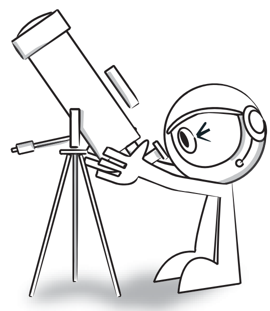

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Contents

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AUSTRALIAN SCIENCE TEACHERS ASSOCIATION
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NATIONAL SCIENCE WEEK

ENGINEERS AUSTRALIA

The Australian Science Teachers Association (ASTA) is proud to present *Out of this World: Investigating Space*, the twentieth in a series of resource books published by ASTA annually since 1984, for schools for National Science Week.

ASTA acknowledges the funding received for this resource from the Australian Government through the National Innovation Awareness Strategy and Engineers Australia. ASTA Council thanks and congratulates the authors and designers of *Out of this World: Investigating Space*, the ASTA National Science Week Representatives in each state and territory and all the teachers and students who organise and participate in the many school and public activities, events and competitions celebrating science.

Gary Thomas
ASTA President

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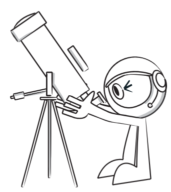
Scientific authorisation: Associate Professor D.J. O'Connor. Head, School of Mathematical and Physical Sciences, University of Newcastle, NSW.

Associate Professor Fred Menk. School of Mathematical and Physical Sciences, University of Newcastle, NSW and Cooperative Research Centre for Satellite Systems, Canberra, ACT.



Introduction

Out of this World: Investigating Space has been designed to assist teachers engage students in space science. People of all ages are stimulated by and curious about the mysteries of the universe, the exploits and discoveries of manned and unmanned space missions, the possibilities of travel to other planets in our Solar System or beyond and the existence of life elsewhere in the universe.

The range of space science topics and the sources of information about space is diverse. The material in this book has been specifically selected to contribute to raising awareness about -

- recent Australian achievements in space exploration and astronomy
- engineering and technological input into space science
- popular and frequently studied space topics
- the possibilities of life beyond Earth
- space missions that are currently being undertaken or planned for a better understanding of the universe.

The information is interesting and up-to-date, prepared in an easily accessible format for adaptation by teachers for appropriate use with their students.

How the book is organised

This book has been organised into **chapters** that introduce students to a range of space topics, interesting facts and space science. Each chapter is structured to include scientific background to the topic or topics introduced, activities, website addresses and uniquefacts.

Activities are included in most chapters as suggested ways to engage students in further exploration of areas of interest.

Websites, where appropriate, have been suggested to enable readers to access further information and triggers for additional student challenges and projects. These websites were checked for suitability at the time of printing but it is not guaranteed that they will be available at all times. Visit the ASTA website www.asta.edu.au for direct links to the top twenty sites.

Did you know?... is a section of interesting facts presented at the end of each chapter.

A **Glossary** of words used throughout the book is included, together with a page of **References** to promote further research relating to the topics and activities.

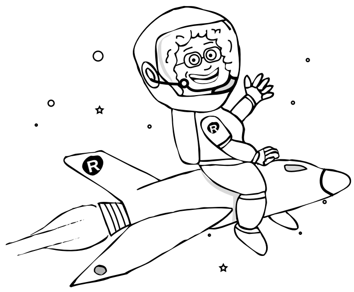
Please complete the **Questionnaire** on page 2 and return it to ASTA so we have your feedback about this resource.

Curriculum guidelines

Whilst there have been moves to integrate and standardise curriculum across Australia, curriculum is still fundamentally state and territory based. This resource book is deliberately not prescriptive in terms of what must or must not be done but seeks to assist teachers to undertake activities and studies of interest to them and their students around space science. Teachers will integrate the activities under appropriate areas of the curriculum framework operating in their state or territory.

Online services

How often has a student asked a question in class that you have found too difficult to answer? It happens to us all. Use these services to seek your answers.



Ask 'Mrs Rocketfuel'. A teacher with expertise in space science will answer you as soon as possible. Email to space.ed@hunterlink.net.au using "Ask Mrs Rocketfuel" as your subject.

'Ask an Astronomer' has over 3000 questions and answers archived. An astronomer from your state will respond to your questions. Visit www.astronomy.org.au/ browse the Education link and email your questions.

Ask Jeeves at http://www.ask.com/ and receive a reference list of websites to help you research your topic.

Safety Awareness

All student activities included in *Out of this World: Investigating Space* have been designed to minimise hazards. However, there is no guarantee expressed or implied that an activity or procedure will not cause injury. Teachers selecting an activity should test it with their own materials before using it in class and consider the occupational health and safety requirements within their state or territory. Where physical activity is involved, the teacher should be qualified to conduct the activity. Any necessary safety precautions should be clearly outlined by the teacher before starting the activity. Students must also be provided with any safety equipment prior to commencement.

C1 Dr Andrew Thomas - Australia's NASA astronaut

Life as an astronaut is exciting and unpredictable. All astronauts are courageous, smart, physically fit and require enormous mental strength to take on the challenges of space missions.

Dr Andrew (Andy) Thomas was born in Adelaide in 1951. He's the third Australian to be involved in NASA's space program. Previously, Dr Phillip Chapman was with the Apollo/Skylab program and Dr Paul Scully-Power, an oceanographer on Challenger 41G in 1984. Andy is the first to be selected as a space shuttle mission specialist.

Dr Andrew Thomas in space. Source: NASA

Planning his next space walk

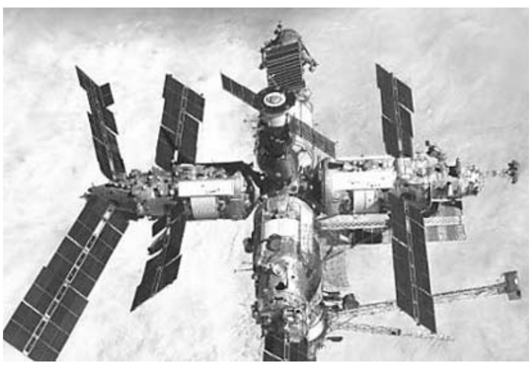
Andy has been assigned to the next space shuttle mission. Part of the mission is to practice heat protection repair methods. This will help prevent another tragic incident like the Columbia disaster in 2003.

Andy's missions so far...

1996 payload commander of the STS77 Endeavour mission - a highlight of the mission was the testing of an inflatable lightweight antenna for future spacecraft design.

1998 lived and worked in space for 20 weeks on the Mir space station, from January to June. He was the last NASA astronaut to work on Mir before the space station's demise in 2001. Andy gives high praise to Mir, as an impressive space facility that provided extremely valuable contributions to the spaceprogram.

2001 space walk outside the International Space Station during his space shuttle Discovery STS 102 mission. He completed the 6.5 hour space walk to install a refrigeration back up system, a stowage platform and a spare coolant pump to the outside of the US Destiny module of the space station. He also used the shuttle's robotic arm to manoeuvre experiments and supplies for the space station.



Mir Space Station. Source: NASA

Fire!

During his stay in 1998, a fire started in the air cleaning apparatus in one of Mir's modules. The fire alarm didn't trigger and the carbon monoxide levels in the thick smoke reached twenty times the accepted safety levels. As a team, the crew worked quickly to avoid a potentially deadly disaster.

Australian artefacts in space

During two of Andy's space shuttle missions he carried artefacts of Australian history into space. These include;

- a wooden section of the anchor from James Cook's ship Endeavour,
- lapel wings of famous Australian aviators Ross and Keith Smith who won the historic England to Australia air race in a twin-engined Vickers Vimy bomber in 1919,
- an Australian boomerang to signify a safe return,
- Charles Kingsford-Smith's watch,
- a wood fragment from Douglas Mawson's Anarctic hut, and
- a special personal keepsake, a very old steel flint that belonged to his great, great grandfather who was an outback explorer. He was a member of the first expedition to successfully cross Australia from south to north.

Andy links the Sydney 2000 Olympic Games and space

To symbolise the international collaboration necessary for both the Sydney Olympic Games and the International Space Station, Andy arranged for a replica Olympic Games torch to be flown onboard the Space Shuttle Atlantis. This coincided with the handover of the Olympic torch to Australia in Athens.

Did you know?..

On Mir, Andy discovered that his Sokol emergency space suit didn't fit. It was too short, possibly due to his body's increase in length in microgravity.

On all space walks, astronauts wear adult sized 'nappies' called Maximum Absorbency Garments.

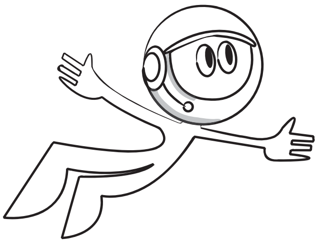
Activities

- Organise information about Dr Andrew Thomas into a poster, powerpoint presentation or brochure.
- Design a time line using the information above and NASA biographical material to represent important events in Andy Thomas' professional life.
- Prepare and present a two minute speech about Dr Thomas using the planning tools above.

Websites

http://www.jsc.nasa.gov/Bios/htmlbios/thomas-a.html
Andy Thomas biography.
http://www.pbs.org/safarchive/5_cool/5_mir/mir2.html
Andy Thomas' mission on Mir.

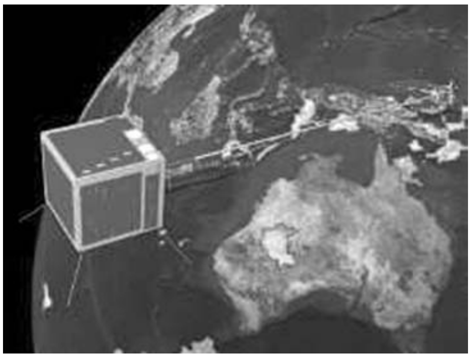
C2 Australian space news



Australia has a rich history in space investigation and discovery. Our scientists are well recognised for their contributions to space research.

FedSat - A space engineering triumph

The Federation Satellite (FedSat) was launched in 2002 through an initiative of the Cooperative Research Centre for Satellite Systems to integrate the research and expertise of Australia's space engineering, space science, communications and satellite systems. Its orbit is 800km above the Earth's surface.



FedSat is a co-operative project intergrating research and expertise of Australian engineering and technology. Source: NASA

FedSat carries six experiments that are involved in communication, engineering, space physics and space weather, remote sensing and a new computer technology that can undergo circuit changes by remote commands.

After a year of successful operation, the project received a National Engineering Excellence Award for its contribution to Australia's economy and quality of life.

It also carries a CD containing audio messages from the Australian public about life and the cosmos.

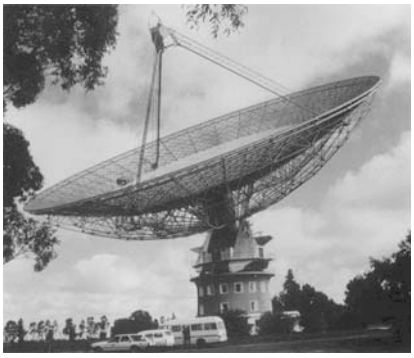
Another star's planet

A Jupiter-like planet has been discovered in orbit around a nearby star that is very like our own Sun.
The Anglo-Australian Telescope in NSW was used to determine that;

- the planet orbits its 'sun' every six years,
- the distance between the planet and its 'sun' is three times the distance between Earth and our Sun.

The first double pulsar

Astronomers at the Parkes Observatory in NSW led by Dick Manchester, have discovered a double pulsar - two pulsars orbiting each other.



The Radio telescope at the Parkes Observatory. Source: NASA

A pulsar is a rapidly spinning neutron star. It's the incredibly dense, collapsed core of a massive star that has ended its life in a supernova explosion. It's only about 10-20km in diameter yet heavier than our Sun. A pulsar emits intense beams of radio energy that can only be detected by radio telescopes, but only if the beams sweep across Earth's path in space.

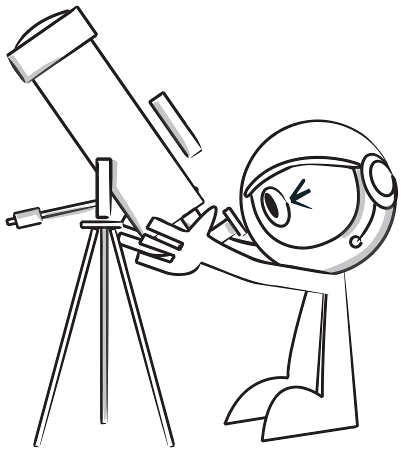
Astronomy in the classroom

Two professional-class robotic telescopes are under construction at the Siding Spring Observatory in NSW and Maui, Hawaii as part of The Faulkes Telescope Project.

The telescopes are designed to bring astronomy directly into the classrooms of students in Australia, the UK and USA.

The telescopes will enable students to make observations of planets, stars and galaxies from their school, view spectacular images of the northern and southern skies, study curriculum based science projects designed by professional astronomers and possibly even make new scientific discoveries.

The two Faulkes Telescopes should be fully operational for Australian schools in 2004.



An extra arm for our galaxy

Radio telescopes at the Parkes Observatory and the Australia Telescope Compact Array discovered an extra spiral arm of our Galaxy. It is about 6,500 light years thick and rich in hydrogen which is detectable by radio Telescope.

A Spiral galaxy spinning in space. Source: NASA

Counting stars

There are 70 thousand million million million stars in the visible universe. This is the most accurate count of stars that has ever been completed.

Australian astronomers used powerful telescopes, including the Anglo-Australian Telescope to look at each galaxy in their field of view. The astronomers calculated the number of stars by determining the brightness of each galaxy and then estimated how many stars it contained. They then extrapolate the number to the whole visible universe.

How many stars can you count in this patch of sky? Source: NASA

Did you know?...

There are more stars in the universe than all the grains of sand on Earth.

3D map of the southern sky

A survey of 250,000 galaxies has been completed to create a 3D map of the southern sky. This was undertaken by the world's most complex astronomical instrument called the Two Degree Field (2sF) system at the Anglo-Australian Telescope. It was designed to collect up to 400 spectra of objects at the same time anywhere within a two degree field of the sky.

Did you know?...

The team at the Parkes Observatory have been responsible for finding over 1000 pulsars.

Activities

- Make use of the Faulkes Telescope project to design and carry out your own experiment. Refer to the websites below.

- Research and identify information about one of the Australian facilities underlined in the text.
  * Prepare an information report using the following questions as stimulus:
    - Where is it?
    - When was it built?
    - How big is it?
    - What important or interesting discoveries have been made there?
    - How does it work?
  * Construct a model of the facility.
  * Display the report and the model.

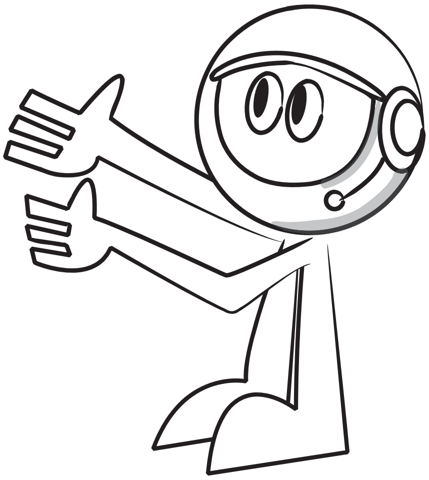
- Find out about one other astronomical facility such as the ATNF, AAO or MSSO.
  * What do the acronyms mean?

