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.

PACK CONTENTS///

- How to use this pack
- Introduction
- Site Guide
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- Teacher Answer Booklet
- Activities

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 Observatory, 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.

ACTIVITY MAPPING THE NIGHT SKY
LOCATION MERIDIAN OBSERVATORY

GALLERY MERIDIAN///

The Meridian Observatory contains many telescopes, but only four remain in their original positions. Facing the Meridian Observatory from the courtyard means that you are looking at the oldest on the right (the mural quadrants) and newest on the left – the Airy Transit Circle.

These instruments could be used to take measurements of stars in the night sky. Walk through the Meridian Observatory inside and see if you can learn a little about these special instruments by answering the following questions.

How are the instruments aligned?///

East-West North-South Northeast-Southwest

In which directions can these telescopes move?///

Up-Down Left-Right Both

What two properties could you measure using such telescopes?///

1.

(HINT: Each of the telescopes has another instrument nearby to help measure this property)

2.

(HINT: The previous question leaves you with only one property to measure using the scales on every telescope)

These instruments could be used to map the night sky. If the instruments could only move in one set of directions how can you map the whole sky?///

(HINT: See the "star trails" picture)

As you move from the oldest to newest telescope in this building what two improvements can you see in the way they are mounted?///

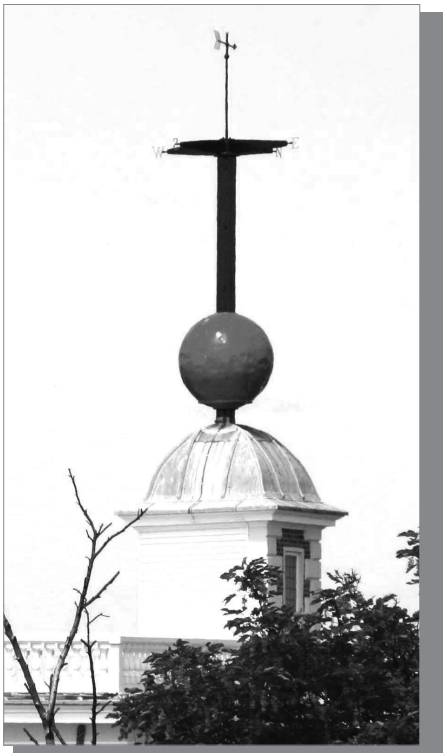
1.

2.

As well as mapping stars in the night sky, astronomers at the Royal Observatory Greenwich took daily observations of the Sun at noon. The famous Greenwich Time Ball (on top of Flamsteed House) drops at 1pm every day.

If the Sun passes over the Airy Transit Circle at local noon, how far will the Sun have appeared to move in the sky when the ball is dropped?///

Degrees



ACTIVITY OBSERVING WITH THE TELESCOPE
LOCATION GREAT EQUATORIAL BUILDING

GALLERY GREAT EQUATORIAL TELESCOPE///

This telescope is called the Great Equatorial Telescope. As you can see this is not the length of the telescope. What is 28 inches (71 cm) referring to?///

The telescope usually operates at a magnifying power of between 200-300 times magnification. You can see the results of looking at the Moon on the screens.

Look around the room near the floor and you will see some dim red lights that are not switched on. Why do you think they would be switched on and the main bright white lights switched

off when observing?///

Look at the panel that shows the old roof compared to the new one. Why did it have to change in shape?///

This telescope has an equatorial mount that allows it to move in an arc. It is much easier to follow targets in the sky in this way as many objects in the night sky rise and set in an arc as the Earth spins. Before motorised tripods, this was the most efficient way to observe objects over long periods of time.

Can you prepare for a night of observing with this telescope?///

The first and the last steps in setting up the 28 inch telescope are given – try and put the steps in between in the right order (2-6). Think about the safety of the telescope and you: the astronomer!

1 Check the wind speeds so the dome doesn't blow off! (Wind speed indicators are to the left and up when you came through the door).

☐ Switch off the bright white lights and switch on the very dim red lights to keep your night vision.

☐ Take off the dust cap at the top of the telescope. It's bigger than the size of a dustbin lid!

☐ Open the dome slit so the telescope has a gap to see through. **Warning!** Dust and dirt may fall into the room at this point.

