

# SECONDARY VISIT GUIDE & ACTIVITIES

ROYAL  
OBSERVATORY  
GREENWICH



# INTRODUCTION



*This pack is designed to support the science curriculum at Key Stage 3 and 4 through activities during a visit to the Royal Observatory Greenwich. The activities cover topics ranging from time and longitude on the Earth to planets, stars and the Universe, highlighting the importance of the Royal Observatory Greenwich in the history of time and space.*

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## USING THE PACK ///

This secondary school teacher pack includes onsite activities for classes at Key Stage 3 and Key Stage 4. Use the activity quicklist to see the activities provided for the whole site.

The activities selected should be photocopied prior to your visit as required for groups. Please ensure you take your map, site guide, teacher answer booklet and writing materials for students with you on your visit to the Royal Observatory Greenwich.

*The Royal Observatory, home of Greenwich Mean Time and the Prime Meridian, is one of the most important historic scientific sites in the world. Commissioned in 1675 by King Charles II, the Observatory was the first government-funded scientific institution and the home of astronomy in the UK. Its purpose was to solve the problem of maritime navigation: there were a significant number of shipwrecks during the 17th century because sailors could not accurately determine their position east or west.*

*It was thought the sky could be used as an overhead clock as the Earth rotated, but to do this required an accurate map of all of the stars. John Flamsteed became the first Astronomer Royal; he lived and worked onsite, building instruments to measure the positions of the stars in the dark skies over Greenwich Park. Flamsteed's star catalogue was the most accurate and extensive catalogue of stars produced at the time.*

*After a huge disaster at sea in 1707, the Board of Longitude was established at Greenwich and an award of £20 000 was offered for a solution to the longitude problem (equivalent to £3.2 million today). John Harrison won the award in 1759 for his 'sea watch,' a clock designed to keep regular time over many months at sea despite the rocking and rolling motions on board. As a result of his invention trade and exploration flourished in the UK, thus enhancing the geopolitical importance of the country. Greenwich was established as a world leader in astronomy and navigation, and became the 'home of time' with the declaration in 1884 of the Greenwich meridian as the Prime Meridian of the world - a line dividing east and west. It is the official starting point for each new day.*

*Other buildings have been added to the Observatory over the years, including the 18th century meridian building, housing most of the instruments that the astronomers used to observe the sky and the Great Equatorial Telescope (Britain's largest refracting telescope). The Observatory became an astrophysical research facility for over 300 years; geomagnetism, spectroscopy, meteorology and solar physics were studied here and it was home to many children, servants, cooks and nursemaids as well as astronomers.*

*The work carried out at Greenwich continued to have practical implications in the navy and the physical sciences. The Observatory was closed during the Second World War and astronomers left for darker skies in 1948, moving to Sussex and then Cambridge. It reopened in 1960 as a museum highlighting historic astronomy and navigation. Since 2007 the new astronomy galleries and the Peter Harrison Planetarium have aimed to inspire visitors with modern discoveries in astronomy and space exploration. Buildings, collections and facilities here help tell the story of what we know about our place in the Universe, how we have learned it and why astronomical research remains as important as ever.*

# ROYAL MUSEUMS GREENWICH

## SITE GUIDE



### ROYAL GREENWICH PARK ///



*Welcome to the Royal Observatory Greenwich. This is the home of astronomy and time where many observations were made. It is situated within Greenwich Park, one of the royal parks of London. It is also a world heritage site. The park belonged to the crown from 1427 and Greenwich Castle was built on the hill. The castle was used as a hunting lodge by Henry VIII after deer were introduced to the park in the 16th century.*

**FACT** Trees from the reign of Elizabeth I can be found in the park.

**THINK** If you could build an observatory, where would you build it?

# ROYAL MUSEUMS GREENWICH

## SITE GUIDE



### FLAMSTEED HOUSE ///



*The oldest building of the site is Flamsteed House, commissioned by King Charles II in 1675, designed by Sir Christopher Wren, the architect of St Paul's Cathedral. It was the home of the first Astronomer Royal, John Flamsteed (below). It was built for £500 (equivalent to £100 000 today) using second-hand materials. During his tenure he measured the positions of 3000 stars. He also recorded Uranus in 1690 but mistook it for a star which he called 34 Tauri. Some of Flamsteed's star designations are still used today—one famous example is 51 Pegasi, the first star found to have a planet orbiting it.*

**FACT** Flamsteed House is famous for the red time-ball which drops at exactly 13:00 every day – this enabled ships on the Thames to set their clocks.

