

School visits

WHAT WE OFFER FOR YOUR CLASS

Sydney Observatory offers educational tours both day and night. Daytime tours can be booked Monday to Friday during school terms for up to 80 students starting at 10.00 am or 12.00 noon. Weekend tours can be arranged for country schools. Night tour session times vary throughout the year depending on daylight saving and start at 6.15 pm or 8.15 pm (except December and January which start at 8.30 pm).

Each 90-minute day tour can be tailored to your students needs and is guided by an astronomy educator. See page 17 for booking details.

PROGRAM OVERVIEW

Astronomy tour (see page 7 for details)

- Tour of the astronomy instruments on display in the Observatory
- 3-D Space Theatre
- Planetarium
- Telescope viewing

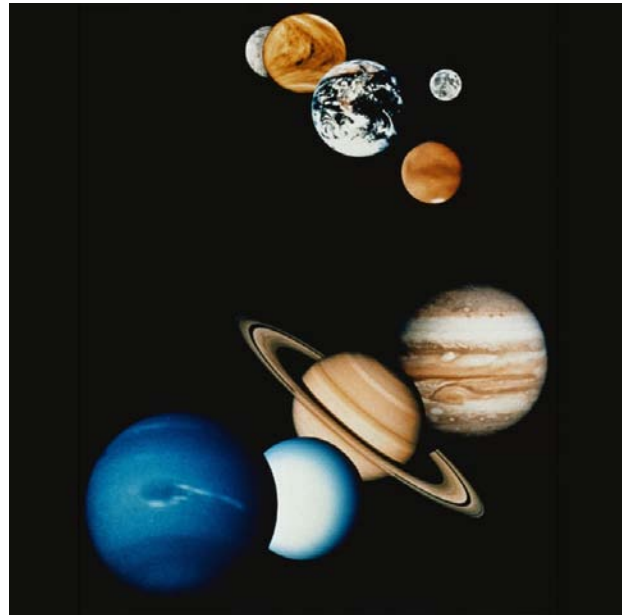
Weather tour (see page 9 for details)

- Visit the *Observing the weather* interactive and historic exhibition at the Observatory
- Data collection using Observatory equipment
- 3-D Space Theatre
- Visit to nearby Bureau of Meteorology instrument lawn

Also available are joint visits with the Powerhouse Museum, IMAX, Sydney Learning Adventures, Australian National Maritime Museum (see page 5 for details).

3-D Space Theatre (see page 11 for details)

Providing an amazing 3-D space experience, the 3-D theatre technology was developed in Australia by the Centre for Astrophysics and Supercomputing at the Swinburne Institute of Technology in Melbourne and shows short films on the solar system, space exploration and cosmology.



Solar System Montage. Photo courtesy Getty.

Planetarium

This is an astronomer led experience in a cosy planetarium. The star field cylinder used includes an extraordinarily precise depiction of the Milky Way based on the beautiful all-sky panoramas created by astrophotographer Dr Axel Mellinger.

Telescopes (see page 13 for details)

The Observatory has two functioning telescope domes. The older south dome now houses the oldest working telescope in Australia, a 290 mm or 11.5 inch refracting telescope. The north dome houses a 400 mm computer controlled Schmidt Cassegrain reflecting telescope and a Coronado Solar telescope for safe viewing of the Sun during the day.

IN THESE NOTES YOU WILL FIND

- Curriculum links — page 2
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- Weather tours — page 9
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CURRICULUM LINKS

The astronomy and meteorology exhibitions can be easily integrated into content strands, units of work or areas of teaching and learning in the following syllabus areas:

SCIENCE AND TECHNOLOGY (YEARS K–6)

Built environments (Stage 2 and 3)

- buildings and the spaces within and surrounding these buildings, eg homes, schools, community facilities and factories, parks and gardens.
- natural environments that have been modified to suit particular needs, eg land cleared for farming and altered waterways
- services provided to communities, eg electricity, water, etc

Information and communications (Stage 2 and 3)

- the nature of communications
- methods of communicating between individuals, groups and communities, eg personal conversation, telephones, satellite link-ups
- changes to information and communication technology over time.

Physical phenomena (Stage 2 and 3)

- relationships between time, space and movement
- sources of energy
- light and some of its characteristics
- heat and some of its characteristics

Earth and its surroundings (Stage 1, 2 and 3)

- the solar system, planets, Earth, Moon and stars
- aspects of the physical environment, eg the Earth's crust, its oceans and atmosphere
- natural changes that occur, such as soil erosion, volcanic eruption, climatic changes and movement of water
- the passing of time and the natural events that make people aware of this passing, eg daily cycles, lunar cycles and seasons
- the variety and characteristics of naturally occurring materials
- the methods people use to obtain and process materials
- the methods people use to manage natural resources
- limitations to resources available on Earth
- renewable resources.

Suggested units of work:

- Stage 1 Hot or Cold, A Place in Time
- Stage 2 Keep in Touch, Cycles in our World
- Stage 3 Out in Space, What's the Weather

HUMAN SOCIETY AND ITS ENVIRONMENT HSIE (K–6)

Stage 2

Change and Continuity, Significant Events and People

- CCS2.1 Describes events and actions related to the British colonisation of Australia and assesses changes and consequences.

Change and Continuity Time and Change

- CCS2.2 Explains changes in the community and family life and evaluates the effects of these on different individuals, groups and environments.

Environments, Patterns of Place and Location

- ENS2.5 Describes places in the local area and other parts of Australia and explains their significance.

Stage 3

Change and Continuity Cultures Significant Events and People.

- CCS3.1 Explains the significance of particular people, groups, places, actions and events in the past in developing Australian identities and heritage.

Change and Continuity Cultures Cultural Diversity.

- CUS3.4 Examines how cultures change through interactions with other cultures and the environment.