☐ Move the telescope dome around so that the gap in the dome is facing your chosen star or planet.

☐ Move the telescope away from the dome slit to prevent dust and dirt falling onto the lens.

7 Move the telescope to the right part of the sky to point at your chosen star or planet and look through it.

ACTIVITY DIFFERENT TYPES OF LIGHT
LOCATION ASTRONOMY CENTRE

GALLERY ASTRONOMY INSPIRES, EXPLORES, QUESTIONS///

Go to the *Astronomy Inspires* gallery and watch the video about the Universe. The reason why astronomers know so much about the Universe is because we look at different types of light such as X-ray and infrared. This allows us to see things we wouldn't see with visible light.

Go to the *Astronomy Explores* gallery. Go to the infrared camera. Place your hand under the plate. Describe what happens.///

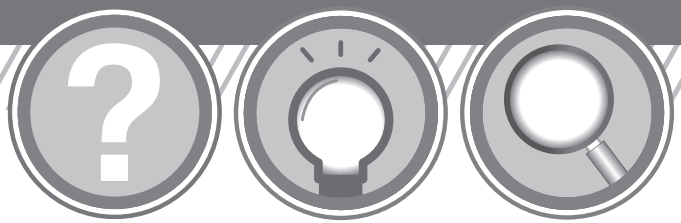
Infrared light is used by the police for night-time observations and in objects such as remote controls. Look around the gallery. Who discovered infrared radiation and how was it done?///

Take a look at the multi-wavelength images of the Sun, our nearest galaxy Andromeda, Saturn and the Crab Nebula. Choose an object and move the dial to see it in different wavelengths. Describe what you see.///

Go the *Astronomy Questions* gallery. Look at the interactive gallery and move the object onto an icon to activate the video.

Select one of these topics: Black Holes, Star Nursery, The Big Bang. What type of light was used to explore this astrophysical phenomenon?///

ACTIVITY EXPLORING THE UNIVERSE
LOCATION ASTRONOMY CENTRE



GALLERY ASTRONOMY QUESTIONS, INSPIRES, EXPLORES ///

Go to the *Astronomy Questions* gallery. Go to the interactive gallery and move the object onto an icon to activate the video.

Select a topic and write down how scientists explored this part of the Universe – think about what was used to gather information.///

TOPIC///

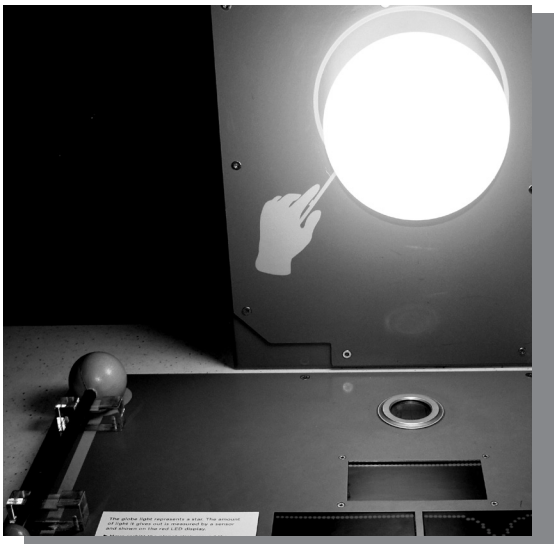
Go to the *Astronomy Inspires* gallery and look at the orrery. This represents what we knew about space in the past. When was it made?///

How many planets can you see? Explain this.///

. Why does the Earth orbit the Sun and not the other way round?///

Watch the video. What kind of things do we know about today and what tools do astronomers have that help us to understand the Universe better?///

Take a look at the spectroscope. Look at the panels nearby and explain how this tool helped us to explore the Universe.///

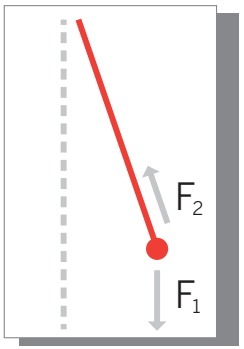


Go to the *Astronomy Explores* gallery. Find this object *(above)*. **Move the planet wand around the globe and look at the display.**

ACTIVITY FORCES & HARRISONS TIMEKEEPERS
LOCATION FLAMSTEED HOUSE

GALLERY TIME AND LONGITUDE///

Pendulum clocks are not found in most modern homes today. They were, however used by astronomers and the general public for over 200 years. The pendulum diagram below has two force vectors labelled.