- Report on the contributions to space research made by the facility.

Websites

http://www.astronomy.org.au
Gateway to all the Australian observatories.

http://www.faulkestelescope.com
Faulkes Telescope.

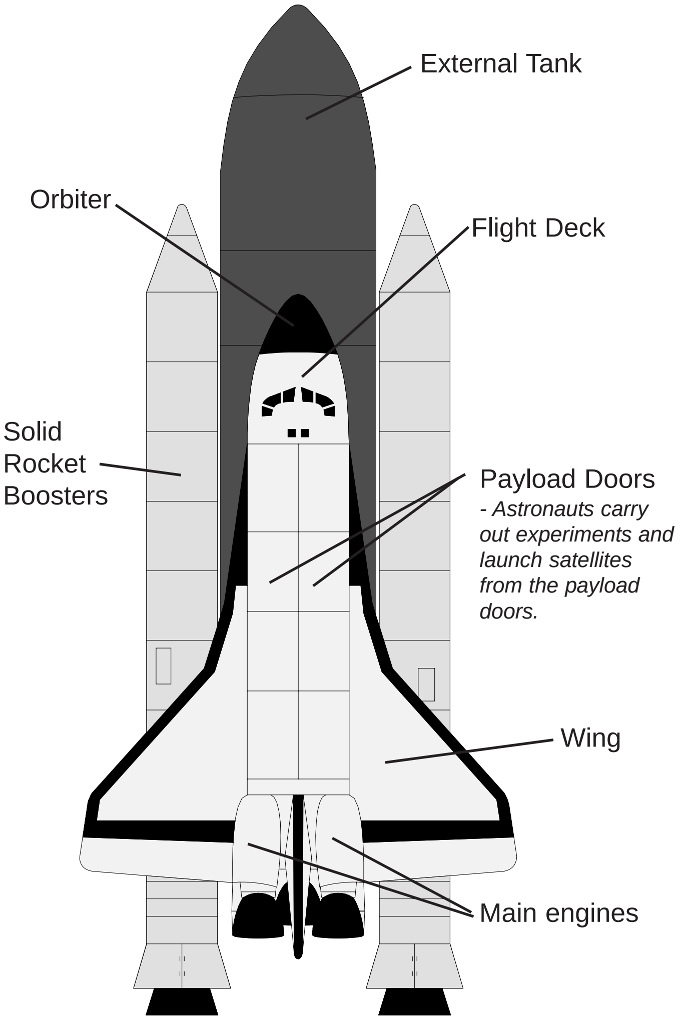


C3 Interview with the space shuttle Endeavour

by Ozzy Orbit, space news reporter

Note: This article is fictional in style but ALL the information provided is factual.

Ozzy: What are all the parts of a space shuttle?
Endeavour: A space shuttle is made up of the space plane which is also called the orbiter, two solid rocket boosters (SRBs) and a foam covered external tank (ET).



The complete space shuttle ready for launch, including the external tank and solid rocket boosters.

Ozzy: How long does it take to prepare for a space mission?
Endeavour: About 3-5 months. After returning from missions, all shuttles are thoroughly inspected. SRB are checked, cleaned and refitted with solid fuel. Any damage is repaired, for example heat shields may need replacing. A general maintenance and clean up is carried out including emptying the toilet and restocking food supplies.

When everything is ready, the space plane, SRB and brand new ET is reassembled in the upright position, on the launch platform, inside the Vehicle Assembly Building (VAB) which is 160 metres high.

Ozzy: How does the space shuttle get to the launch pad?
Endeavour: On a crawler - the largest, slowest moving vehicle in the world. It takes six hours at 1.6 km/hour. The road is made of smooth pebbles. They are crushed under the massive weight but they are easy to replace.

The space shuttle on the crawler, moving towards the launch pad. Source: NASA

Ozzy: What makes you most anxious when sitting on the launch pad?
Endeavour: The birds! Woodpeckers think the space shuttle is a tree. They peck at the foam on the ET. Once they made 72 holes, the whole space shuttle had to be returned to the VAB and the tank was replaced. A very expensive exercise! Now NASA mounts wooden birds of prey around the space shuttle and employs bird watchers to scare the birds.

Ozzy: How noisy is it during lift off?
Endeavour: The roaring noise of a space shuttle launch is one hundred million times louder than normal conversation. It would definitely damage your hearing. The astronauts cannot hear more than a muffled rumble because of the headphones and helmets they wear.

Ozzy: Why is there so much smoke when you launch?
Endeavour: It's mainly water. The sound vibrations could seriously damage the space shuttle. Most of the vibrations are absorbed into millions of litres of swirling water in a trench underneath the shuttle. During launch, the burning engines cause the water to evaporate. The water vapour rapidly condenses to tiny water droplets forming impressive billowing clouds. The hydrogen and oxygen fuels from the ET also make water when they ignite.

The space shuttle on the launch pad. Source: NASA

Ozzy: How are you able to lift off?

Endeavour: The upward thrust must exceed the weight. This is an example of Newton's 3rd law of motion, 'to every action there is an equal and opposite reaction'. The engines push hot gases downwards causing the space shuttle to accelerate upwards. The total weight at launch is over two million kilograms (equivalent to more than 1000 cars). The SRB and main engines provide a total thrust of about 32 million Newtons to launch the space shuttle.

The space shuttle launch is always impressive with the billowing clouds of water vapour. Source: NASA

Ozzy: What are the maximum 'g' forces experienced by the astronauts?

Endeavour: 3 g's during launch. The astronauts feel three times heavier than their normal weight. While lying on their backs during launch they feel like their chests are being crushed.

Ozzy: The space shuttle maintains the same thrust, why does it get faster?

Endeavour: That's easy. As the space shuttle rises higher it uses fuel. The mass of the space shuttle decreases, the result is an increase in speed.

Ozzy: What makes a space shuttle the best choice for space missions?

Endeavour: The space shuttle is very versatile. It functions like a rocket during launch, orbits Earth like a spacecraft, carries equipment like a truck, flies back to Earth like a glider and lands like a plane. New plans are on track for an improved space vehicle called a Crew Explorer Vehicle which means the space shuttle will retire by 2014.

Ozzy: Is your orbit out near the Moon?

Endeavour: Goodness no! It only takes eight minutes to reach the space shuttle's orbit at 300 km. It takes three days to reach the Moon which orbits at 384 000 kilometres.

Ozzy: Most people believe that there is no gravity in space orbit. Is that true?

Endeavour: No, no, no! Anything in orbit is under the influence of gravity, or it would not stay in orbit. The astronauts experience weightlessness because the orbiter essentially 'falls' around the Earth. Even on Earth, when you fall you are weightless - until you land!

Ozzy: Does the orbiter get damaged while in space?

Endeavour: Space rubbish, natural (cosmic debris) and man-made (space junk) doesn't usually cause any serious damage.

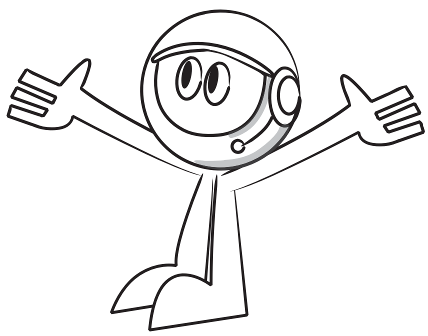
Ozzy: What's landing like?

Endeavour: The orbiter approaches the runway at an angle six times steeper than a passenger jet approaches, at a speed of about 300 km per hour. The runway is 4572 metres, the longest in the world The space shuttle also uses a parachute to reduce speed.

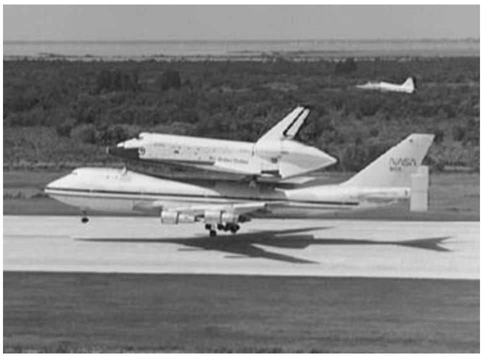
The space shuttle landing after a mission in space. Source: NASA

Ozzy: Can astronauts escape the orbiter during launch or re-entry?

Endeavour: On the launch pad, there are escape or egress baskets. If necessary, astronauts can slide down to catch nets and escape to a safe bunker. In flight, astronauts can attempt an escape through the hatch but only at 10 000 metres or less. The astronaut's orange suit includes a parachute, oxygen supply, a life raft, a survival kit with water, rations, radio beacon, signal mirror, flares and water dyes.



Ozzy: What happens if the weather is unsuitable for landing in Florida?
Endeavour: The Edwards Air Base in California becomes the landing destination. The space shuttle is returned to Florida, piggy backed on a specially modified 747.



This specially modified 747 is returning the space shuttle to Florida with a piggy back ride after it landed in California. Source: NASA

Did you know?...

Alligators like to bask in the sun on the Florida runway. They need to be moved before the space shuttle can land safely.

Ozzy: How did you get your name?
Endeavour: I was named after Captain James Cook's ship. He commanded the ship on its maiden voyage to observe the transit of Venus across the Sun. The measurements assisted scientists to determine the distance of the Earth from the Sun. During that trip he also surveyed the east coast of Australia and navigated the Great Barrier Reef.

Did you know?...

For every mission the astronaut crew design a 'mission patch'. They wear it on their space suits and clothing. It conveys information about the team and the destination or aim of the mission.

Mission patch from STS 41. Source: NASA
Who were the astronauts in this mission?

Activities

- Research technology spin-offs from the space program.
  * List innovations that have come out of space program technology that we use to improve our lives in the home and at play (eg. smoke detector, polaroid sunglasses).
  * Investigate the orginal purpose of the technology behind these innovations.
  * Write a report on one of these innovations and publish it in the school newsletter, on the school internet or website.

- Investigate a range of materials to determine the most effective sound insulator for earmuffs to be used in noisy conditions.

- Research the decibel level of everyday noise sources.
  * What is the loudest noise a human can tolerate without damage to hearing?
  * How does this compare to the decibel level of a space shuttle launch?
  * How does continued exposure to loud noises affect humans?

- Design a mission patch.
  * Research the mission patches that Andy Thomas wore for his missions.
  * Imagine you are a member of an Australian team undertaking a space mission to Mars. Work with your team to design the patch.

- Write an interview between an astronaut and a reporter.

- Design and make a model of a launch pad escape device. Consider all the dangers of the launch site in your planning.

Websites

http://www.decaturco.k12.in.us/space/STS MissionPatches.html Mission patches.

http://nasasolutions.com/at_home.html
Spinoffs for the home, farm, airport etc.

http://www.thespaceplace.com/nasa/spinoffs.html#chr
Spinoffs.

http://spaceflight.nasa.gov
Kinds of information about spaceflight.

http://kids.msfc.nasa.gov
Great for animated explanations.

C4 Top questions asked about space flight

Many questions are frequently asked about space flight. These are some of the most popular.

How does an astronaut go to the toilet in space?

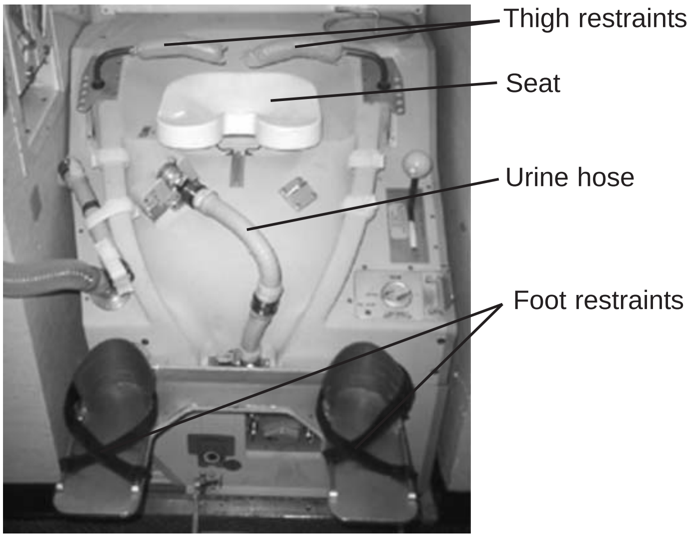
In the early space missions, astronauts had to go to the toilet in plastic bags. Things have come a long way as there is now access to a special toilet on board the space shuttle and the International Space Station.

During launch, re-entry and space walks, astronauts wear adult sized disposable nappies. NASA calls the nappy a Maximum Absorbency Garment.

Liquid waste

When an astronaut wants to urinate:

- They don't sit down.
- They attach a personal plastic funnel to a suction hose, then hold the funnel against their body (different shapes and sizes are available for different sexes).
- Urine is 'vacuumed' away.
- The urine is stored in a holding tank until dumped into space where it immediately vapourises due to a drop in pressure. It then crystalises due to the the cold. The result is an ‘ice shower’.



Space Shutte Toilet. *Source: NASA*

Solid waste

When an astronaut wants to defecate:

- They sit down and make sure they are in the right position. The hole diameter is only 20cm (much larger than the previous 10cm model), a good tight seal is important.
- To avoid floating away the astronaut uses foot restraints and bars that swing across the thighs. This ensures a tight seal so nothing escapes and there will be no unnecessary embarrassment.
- Air suction removes the faeces into the compartment below. These wastes are disposed of back on Earth.

Why is the launch dangerous?

90 per cent of the two million kilogram weight of the launching space shuttle is explosive fuel.

The solid rocket boosters (SRB) contain a very dangerous solid fuel mix. The propellant is an explosive combination of

- 16% aluminium powder - fuel,
- ammonium perchlorate - oxidizer,
- iron oxide - catalyst to speed up the reaction.

Once the SRB fuel has been ignited at the lift off time of 'T minus zero' the space shuttle is committed for launch.

What happens to the empty solid rocket boosters?

Fuel in the SRB is exhausted in just over two minutes, when the shuttle is already 45 km above the ocean. The empty, reusable, stainless steel SRB are disconnected from the external tank (ET). This is done with small explosives that disintegrate the connecting bolts. The SRBs fall into the ocean aided by parachutes. NASA ships drag the empty casings back to port where they are inspected, cleaned and refilled for a future mission.

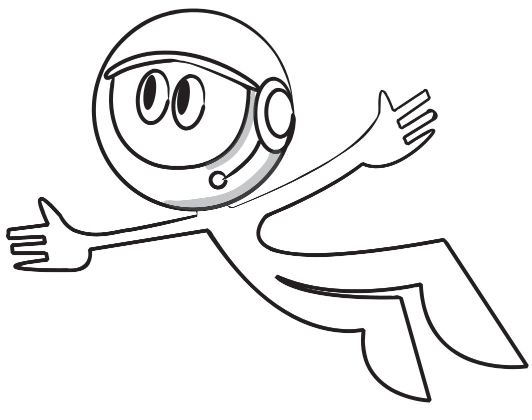
What dangers exist during re-entry?

During re-entry, the air outside the orbiter becomes super heated to about 1650^{0}C and ionised (the air particles become electrically charged) creating a plasma that causes communication problems. This produces a flickering pinkish-orange glow outside.

The intense heat can melt the aluminium framework of the orbiter if the protection system is seriously damaged. The orbiter is protected by a thermal protection system of

- 24 000 tiles,
- felt surface insulation blankets,
- reinforced carbon-carbon fibre on the places that become most heated, such as the leading edge of the wings.