MATHEMATICS (K–0)

Early Stage 1 Measurement: Time

- Describe the duration of events using everyday language
- Sequence events in time
- Name days of the week and seasons

Stage 1 Measurement: Time

- Use informal units to measure and compare the duration of events
- Name and order the months and seasons of the year
- Identify the day and date on a calendar

Stage 2 Measurement: Time

- Recognise the coordinated movements of the hands on a clock
- Read and record time using digital and analog notation
- Convert between units of time
- Read and interpret simple timetables, timelines and calendars

Stage 3 Measurement: Time

- Convert between am/pm notation and 24-hour time
- Compare various time zones in Australia, including during daylight saving
- Draw and interpret a timeline using a scale
- Use timetables involving 24-hour time

Stage 4 Measurement: Time

- Perform operations involving time units
- Use international time zones to compare times
- Interpret a variety of tables and charts related to time

Stage 4 Data: Data

- Draw, read and interpret graphs (line, sector, travel, step, conversion, divided bar, dot plots and stem-and-leaf plots), tables and charts
- Distinguish between types of variables used in graphs
- Identify misrepresentation of data in graphs

Stage 2 Space and Geometry: Positions

- Determine the directions N, S, E and W; NE, NW, SE and SW, given one of the directions
- Describe the location of an object on a simple map using coordinates or directions

SCIENCE (7–10)

- Outcome 4.1 — Identifies historical examples of how scientific knowledge has changed people's understanding of the world
- Outcome 5.1 — Explains how social factors influence the development and acceptance of scientific ideas

- Outcome 4.2 — Uses examples to illustrate how models, theories and laws contribute to an understanding of phenomena
- Outcome 5.2 — Describes the processes that are applied to test and validate models, theories and laws
- Outcome 4.4 — Identifies choices made by people with regard to scientific developments
- Outcome 5.4 — Discusses scientific evidence supporting different viewpoints
- Outcome 4.6 — Identifies and describes energy changes and the action of forces in common situations
- Outcome 5.6 — Applies models, theories and laws to situations involving energy, force and motion
- Outcome 4.9 — Describes the dynamic structure of Earth and its relationship to other parts of our solar system and the universe
- Outcome 5.9 — Relates the development of the universe and the dynamic structure of Earth to models, theories and laws and the influence of time
- Outcome 4.12 — Identifies, using examples, common simple devices and explains why they are used
- Outcome 5.12 — Relates the interactions involved in using some common technologies to their underlying scientific principles
- Outcome 4.13 — Clarifies the purpose of an investigation and, with guidance, produces a plan to investigate a problem
- Outcome 5.13 — Identifies a problem and independently produces an appropriate investigation plan
- Outcome 4.15 — Uses given criteria to gather first-hand data
- Outcome 5.15 — Gathers first-hand data accurately
- Outcome 4.16 — Accesses information from identified secondary sources
- Outcome 5.16 — Accesses information from a wide variety of secondary sources
- Outcome 4.22 — Undertakes a variety of individual and team tasks with guidance
- Outcome 5.22 — Plans, implements and evaluates the effectiveness of a variety of tasks independently and as a team member

GEOGRAPHY (7–10)

Focus Area 4G1 Investigating the World

- read synoptic charts

Focus Area 5A1 Investigating Australia's Physical Environments

- read and interpret synoptic charts

Focus Area E1 Physical Geography

- climate
 - global circulation: insolation, pressure, wind, temperature, rainfall
 - global climatic patterns
 - factors affecting climate: latitude, altitude, maritime and continental influences
 - climate change
- distinguish between weather and climate
- explain the global circulation of the atmosphere
- describe global climatic patterns
- analyse climate data from a variety of sources
- weather
 - types of rainfall
 - factors affecting temperature and humidity
 - extreme weather events: droughts, floods, storms
- examine issues resulting from climate change
- collect and record weather data
- describe meteorological processes
- create a multimedia presentation assessing the impacts of an extreme weather event on a community

PHYSICS

8.5 The Cosmic Engine

1. Our Sun is just one star in the galaxy and ours is just one galaxy in the Universe
2. The first minutes of the Universe released energy which changed to matter forming stars and galaxies
3. Stars have a limited life span and may explode to form supernovas
4. The Sun is a typical star, emitting electromagnetic radiation and particles that influence the Earth.

9.2 Space

1. The Earth has a gravitational field that exerts a force on objects both on it and around it
3. The Solar System is held together by gravity
4. Current and emerging understanding about time and space has been dependent upon earlier models of the transmission of light

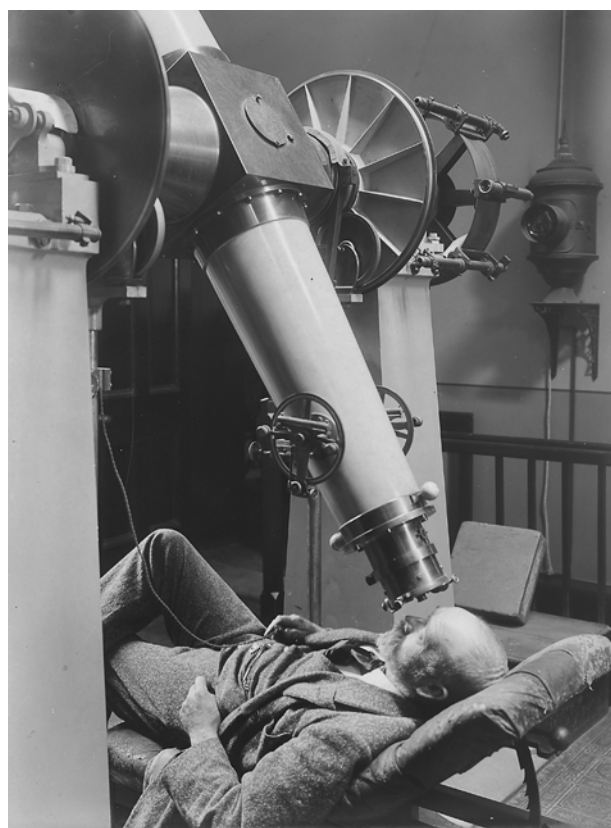
9.7 Option — Astrophysics

1. Our understanding of celestial objects depends upon observations made from Earth or from space near the Earth
2. Careful measurement of a celestial object's position in the sky (astrometry) may be used to determine its distance
3. Spectroscopy is a vital tool for astronomers and provides a wealth of information
4. Photometric measurements can be used for determining distance and comparing objects
5. The study of binary and variable stars reveals information about stars
6. Stars evolve and eventually “die”