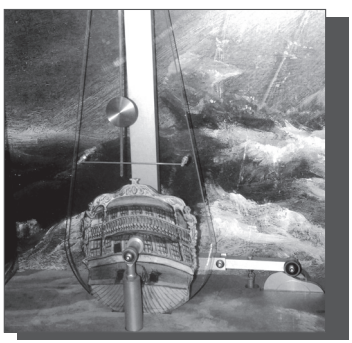


Can you name the forces acting on the pendulum bob?///

F_1

F_2

Go to the interactive shown in this picture and press the button. Listen to the "tick-tock" of the clock. The period changes as the boat rocks – this led to inaccurate timekeeping, and poor current location calculations. Explore the story of longitude around you.



When stationary on land, what force will slow the pendulum down and eventually stop it?///

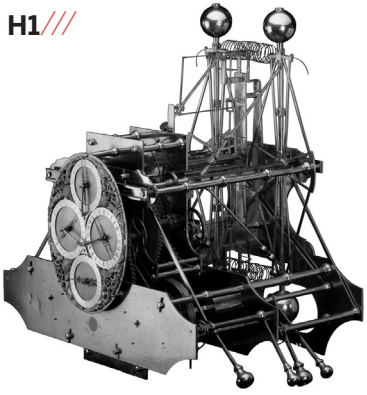
(Think of how brakes on a car or bike work)

John Harrison, the famous clockmaker found a number of ways to counteract this force. Can you identify two ways he did this in his clocks (H1, H2, H3, H4) and learn more about them using the interactives?///

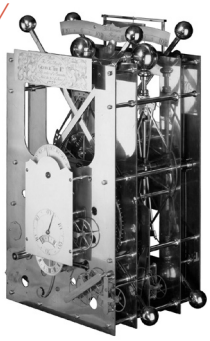
1 These are commonly used to dampen or reduce the bumps you feel while travelling in a car.

2 This is in every thermostat in devices for heating like kettles and central heating. It is an invention by John Harrison. *(HINT Look at the repeating animation next to H3)*