The orbiter glides back to Earth, using aerodynamic drag to reduce its speed from 28 000 km/hour to the 300 km/hour touchdown speed. There is a once only opportunity to land, no turning back for a second try.



What are the dangers for astronauts?

In space, the astronaut's life support system is provided by the space craft, the space station and/or their space suit. There are many dangers which include;

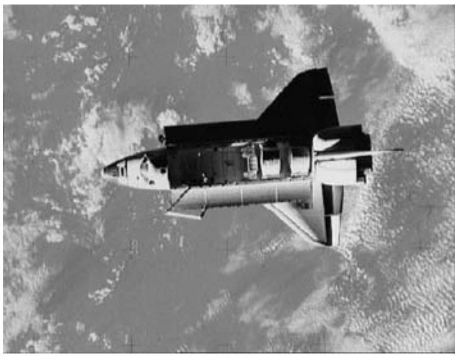
- very harmful radiations from solar flares, X-rays, gamma rays, solar wind and cosmic rays can damage DNA and cause cancer.
- fast moving meteoroids (small rock particles) striking the space suit could puncture the suit causing instant depressurisation. The astronaut's blood would boil and their body inflate inside the suit.
- the Sun causes the outside of the suit to be exposed to temperatures up to 120^{0}C while the part of the astronaut in shade would cool to at least -120^{0}C. The astronaut wears a water-cooled garment underneath the many layered suit to prevent overheating while working in space.

The astronaut's space suit provides a life support system, protection from harmful radiation and insulation from extremes in temperature.

Source: NASA

How fast does the orbiter move around Earth?

Once in space, the orbiter will complete one trip around the Earth every 90 minutes. The crew will experience 45 minutes of brilliant sunshine and 45 minutes of the blackest night. The orbiter travels at approximately 28 000 km/hour.



The orbiter in space, about to release a satellite from its cargo bay. Source: NASA

What can an astronaut see from space?

The man-made features include cities, runways of airports, some very large buildings, highways, wakes of ships, contrails of jets, agricultural lands and the pyramids by the shadows they cast.

Natural features include large storms, mountain ranges, deserts, volcanic eruptions, river systems, bushfires, impact craters and the Great Barrier Reef.

Australia is easily recognisable from space because it is coloured rich red and orange. Source: NASA

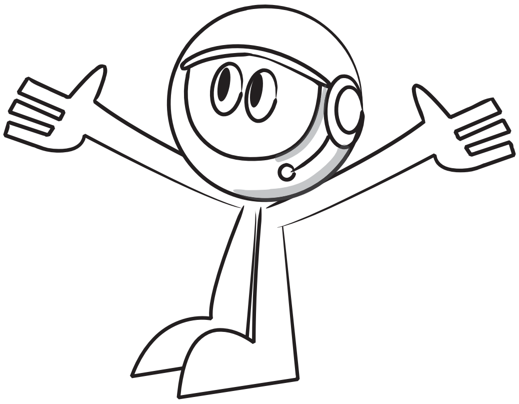
Do astronauts get paid a lot more money for being on a space mission?

Astronauts get paid an extra $US2 per day on top of their normal pay.

Why is the external tank (ET) a cause for concern?

Vibrations caused during launching could dislodge chunks of foam from the ET. As they fall they may strike the orbiter and cause damage. This may threaten the astronauts' safety during their re-entry to Earth. On the Columbia space shuttle, a larger than normal chunk of foam fell from a higher than usual altitude at many hundreds of kilometres per hour, which caused irreparable damage to the exterior carbon fibre heat shield.

The aluminium alloy ET empties in just over eight minutes. It separates from the orbiter to tumble towards Earth. It disintegrates into small pieces which are dispersed in a long trail over the Indian Ocean. The ET is the only part of the space shuttle which is not reusable. Each ET costs about $A60 million.

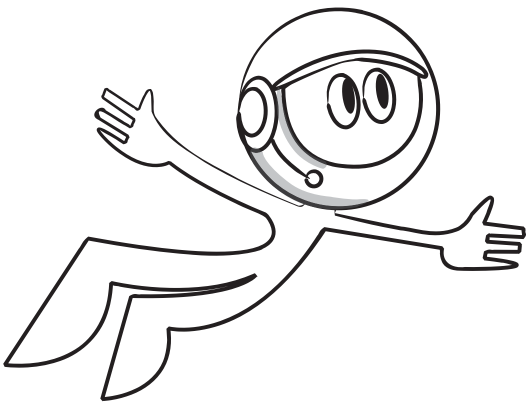


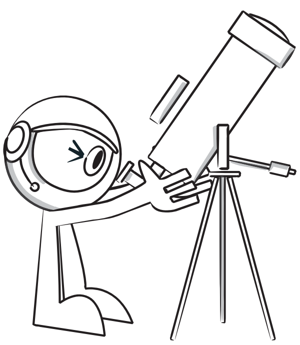
Activities

- ✚ Design and make a rocket.
  * You will need a film canister (the lid must fit into, not over the canister), Alka Seltzer or effervescent vitamin C, water, Blu-Tack, paper towels, safety glasses, students at a safe distance when launching.

  * Use a film canister, remove the lid. Stick one-quarter of an Alka Seltzer tablet to the inside lid with a small blob of Blu-Tack. Half fill the canister with water. Place the lid firmly on the canister. Turn it upside down and put it in the middle of some paper towels. The gas will build up and cause the canister to fly into the air.

  * Extend this activity to find what makes the best rocket. Students can:
    - change any of the variables - amount of water, type of liquid (juice, vinegar, sparkling water), temperature of the water surface area of the tablet, etc.
    - make predictions and test them
    - make comparisions between each test - height rocket reached, time to launch etc.





- Investigate the water absorbing capacity of a range of brands of disposable nappies.
  * Relate this to the many hours that an astronaut would need to wear a nappy (maximum absorbency garment) while working in a space suit.
  * Recommend the most absorbent brand and justify your decision.

- Research how the toilet works in your home.
  * Draw and label a diagram of the toilet.
  * Write a scientific explanation of how it works.
  * Make comparisons to the space toilet.

- Design and conduct an experiment that investigates whether black tiles or white tiles are best for preventing the orbiter from overheating.
  * Use the Sun as your heat source.

  ✚ Do not use heating equipment for this experiment.

- Research and discuss why Kevlar is used as the outer layer of space suits.
  * Find other uses for Kevlar on Earth.

Did you know?...

Radiations are damaging to living tissue. Astronauts wear a device that monitors their exposure to radiation.

They are not allowed to receive more than a certain radiation dose. The dose received on anyone mission will depend on the nature of the mission as well as the exposure.

The Great Wall of China is not easily visible from space.

Space toilet training is important before a mission. During astronaut training, a special toilet is set up with a video camera in the compartment underneath the hole in the seat and a monitor in front of the astronaut to check the correct position.

Websites

http://spaceflight.nasa.gov
General information about spaceflight.

http://nasa.gov/home/index.html
General information about spaceflight.

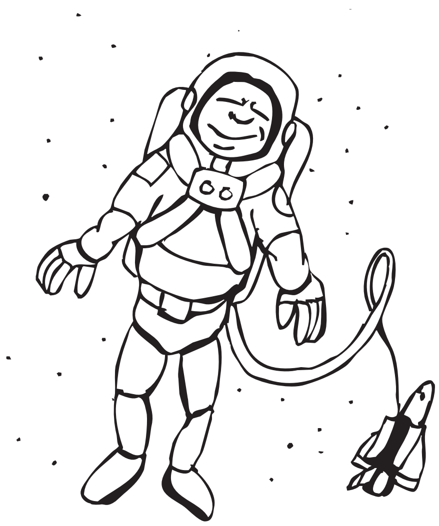
C5 Living in space

Astronauts and cosmonauts are modern day explorers who face the challenges of life in the most dangerous environment for the benefits of scientific research. While on board the space shuttle (10-15 days) and the space station (six months), they are exposed to a totally different way of living with some minor inconveniences.

Effects of space on the body

Fluids in the body

A 'moon-face' with squinty eyes, skinny legs and stuffy noses from blocked sinuses all occur as a result of body fluids moving to the upper part of the body in space. On Earth, due to gravity, body fluids tend to collect in the lower parts of our body.



In space there are many effects on an astronaut's body. Most are caused by weightlessness including squinty eyes and skinny legs.

Astronauts increase in length. The spinal column is no longer compressed and fluids fill the disks between the vertebrae of the backbone, causing the body to lengthen by about 5cm. This often causes backache due to the prolonged extension of the back muscles. Curling up in a ball can help to relieve this ache.

Smaller heart

The body also responds to the upward shift of body fluids by reducing blood volume. With less blood in the body, the heart doesn't need to pump as hard and reduces in size.

Muscles and bones

On Earth, any exercise we do is weight bearing because we move against the force of gravity. This promotes the development of strong bones and muscles. In space, an astronaut will suffer loss of muscle strength and a decrease in bone density as a result of weightlessness.

The muscles of the calves and spine reduce in mass the most, about 5% per week. On return, an astronaut's muscles may take only weeks to recover depending on their exercise regime.

Bone density decrease is more of a problem because it can take up to three years for bones to recover. Calcium supplements, which could help with bone density reduction, are avoided because they increase the chance of kidney stones - an already possible side effect of being in space.

Demonstration - Soak a chicken bone in vinegar. Over a period of a week observe changes to the bone. The mineral content of the bone will decrease leaving only the organic matter, this will become quite rubbery. Vinegar decreases the mineral content in a chicken bone showing a similar (but faster and quite dramatic) effect to the calcium reduction in bones suffered by astronauts in space.

Exercise in space

Exercise helps to reduce bone density loss and muscle deterioration but it does NOT prevent it. Astronauts can exercise on an exercise bike or treadmill, attached by a harness, to simulate weight bearing exercise. Scientists need to learn more about the effects on the body of long duration space flight before space travel to distant places can be seriously considered.

Space sickness

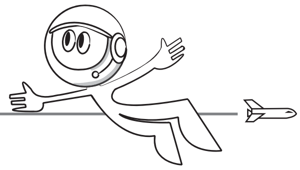
Up to 70% of astronauts use medication to prevent Space Adaptation Syndrome (space sickness). One symptom in the weightless environment is for an astronaut to get confused with upside down or right side up and it can make an astronaut disorientated, nauseous and cause them to vomit. Space Adaptation Syndrome is caused by confused signals from the inner ear.

Astronauts who suffer from space sickness often can't participate in space walks, or other important tasks, until they've adjusted, usually about three days. This is to avoid the possibility of vomiting in the space suit, which could result in blocked airways and death.

Sleeping in space

Sleeping in space is extremely comfortable although very noisy inside the orbiter.

Astronauts experience a super-bright period of daylight every 45 minutes followed by 45 minutes of total darkness as the shuttle or space station orbits the Earth. In the absence of normal day and night, the twenty-four hour circadian rhythms of the body can be severely affected, particularly sleep patterns. The astronaut may become tired and slow to react, even in routine situations. Poor concentration and reaction times may not only endanger the astronaut but ultimately the entire crew and the mission. Many astronauts take sleep medication and wear eyeshades to ensure better quality sleep.



There is a variety of ways in which astronauts can sleep

- in sleeping bags attached vertically or horizontally to the wall,
- floating free in the mid deck,
- pilot or commander in the flight deck seat,
- sleep compartments (on some flights which look like cupboards with sliding doors).

Wherever sleep occurs, it is important to maintain a flow of air over the face to prevent a build-up of exhaled carbon dioxide that could cause oxygen starvation.

Meals in space

In the early space missions meals were quite bland. These days they are nutritious and delicious. The job of some NASA chefs is to create and prepare the very best menus, then work out how they can be stored, transported and eaten in space. Unfortunately astronauts find that their taste sensation is very poor in space and they cannot appreciate the flavours. Many astronauts often add extra seasoning or chilli sauces.

Foods are carefully selected to keep the production of body gases to a minimum as these could cause abdominal pain and/or regurgitation if burping occurs and an unpleasant environment for all the crew.

There is a huge variety of foods which are preserved in many different ways: plastic or foil pouches, cans, freeze-dried, semi dried, etc. The most popular meal, freeze-dried prawn cocktail, is served in a plastic pouch. To reconstitute this meal, water is added from a needle dipenser into the plastic pouch. The astronaut waits for the food to soak up the water and then the meal is ready for eating. Other foods may only require reheating.

Overuse of water is not an issue on the space shuttle as it is made as a by-product of the electricity producing fuel cells. On the space station, water must be conserved and recycled because power is generated only by solar cells.

Drinking and eating in space is almost as normal as on Earth. Astronauts have to drink through a lockable straw, to prevent liquid from continually coming from the container. Meals usually have sauces or gravies to bind the food together to prevent it separating and floating away.

Personal time

Astronauts cannot take many items into space but books, audiotapes, CDs and DVDs are popular items for personal time. Leisure time is also spent writing emails to family and friends or talking on ham (amateur) radio.

Did you know?...

Astronauts on the space shuttle or space station experience 16 dawns and 16 sunsets each day.

Activities

- Design an experiment to test reaction times.
  * Work in pairs. Use the scale on the ruler as a measure of reaction time.
  * Record your results.
  * What factors could affect reaction times? (time of day, hunger, distraction, being 'watched', think of some others).
  * When are reaction times the best/poorest?

- Design and construct a simple piece of exercise equipment and an exercise routine to improve cardiovascular fitness during a long space flight.
  * The equipment must be easy to transport and not take up too much room - personal space is limited.
  * The exercise routine must include two or more major muscle groups.
  * What other muscle groups need to be catered for?
  * Test what effect the use of this equipment and the routine has on your pulse rate.

- Investigate a range of materials to make a comfortable, effective set of eyeshades for space travellers.
  * Test the effectiveness of the different eyeshades for periods of extreme darkness through to periods of bright light.
  * Report on the most effective materials.

- Investigate dried foods.
  * Discuss dried foods that are commonly eaten which need to be rehydrated.
  * Place dried 'potato flakes' in a snap lock bag and use a syringe (no needle) to add water. Describe the effects of adding water. Try other food products.
  * Design and make a menu for a meal using only dried foods. Describe how they could be rehydrated and served.
  * Foods used by astronauts are preserved in different ways and some are eaten fresh. List preserved foods from the kitchen cupboard and determine how they have been preserved. Note the 'shelf life' of each food and relate this to the type of preservation technique used.

- Research space foods that have made their way into todays supermarkets.

- Design and make a game or some other form of entertainment for astronauts. Remember, you're not limited by the restrictions of gravity.

Websites

http://spaceflight.nasa.gov/living/ Living in space.
http://liftoff.msfc.nasa.gov/academy/astronauts/food-history.html Space food changes over time.

C6 Space weather

Space weather refers to change in the space environment caused by increased solar activity. As a result of the solar activity, explosions of particles and electromagnetic energy like X-rays rush from the Sun into space.

The Earth's magnetic field repels most of the solar wind. This reduces the effects of solar activity on Earth.

The violent Sun

The Sun is violently turbulent due to the combined effect of internal eddies and the Sun's rotation that is more rapid at the equator than the polar regions. The resulting twisted magnetic field gives rise to explosive flares and spectacular loops of hot gases called prominences that arch into the solar atmosphere. A flare is billions of times more powerful than a nuclear bomb.