**THINK** How has astronomy progressed since the time of Flamsteed?

## ASTRONOMER ROYAL APARTMENTS ///

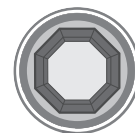


*Flamsteed and his astronomy assistants moved into the building in July 1676 and despite government pay of £100 per year (£20 000 today) Flamsteed had to pay for all his own instruments and did not live in luxury. Visitors such as the great physicist and mathematician Isaac Newton and Peter the Great, the Tsar of Russia came to visit Flamsteed here.*

**FACT** The display shows the apartments set up as they would have been in Flamsteed's day.

**THINK** If you were an astronomer living and working here today, how would it be different?

## THE OCTAGON ROOM ///



*The Octagon Room (also known as the Great Star Room) was designed to be the main observing room though not aligned on a local meridian. The room was used for observations of planets and transient celestial events such as comets.*

**FACT** Newton and Flamsteed held great scientific debates here.

**THINK** Look for the three Tompion clocks. What do we think is special about the clock on the far right?

## TIME & LONGITUDE GALLERY ///



*Solving the Longitude Problem was a great triumph in British history – a series of shipwrecks and maritime disasters led to the first ever accurate catalogue of stars that could be used to determine local time at sea and the invention of a portable watch by John Harrison that kept regular (Greenwich) time on a rocking ship.*

**FACT** It took Harrison over 40 years to perfect his sea clocks. He eventually became a multi-millionaire by modern standards for his inventions.

**THINK** What conditions affected the accuracy of Harrison's first three clocks?

## TIME & GREENWICH GALLERY ///



*The process of timekeeping has evolved considerably and Greenwich has played an important role in the progress from local time to global time. Technological advancement has led to incredible accuracy in timekeeping and the creation of a global positioning system that has transformed the world.*

**FACT** The most accurate way of keeping time now is by using transitions in caesium atoms, where radiation is released with a frequency of 9 191 631 770 cycles per second. Atomic clocks are accurate to seconds in millions of years.

**THINK** Take a look at the pendulum clocks. What forces affect the moving bob?

# ROYAL MUSEUMS GREENWICH

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### ASTRONOMER'S GARDEN ///



*The Dolphin sundial can be found here. It was made for the Queen's silver jubilee in 1977. All clocks in the UK are synchronised to Greenwich Mean Time however there is a small difference between the time on the sundial and clock time. This is because we assume the Earth is moving around the Sun at a constant speed however in reality the speed varies because of the non-circular orbital path. This difference has to be taken into account when comparing sundial time with clock time.*

**FACT** The garden was a place where the astronomer royals and their families could sit and play.

**THINK** How do you think the Dolphin sundial works?

# ROYAL MUSEUMS GREENWICH

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### MERIDIAN BUILDING ///



*The Meridian Building was extended eastwards (right to left facing the building) by successive Astronomer Royals. There have been four separate meridian lines since the time of Flamsteed, the fourth was set by George Biddell Airy in 1851 and became internationally recognised as the prime meridian in 1884. This line marks the beginning of each day and all time zones are set relative to Greenwich Mean Time (the whole of the UK is synchronised to Greenwich time). It also marks 0° longitude, so that all places east of this line are*

*ahead of GMT and all places west of this line are behind GMT. Within the building there are transit instruments – these were used to measure the positions of stars and the roof would have been opened above the big transit telescope.*

**FACT** GPS marks zero longitude 102 m east of the prime meridian and Ordnance Survey maps use Bradley's line positioned 6 m west.

**THINK** In which directions can the transit instruments be moved to look at the stars?

## MERIDIAN GALLERY ///



*The astronomer royals used specialised transit telescopes to measure the positions of the 'clock' stars. Telescopes use mirrors and lenses to magnify light, allowing us to watch the ever expanding Universe.*

**FACT** Spider webs were used as a measuring grid to enable astronomers to determine when stars crossed the meridian in the sky.