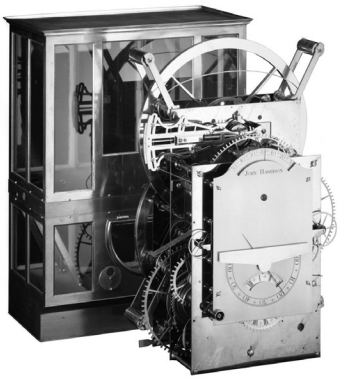
H1///



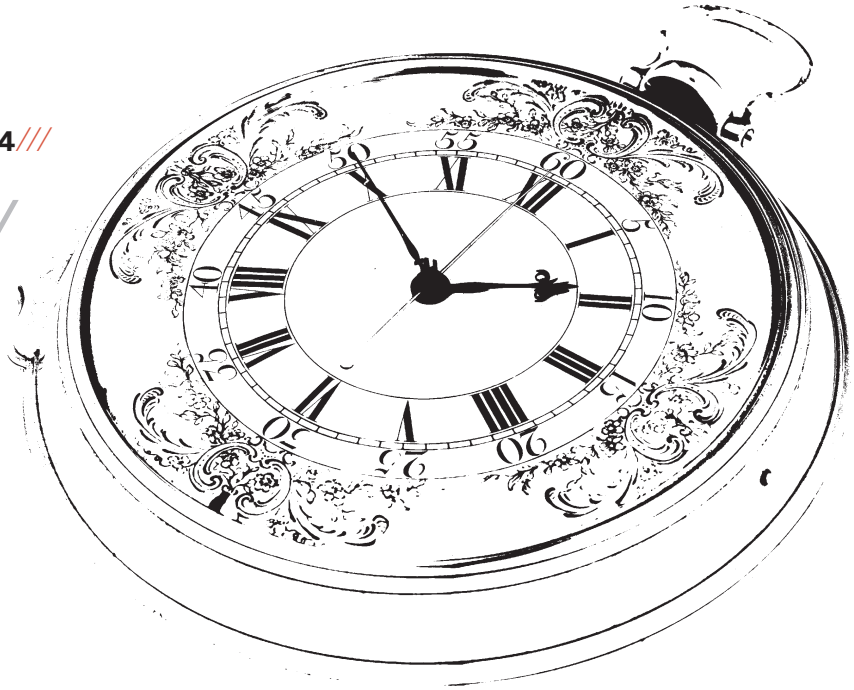
H2///



H3///



H4///



H4 is John Harrison's ultimate triumph. It was portable, it kept regular time at sea and as a result it won him the rest of the longitude prize fund.

What other (astronomical) method of finding longitude at sea was used alongside Harrison's timekeepers?///

(HINT Find the panel nearest the largest 90 degree instrument in the gallery).

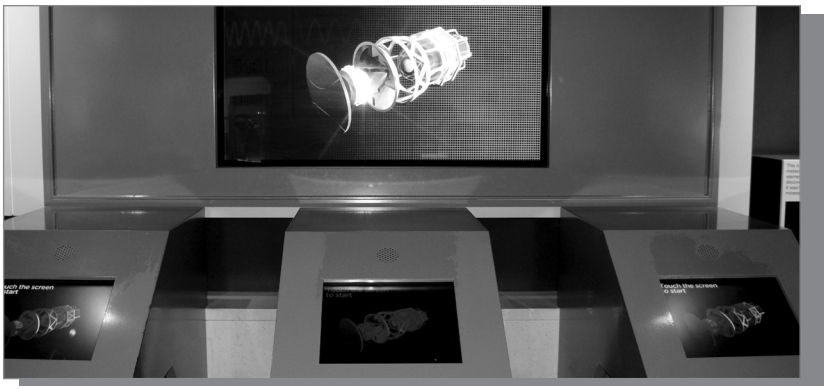
In the 21st century we have used our skills in timekeeping and space exploration combined to tell our position accurately. What do we use?///

ACTIVITY SPACE PROBES
LOCATION ASTRONOMY CENTRE

GALLERY ASTRONOMY EXPLORES & QUESTIONS///

Go to the space mission stand. Form a team of three and decide who will be Chief Engineer, Lead Scientist and Comms Officer. Have a go at building a probe.

Where is your probe going?///



Within your group discuss the following points: Was your mission successful? Why? Do you think we should send people instead of probes? Why?///

Look at the panel on the left of the space probe stand. The Mars rovers Spirit and Opportunity were launched in summer 2003 and were designed to study the surface of Mars. They cost $820 million to build. Do you think we should be spending billions of dollars on building space probes? Why?///

Go to the *Astronomy Questions* gallery and select the Solar System topic. Now select Visit other Worlds. How did we explore this planet/moon and what did we find out?///

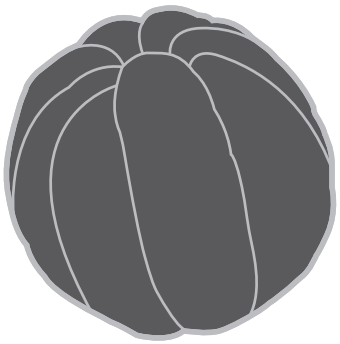
ACTIVITY COMMUNICATING TIME
LOCATION FLAMSTEED HOUSE

GALLERY TIME AND LONGITUDE///

Go to the Time Globe downstairs in Flamsteed House. Here you can investigate time zones and Greenwich Mean Time.

What is the imaginary line around the Earth that divides the world into the Northern and Southern hemisphere?///

It is a line of latitude (horizontal imaginary lines), the vertical lines going from North Pole to South Pole are lines of longitude. Each one here is separated by 15 degrees.