The corona is the very faint, upper layer of the Sun's atmosphere. Its temperature is more than 1 000 000^{0}C while the surface of the Sun is only 6000^{0}C. The largest disturbances on the Sun are coronial mass ejections - the expulsion of billions of tonnes of material.

Changing magnetic field

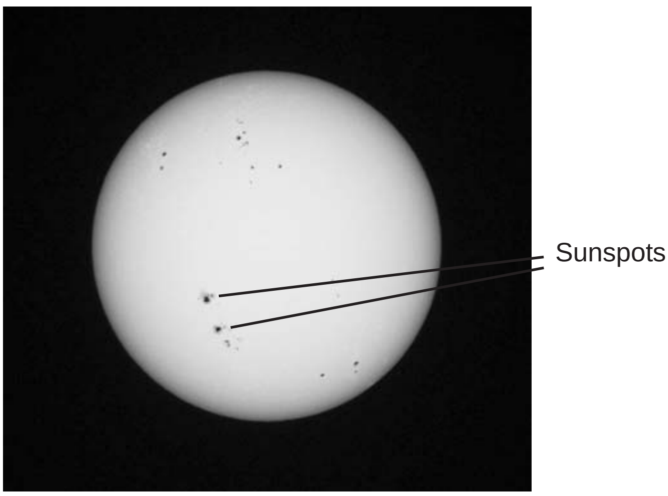
The SOHO spacecraft determined that the Sun's violent activity creates and destroys its own magnetic field every eleven years. As a result the magnetic poles reverse.

Sunspots

Sunspots are the source of the explosive flares. These dark, cooler spots which occur as a result of the constantly changing magnetic field, can be seen on the Sun's surface.

Scientists can predict flare activity by examining the arrangement and shapes of the sunspots. Flares are more likely to explode from more complex sunspots.

Sunspots peak during the Sun's eleven year magnetic cycle. The next cycle will peak in the years 2010-2011 when more dangerous flare eruptions will occur.



Sunspots are easy to identify on images of the Sun. Remember - never look at the Sun directly. Source: NASA

Effects of space weather

The effects of space weather can be noticed on Earth in a number of ways:

- Interference with communication technologies through radio noise, sometimes causing radio blackouts.
- Problems at power plants due to power surges which may cause major blackouts.
- Errors in computers due to radiation damage.
- Making compass needles wander.
- Bombarding radiation damage to satellites.
- Increased atmospheric drag on low earth orbit satellites causing their orbits to decay and satellites to crash back to earth.
- Exposing passengers in commercial jets to increased radiation.
- Aurora Australis is a display of coloured lights as a result of solar activity. This is seen in Antarctica and other southern regions. Aurora Borealis is seen close to the north pole.

Activity

- Map the magnetic field of a bar magnet.
  * Cover a bar magnet with plastic wrap to prevent iron filings (very small pieces of iron) from sticking to the magnet. They are difficult to remove.
  * Place the bar magnet beneath a piece of paper.
  * Sprinkle the iron filings all over the paper around and over the magnet.
  * Use this activity as an analogy for the structure of the magnetic fields of the Sun and Earth.
  * Determine the location of north and south poles of the bar magnet's magnetic field.
  * Predict where auroras would be observed on the map of the magnetic field if it represented the Earth's magnetic field.

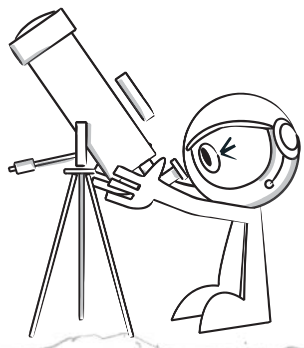
Websites

http://www.spacescience.org/ExploringSpace/SpaceWeather/TrackingTheSun/1.html
Space weather.

http://www.thursdaysclassroom.com/06jan00/article1.html
Space weather.

Did you know?...

Galileo first observed sunspots in 1610. He became blind as a result of his observations.



C7 Solar system exploration timeline 2004-2006

KEY

◀ Flyby of the solar system body
▶ Landing on the solar system body
⟳ Orbit of the solar system body
▼ Sample returned to Earth
▲ Launch of spacecraft
⧗ Impact penetration of the body

Table: 7.1 Summary of planned space missions 2004-2006

Destination	2004	2005	2006
Sun	▶ *Genesis (captured particles of solar wind) (NASA)*		
Moon	▲⟳⧗ *LUNAR-A (Japan)*	⟳ *SMART-1 (European Space Agency - ESA)* ⟳ ▼ *Selene (Japan)*	
Mercury	▲ *Messenger (NASA)*		
Venus	◀ *Messenger (NASA)*	▲ *Venus Express (ESA)*	◀ *Messenger (NASA)* ⟳ *Venus Express (ESA)*
Mars	▼ *Spirit (NASA)* ▼ *Opportunity (NASA)*	▲ *Mars Reconnaissance Orbiter (NASA)*	⟳ *Mars Reconnaissance Orbiter (NASA)*
Jupiter	◀ *Ulysses - launched in 1990- unusual orbit brings it close to Jupiter. (ESA/NASA)*		
Saturn/Titan	◀ *Cassini-Huygens (NASA/ESA/Italian Space Agency) - launched 1997*	◀ *Cassini* ▼ *Huygens Probe to Titan*	◀ *Cassini (will continue until 2008)*
Pluto			▲ *New Horizons Pluto-Kuiper Express (NASA)*
Asteroid		▼ ▶ *Hayabusa to Asteroid Itokawa - launched in 2003 (Japan)*	▲ *Dawn (NASA)*
Comet	◀ *Stardust encounter with Wild 2 (NASA)* ▲ *Rosetta - 8 years later will* ⟳ ▼ *at Comet Churyumov-Gerasimenko (ESA)* ▲ *Deep Impact (NASA)*	⧗ *Deep Impact encounter with Tempel 1 (NASA)*	▶ *Stardust return - comet dust from Wild 2 (NASA)*
Kuiper Belt			▲ *New Horizons Pluto-Kuiper Express (NASA)*

Activities

- Translate the information in Table 7.1 into word descriptions.
  * The country responsible for the exploration, when will it occur and the aim of the exploration. Eg. Lunar A will be launched by Japan in 2004, it will go to the Moon, orbit the Moon then collide with the Moon to penetrate the surface.
- Extend the timeline by researching the space missions that were launched in 2003 and are planned for 2007. Eg. Mars Express with Beagle 2, SMART-1, Kepler.

The rover, Spirit, on the surface of Mars. Credit: NASA

C8 Pluto, Sedna and other cosmic debris

There has always been a great deal of debate as to whether Pluto was really a planet. Now further questions have been raised with the discovery of Sedna. Is it a tenth planet?

Facts about Pluto

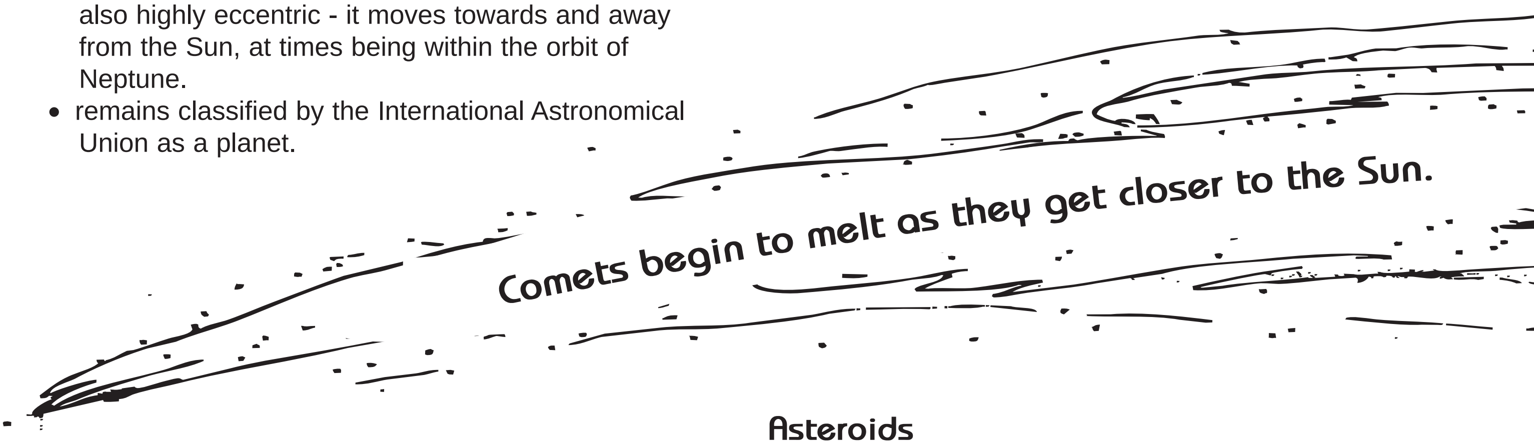
Pluto

- is the smallest planet, only 2300 km in diameter. It's smaller than our Moon.
- is very small to even be considered a planet.
- is spherical like a planet, but the largest known asteroid is also spherical.
- has a moon called Charon. Many astronomers believe both Pluto and Charon are rocky bodies from the Kuiper-Edgeworth Belt, an icy region that extends many billions of kilometres beyond Neptune.
- has an unusual orbit. It crosses above and below the orbits of the eight other planets. Some people believe this suggests that it may have formed elsewhere and later moved into orbit around the Sun. Pluto's orbit is also highly eccentric - it moves towards and away from the Sun, at times being within the orbit of Neptune.
- remains classified by the International Astronomical Union as a planet.

Comets

A comet is made up of ice, rock, dust and organic compounds from the earliest formation stages of the solar system. Often described as a 'dirty snowball', it is more like a 'snowy dirtball'. As a comet approaches the Sun, the ice melts and the gas and dust stream out as an amazing tail. When the Earth crosses a comet's path, the comet dust burns up in the atmosphere creating a meteor shower. This looks like lots of 'shooting stars' in the sky. A comet is such a long distance away that it appears stationary in the sky, just like any star. If you tracked a comet every night you would be able to see its movement relative to the background of stars.

Many comets collide with the Sun or planets. In 1994, Comet Shoemaker-Levy 9 plummeted into Jupiter. 65 million years ago, a comet may have collided with the Earth causing the extinction of many life forms including the dinosaurs.



Sedna - is it a planet?

To add to the debate, an object has recently been discovered far beyond Pluto, about 86 times the Earth-Sun distance. It is also round like a planet and it may have a moon. It has been named Sedna and is

- the largest cosmic object discovered since Pluto in 1930,
- only about 1770 km in diameter,
- too small to be called a planet, according to the team of astronomers led by Mike Brown.

Cosmic debris of the solar system

Scientists are able to gather pieces of cosmic debris from areas where objects from space have collided with Earth. These 'space objects' contain valuable information and can help scientists build up a picture of the early Solar System.

Historical records in all cultures are filled with stories and tales which try to explain strange visions in the sky. These can help scientists to create a timeline throughout recorded human history of solar events. Some of these may be random, like passing comets. Others may happen with some regularity, like the passage of Venus in front of the Sun.

Asteroids

Asteroids are small, rocky, metallic bodies found all over the Solar System. There is a 'belt' of asteroids orbiting the Sun between Mars and Jupiter. At least 30 known asteroids have their own moon. Scientists know that asteroids have impacted with Earth in the past. Craters on the Earth's surface show the asteroids' points of impact. Sometimes craters are hard to identify because they are so big. The Earth's 5th largest crater was recently discovered in Western Australia. Scientists believe the asteroid that created the 120 km wide crater was 5km wide.

Did you know?...

A 30 metre asteroid, named 2004FH, recently passed by Earth at the closest approach ever recorded - only 43 000 kilometres away, about 1/10th the distance to the Moon. Too close for comfort!

Kuiper Belt Objects

At least 1000 rocky bodies called Kuiper Belt Objects (KBOs), similar to comets and asteroids, have been discovered beyond Neptune. They are located in an area called the Kuiper-Edgeworth Belt which is between 30 and 50 Astronomical Units (AU) away from the Sun. KBOs, made of ice and rock, are thought to be the leftovers from the birth of the Sun and planets.

Did you know?...

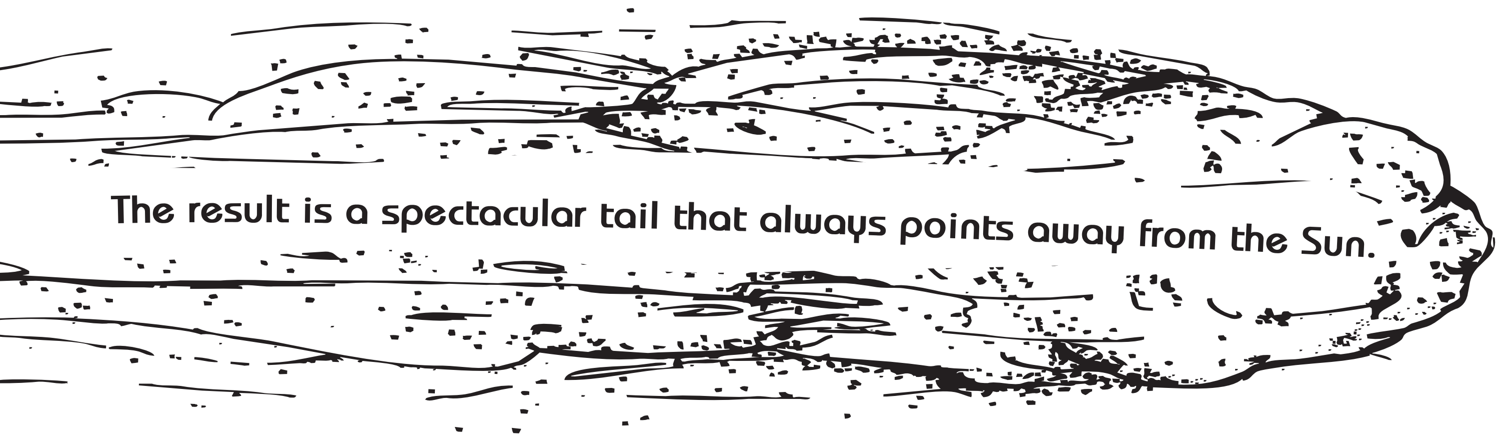
My Very Energetic Mother Just Served Us Nine Pancakes is one way to help you remember the order of the planets - Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto.

The current moon count for Jupiter is 63, Saturn 31, Uranus 27 and Neptune 13. The increasing number being detected reflects the engineering and technological advancements that continue to be made in astronomy.

NASA has crash landed a space probe on the asteroid called Eros.

- Determine the unknown shape of a 'space' body hidden from view.
  * Select a 'space object' before the lesson.
  * Place in a box so that it cannot move.
  * Pierce small holes, at regular intervals all around the box. The holes should be only large enough for a knitting needle (with the point removed) to be inserted.
  * Insert the knitting needle through each of the holes, measuring the length of the needle each time.
  * Plot your measurements to gradually build up a picture of the 'space object'.

Earth-based telescopes cannot see the surface of Venus because it is covered with thick clouds. A spacecraft orbiting Venus used radar in a similar way to this experiment to build up a picture of the surface of Venus.