SENIOR SCIENCE

9.9 Option — Space Science

1. While the atmosphere has limits there is no such thing as ‘empty’ space
2. The strength of gravity varies at different points in space
3. Space stations and probes provide information about our solar system, galaxy and deep space



Astronomer HA Lenehan using the transit circle at Sydney Observatory 1907–1908.

JOINT DISCOUNT VISITS WITH SYDNEY OBSERVATORY PARTNERS

Joint, discounted visits can be arranged with the Powerhouse Museum, IMAX, Sydney Learning Adventures and Australian National Maritime Museum. Visiting school groups can take advantage of the Observatory's maximum group of size of about 60 by organising an excursion of 120 students where one group of 60 visits Sydney Observatory and the other group of 60 visits another venue. The two groups then swap venues.

For all the learning programs and partnerships, see www.sydneyobservatory.com.

POWERHOUSE MUSEUM

Visit the Powerhouse Museum exhibitions *EcoLogic: creating a sustainable future*, *Space* or *Pathways to space* and then visit Sydney Observatory.

Total cost: \$15 per student (day visit: \$9 Observatory and \$7 Powerhouse).

Contact: Powerhouse Museum, ph (02) 9217 0222 or email edserv@phm.gov.au
www.powerhousemuseum.com
Sydney Observatory ph (02) 9921 3485

IMAX

Visit IMAX to view the shows *Hubble 3-D* (from May 2010) or *Space station 3-D* (terms 1 and 2 only) and then an Observatory 3-D Space Theatre and telescope viewing.

Total cost: \$14.50 (day visit: \$6 Observatory and \$8.50 IMAX)/ \$17.50 per student (night visit: \$9 Observatory and \$8.50 IMAX).

IMAX Theatre Sydney ph (02) 9213 1600 or email education@imax.com.au; www.imax.com.au
Sydney Observatory ph (02) 9921 3485

SYDNEY LEARNING ADVENTURES

Visit Sydney Learning Adventures in The Rocks for the primary program HMS Discovery or the secondary program Rocks Dreaming then a tour of an astronomy or weather fully guided experience at the Observatory. The Rocks Dreaming tour includes the Planetarium, *Cadi Eora Birrung* exhibition and (safe) telescope viewing of the Sun.

HMS Discovery total cost: \$19 (day visit: \$9 Observatory and \$10 Sydney Learning Adventures)

Rocks Dreaming total cost: \$23.40 (day visit: \$9 Observatory and \$14.40 Sydney Learning Adventures)

Contact: Sydney Learning Adventures, ph (02) 9240 8552 or email tours@shfa.nsw.gov.au
Sydney Observatory ph (02) 9921 3485

AUSTRALIAN NATIONAL MARITIME MUSEUM

A full day program on weather is available with a combined Australian National Maritime Museum (ANMM) package, *Ways of watching weather*

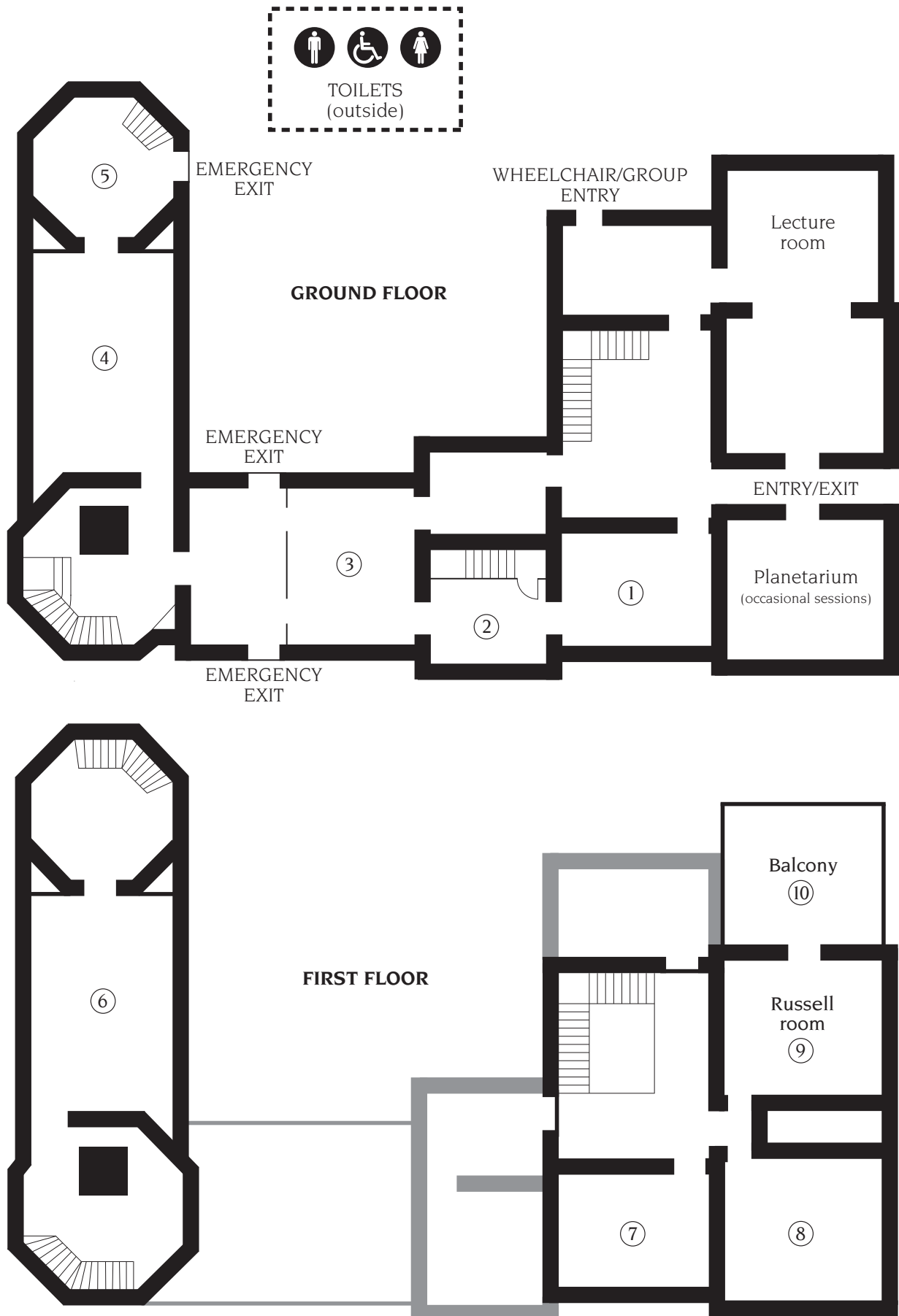
Total cost: \$17 (day visit: \$9 Observatory and \$8 ANMM)