How many degrees are in a circle?///

How segments are there around the globe?///

Let's see if you can navigate the Time Globe and tell where you are:

Move 15 degrees East from Greenwich (along the same latitude). Which country are you now in?///

☐ *Poland* ☐ *Germany* ☐ *Sweden* ☐ *Czech Republic*

Move 37.5 degrees East from Greenwich (along the same latitude). Which country are you now in?///

☐ *Russia* ☐ *Ukraine* ☐ *Belarus* ☐ *Finland*

Have you been to a country where you had to change your watch forward or back? If so, can you say if you changed it forward or backwards and by how many hours?///

Long ago people used a timepiece with no moving parts that uses light and shadow to tell their local time. Do you know what it was?///

Hint: Two dolphins outside the exit of these galleries can tell you the time at the Observatory!

P.T.O.

Let's see if you can work out the local time for a few destinations around the world. Note: Every degree you move is equal to 4 minutes local time difference. So if the time in London is 12:00pm then the time 1 degree east will be 12.04pm.

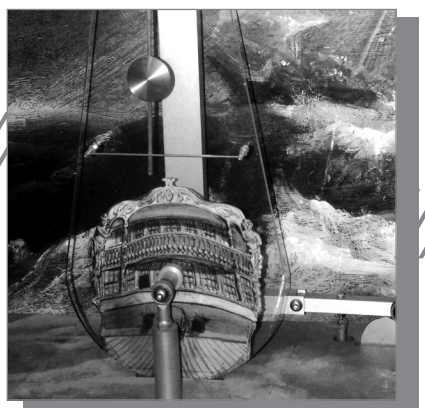
Travel from Dover to Reykjavik in Iceland. Which direction did you need to travel in (East/West)? Are you behind or ahead of Greenwich Time? And by how many minutes?///

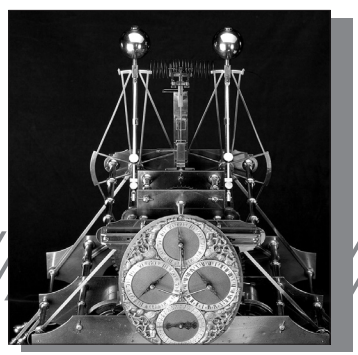
- ☐ *East, Ahead, 60 mins*
- ☐ *East, Behind, 40 mins*
- ☐ *West, Behind, 90 mins*
- ☐ *West Ahead, 60 mins*

Travel from Dover to Seoul in South Korea. Which direction did you need to travel in (East/West)? Are you behind or ahead of Greenwich Time? And by how many hours?///

- ☐ *West, Behind, 9.5 hours*
- ☐ *East Behind, 8.5 hours*
- ☐ *West, Ahead, 9.5 hours*
- ☐ *East, Ahead, 8.5 hours*

This gallery tells the story of accurate measurement of longitude at sea. See if you can find the two stories that eventually solved the Longitude Problem – one centred on time and the other on astronomy.





ACTIVITY ELEMENTS IN THE UNIVERSE
LOCATION ASTRONOMY CENTRE

GALLERY ASTRONOMY INSPIRES & EXPLORES///

Go to the *Astronomy Inspires* gallery and watch the video.
Where did all of the elements we see on Earth originally come from?///

Meteorites are relics from the birth of the Solar System. The composition of a meteorite tells us about its birthplace: a high fraction of light elements (that have low boiling points) suggests they were made in the outer colder regions of the Solar System whereas a high percentage of heavier elements suggests a formation site in the warmer inner regions.

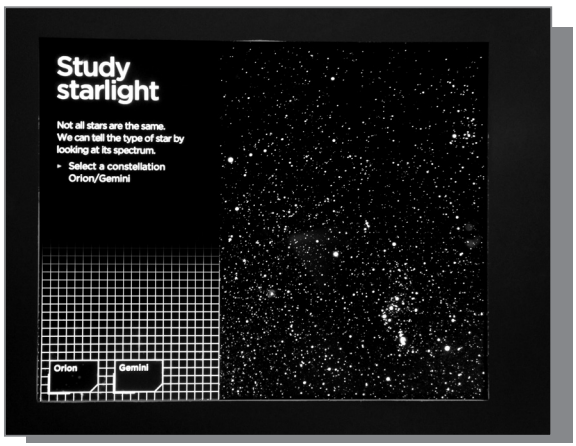
Go to the *Astronomy Explores* gallery and look at the Allende meteorite. Shade in the correct elements in the periodic table below.///

hydrogen 1 H 1.0079																	helium 2 He 4.0026
lithium 3 Li 6.941	beryllium 4 Be 9.0122												boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305												aluminium 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948
potassium 19 K 39.098	calcium 20 Ca 40.078		scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80
rubidium 37 Rb 85.468	strontium 38 Sr 87.62		yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29
caesium 55 Cs 132.91	barium 56 Ba 137.33	57-70 ✶	lutetium 71 Lu 174.97	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]