Activities

- Debate: Is Pluto really a planet?
- Model the size of the Solar System planets in comparison to Pluto using food samples.
  * Work out a scale to make sure the 'planets' are the correct distance apart.
  * Foods/Planets - Sun (large exercise/gym ball), Mercury (peppercorn), Venus (pea), Earth (pea), Mars (a dried pea), Jupiter (grapefruit), Saturn (orange), Uranus (plum or walnut in shell), Neptune (plum or walnut in shell), Pluto (half a peppercorn).
- ✚ Discover why the remains of comets can not be easily found after impact on Earth.
  * Place a small amount of flour, a known number of small rocks (coloured or painted are best) and enough water to bind all in a balloon (use a funnel for convenience). Do not allow the balloon to become too large.
  * Tie the balloon securely. This will simulate a fragile comet.
  * The teacher/student must throw the balloon onto the ground outside as hard as possible while the students stand well back. How many of the original rocks can be found?
  * Compare results using different surfaces.
- ✚ Simulate the relationship between a planet's distance from the Sun and the time taken for it to orbit the Sun.
  Safety glasses should be used.
  * Thread a one metre length of string through a piece of narrow tubing, eg. an empty pen barrel.
  * Tightly secure the string at the top of the tube to a weight, eg. key on a ring. The key will simulate the planet.
  * Hold the end of the string firmly beneath the tube. Carefully spin the 'planet' around in orbit at arm's length.
  * Pull the string through the tube as the planet spins.
  * Is there a change in velocity as the planet is pulled closer to the tube (the Sun)?
  * Relate your observations to all the planets in their orbits around the Sun and Kepler's 2nd law of planetary motion.

Websites

http://universetoday.com Search Sedna discovery.

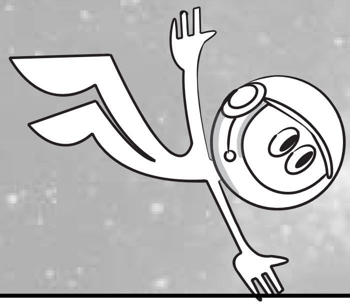
http://science.nasa.gov/newhome/headlines/ast17feb99_1.htm Pluto debate.

National Science Week 2004

14 - 22 August

SCHOOL THEME:

Out of this World: Investigating Space



ASTA members of 2004 receive a FREE copy of the resource book Out of this World: Investigating Space through their state/territory Science Teachers Association. Check your membership.

ASTA National Science Week Science Teachers Association Representatives

In each state and territory there is a representative from the local Science Teachers Association to assist schools, teacher and student participation in National Science Week. Give them a call.

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Kate Padman • t 08 9383 0235 • e kpadman@mlc.wa.edu.au

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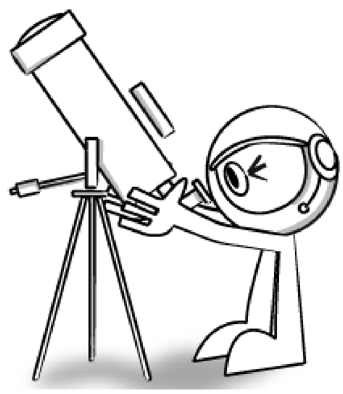
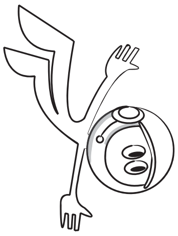
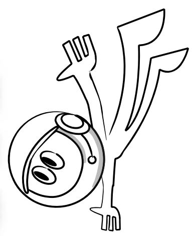


Australian Science Teachers Association

Australian Science Teachers Association
t (02) 6282 9377 f (02) 6282 9477 e asta@asta.edu.au www.asta.edu.au



ENGINEERS IN SPACE



If people have designed it, built it, saved it, recycled it or launched it into space, you can be sure that engineers have had something to do with it.

Engineers are professional problem solvers. They use math and science along with skills in communications, critical thinking and management to find practical solutions that benefit people and society. They design, create, build, improve and invent – everything from heart valves and microchips to skyscrapers and space vehicles.

Engineering is about imagination and meeting the challenges that face individuals, communities and the planet. To 'engineer' literally means to make things happen!

In teaching science theory and its practical applications, engineering concepts are often being taught as well. This provides an excellent opportunity for teachers to highlight the links between science and engineering and to explore with students the many and varied career opportunities in engineering.

Engineers Australia in collaboration with its many science, math and technology partners develop teaching resources and run cost free exciting hands-on competitions, events and workshops to enable teachers and students to make the links between science and engineering, innovation and entrepreneurship in Australia.

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Neighbourhood Engineers Hear first hand from a professional engineer about what an engineer does and how engineering links with science and technology to create innovative products we see and use everyday! Call your local Engineers Australia division to have an engineer visit your school at your convenience.

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Want more information on how to bring engineering to your school?

Visit the SetOz website at www.setoz.com.au (science and engineering education site specifically designed for teachers), call the national office toll free on 1300 653 113 or call your local division direct.

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Using astronomy research together with scientific and mathematical theory, engineers find practical solutions to space exploration and discovery. Engineers Australia is pleased to be a sponsor for the 2004 ASTA National Science Week Resource Book *Out of this World: Investigating Space.*

C9 Back to the Moon

The Moon has intrigued mankind for centuries.

Currently, the scientific community is excited by the possibility of returning to the Moon.

Moon Fever

Serious consideration is being given to the planning for future research on the Moon. Unmanned research spacecraft would provide valuable information. Manned space visits could extend that research further. In time, this information could help in developing a proposal to establish a lunar base.

An impression of a colony on the Moon.

Source: NASA

Essentials for survival on the Moon

The Moon's environment is hostile with extremes of temperature, no air, no water and no protection from the Sun's deadly radiation and cosmic rays. Life in a lunar settlement would be very difficult although some of the essentials could be readily obtained from the Moon's natural resources.

Three possible reasons for establishing a moon base would be:

- training for long distance space travel. Only three days from Earth, astronauts could train for survival on another planet.

- astronomical observations
  - * If an optical telescope could be constructed on the Moon, there would be no atmosphere to distort the images of space. As the Moon has a period of darkness that is 14 days long, enormous amounts of research could be completed.
  - * A lunar radio telescope would be shielded from the radio noise of Earth.

- to mine minerals for aluminimum and titanium.

Is there ice on the Moon?

Water could have arrived on the Moon by a comet impact millions of years ago. The Clementine (1994) spacecraft collected information, which infers that ice may be present in a deep, constantly shaded crater near one of the poles.

The Lunar Prospector (1998) spacecraft also discovered the signature of hydrogen in the shadows of the polar craters. Many scientists believe this may be the tell tale sign of water as ice.

In 2005, the SMART-1 spacecraft will enter orbit around the Moon to look for clues of the Moon's origin and try to confirm the frozen water theory.

Table 9.1 Some Moon resources for potential use.

Requirement	Source on Moon	How it could be used
Oxygen	*Rocks/soils*	*Contain at least 45% oxygen. When extracted, it could be used to make:* • *air for breathing.* • *water by combining with hydrogen.*
Water	*Ice* *Rocks/soil*	*Water is needed in many ways: eg drinking, bathing and growing plants. It may be:* • *directly obtained from the ice in the dark craters, if in fact the ice is actually there.* • *combining oxygen and hydrogen extracted from the lunar rocks and soils.*
Electrical power	*Lunar soil*	• *Solar cells - The Moon's soil contains high levels of silicon and aluminium that could be extracted to make the solar cells for power.*
Construction materials	*Lunar soil* *Basalt* *Armalcolite* *Anorthosite rock*	• *If there is enough water, the dust and rock fragments are ideal for making concrete.* • *Basalt is a very useful material for construction* • *The Moon mineral armalcolite is rich in titanium. Titanium is a light weight, durable metal with many uses.* • *Anorthosite rock is very rich in aluminium that has many construction uses and can be used in rocket fuel.*

Did you know?

Apollo astronauts returned 382 kilograms of moon rock and soil for study back here on Earth.

The sun-exposed surface of the Moon reaches temperatures greater than 120^{0}C.

Armalcolite is a new mineral that was discovered on the Moon and named after the Apollo 11 astronauts - Armstrong, Aldrin and Collins.

The Moon's surface is marked with many craters. Credit: NASA

Activities

- Investigate the effect of sunlight on moist soils.
  - * Place the same amount of soil and water in two clear containers. Weigh them.
  - * Place one on a windowsill, which receives at least four hours of sunlight per day.
  - * Place the other on a windowsill that receives no sunlight (control).
  - * Record the weight of each container daily, for one week.
  - * Guide students in forming a hypothesis about soil moisture on the Moon.

- Safety simulation of Moon soil formation.
  - * What happens when biscuits (in a plastic bag) are exposed to constant impacts from 'falling bodies' eg a hammer?
  - * Relate your observations to the formation of lunar soil by repeated impacts from space rocks over time.
  - * How is the formation of Moon soil different to the formation of soil on Earth?

- Design a Moon base to provide protection for astronauts. Consider food supplies, water, oxygen, energy supplies and transport.

- Observe and record the position and shape of the phases of the Moon.
  - * Keep a journal of Moon observations taken at the same time, eg 8 pm, each night for 2 weeks from new moon to full moon.
  - * Sit in the same place each night.
  - * On the first night draw the horizon. Add the position, shape and surface features of the Moon onto your page.
  - * Each night record your observations in a different colour on the same page.
  - * Construct a key to identify each day's Moon.
  - * Use this data for class discussions.

- Calculate the time taken for a trip to the Moon.
  - * Assume the spaceship travels at 40 000 km/hour. Research the distance between the Earth and the Moon. (Speed = Distance/Time)
  - * How long would it take for a laser beam to travel from Earth to a reflector on the Moon and back? (Hint: You need to know the speed of light).
  - * Find out what scientists have discovered about the Moon's distance from Earth.

- Design and conduct an experiment to extract water from frozen soil.
  - * Make frozen soil by placing a mixture of soil, rocks and water in the freezer overnight.
  - * Describe what the mixture looks like after freezing. Is the ice seen easily?
  - * How could you extract the water without applying direct heat?

Websites

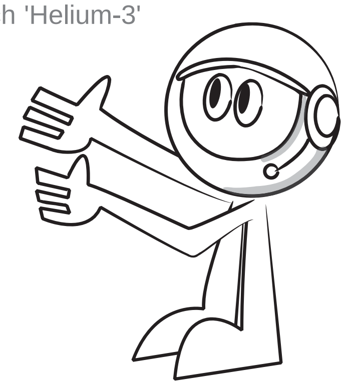
http://www.abc.net.au/juniors/
Click on 'The Moon' for information.

http://www.star.ucl.ac.uk/~idh/geology/moon.htm
Information about the Moon.

http://www.scitech.org.au/space/
Surviving on the Moon.

http://www.extremescience.com/moon.htm
Animation of Moon phases.

http://www.space.com/ Search 'Helium-3'



C10 Destination Mars

Millions of years ago Mars may have been warmer, wetter and possibly more suitable for life than it is today. Ancient features on the surface indicate water may have once flowed. Oceans, lakes and rivers may have disappeared because of the planet's low mass and therefore low gravity.

However, Mars, often called the red planet, appears to be more Earth-like than any other planet in the Solar System. It is still extremely harsh - too cold, too little oxygen, too little water for life as we know it.

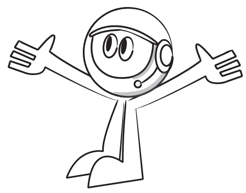


Table 10.1 Comparison between Earth and Mars

Feature	Earth	Mars
Distance from the Sun	*150 million kilometres*	*Average 230 million kilometres*
Day (period of rotation)	*24 hours*	*24 hours and 37 minutes*
Year length	*365 1/4 days*	*Two Earth years long*
Rock or gas?	*Rocky planet*	*Rocky planet - about half the size of Earth, therefore less gravity*
Moons	*One natural satellite - the Moon*	*Two small moons that look like giant potatoes - Phobos and Deimos (Fear and Panic). They may be captured asteroids.*
Ice caps	*Two polar ice caps of frozen water*	*Two polar ice caps of frozen carbon dioxide and water.*
Craters	*Some impact craters are still evident but most have been eroded over time.*	*Surface is covered with many impact craters.*
Valleys	*One of Earth's largest valleys is the Grand Canyon that is often described as a mere crack in a footpath in comparison to the canyons on Mars.*	*Possesses a very large fracture over its surface called Valles Marineris. It is described as a canyon 4000 km long, up to 600 km wide with 7km towering cliffs. It is long enough to extend across Australia.*
Water	*About three-quarters of the surface is covered in liquid water.*	*Has water flow features such as branching networks of river channels, islands, gullies and a huge valley. Recent exploration has detected water on Mars.*
Volcanoes	*Volcanoes, many of which are very active.*	*Huge volcanoes that appear to be extinct. Olympus Mons is about three times higher than Mt Everest.*
Atmosphere	*Atmosphere - 78% nitrogen, 21 percent oxygen with a very small amount of carbon dioxide, noble gases (e.g. helium, argon, neon) and varying amounts of water vapour.*	*Thin atmosphere that is over 100 times thinner than Earth's atmosphere - approximately 95% carbon dioxide.*
Temperature	*Ranges from very cold to very hot i.e. about 59^{0}C down to - 91^{0}C*	*Extremely cold, night temperatures may drop to -140^{0}C but can reach a warm 18^{0}C at the equator on a summer's day.*
Sky	*Sky is blue caused by the scattering of light through gas molecules, water droplets and dust in the atmosphere.*	*Sky is pinkish yellow in colour due to the dust particles in the atmosphere absorbing the blue spectrum of light.*
Clouds	*Clouds with water, ice and snow.*	*Clouds of ice and dust, no rain.*
Soil	*Soil varies in colour from rich black through to white sands. Astronauts have observed that Australia is very red compared to other countries, due to its iron minerals.*	*Red soil - red due to iron oxide content*

Exploring Mars

There have been many spacecraft sent to Mars to investigate. These include:

- Mariner
- Viking
- Pathfinder
- NASA's two rovers, Spirit and Opportunity
- Mars Global Surveyor spacecraft and Mars Express in orbit around Mars
- European Space Agency's Beagle 2 (named after the ship that carried Charles Darwin). Unfortunately it did not make contact with Earth after its landing on Mars in December 2003.

The next generation of spacecraft will carry a robotic rover that will conduct research on the Mars' surface and return the samples to Earth. In 2005, the Mars Reconnaissance Orbiter will be launched. It will be capable of imaging objects as small as 30cm in diameter on the surface of Mars.

Landing robotic explorers

In 1997, Pathfinder made a dramatic landing on Mars. The microwave oven sized robotic explorer, called Sojourner, was cushioned from landing impacts by giant, inflated airbags. When stationary, the airbags deflated and the Pathfinder opened like the petals of a flower, enabling the rover to move about the surface. More recent landings have also used the inflated airbag technique.

Life on Mars?

An impact on Mars millions of years ago launched bits of Martian crust into space. At least one of these meteorites was eventually captured by Earth's gravitation. Meteorite ALH84001 came to rest in Antarctica, 13 000 years ago. NASA scientists believe they have discovered traces of ancient life in the Martian meteorite. It contains stuctures that resemble bacteria and mineral deposits that are normally associated with simple forms of life.

Questions scientists often ask about life on Mars

If liquid water bodies did exist at one time, could primitive life have flourished there as well?

Would the life forms be similar to bacteria that we have observed on Earth?

Water on Mars

Spacecraft images has shown various features on the surface of Mars which could have been formed by water:

- Branching networks of valleys - these could have been formed by the flow of water in streams and rivers.
- A channel running down the middle of a large valley - possibly a river eroding its path over a long period of time.
- Terraces mark the surface of Mars - these could be the shoreline of a larger water body.
- A large depression in the surface surrounded by a network of small channels - this may have been water courses draining into a lake.