Contact: ANMM, ph (02) 92983655 or email bookings@anmm.gov.au
Sydney Observatory ph (02) 9921 3485



Earnshaw 520 chronometer, made about 1790–1801.

SYDNEY OBSERVATORY FLOOR PLANS



ASTRONOMY TOURS

The 90-minute tour is guided by an astronomy educator and includes a tour through some of Observatory displays, an awesome 3-D Space Theatre experience, a look at the night sky in our Planetarium and viewing through a telescope (weather permitting). During the day students can safely view the Moon, Venus, bright stars through a large telescope as well as the Sun using a special (safe) solar telescope. At the end of the visit each teacher will receive an up to date set of Solar System notes for use at school.

ASTRONOMY INSTRUMENTS TOUR

Room 1 'Watchers of a different sky'

Find out what makes the southern sky special and 'meet' some of the astronomers and explorers who have observed the night sky.

Some of the things you will see:

- Brisbane's telescope — used at Governor Thomas Brisbane's observatory to observe Encke's Comet in 1822
- Repeating circle — used at Parramatta Observatory in the 1820s to measure angles between stars
- Apollo feedhorn — received the historic television images of Neil Armstrong's first footsteps on the Moon in 1969 for a broadcast watched by millions on Earth

Room 2 'Knowing the time and finding the way'

This room looks at the instruments used by Matthew Flinders to chart the Australian coastline in the early 1800s.

Some of the things you will see:

- Earnshaw 520 chronometer — one of the five chronometers used on Flinders' voyage around Australia and the only one still working at the end of the journey
- Earnshaw astronomical clock — this highly accurate clock built in 1791 was used by Flinders to check the timekeeping of the chronometers on his ship
- Sextant — navigators like Flinders used a sextant to determine both the time and the latitude

Room 3 'Transit circle: the biggest clock in the world'

This room is the home of the transit circle, a telescope which was used to determine the exact time, the positions of stars and the geographical coordinates of the Observatory.

Some of the things you will see:

- Transit circle — a special telescope that only moves north and south and used the regular daily spin of the Earth to determine the time
- Chronograph — a machine used to record the transit circle observations
- Pendulum clock — purchased in 1860, this is a highly accurate astronomical regulator clock

Room 4 'Planets and stars of the southern sky'

Explore the solar system and discover the constellations! Did you know that Pluto is no longer considered a planet? In 2006, astronomers reclassified the ice-covered sphere by dubbing it a 'dwarf planet.'

Some of the things you will see:

- Southern Cross 3-D model — peer through the eyepiece and see how the stars on the Australian flag are really distributed in space.
- Solar system models (orreries) — watch a year go by and discover why we have seasons, why the Moon shows phases and how eclipses occur.

Room 5 'Cadi Eora Birrung: under the Sydney stars'

Aboriginal people were Australia's first astronomers and have watched the southern sky for more than 50,000 years. The stars were used as a calendar, for navigation by land and sea and to convey laws to future generations. This room looks at some of the Indigenous Dreaming stories about the different constellations.

Room 6 'Transit of Venus:'

The transit of Venus is of special interest to Australians. Captain James Cook travelled to Tahiti to observe Venus passing in front of the Sun in 1769 and on his return voyage mapped the east coast of Australia. Australia is in a prime location to observe the next transit of Venus in 2012.

Some of the things you will see:

- The photoheliograph — a telescope for photographing the Sun and one of only half a dozen such instruments in the world
- The photographic revolver — designed for use with the photoheliograph and the forerunner of the movie camera.

THE TIME BALL TOWER

The time ball atop Sydney Observatory dropped for the first time on 5 June 1858, alerting Sydneysiders and ships in the Harbour of the exact time. Today the timekeeping tradition continues, with Observatory staff dropping the time ball daily at 1.00 pm. Time measurement and communication to shipping were vital components of astronomical work dating back to the £20,000 prize promised under the Longitude Act of 1714 to solve the problem of determining position at sea.

3-D SPACE THEATRE AND TELESCOPE DOMES

After exploring the displays inside the Observatory, experience the amazing 3-D Space Theatre and telescope viewing (weather permitting). In the day time students can view the Moon, Venus, bright stars through a large telescope as well as safely view the Sun using a special solar telescope.