Which part of the Solar System do you think meteorites come from?///

You can see a large meteorite near the entrance. We can study a meteorite that has landed on the Earth by cutting it open and analysing the material. Most space objects are too far away for us to take samples for analysis.

Use the exhibits in this gallery to learn about the tools astronomers use to understand the Universe. How can we find out the composition of stars?///



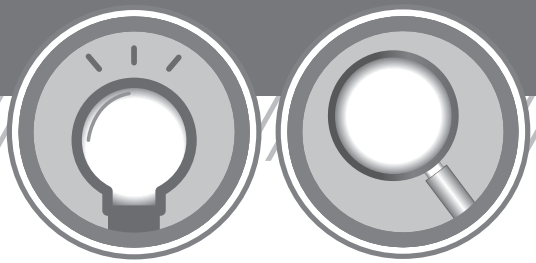
Go to the **Studying Starlight** activity. Choose **Orion.**

What type of star is Betelgeuse?///

What type of star is Bellatrix?///

Why are these stars different colours?///

ACTIVITY MULTI-WAVELENGTH ASTRONOMY
LOCATION ASTRONOMY CENTRE



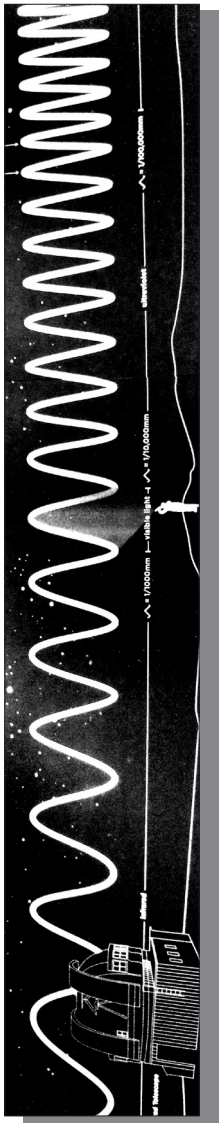
GALLERY ASTRONOMY INSPIRES & EXPLORES///

Go to the *Astronomy Inspires* gallery. Watch the video. Write down a few things we have discovered about the Universe.///

Astronomers use telescopes that are able to detect multi-wavelength light – this allows us to see all of the different parts of astrophysical objects and gain a more complete understanding of the Universe.

Go to the *Astronomy Explores* gallery. Take a look at the panel on the wall *(far left)* **and put these types of light in the correct order starting with the highest energy radiation:**

X-ray // infrared // radio // gamma-ray // ultraviolet // microwave // visible.



What are they part of?///

Take a look at the infrared camera. Why do we use infrared telescopes to look at objects in space?///

What do you think might affect an infrared telescope on Earth?///

Look around the gallery. Who discovered infrared radiation and how was it done?///

Take a look at the multi-wavelength images of the Sun, our nearest galaxy Andromeda, Saturn and the Crab Nebula. Choose an object and move the dial to see it in different wavelengths. Describe what you see.///

The atmosphere protects us from high-energy radiation such as X-rays and gamma rays. How can we see this emission from the objects above

ACTIVITY SPACE NEWS
LOCATION ASTRONOMY CENTRE

GALLERY ASTRONOMY QUESTIONS///

You are a journalist and have been asked to write an article about space for a newspaper. Look at the interactive gallery and move the object onto a topic of your choice.