Activities

- What are the common and differnet surface features of Mars and Earth?
  * Represent in a Venn Diagram.

- Design a kit to help humans survive on Mars for a period of one Earth month. The kit must contain no more than 12 items.

- Investigate the use of airbags which protect the robotic landers.
  * Design and make your own landing vehicle, use balloons as airbags.

- Compare the landing sites of the robotic rovers on Mars with the same locations on Earth.
  * The coordinates of past landing sites on Mars are presented in Table 10.2.
  * Identify these locations on Earth.
  * What evidence of life would the Martians discover in each of these locations.
  * Discuss conclusions the Martians might draw after sampling these locations.

Table 10.2 Coordinates of past landing sites on Mars

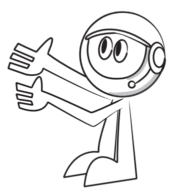
Latitude	Longitude	Lander on Mars	Earth location
22^{0}N	48^{0}W	Viking 1	
46^{0}N	150^{0}W	Viking 2	
19^{0}N	34^{0}W	Pathfinder	
11^{0}N	270^{0}W	Beagle 2	
15^{0}S	175^{0}W	Spirit	
2^{0}S	354^{0}E	Opportunity	

- Research recent observations of Mars made by orbiting spacecraft and the rovers.
  * Complete a table of information.
  * Consider inferences about five observations such as methane gas in the atmosphere, ripple features in rocks, water and grey haematite.

- Investigate the apparent movement of Mars (backwards and forwards), from Earth, known as retrograde motion.

Websites

http://mars.jpl.nasa.gov/
Spirit and Opportunity and all things about Mars.
http://mars.sgi.com/default.html Pathfinder.

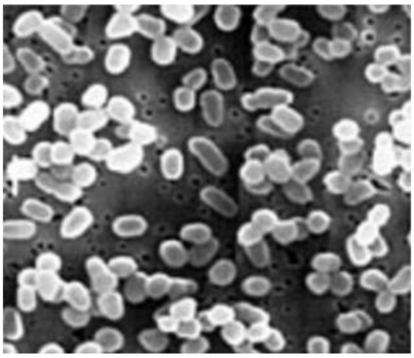


C11 Is there life out there?

Astronomers suggest that there is the potential for about 30 billion stars to have planetary systems in the Milky Way galaxy. There must also be a significant potential for planets to have life. But what kind of life? The other planets in our Solar System exhibit environmental conditions that to us would appear to be harmful to life. Perhaps this is the same for extrasolar planets. How could life possibly develop and evolve in such harsh conditions?

What are extremophiles?

Astrobiologists are scientists who seek to understand the origins of life and the possibility of life somewhere else in space. They have found that life on Earth generally finds a way to survive and thrive, even in the most extreme conditions. Lifeforms in these conditions are called extremophiles. They are considered by astrobiologists to be models for life elsewhere. Extremophiles are mainly varieties of bacteria and Archaea. Archaea resemble bacteria but are genetically and structurally distinct.



Extremophiles. Source: NASA

Where are extremophiles found on Earth?

No matter which extreme environments astrobiologists have investigated on Earth, extremophiles have been found to be flourishing. It seems that extremophiles possess DNA repair mechanisms to assist with survival. Extreme environments studied include:

- Places that are strongly acidic or very alkaline eg. the red coloured, highly acidic Tinto River in Spain: caves that ooze concentrated sulfuric acid as in the long passages of Cueva de Villa Luz in southern Mexico. There are mucous-like formations called snottites, which contain colonies of bacteria that hang from the ceilings. They convert toxic hydrogen sulfide gas (rotten egg gas) inside the cave into strong acid that drips to the floors.
- Hot volcanic pools in Yellowstone Park, USA.
- Hot springs rich in dissolved radioactive radon and radium such as the Paralana hot spring in South Australia.
- Areas of high exposure to radiation in cooling ponds for nuclear power stations where the fuel cans from nuclear reactors are stored. Radiation exposure here has been up to 5000 times greater than a fatal dose for humans.
- Super-heated, volcanic vents an the bottom of the ocean where no light or oxygen is present.
- In rocks, many kilometres deep below the surface of the Earth where the microbes exist on a starvation diet of minerals and gases.
- In the bitter cold, dry areas of Antarctica where temperature conditions closely resemble those on Mars.
- Water bodies that contain about 30% salt.

Scientists now recognise that what had seemed too extreme for suitable habitats on Earth might actually be normal for extraterrestrial life, perhaps even intelligent life. Many scientists also concede that very tough micro-organisms may have survived interplanetary journeys protected from the damaging effects of the solar and cosmic radiation within a comet or asteroid.

The necessary ingredients for a habitable planet

Scientists believe that life as we know it is limited to temperatures at which water is a liquid, since liquid water is the solvent in which all life chemistry takes place. This is a range from just below the boiling point to just above the freezing point of water. Yet, it is also suggested that Earth's life originated in a very hot, sulfurous, non-oxygen environment that is considered to be too extreme or lethal for life today. With the knowledge obtained from extremophiles and an understanding of the beginnings of Earth's primitive life, it seems reasonable to speculate that life may exist elsewhere in the cosmos, even in the most hostile environments.

Astrobiologists search the Solar System and beyond for the following factors upon which life as we know it on Earth depends on:

1. suitable temperature range (about -15^{0}C to 115^{0}C)
2. water
3. energy to enable life processes to occur
4. an atmosphere to insulate and protect the planet (or moon) from harmful radiation from the star
5. continual supply of nutrient raw materials to sustain the life processes.

The region around any star that might potentially support a planet with life is called 'The Habitable Zone'.

Did you know?...

Snottites are mucus-like formations that can be found in caves that ooze sulfuric acid.

Activities

- Design and conduct an investigation to determine the relationship between temperature and the fermentation process involving microscopic yeast cells in baker's or brewer's yeast.
  - * Include in the design the use of different temperatures such as very cold, body temperature and very hot and a method of collecting the liberated gas to further clarify the temperature/ fermentation links.
  - * Predict from the results if this single-celled organism could be an example of an extremophile or not.

- Compare adaptations for survival in two examples of extreme conditions.
  - * Choose an animal that inhabits an extremely hot environment and one that inhabits an extremely cold environment.
  - * State how the animals are equipped to survive the temperature, water conditions, wind, food constraints, predators and day/night patterns.
  - * What adaptations would the two animals need to develop to be able to survive on a planet that is very hot and one that is very cold?

- Determine the possibility of human survival on the surface of a planet from the Solar System by considering positive, negative and interesting (PMI) aspects.
  - * Write a recommendation to NASA as to whether or not it would be advisable to land on the surface and/or establish a colony for human habitation there.

- Debate the topic ' We are alone in the Universe'.
  - * Introduce the statement 'absence of evidence is not evidence of absence' to brainstorm reasons for no contact with Earth from intelligent extra-terrestrial life, if it is out there.
  - * What might be the positive and negative aspects of alien contact with Earth?

- Research the Drake Equation to predict how many planets in our galaxy might exist with technically advanced civilisations that could communicate with us. www.planetarysystems.org/drake_equation.html

- The largest radiotelescope in the world is Aricebo in Puerto Rico. In 1974, Frank Drake and Carl Sagan sent a message into the galaxy from the Aricebo telescope to a destination 25 000 light years away. The message was made up of radio pulses.
  - * Research what information was conveyed in that communication.
  - * Calculate the year that the message will reach its destination.

- Research the Search for Extra-Terrestrial Intelligence (SETI) project.
  - * Use your own computer to assist the SETI program for the detection of possible alien communication via a website search for seti@home.

- Alien Code - Use the code below to decipher the Alien's question, then write the Earthling's answer in code.

♋	♌	♍	♎	♏	♐	♑
A	B	C	D	E	F	G

♒	♓	🙰	🙵	●	❍	■
H	I	J	K	L	M	N

□	🞐	❑	❒	⬧	⧫	◆
O	P	Q	R	S	T	U

❖	⬥	⌧	⍓	⌘
V	W	X	Y	Z

Alien's question:

⬥♒□ ♋❒♏ ⍓□◆

⬥♒♋⧫ ♎□ ⍓□◆ ⬥♋■⧫

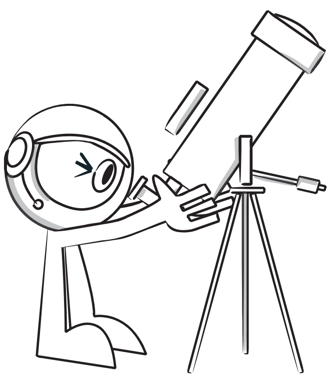
Earthling's answer: We come from Earth to explore your planet. We come in peace.

Websites

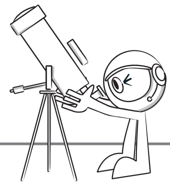
http://aca.mq.edu.au Astrobiology

http://seti.uws.edu.au/SETI%20Pages/Arecibo%20Messages.htm Aricebo message

http://www.astrobiology.com/adastra/extremophiles.html What is extreme here may be just business-as-usual elsewhere.



C12 Starry nights



Throughout time, humans have looked up in awe at the wondrous display of stars in our galaxy. This scene has been immortalised on canvas by Vincent van Gogh in one of his most famous paintings 'Starry Night'. Also, by the superb night sky images taken by Australia's David Malin, internationally renowned astrophotographer of the Anglo-Australian Observatory.

On clear nights, it appears that millions of stars can be seen. In reality you can only see about three thousand stars with the naked eye. However, the darker the sky, the more stars you can see. There are billions of stars you cannot see because of their immense distances from Earth.

Stars have different sizes, different colours and different brightness. These things represent different stages in the life cycle of stars.

How long do stars exist?

The life and death of any star depends on its mass. Our Sun, an average size star, will exist for another five billion years. The blue supergiant Rigel in the Orion constellation will only exist for about 20 million years. Huge stars that have 60 times the mass of our Sun may only exist for three million years. A very small star, like the red dwarf star Proxima Centauri (not visible from Earth, but the closest star to Earth) could potentially exist for 100 billion years, longer than the present age of the universe.

The death of very large stars result in awesome explosions called supernovae resulting in black holes or neutron stars. Some of these may become pulsars, remaining as the remnant of the original star.

What will happen to our Sun as it dies?

Once the Sun has used up its hydrogen fuel it will continue to shine but undergo major changes. It will dramatically expand to become a cooler, red giant - up to 100 times larger than its present size. Its outer shell will then reach beyond Earth's orbit. The Earth's oceans will evaporate and life will no longer exist.

As the Sun expands, its core is continually being crushed by gravity until it shrinks to about the size of Earth. The result will be a very hot white dwarf star at the centre of a planetary nebula. The outer atmosphere of the former red giant will be blown away into space to form a spectacular ring around the now dead Sun.

Star sizes

The Sun is so large compared to our planet, it could hold one million Earths. However, in comparison to other stars it is almost insignificant. If our Sun is given a value of one solar diameter, then we can compare how big or small another easily visible star in the night sky may be. A star that is three solar diameters is three times the diameter of our Sun.

Table 12.1 Star sizes

Star	Size (solar diameter)
neutron star	*0.00001*
white dwarf	*0.01*
our Sun	*1*
Sirius A (the brightest star in the night sky)	*2*
Rigel (blue giant star in the Orion constellation)	*50*
Betelgeuse (red supergiant star in the Orion constellation)	*400*

Are 'bright' stars really bright?

How bright a star appears to the observer is influenced by its distance from Earth and its size. Because our Sun is close to Earth (150 million kilometres away) it gives the impression of being monstrous and brighter than any other star. A star that is small will appear to be much dimmer than a large star with the same brightness at the same distance. Luminosity is the total energy radiated by a star each second. It depends upon the size of the star and its surface temperature.

The Moon, Jupiter and Venus are three bright, night sky objects. They only appear to be very bright because they are so close. They are not naturally bright at all. Planets only reflect light from the Sun and do not make their own light.

The colours of stars

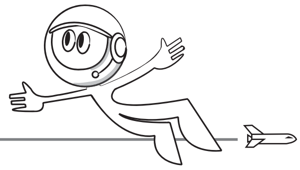
If you look at the stars, most of them appear white. Look closely and some are distinctly red or blue. Stars appear different colours because they have different surface temperatures.

In the Orion constellation (the Hunter), there are two stars called Betelgeuse (pronounced Beetle-juice) and Rigel (pronounced Ri-jel). Betelgeuse is red in colour because its surface is very cool. Rigel is blue because its surface is very hot.

Stars are classified using the letters: **O, B, A, F, G, K, M.** This classification is based on the star surface temperature and therefore their colour and age: Stars of different ages give off different coloured light.

Activities

- Investigate the effects of light pollution while viewing stars from your back yard.
  - * the hypothesis: The night sky can be best viewed from a dark location.
  - * Choose the darkest space available and record the night sky view.



* Add light from one torch, several torches, external house lights, car lights and record the sky view for each.
* Is your hypothesis correct?
* If available use a small telescope for viewing.
* Brainstorm reasons why optical telescopes are not usually located near cities.

- Research the death of massive stars and find out how astronomers detect the presence of cosmic objects like black holes and pulsars.

- Plot star temperature (horizontal axis, decreasing from left to right) and luminosity (vertical axis) using table 12.2: Star classes.
  * Use different colours eg. blue for large (O class) and red for small (M class).
  * Research the terms 'main sequence stars' and 'Hertzsprung-Russell Diagram'
  * How do the terms relate to your graph?

- Model the mirror of the largest optical telescope, Keck. Keck's mirror is made up of a number of hexagonal segments (a hexagon is a shape with six equal sides).
  * Cut a number of hexagons and arrange them into a much larger hexagon.
  * How many are needed if the centre hexagon is removed?
  * Research this famous telescope and list three astronomical achievements that have occurred using this telescope.

Did you know?...

Students of astronomy remember the order of the star classes from hottest (blue) to coolest (red) by saying 'Oh Be A Fine Guy (or Girl) Kiss Me'.

- Design and make a radio telescope using an umbrella with a foil lining and a radio. The Parkes Observatory uses a radio telescope to investigate bodies in space that cannot be seen easily by their light.
  * Use your model to determine why the dish must move to continually track a cosmic source of the radio energy.
  * Why does any cosmic source appear to move over time?

- Design an investigation that will verify or disprove the following hypothesis: 'The smaller the size of the star, the greater its apparent brightness'.
  * Use the following materials;
    - torch
    - white paper screen
    - two aluminium foil covers for the torch (one with a small hole, one with a large hole).
  * Investigate if distance affects the apparent brightness of stars using the torch and white paper screen.
    HINT: the hypothesis is incorrect.

- Compare the sizes of stars.
  * Prepare paper models of the first three stars in Table 12.1. Use a diameter of 1 cm for the Sun.
  * Explain why it would be impractical to model Betelgeuse.

Websites

http://www.schoolsobservatory.org.uk/astro/textb/stars/hotcold.htm Temperature of stars.
http://www.naasbeginners.freeuk.com/AbsoluteBeginners/Star_Colours.htm Colours of stars.
http://www.enchantedlearning.com/subjects/astronomy/stars/startypes.shtml All about stars.
http://observe.phy.sfasu.edu/ Star charts.
http://www.anzwers.org/free/universe/hr.html Hertzsprung-Russell diagram.