PLANETARIUM

The digitally produced star field simulates the night sky at any time, season or location on earth. Over 3000 stars are projected to a limiting magnitude of 5.5 with the brightest stars individually lensed to produce intense pinpoint images. Star locations are accurate to within 1 minute of right ascension and 6 minutes of declination. Betelgeuse, Rigel, Antares, Spica, Arcturus, Capella and Pollux appear in full colour. Twelve aperatures show the position of the sun throughout the year. The Planetarium is suitable for students from primary and high school and includes both Indigenous stories and traditional western mythology.



Sydney Observatory time ball.



Sunshine or solar recorder, made about 1892–1905.



View of Observatory Hill and Sydney Harbour Bridge from Sydney Observatory.

WEATHER TOURS

Developed with the support of the Bureau of Meteorology, this 90 minute program consists of four key areas:

1. *Observing the weather* exhibition and weather wheel activities conducted by Observatory staff. Exhibition sections include:
 - 'What was the weather on your birthday?' interactive
 - 'Tipping bucket rain gauge' interactive
 - 'Make a cloud' interactive
 - Historic anemometers, barometers, sun gauge, and Australia's first weather map displays
2. Data collection using our equipment supervised by Observatory staff.
Don't forget a pencil!
 - Temperature
 - Barometric pressure
 - Wet and dry temperature to calculate relative humidity
 - Wind speed
 - The ultra-violet index
 - Rainfall
3. 3-D Space Theatre presentation 'Extreme places', which describes extreme weather conditions throughout the Solar System, including the surfaces of Venus and Mars along with the icy depths of the frozen moon of Jupiter, Europa.
4. A visit to the nearby Bureau of Meteorology instrument lawn. This significant historic site is still one of the prime locations for the remote collection of weather data for the Bureau. Instruments include:
 - Stevenson screen for temperature and humidity measurements
 - Pluviographs for rainfall
 - Rain gauge for rainfall
 - Tipping bucket rain gauge for rainfall

Each teacher will receive at the end of the visit a copy of the book *Stormy weather* courtesy of the Bureau of Meteorology and Sydney Observatory.

OBSERVING THE WEATHER EXHIBITION

Room 7 'Observing the weather: measuring and forecasting'

When the Observatory opened in 1858, its astronomers began recording Sydney's rainfall and temperature. This room displays the many instruments that have measured the weather over the many years since that time.

Some of the things you will see:

- Laser ceilometer — a modern instrument used to measure the height of clouds.
- Newman and Bros mercury barometer — an instrument used at the Observatory in the late 1800s to measure atmospheric pressure.

Room 8 'Observing the weather: surviving the extremes'

An exhibition looking at 150 years of Sydney's weather. Find out about the heatwave of 1939, the floods of 1984 and the hailstorm of 1999.

Some of the things you will see:

- Cloud maker — learn about different types of clouds through an interactive touch screen. If you spot white puffy rolls on a humid morning, expect these altocumulus clouds to bring rain in the afternoon

Room 9 Russell Room

H C Russell was an important pioneer of photography and a significant astronomer who lived and worked at the Observatory between 1870 and 1905.

Some of the things you will see:

- Historic astronomical, weather and family photographs
- Stunning views of the city, Harbour Bridge, the time ball tower and flagstaff from the balcony. The flagstaff flies a variety of meteorological, astronomical and ceremonial flags that change on a daily basis. A flag decoder is available for 50 cents or as a downloadable PDF file from the Observatory's website.

The time ball tower

A wind vane on the tower shows the direction from where the wind is coming and the flagstaff signals which way it is going.

DATA COLLECTION

In the ground of the Observatory students will use instruments to measure temperature, barometric pressure, wet and dry temperature to calculate relative humidity, wind speed, the ultra-violet index and rainfall

3-D SPACE THEATRE

After exploring the displays inside the Observatory, experience the amazing 3-D Space Theatre.

BUREAU OF METEOROLOGY LAWN

Only 50 metres from the Observatory this lawn houses many instruments used daily by the BOM to produce comprehensive weather reports for Sydney. Instruments include:

Pluviographs — no longer used but they measured the amount of rainfall over a certain time.

Traditional 203 mm (or 8 inch) rain gauges — used as backups. Rain falls into a funnel and collects in a graduated measuring cylinder.

Tipping Bucket Rain Gauge (TBRG) — as rain, or precipitation falls into the funnel it drips into one of two very carefully calibrated 'buckets' balanced on a pivot (like a seesaw). The top bucket is held in place by a magnet until it has filled to the calibrated amount (usually approximately 0.2 mm of rain). When the bucket has filled to this amount, the weight of the bucket is enough to break free of the magnet, causing the bucket to tip. When the bucket tips, it triggers an electronic switch. A computer counts the number of tips and calculates the rainfall in millimetres.

The instrument shelter or Stevenson screen — the shelter contains several thermometers.

Typically, minimum temperatures occur just before dawn and maximum temperatures typically before 3.00 pm.

Westpac barometer — though not part of the Bureau lawn the general region does provide a good view of the nearby Westpac building which incorporates a barometer. The eight horizontal lights indicate the barometric pressure from 990 hPa to 1025 hPa in 5 hPa increments.



The Bureau of Meteorology lawn.



The Westpac building barometer.

3-D SPACE THEATRE AND INTERACTIVES

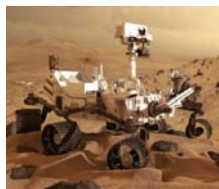
The 3-D Theatre has the ability to show a wide variety of astronomical and space related materials relevant to the NSW primary and secondary curricula. This includes 3-D movies and a selection of interactive experiences delivered by our trained astronomy educators.

Presentations in the 3-D Theatre can be tailored to meet student needs and the topics being studied if prior notice is given.

Please feel free to consult with our staff for selection recommendations.