Select a topic and write a report about this area of science for the 'Space News' newspaper.///

Remember you must translate any scientific information into everyday language that a non-scientific audience can understand.///

SPACE NEWS

WEDNESDAY 14TH MARCH///

50p

HEADLINE *This must be your own catchy title*

QUICK SUMMARY *Write in one sentence why this topic is exciting*

FACTS *Explain what was found out, how this was done and why this information is important.*

ACTIVITY THE POWER OF THE SUN
LOCATION ALTAZIMUTH PAVILION

GALLERY ALTAZIMUTH///

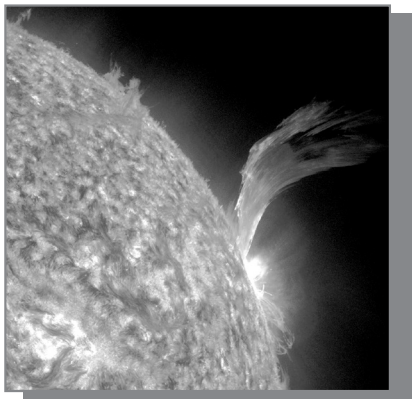
Press the first button on the interactive: "How does the Sun affect us?"

Can you name three things that extreme solar activity can affect in our daily lives?///

1

2

3



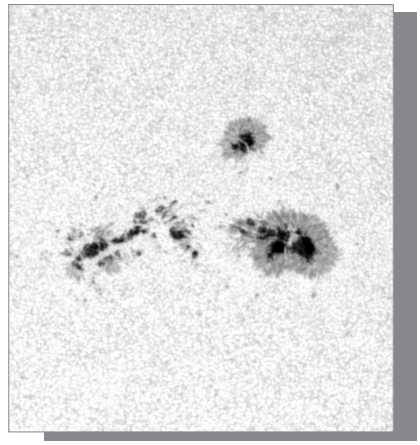
Use the panels in this building to determine what the Sun will become in 4.5 billion years time///

- [ ] Blue Supergiant
- [ ] White Dwarf
- [ ] Red Giant

Research into the structure of the Sun is called?///

- [ ] Helioseismology
- [ ] Heliogeology
- [ ] Heliobiology

Sunspots on the surface of the Sun. Magnetic fields temporarily trap part >> of the Sun where it can cool and appear darker than the rest of the Sun.



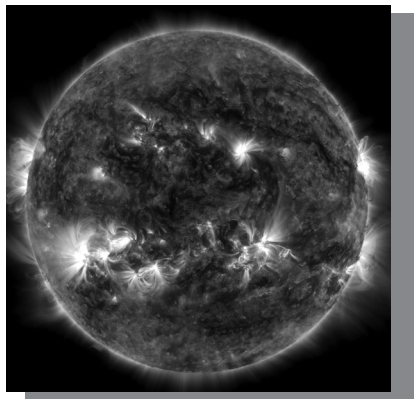
It is said that the Earth can be placed inside the Sun 1 million times (i.e. the volume of the Sun = 1 million times the volume of the Earth). Using the panels, can you find out how much more massive the Sun is compared to Earth?///

When you find this figure on the panels, you will have the mass and volume of the Sun compared to the Earth. Use the following equation to find out the density of the Earth compared to the Sun.///

$$\text{DENSITY} = \frac{\text{MASS}}{\text{VOLUME}} =$$ ____ **OF EARTH'S DENSITY**

What is the unit of density?///

(Mass in kilograms and volume in metres cubed)



Why is the Sun less or more dense than the Earth?///

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?

FLAMSTEED HOUSE///

The oldest building of the site is Flamsteed House, commissioned by King Charles II in 1675 and designed by Sir Christopher Wren, the architect of St Paul's Cathedral. It was the home of the first Astronomer Royal, John Flamsteed. 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 know 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.

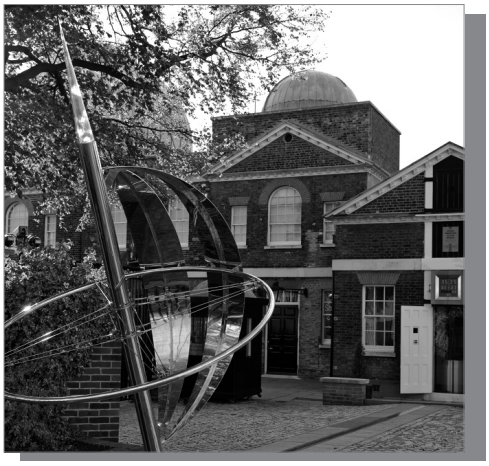
THINK Take a look at the pendulum clocks. What forces affect the moving bob?