Table 12.2 Star classes

Star Type	O	B	A	F	G	K	M
Colour	*Very blue*	*Blue*	*White*	*Yellow-White*	*Yellow*	*Orange*	*Red*
Luminosity (Sun = 1)	*10 000*	*1 000*	*20*	*4*	*1*	*0.2*	*0.01 down to 0.00005*
Average temperature in ^0C	*30 000*	*20 000*	*10 000*	*8 000*	*6 000*	*4 000*	*3 000*
Mass (Sun = 1)	*50*	*10*	*2*	*1.5*	*1*	*0.7*	*0.1*
Potential life span (millions of years)	*10*	*100*	*1 000*	*5 000*	*10 000*	*50 000*	*100 000*
Example of this star class	*Alnitak (Zeta Orionis)*	*Regulus*	*Sirius A*	*Procyon A*	*Our Sun*	*61 Cygni A*	*Barnard's Star*

C13 Vast cosmic distances

It is a hopeless task for astronomers to try and measure the vast distance in the universe using units we commonly use on Earth, like kilometres or metres. They are too small.

Measuring distance in space

There are a few different units which can be used to measure distance in space. The one most people are familiar with is the light year. This is the distance that light would travel in one year, at the speed of 300 000 kilometres per second. One light year is equivalent to about 9.5 million million kilometres. Astronomers tend to use the parsec. One parsec is equal to 3.26 light years.

Astronomical unit

Astronomers do not use light years when determining the distances within our Solar System. The distances between these celestial bodies are no-where near the distance of a light year. Astronomers use a smaller unit called the astronomical unit (AU). This is the average distance of the Earth from the Sun, about 150 million kilometres. Earth's closest neighbour, the Moon, is approximately 384 000 kilometres away. 1 AU is 390 times greater than this distance.

Table 13.1 Distances from the Sun

Celestial body	Average distances from Sun (AU)
Mercury	*0.40*
Venus	*0.75*
Earth	*1.00*
Mars	*1.50*
Jupiter	*5.00*
Saturn	*9.50*
Uranus	*19.00*
Neptune	*30.00*
Pluto	*39.50*
Alpha Centauri (the nearest visible star)	*270 000.00*

NOTE: The distance to Alpha Centauri is not usually given in AU.

The distance of some bright stars

The two stars that are known as 'The Pointers' near the Southern Cross are Alpha and Beta Centauri. The yellow star, Alpha Centauri is only 4.3 light years away. The blue giant, Beta Centauri is over 100 times further away. From Earth, they appear similar in distance and brightness. Table 13.2 shows some approximate distances of stars we can see with the naked eye, including the Sun for comparison.

Table 13.2 Distance of stars from Earth

Star	Location in the sky	Distance from Earth (light years)
Our Sun	*Moves east to west in the sky*	*8.3 light minutes*
Sirius A (brightest star in the night sky)	*Canis Major constellation*	*8.6*
Betelgeuse (red supergiant)	*Orion constellation*	*427*
Antares (red giant)	*Scorpius constellation*	*604*
Rigel (blue giant)	*Orion constellation*	*773*

Beta Centauri

When we look at the bright, binary (double) star Beta Centauri at night, we see it as it was 525 years ago. The starlight left its surface during the time of our 16th century when Nicholas Copernicus was developing his theory that the Earth actually travelled around the Sun. His ideas contradicted all philosophical and religious beliefs of the time.

Suppose Beta Centauri ended its existence tonight. We would have to wait another 525 years before observing its supernova explosion. The violent event would become as bright as the Moon then eventually blink out of sight.

When astronomers look towards the edge of the visible universe, they are reaching back in time to a very young universe. Galaxies that are billions of light years away must have formed early in time. They may not exist today but we see them because their light is still reaching us from all those billions of years ago.

Activities

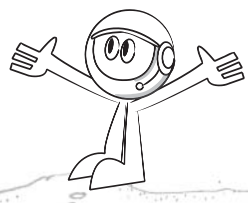
- Plot the distance of the planets from the Sun on graph paper using the scale 1mm = 1 AU.
  - * Use the Table 13.1 in the chapter.
  - * How large would the paper need to be to fit Alpha Centauri on the graph?

- Calculate the time taken to travel to Mars by;
  - * spaceship at 40 000 km/hour
  - * car at 100 km/hour
  - * school bus at 50 km/hour
  - * bicycle at 15 km/hour
  - * Use:
    - 56 million million kilometres, the minimum distance between Mars and Earth.
    - speed = distance/time (convert answers to days or years)
  - * *Answers- 58 days, 64 years, 128 years, 426 years, expressed to the nearest whole day or year.*

- Model the distances of the planets from the Sun in the Solar System.
  - * Using the scale 1 AU as represented by one long student stride, arrange students to represent the distance of the planets from the sun.
  - * Use the information in Table 13.1.

Websites

http://www.howstuffworks.com/question94.htm
Light years.
http://en.wikipedia.org/wiki/Light_year
Light year.
http://www.anzwers.org/free/universe/12lys.html
The universe within 12.5 light years.
http://www.what-is-the-speed-of-light.com/light-year.html
Calculating a light year in kilometres.
http://.k12science.org/noonday



C14 The Milky Way

Our Sun is just one of 200-400 billion stars in our galaxy, the Milky Way which is one of billions of galaxies in the universe. The Milky Way has a spiral structure with a central bulge. It slowly spins in space at about 250 kilometres per second. If viewed from above, it would look like a great rotating hurricane of stars. Our galaxy is about 100 000 light years in diameter with a supermassive black hole at the centre, millions of times the mass of our Sun.

The Milky Way is consuming nearby galaxies

One of our galaxy's nearest neighbours, discovered in 1994, is a small satellite galaxy on the other side of the Milky Way called the Sagittarius Dwarf galaxy. It is only 75 000 light years away and is in the process of being consumed by the Milky Way. The end will come about 750 million years from now. It will be unlikely that any stars of the two galaxies will collide.

More recently discovered is a small, one billion star galaxy that is only 25 000 light years from the Milky Way. Our galaxy's gravity has been violently tearing apart the Canis Major dwarf galaxy and stealing its stars. This has left just a remnant in the form of a vast starry ring around the Milky Way.

Observing our own galaxy

On a clear dark night, we can easily see a milky band of stars stretching across the sky. It's commonly named 'The Milky Way'. Our Sun is located on the inner edge of one of the galaxy's spiral arms. We are really looking across the plane of our galaxy towards its centre.

To locate the centre of the galaxy, find a teapot arrangement of stars (called an asterism) in the Sagittarius constellation near the tail of the scorpion. This is like the gateway to the galaxy centre.

Galaxies of the local group

There are billions of galaxies in the universe. They are mainly classified as being

- spiral - with at least two arms of the spiral,
- elliptical - like a football but some are almost perfectly spherical, or
- irregular - no special shape.

Most of these galaxies are so distant that they are only as points of light like stars, or cannot be seen at all. Two galaxies that are easily visible with the naked eye from Earth are the very close, irregular shaped, hazy formations of the Large and Small Magellanic Clouds. They are located in the night sky near the South Celestial Pole, the imaginary point around which all stars appear to move in the southern sky. They are often mistaken for faint, atmospheric clouds even if the night sky is perfectly clear.

Did you know?...

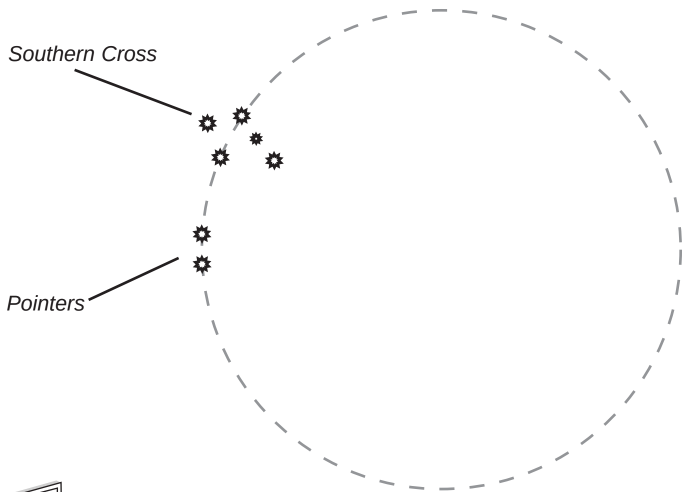
An asterism is a shape within a constellation - like the 'saucepan' in the Orion constellation.

Activities

- Practise skymapping by drawing constellations.
  - * Reference a section of the sky using a compass to show direction from a set landmark in the school grounds.
  - * Seek assistance from your local Astronomical Society.

- Use the websites below to find more information about "The Emu" and other Aboriginal stories associated with the sky.

- Locate the Large and Small Magellanic Clouds in the night sky.
  - * Use the diagram of the Southern Cross and the near-by Pointers Alpha and Beta Centauri to locate the South Celestial Pole and the two galaxies, the Large and Small Magellanic Clouds.
  - * On the diagram below, draw a line through the long axis of the Southern Cross to the other side of the paper. Now draw a line through the middle of the two Pointers to bisect the first line.
  - * The South Celestial Pole in the night sky will be the point where the two lines intersect.
  - * The two galaxies that resemble clouds will be found opposite the Southern Cross on the other side of the South Celestial Pole.
  - * Look hard! Light pollution in a city will make it difficult for clear viewing.



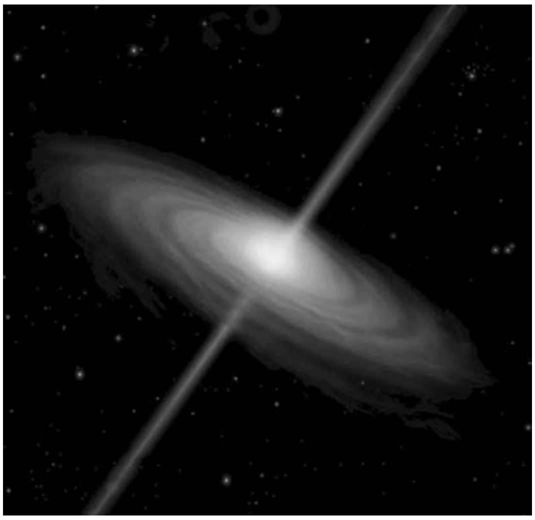
Websites

http://library.thinkquest.org/C005462/index2.html Aboriginal astronomy.
http://www.questacon.edu.au/html/the_emu.html Aboriginal astronomy.
http://seds.lpl.arizona.edu/messier/more/mw.html Milky Way information.
http://www.saao.ac.za/sky/findsouth.pdf Locating the south celestial pole.

C15 Clarifying cosmic concepts

The mysterious black hole

This cosmic phenomenon is the most intriguing object in the universe. Supergiant stars will die in a rarely seen cosmic spectacle called supernovae. They are gigantic, violent explosions that release more energy than the entire Milky Way galaxy. This kind of star death is so bright, it can easily be seen during the day. When the core of a dying star has a mass many times the mass of our Sun, gravity can create an unstoppable, rapid collapse until it becomes an unimaginably small, dense point known as a singularity - a black hole.



Black Hole. Source: NASA

Even light cannot escape

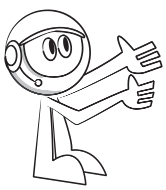
The gravity of a black hole is so powerful that both matter and light cannot escape. The 'black hole' ceases to radiate light and as a result, it cannot be seen.

Misunderstandings

To put to rest misunderstandings commonly associated with a black hole:

- Its gravity may be enormous for such a small object but it is no greater than the gravity of the original star before its death.
- It is not a cosmic 'vacuum cleaner' sucking matter from far away in the galaxy. Objects that come within the gravitational field of the black hole will be drawn towards it. This is exactly the same as if the object had come within the gravitational field of the original star.

If the Sun became a black hole (which is impossible because it is too small) the planets would be dark and cold but they would not be disturbed in their orbits.



Supermassive black holes

There are black holes that are millions of times the mass of a single large star. Over billions of years they will have consumed large quantities of gas and star matter that has come within their gravitational field. The effects of this kind of black hole are dramatically different. A supermassive black hole is located at the centre of our galaxy.

Meteorites

Millions of meteors burn up in the Earth's atmosphere each day. They create dust, which increases the volume of soil on Earth by about 300 tonnes a day. Meteors are lumps of rock or metal (nickel and iron) or a mixture of both. Meteors become known as meteorites when they survive the fall to Earth.

Most meteors are generally only as small as a grain of sand, on average 0.6mm in size. A bright fireball may be from a meteor that is only the size of a marble.

Very hot or very cold?

Friction is not the reason that a meteor becomes hot during its fall through the atmosphere. A meteor falls at the rate of about 15 km per second, creating a shock wave.

The violent compression of air in front of the meteor becomes superheated. (A bit like a bike pump becoming hot from the compression of air inside). The hotter parts of the meteor do melt but get blown away in a process called ablation. The stripped off meteor particles create the long, bright trail that we see as a 'falling star'.

A newly landed meteorite is usually very cold and not hot, as one would assume. The hot parts are removed in flight leaving a chilly remnant of the cosmic rock that wandered the deep freeze of space for millions or billions of years.

Did you know?...

You could create a black hole situation if you could crush the Earth down to the size of a large pea while retaining its original mass.

A spacecraft flying away from Earth needs an escape velocity of 11 km per second. To escape a black hole, the spacecraft would have to fly faster than the speed of light - greater than 300 000 km per second.

The nearest black hole, recently discovered by astronomers, is only about 1 600 light years away.

The process of ablation was used in the early space progam to remove heat from the bottom of the space capsules during their re-entry.

Science fiction or science fudge?

Some science fiction movies and books do use accurate science. However, for dramatic effect, many situations are scientifically incorrect. The two most obvious errors relate to laser light and sound.