MARS - NEW 3D MOVIE

Through incredibly detailed terrain models and high-resolution stereo photographs from key NASA missions, we join the search for signs of life on the Red Planet. 'Mars' is the closest thing to going there yourself.
Duration: 9 minutes



EXTREME PLACES

From the indescribable heat of Venus' surface, to the raging dust-storms of Mars and the violence of Io, experience what it takes to survive in the extremes climates of our Solar System.
Duration: 13 minutes



BIGGER-THAN-BIG

What is big? Is the Sun big? What about Betelgeuse which is 1000 times larger than the Sun? Discover just how big the Universe really is.
Duration: 7 minutes



DETECTIVE

It's a race to solve a case from outer space! Join young reporter Penny and private investigator Sam Charleston to research the facts behind a video of an alien attack.
Duration: 13 minutes



THE LITTLE THINGS

Comets, asteroids and Kuiper Belt objects! This is the story of the amazing little things in the solar system and the incredible space missions that have visited them.
Duration: 10 minutes



OUR SUN: WHAT A STAR!

Have you wondered where the Sun came from? How it creates energy? And what its ultimate fate is? Learn all about our nearest, and most important, star.
Duration: 19 minutes



ELYSIUM 7

Hop on board the futuristic tourist ship Elysium 7 and take a 3-D journey to Mars, with surface features based on data from NASA's Mars Global Surveyor spacecraft.
Duration: 9 minutes



AFTER STARS

A red supergiant star is about to end its life – but when the star explodes will it produce a black hole or a pulsar? Join an alien reporter, scientist and the robot WLR-309 to find out.
Duration: 11 minutes



EINSTEIN'S UNIVERSE

Realising Einstein's Universe. A journey into the universe Einstein envisaged almost 100 years ago. Today, modern supercomputers enable scientists to visualise the most wondrous astronomical objects, unlock their secrets and allow everyone to comprehend the natural beauty of Einstein's Universe.

Duration: 9 minutes

During your visit our astronomy educators will also use the 3-D interactives to demonstrate and explain topics relevant to your needs including the latest astronomical developments. For primary level students, we can focus on the solar system, asteroids, space exploration, constellations or seasons, while with years 11/12 we can explore more advanced topics like the evolution of stars.

Examples of the types of topics covered by the 3-D interactives;

- Solar System
- Asteroids
- Exploration of Mars including Phoenix
- Earth and Moon
- Saturn and Cassini
- Sun and Solar Flares
- Transit of Venus
- Scale of the solar system
- Extra-solar Planets
- Dwarf Planets
- Stars
- Light and Spectra
- Space Probes, Lofar, and Hubble
- Pulsars
- Galaxies
- Milky Way model
- Galaxy interaction
- Universe
- Large scale structures of the Universe



Earth by day seen from space. Image based on satellite data, created by Reto Stöckli for the NASA GSFC Earth Observatory.

BACKGROUND INFORMATION

TELESCOPES

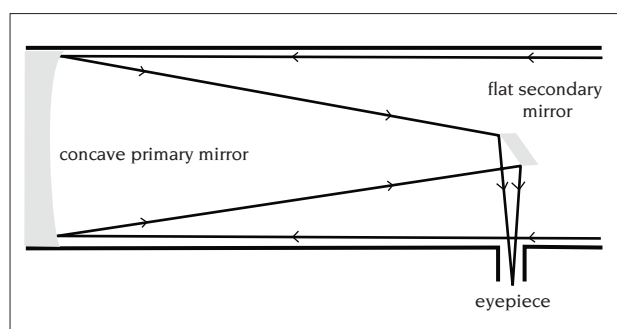
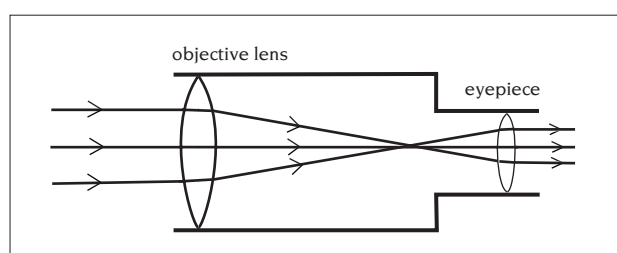
(from the Greek, *tele* 'far' and, *skopein* 'to look or see'; τηλεσκόπος, *teleskopos* 'far-seeing')

There are many different types of telescope. Some like the Hubble and Kepler are in space, while others like the Parkes Radio Telescope don't 'look' at objects but rather listen to their radio noise.

As far as most people are concerned there are two main types of optical telescopes. Those that use lenses to magnify are called refractors and those that use mirrors to collect light are called reflectors.

The inventor of the refractor was probably the Dutch optician Hans Lippershey although others claimed to have made the same invention at the time.

Refractors like the one in Sydney Observatory's south dome have at the front of the tube a convex glass lens that is thicker in the middle than at its edge. As light from distant objects passes through the lens it bends or refracts more at the edge of the lens than light passing through the centre. At just the right distance from the lens the light comes to a focus where the image is created. Another lens called the eyepiece magnifies the image.



Early refractors had problems as the images were not always sharp or the right colour because different colours bent differently as they passed through the main lens. The development of achromatic lenses made up of two pieces of glass each with a different density solved the problem.

Whereas Galileo's telescopes had magnifications of 8x up to 20x the Observatory's refractor works at about 80x making objects look 80 times closer or 80 times bigger. However, all refractors do something unusual to the view. Use the light path above and try to work out what it is?

Reflecting telescopes like the one in Sydney Observatory's north dome work by bouncing light off a combination of curved and flat mirrors. The main mirror usually has a cross-section in the shape of a parabola or sphere.

Sir Isaac Newton is credited with the first working reflector in 1668. It was designed to overcome the colour problems associated with early refractors.