**THINK** How were measurements taken if the transit telescopes only tilted up and down?

## TIME & SOCIETY GALLERY ///



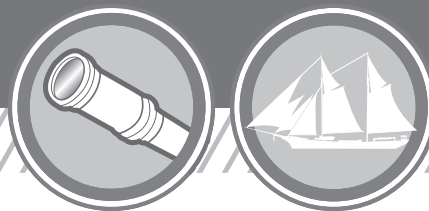
*Today we use clocks to track time but how did civilisations keep time in the past? Various timekeeping instruments can be seen here following society's progress in measuring time. These range from using the sky with sundials and astrolabes to using vibrating quartz crystals in watches and clocks.*

**FACT** Ancient civilisations used the Sun, Moon and stars as a giant calendar.

**THINK** What instruments did people use to tell the time at night?

# ROYAL MUSEUMS GREENWICH

## SITE GUIDE



### GREAT EQUATORIAL BUILDING ///



*The Great Equatorial Building was constructed in 1857 to house a 12 inch Mertz refracting telescope inside. Unlike today, back then the building was topped with a barrel-shaped top, which rested on cannonballs so it could swivel around. The dome was replaced towards the end of the 19th century with the now iconic green 'onion dome' that houses the larger 28 inch telescope also known as the Great Equatorial telescope. The original onion dome was made from papier-mâché, but destroyed during the Second World War by a V2 flying bomb. The dome has been replaced with a fibreglass edition, but you can still see the shrapnel marks in the statue of General Wolfe overlooking Greenwich Park.*

**FACT** The base of the building is home to the horology department where conservation of the precious timekeepers exhibited at the Observatory takes place.

**THINK** What must happen with the dome for astronomers to keep track of an object with the telescope?

## GREAT EQUATORIAL TELESCOPE ///



*The telescope is a refractor which means it has a glass lens that bends light to form an image – this lens is 28 inches wide (71 cm) and can achieve magnifications up to 300 times. The telescope has an equatorial mount whereby the telescope is tilted at an angle equal to the latitude of Greenwich. It is driven by a motor that matches the Earth's rotation allowing the telescope to track objects as they appear to move. The telescope is now used for public evening sessions.*

**FACT** : All of the large professional telescopes around the world are reflectors i.e. they have mirrors instead of lenses.

**THINK** How do you think we use this telescope to observe an object?

## TIME FOR THE NAVY GALLERY ///



*After John Harrison solved the Longitude Problem with his portable sea watch in the 1750s safety at sea improved considerably. The Royal Navy used chronometers to work out their longitude until the 1950s when radio and satellites were used instead for navigation. Staff here checked the accuracy of every chronometer – this was vital to ensure the safety of sailors out at sea.*

**FACT** There used to be oven heaters here that were used to test the accuracy of all of the chronometers at high temperatures.

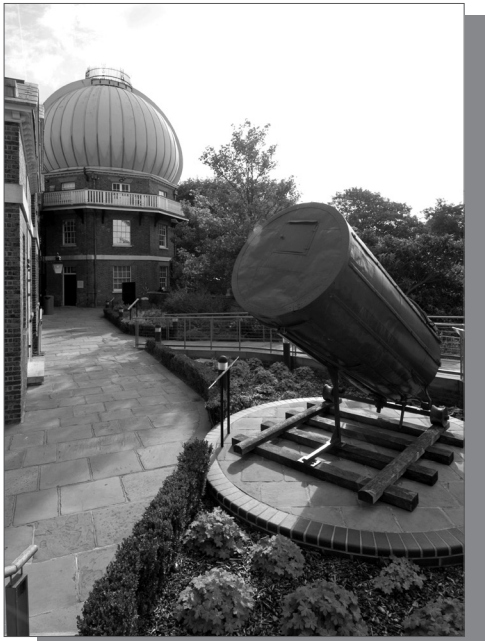
**THINK** GPS is now used for navigation at sea. Where else is GPS used?

# ROYAL MUSEUMS GREENWICH

## SITE GUIDE



### MERIDIAN GARDEN ///



*The prime meridian is situated here. This is a line that separates east and west. There are other meridians set by previous astronomer royals. Flamsteed built a well here that was 30 metres deep and had a telescope at the bottom. He used the telescope well to make precise measurements of the stars moving overhead almost 350 years ago. Also situated in the garden is part of William Herschel's telescope, the astronomer who discovered Uranus in the 18th century.*

**FACT** The entrance to this part of the site was built over the original plan of Flamsteed's observational hut from where he made most of his measurements.