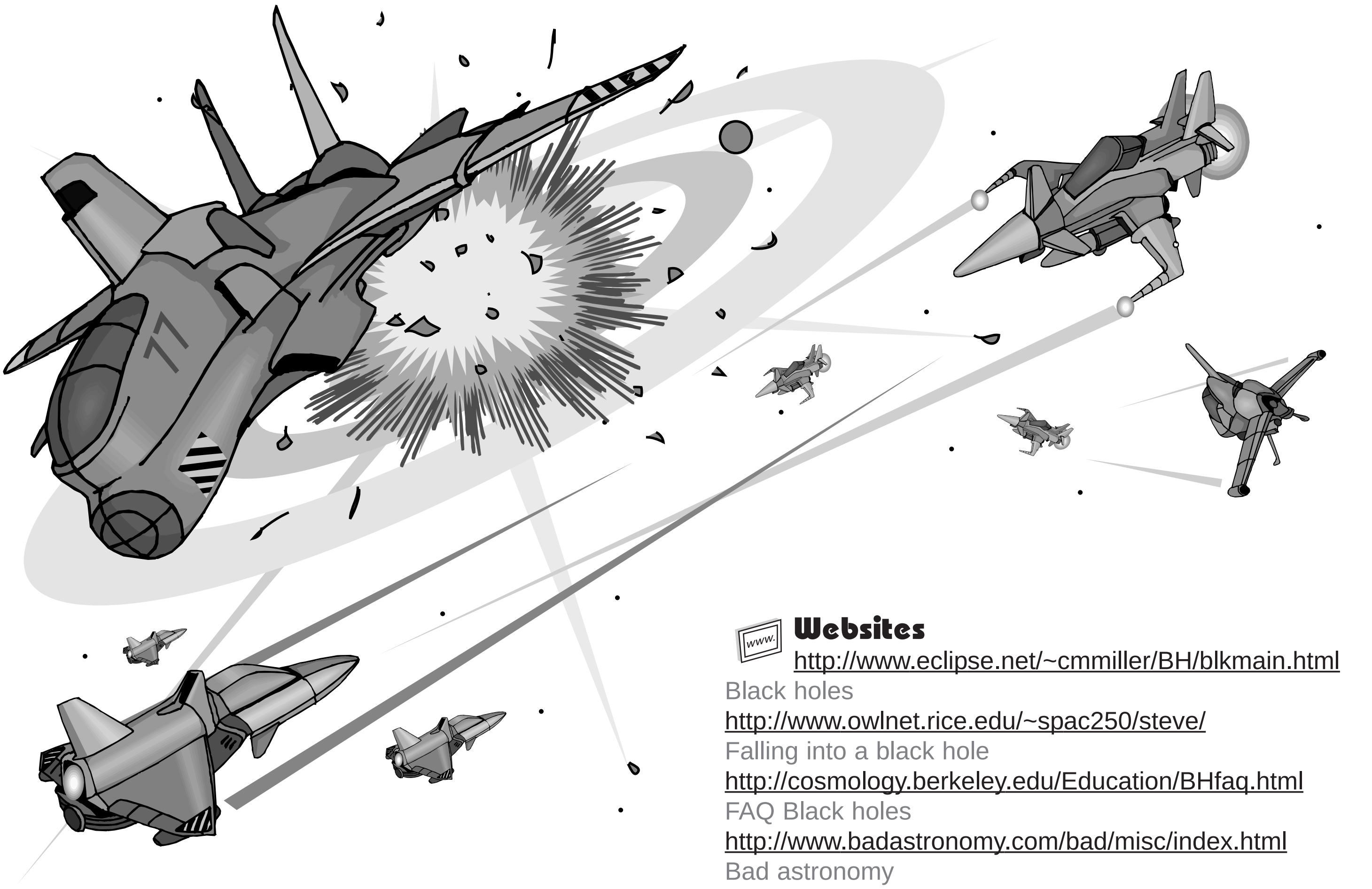
The light from a spaceship's laser guns, used to destroy enemy spacecraft, would not be visible. Space is classed as a vacuum. It only contains an average of one atom per cubic centimetre, compared to 10^{19} molecules in the same volume of air on Earth. Laser light can only be seen if it is reflected from the surface of matter, even if the matter is only as small as dust particles. Space has too few particles to scatter the laser light and allow visibility.

Similarily there are no particles of matter to transfer energy or shock waves in space. Hence you would not hear an audible blast, nor experience violent rocking from an exploding spacecraft.

Activities

- Review a science fiction media sample that is suitable for classroom discussion.
  - * Examples include *Dr Who, Lost in Space, ET, My Favourite Martian, Star Trek, The Jetsons, Astroboy, Hitchhikers Guide to the Galaxy.*
  - * Record the differences between different species/machine characters. Include communication, travel, species/personal priorities, requirements for survival, etc.
  - * Place the sample in a time context.
  - * Choose two futuristic aspects and analyse/evaluate the correctness/plausibility of the science involved.

- Discover why meteorite craters have different shapes.
  - * Use a tray of flour covered with cocoa or powdered coffee.
  - * Use different sized objects dropped from different heights and angles to determine how the shape, depth and diameter of a crater is affected by the falling artificial meteorites.
  - * What other impact features are observed?



Websites

http://www.eclipse.net/~cmmiller/BH/blkmain.html
Black holes

http://www.owlnet.rice.edu/~spac250/steve/
Falling into a black hole

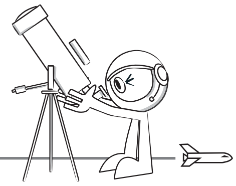
http://cosmology.berkeley.edu/Education/BHfaq.html
FAQ Black holes

http://www.badastronomy.com/bad/misc/index.html
Bad astronomy

http://starchild.gsfc.nasa.gov/docs/StarChild/
'Search' for Meteors

http://www.geocities.com/naran500/infamy/index.html
Science blunders in movies

C16 Other solar systems



In the times of Galileo, just mentioning that other planets or perhaps life may exist beyond Earth would have resulted in being burned at the stake. Giordano Bruno unfortunately discovered this in 1600. Galileo himself barely escaped death for heresy when he published literature in support of the theory that the Sun, not the Earth, was at the centre of our Solar System (called the universe at the time). In 1992, Galileo was finally exonerated by the Catholic Church, after 359 years.

Extrasolar planets

Astronomers have discovered over 130 extrasolar planets. These are planets around distant stars. The star (or sun) that a planet orbits is called a parent star. Planets may be part of a natural process in the formation of stars.

Astronomers have detected early stage solar systems in formation. One is the apparent planet forming disk of the star Beta Pictoris. As a star forms in a contracting, spinning cloud of dust and gas, the leftover material sticks together over time through many collisions to form the planets. Within our own galaxy, there would be the potential for billions of other solar systems. The closest star to us apart from the Sun, considered to have planets, is just over 8 light years away.

Why can't astronomers actually see planets around other stars?

In comparison to their parent star, planets are too small, too dark and too close to their parent star when observed from a distance. On Earth, the Moon, Venus, Mars, Jupiter and Saturn appear to shine brightly as they reflect light from the Sun. In comparison, the very faint reflection from far-off extrasolar planets is lost in the powerful brilliance of their parent star.

How do astronomers identify planets around other stars?

Astronomers must look for clues of planets around other suns (parent stars) especially smaller planets like Earth and Mars. They:

- seek out large Jupiter-like planets by detecting a characteristic wobble of the parent star, caused by the gravitational pull of the planet. The bigger the planet, the more obvious is the wobble of the parent star. The actual motion is not observed, only the slight changes in the stars position that indirectly suggests movement. The extent of the wobbles gives astronomers information about the size of the planet, its orbit time and distance from the parent star.
- look for a dimming in the brightness of a parent star, as a large planet orbits in front of it. How much the star dims and for how long allows astronomers to calculate the approximate size of the planet.

Our current technology cannot sense a noticeable wobble or brightness change created by small planets the size of Earth.

New technology to find other planets

New methods to enhance the detection of extrasolar planets will be investigated by the spacecraft Kepler that should be launched in 2007. It will monitor 100 000 stars every 15 minutes for four years, searching for a tell-tale drop in brightness indicating an Earth-sized planet in an Earth-like orbit crossing in front of its parent star. Kepler may also provide the first survey of planets that could support life within a 'habitable zone' around each star. In the mean time, many ground based searches are being conducted for extrasolar planets. One project is currently being conducted at the Anglo-Australian Telescope.

How could scientists investigate a new planet discovered in another solar system?

Astronomers embark on several stages of observations during their investigations.

1. A telescope on Earth may be used but the atmosphere always obscures the image.
2. A telescope in space could be commissioned to make a clearer observation because it is above the atmosphere but not much closer.
3. With much improved technology, a spacecraft could be sent to conduct a fly-by observation of the target.
4. Another space probe could undertake an orbital observation of the planet.
5. Finally, a robotic lander may be used for first hand observations.

By making accurate observations, gathering and recording data from different viewpoints, scientists can make plausible inferences and create a hypothesis for further investigation.

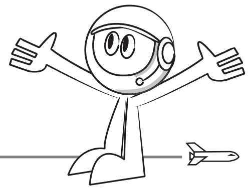
Activities

- Determine the type of information gathered on a model planet or objects in the classroom. Use the following observation techniques.
  - * An optical telescope on Earth. Use a paper towel roll as a model telescope and plastic bubble wrap to represent the Earth's atmosphere. Observe for one minute.
  - * A space telescope near Earth. Remove the bubble wrap. Observe for one minute.
  - * A spacecraft fly-by of the planet. Observe the model planet with the telescope by walking past no closer than 1.5 metres.
  - * Orbiting around the planet. Observe the model planet with the telescope by walking around the planet for two minutes at a distance of one metre.
  - * Record all observations as a drawing of the model or objects with written descriptions.

Websites

http://www.btinternet.com/~patricks.web/astro/othersolarssys.htm Other solar systems.

Glossary and Additional resources



AAO - Anglo-Australian Observatory located at Siding Spring, NSW

Ablation - the process of heat being carried away from an object as its burning surface is blown away.

ALH84001 - meteorite from Mars found in Antarctica.

Archaea - ancient microbes that are possibly one of the earliest lifeforms to have evolved on Earth.

Asteroids - small bodies of rock, ices and metal found all over the Solar System.

Asterism - small group of stars that forms a pattern but is a part of a larger constellation.

Astrobiologist - scientist that seeks to understand the origins of life and the possibility of life out there in space.

ATNF - Australia Telescope National Facility consists of the radio telescopes of Parkes Observatory, the Compact Array, Narrabri and the Mopra Observatory, 20 kilometres west of Coonabarabran.

AU (Astronomical unit) - unit of measurement that is the average distance between the Sun and the Earth.

Binary star - a star that is really two stars.

Black hole - a region of space from which neither light nor matter can escape.

Bone density - refers to the amount of minerals in the bones.

Celestial bodies - all natural bodies visible in the sky.

Circadian rhythms - the body's internal clock that is guided by the light cues of day and night.

Comet - bodies of mainly ice, rock, dust that orbit the Sun and form a long tail when nearing the Sun.

Corona - layer of hot, thin gas that is the outermost region of the Sun.

Coronal mass ejection - expulsions of billions of tonnes of material from the Sun.

Cosmos - everything that exists anywhere, i.e. the universe.

Crawler - large slow moving vehicle that transports the space shuttle out to the launch pad.

Decibel - unit of measurement of the loudness of a sound.

DNA - molecules that carry genetic information inside the cells of living things.

Escape velocity - velocity required by a spacecraft to escape from the Earth's gravitational pull, i.e. 11 km/sec.

ET - External tank of the space shuttle.

Extrasolar planet - a planet detected around a distant star beyond our Solar System.

Extremophile - primitive life form that can exist in extreme environmental conditions.

'g' - symbol for a unit of force equal to the force exerted by gravity on Earth. It is used to indicate the force to which a body is subjected when it is accelerated as in a space shuttle launch.

Galaxy - collection of billions of stars, gas and dust bound by gravity.

Gravity - force of attraction between any two objects with mass.

Habitable zone - region around any star that might potentially support a planet with life.

KBO (Kupier Belt Object) -a rocky object found in the distant Kupier-Edgeworth Belt beyond Neptune.

Kepler's 2nd Law of Planetary Motion - the closer the planet is to the Sun, the faster it moves in its orbit around the Sun.

Kuiper-Edgeworth Belt- a region of rocky bodies located beyond Neptune.

Light year - unit of distance measurement - the distance that light travels in one year.

Luminosity - total energy radiated from a star every second and depends on the size of the star and its surface temperature.

Meteor - small rocky body from space that falls through the atmosphere and is seen at night by a streak of light.

Meteorite - meteor that impacts the Earth's surface.

Moon - a natural satellite around a planet or asteroid.

MSSO - Mt Stromlo Scientific Observatory, Canberra.

Nebula - cloud of dust and gas in

Neutron star - is an incredibly dense, collapsed core of a massive star resulting from a supernova.

Parsec - standard unit of distance used by astronomers (1 parsec = 3.26 light years).

Payload commander - an astronaut responsible for coordinating the science experiments in space.

Planetary nebula - a halo-like shell of expanding matter pushed outward from a dying red giant star. A white dwarf star is found at its centre.

Progress vehicle - unmanned Russian spacecraft that carries cargo to the space station.

Pulsar - incredibly dense, neutron star that spins rapidly and emits beams of radio energy.

Retrograde motion - planet appearing to move backwards in the sky because Earth in its faster orbit has overtaken it.

SETI - Search for Extraterrestrial Intelligence.

Snottites - mucous-like formations that hang from the ceilings of caves containing acid and colonies of bacteria.

Solar flare - explosive release of energy from the Sun

Solar prominence - huge bright arc or loop of material in the sun's atmosphere.

Solar wind - streams of charged particles that flow into space from the Sun.

Solid fuel - rubbery textured fuel consisting of aluminium, ammonium perchlorate and iron oxide used in the solid rocket boosters.

South Celestial Pole - imaginary point in the southern sky around which the stars appear to rotate.

Space weather - changes in the space environment of Earth due to the Sun's activity.

Spiral arm - a bright, starry region that forms part of the spiral pattern of a galaxy and extends from the central bulge of the galaxy.

SRB - Solid Rocket Booster that provides extra thrust for the space shuttle during its launch to space.

STS - Space Transportation System. All names of all space shuttle missions begin with STS.

Sunspot - dark, cooler area on the surface of the Sun.

Supergiant star - a very large star more than 8 times the mass of our Sun.

Supernova - a violent explosion at the end of the life of a massive star.

VAB - Vehicle Assembly Building in which the space shuttle is assembled.

Weightlessness - the feeling of having no weight due to freefalling.

White dwarf star - final stage in the life of a star that results in a body that is no larger than 1.4 and no smaller than 0.8 the mass of our Sun.

Additional resources

There is a vast collection of resources available to support further research into space science. A sample is listed to the right.

Articles on space related topics published in -

Teaching Science, the journal of the Australian Science Teachers Association. Published by the Australian Science Teachers Association. Contents indexed in Australian Education Index (ACER) and Current Index to Journals in Education (ERIC).

The Australian Science Teachers' Journal. Published by the Australian Science Teachers Association. Contents indexed in Australian Education Index (ACER) and Current Index to Journals in Education (ERIC).

Investigating, Australian Primary and Junior Science Journal. Published by the Australian Science Teachers Association. Contents indexed in Australian Education Index (ACER) and Current Index to Journals in Education (ERIC).

The Helix, the bimonthly magazine of CSIRO's Double Helix Science Club for ages 10+) published by CSIRO Education. www.csiro.au/helix

Scientriffic, the bimonthly magazine of CSIRO's Double Helix Science Club for ages 7+) published by CSIRO Education. www.csiro.au/scientriffic

New Scientist, Reed Business Information Ltd, www.newscientist.com

Australian Science, Control Publications Pty Ltd www.control.com.au

Space Frontier News, the bimonthly journal of the Australian Space Community, published by the National Space Society of Australia Ltd. http://www.nssa.com.au

Books of interest

Couper, H. & Henbest, N. (1994). *How the Universe Works*. Australia: RD Press.

Dawes, G., Northfield, P. & Wallace, K. (2004). *Astronomy 2004: A practical guide to the night sky*. Australia: Quasar Publishing.

De Pree, C. & Axelrod, A. (1999). *The Complete Idiot's Guide to Astronomy*. New York: Alpha Books.

Ellyard, D. & Tirion, W. (1994). *The Southern Sky Guide*. Australia: Cambridge University Press.

Gordon, S.A. (2003). *The Solar System*. Leicestershire: Armadillo Books.

Levy, D.H. (1995). *Skywatching.* Australia: Ken Fin Books.

Sparrow, G. (2001). *The Universe and How to See it*. London: New Burlington Books.

Materials available for download from the internet

Space Science Institute http://www.spacescience.org/Education/CurriculumDevelopment/1.html
NASA http://spacelink.nasa.gov/.index.html

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Curriculum Framework links

- Earth and Beyond
- Science in Society

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