As light enters the telescope tube it bounces off the curved primary mirror. A smaller secondary mirror angled at 45 degrees is placed in the light path before the focus point and aims the light out of the side of the tube. An eyepiece is then used to magnify the image.

For the same size of telescope, reflectors are much cheaper to make and can be built too much larger scales. They too suffer problems and bend under their own weight when around 5m in diameter. All modern large telescopes are a modified version of Newton's design and many use multiple small mirrors instead of one large one. The magnification of the mirror telescope in the Observatory's north dome is around 160x. The Hubble Space Telescope is a variation of Newton's original design.

SIZE AND DISTANCES IN ASTRONOMY

It is difficult to understand how big the Universe is. Size is relative so that a chip may seem huge to an ant and an elephant at the Zoo may seem huge to a child. The Earth's diameter is 12,700 km and it can take up to 20 hours to fly half way

around in a commercial aeroplane from Australia to London, for example. Imagine flying to the Sun which is a staggering 150 million km away! It is also 114 times wider than the Earth but that is fairly average compared with other stars.

The next closest star to the Sun is about 40,000 billion km away. Space becomes so large that distances measured in km become meaningless rows of zeros. As a result other larger units of distance are used. The light year is the one most commonly used in popular books and is simply the distance that light travels in one year in the vacuum of space. To work it out in km multiply the speed of light in a vacuum, which is 300,000 km every second multiplied by the number of seconds in a year. This works out to be roughly 9500 billion km or 1×10^{15} m. The centre of the Milky Way galaxy is about 33,000 light years away and the nearest observable galaxy, the Large Magellanic Cloud, is about 160,000 light years away.

Astronomers use a slightly larger unit called the parsec or the even larger units, Mega parsec (Mpc) and Giga parsec (Gpc). With a definition based on the geometry of the Earth's orbit around the Sun, the parsec is equal to 3.26 light years and so a Mega parsec is 3.26 million light years while a Giga parsec 3.26 billion light years.

The observable Universe has a radius of about 4.2 Gpc! Space is really really big!

ELECTROMAGNETIC RADIATION AND THE DIFFERENT TYPES OF TELESCOPES

The visible light that Galileo observed through his telescope 400 years ago represents only a fraction of the actual spectrum of light that we today know radiates across the universe. Modern telescopes on Earth and in space allow us to detect electromagnetic radiation beyond the kind that we can identify with the human eye.

Electromagnetic radiation or light is a form of energy which travels through space as waves of electric and magnetic fields. Electromagnetic spectrum (see the illustration below) is the range of all possible wavelengths or frequencies of electromagnetic radiation.



Isaac Newton's telescope.

Objects such as planets, asteroids, comets and stars emit light of different wavelengths or frequencies. Visible or optical light (red, orange, yellow, green, blue and violet) that human eyes can see only represents a small part of the whole electromagnetic spectrum. It is only relatively recently in human history that scientists have been able to explore and study wavelengths beyond the visible light spectrum, through the use of telescopes. The illustration below highlights the types of telescopes used in astronomy today, both in space and on the ground. All of these allow views of the sky that Galileo, back in 1609, could never have imagined. Utilising different types of light to examine the cosmos provides us with a more complete understanding of the Universe.

ASTRONOMY RESOURCES

- Follow us on Facebook or Twitter #sydneyjobs
- 2012 *Australian Sky Guide* — the celestial equivalent of a street directory! Compact, easy to use and reliable, this popular guide contains everything you need to know about the southern night sky with monthly star maps, diagrams and details of all the year's exciting celestial events. Wherever you are in Australia, easy calculations allow you to determine when the Sun, Moon and planets will rise and set throughout the year. Available from large bookstores and online at <http://from.ph/8r>
- Solar System Guide, Sydney Observatory — a quick online overview of our solar system <http://www.sydneyobservatory.com.au/education/solar-system-guide/>
- Sydney Observatory News and Blog — find out about the latest news and astronomy views from the Sydney Observatory team <http://www.sydneyobservatory.com.au/observations-blog/>
- Monthly Sky Guides, Sydney Observatory — learn about the stars, constellations and planets visible in the evening night sky from Sydney, with monthly star charts <http://www.sydneyobservatory.com.au/category/astronomy/monthly-sky-guides/>
- Space Weather — the latest information on the Sun's weather. www.spaceweather.com
- The Anglo Australian Observatory — Astronomical and astrophysical links and images <http://www.aao.gov.au/about/abouttheaao.html>
- Astronomy Picture of the Day. The greatest astronomical images from around the world with a simple explanation. <http://apod.nasa.gov/apod/>
- NASA for Educators. NASA's Education



- Materials Finder will help teachers locate resources that can be used in the classroom. <http://www.nasa.gov/audience/foreducators/index.html>
- The Nine Planets. Information about the planets and their moons. <http://nineplanets.org/>
 - Exoplanets. The complete database for all planets discovered beyond the Solar System so far. <http://exoplanets.org/>
 - Scale of the Universe. Nasa. Downloadable pdf file. http://www.cdsc.nasa.gov/Download/Scale_Universe.pdf
 - Scale of the Universe — Harvard. Downloadable activity. <http://www.cfa.harvard.edu/seuforum/mtu/MTUrealms.pdf>
 - Astronomy: Science Without Limits. A K–12 resource book of ideas for teachers by the Australian Science Teachers Association http://www.asta.edu.au/national_science_week_2010/2009_asta_national_science_wee_2 <http://www.asta.edu.au/>
 - Window to the Universe. The Square Kilometre Array. Developed as part of the Questacon-Scitech SKA Education project for years 9–10 http://www.asta.edu.au/resources/windows_to_the_universe
 - Space Based Astronomy Educator Guide, NASA. Units of study that include science demonstrations, lesson plans and student sheets on Earth's atmosphere, the electromagnetic spectrum and telescopes <http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Space.Based.Astronomy.html>
 - Explore Space and Beyond, ABC. News, quizzes, games and images on space and astronomy <http://www.abc.net.au/science/topics/?topic=space>
 - Science & Nature: Space, BBC. General information and news on space and astronomy <http://www.bbc.co.uk/science/space/>

FREE APPLICATIONS

- Celestia — a real time 3-D space simulator that runs on PC, Linux or Mac OS.
<http://www.shatters.net/celestia/>
- Google Sky. View the sky and explore the universe online.
<http://www.google.com/sky/about.html>

WEATHER RESOURCES

The Bureau of Meteorology has provided the following list of websites that may be of use prior and after the visit.