**THINK** Investigate the various meridians on site – why are they all different?

# ROYAL MUSEUMS GREENWICH

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### ALTAZIMUTH PAVILION ///



*The Altazimuth Pavilion was commissioned by William Christie in 1899 to house instruments used to measure the positional coordinates of celestial objects: azimuth (position east along the horizon) and altitude (position above the horizon). The lower floor explains what astronomers know about the Sun: how we listen to it and how it will evolve over time. The upper floor contains two historic instruments used by the solar department until 1949 to photograph the Sun and make measurements of sunspots*

*on the solar disc. Five photoheliographs from the Observatory were packed and shipped in 1874 to be used in the transit of Venus expedition.*

**FACT** Venus last transited the Sun in the summer of 2004 and 2012 and won't transit again until December 2117.

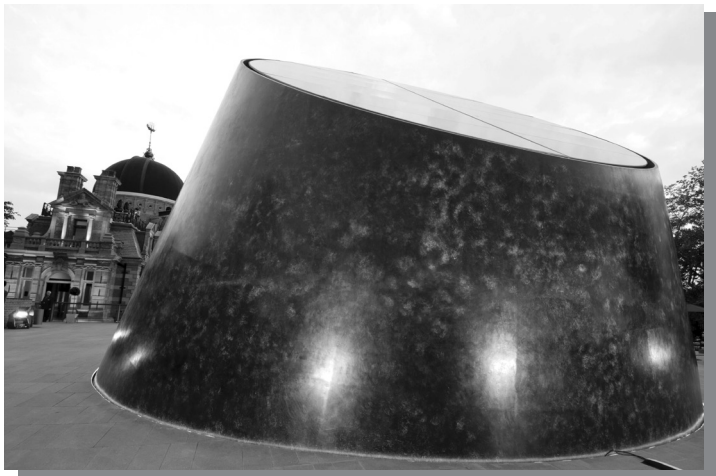
**THINK** How could you observe the Sun safely?

# ROYAL MUSEUMS GREENWICH

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### PLANETARIUM COURTYARD ///



*The centrepiece here is the large metal structure below which is the planetarium. One wall points directly overhead. One wall is slanted at an angle equal to our latitude ( $51.5^\circ$ ) and points to the North Star (Polaris). The cone is sliced at an angle equal to  $90^\circ - 51.5^\circ$  and represents the celestial equator (the extension of the Earth's equator out into space). It is aligned north-south so it acts as a giant sundial.*

**FACT** There used to be a library facing the road here that held all of the Greenwich observations.

**THINK** Use the planetarium structure to navigate your way round the courtyard. What can you see due south? What is visible due north? In which direction is the General Wolfe Statue?

# ROYAL MUSEUMS GREENWICH

## SITE GUIDE



### ASTRONOMY CENTRE ///



*The Astronomy Centre was built in 1899 and was used for different areas of scientific research: spectroscopy, photography, magnetic measurements, and meteorology. The central part of the building was built first and each of the four wings were added on separately as soon as government funding came through.*

*It is now used as an educational centre with three interactive galleries and three learning spaces and also the Peter Harrison Planetarium.*

**FACT** Airy wouldn't allow a train line to be built between Greenwich and Charlton because the trains were disturbing magnetic measurements.

**THINK** This part of the site was built over 100 years ago. How might Greenwich be different 100 years from now?

## ASTRONOMY INSPIRES GALLERY ///



*This gallery explores how we look for things in space. Interactive displays answer questions such as what stars are made of, how we find planets orbiting other stars, why astronomers use different types of light to understand the Universe and how to build a space probe.*

**FACT** The Universe is 13.7 billion years old, almost three times as old as our Solar System. The oldest objects we can see in the Universe are 13.2 billion years old.

**THINK** Why do we think there might be life elsewhere?

## ASTRONOMY EXPLORES GALLERY ///



*This gallery explores how we look for things in space. Interactive displays answer questions such as what stars are made of, how we find planets orbiting other stars, why astronomers use different types of light to understand the Universe and how to build a space probe.*

**FACT** : Astronomers use imaging and spectroscopy to answer questions about objects in space and the birth and fate of the Universe.

**THINK** Can you see a model of the Beagle space probe in this gallery? What was it designed to explore?



# ASTRONOMY QUESTIONS GALLERY ///



*All of the big questions about our Universe are answered here by virtual astronomers. Topics range from the formation of our Solar System to the fate of our Universe and the other 96% of space we still don't know. The evolution of our understanding of the Universe can also be explored here.*

**FACT** The Universe has been expanding since its birth and its growing faster and faster probably forever.

**THINK** Look for Newton's optics publication – he was the first person to study the nature of light along with gravity.

# TEMPORARY EXHIBITIONS GALLERY ///



*This mini-gallery including a hands-on interactive display is host to a changing programme of exhibitions, with topics ranging from the history of science to cutting-edge astronomy and winning images from the Astrophotographer of the Year competition.*

**FACT** Every year we display winning images from the Astronomy Photographer of the Year competition run by the Observatory here in this gallery.

**THINK** If you had access to a large telescope, what would you most like to observe and photograph?