- Latest Warnings.
www.bom.gov.au/weather/nsw/
- Severe Thunderstorm warnings.
www.bom.gov.au/catalogue/warnings/GSTW/graphicalproductsnsw.shtml
- About Warnings.
www.bom.gov.au/catalogue/warnings/
- Latest Weather Chart.
www.bom.gov.au/cgi-bin/nmoc/latest_MSLP.pl?IDCODE=IDY00050
- Current Satellite Loop.
<http://www.bom.gov.au/products/IDE00902.loop.shtml>
- Latest Sydney Observations
<http://www.bom.gov.au/products/IDN60900.shtml>
- Recent Observatory Hill Observations.
<http://www.bom.gov.au/climate/dwo/IDCJDW2124.latest.shtml>
- Graphs.
www.bom.gov.au/watl/weather/observations/nsw-latest-weather-graphs.shtml
- Radar Images.
www.bom.gov.au/watl/rainfall/radar.shtml
- About Web Radar.
<http://www.bom.gov.au/weather/radar/about/index.shtml>
- Latest Rainfall Maps.
www.bom.gov.au/australia/flood

Forecasts

- Weather Charts.
www.bom.gov.au/products/IDG00073.shtml

- NSW State Forecast: Provides an overview of the coming weather:
www.bom.gov.au/cgi-bin/wrap_fwo.pl?IDN10031.html
- Rainfall Forecast Maps.
www.bom.gov.au/jsp/watl/rainfall/pme.jsp
- Wind Forecast Maps.
www.bom.gov.au/jsp/watl/wind/index.jsp
- Text forecasts.
www.bom.gov.au/weather/nsw/nsw-forecast-map.shtml
- Sydney forecast.
<http://www.bom.gov.au/products/IDN10064.shtml>
- Sydney UV Index.
http://www.bom.gov.au/products/UV/Sydney_NSW.shtml

Historical Data

- Climate of Observatory Hill.
http://www.bom.gov.au/climate/averages/tables/cw_066062.shtml
- Historical Monthly Data.
www.bom.gov.au/climate/data

Learn About Meteorology

- Reading the Weather Map.
www.bom.gov.au/info/weathmap/weathmap.htm
- Forecasting the Weather.
www.bom.gov.au/info/ftweather/
- Severe Weather in NSW.
www.bom.gov.au/weather/nsw/sevwx/facts/index.shtml
- Weather Words.
www.bom.gov.au/info/wwords/
- Australian Climate Influences.
www.bom.gov.au/watl/about-weather-and-climate/australian-climate-influences.html
- Summaries of Significant Thunderstorms in NSW.
<http://www.bom.gov.au/weather/nsw/sevwx/significant.shtml>
- Stormy Weather.
<http://www.bom.gov.au/weather/nsw/sevwx/facts/stormy-weather.shtml>

Please note: the websites listed were available and suitable at the time of publication. We advise teachers to check sites before recommending them to students.

A BRIEF HISTORY OF THE OBSERVATORY

The Australian Aboriginal people have been observing the southern sky for tens of thousands of years and the early colonists also recognised the importance of studying the, to them, unfamiliar southern stars. A young lieutenant by the name of William Dawes was given the task of setting up an observatory when he travelled to Australia with the First Fleet in 1788. He set up his instruments in a wooden building at what is now called Dawes Point that was only a few hundred metres to the north of the present day Sydney Observatory and located where the southern pylon of the Sydney Harbour Bridge is today.

In 1821, Governor Thomas Brisbane established Australia's first major observatory near Government House in Parramatta. Personally paying the salaries of two astronomers and installing his own equipment, Governor Brisbane with the help of his staff observed the southern sky and began documenting unknown stars. The observations were published in the Catalogue of 7385 stars from observations made at the observatory at Parramatta in 1835. With little

support for its continuation, Parramatta Observatory was forced to close in 1847. However, by 1855, the colonial government could not ignore the need for a time ball to provide accurate time to ships in the Harbour as well as for an observatory in Sydney.

Three years later construction of the new observatory with its time ball tower was sufficiently advanced for observations to begin. Work at the Observatory included determining star positions, measuring precise longitudes and latitudes, keeping time and making meteorological (weather) observations.

More than 150 years later Sydney Observatory is a public observatory and is part of the Powerhouse Museum. We specialise in astronomical, meteorological and archaeological learning and enjoyment.

School programs operate throughout each term day and night making it the busiest cultural institution of its type in Australia.



BOOKING YOUR VISIT

Bookings are essential for all education groups. When you book, education staff are allocated to assist your group on arrival. Discuss your needs with our education staff on booking, to get the most from your visit.

Contact Details

Sydney Observatory
Watson Road, Millers Point
Phone: (02) 9921 3485
Fax: (02) 9921 3489
Email: observatory@phm.gov.au
Web: www.sydneyobservatory.com

Images above: inside the 3-D space theatre; Sydney Observatory, north dome; a lunar eclipse, photo by Melissa Hulbert; Sydney Observatory at night.

Cancellation Policy — schools can cancel a booking up to two weeks prior to the date of their tour. Cancellations made less than two weeks prior to a visit are charged half the full rate of the booked tour. You must cancel by fax.

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Sydney Observatory, part of the Powerhouse Museum, is a NSW government cultural institution.