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?

MERIDIAN OBSERVATORY///

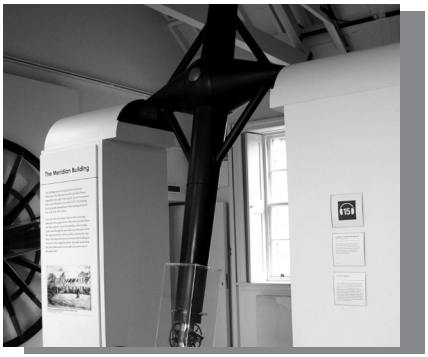


The Meridian Observatory was extended eastwards (right to left facing the building) by successive Astronomer Royals. There have been four separate meridian lines since the time of Flamsteed, the fourth was set by George Biddell Airy in 1851 and became internationally recognised as the prime meridian 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 - an imaginary line in the sky.

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

TIME & SOCIETY GALLERY///

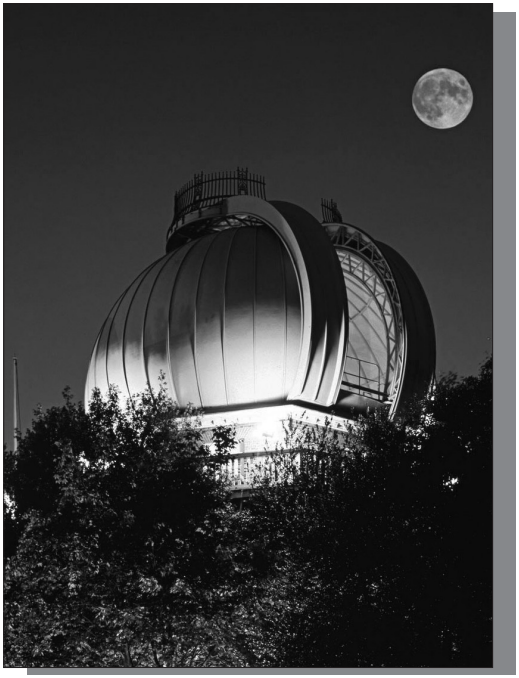
Today we use clocks to track time but how did civilisations keep time in the past? Various timekeeping instruments can be seen here following society's progress in measuring time. These range from using the sky with sundials and astrolabes to using vibrating quartz crystals in watches and clocks.

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 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 with the sky. 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?

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?

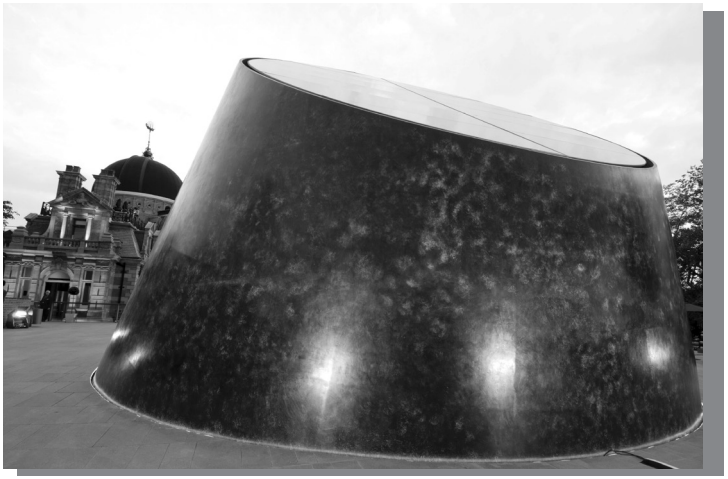
ALTAZIMUTH PAVILION///

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 untill December 2117.

THINK How could you observe the Sun safely?

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°) and points to the North Star (Polaris). The cone is sliced at an angle equal to 90° - 51.5° 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, built in 2007.

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///

The story of the Universe is told here, starting with its birth and the eventual emergence of the first stars, galaxies and planetary systems and the possibility of life elsewhere. An 18th century model of the Solar System called an orrery can be seen here.

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 are stars made of, how do we find planets orbiting other stars, why do 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 the Universe and the other 95% 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.

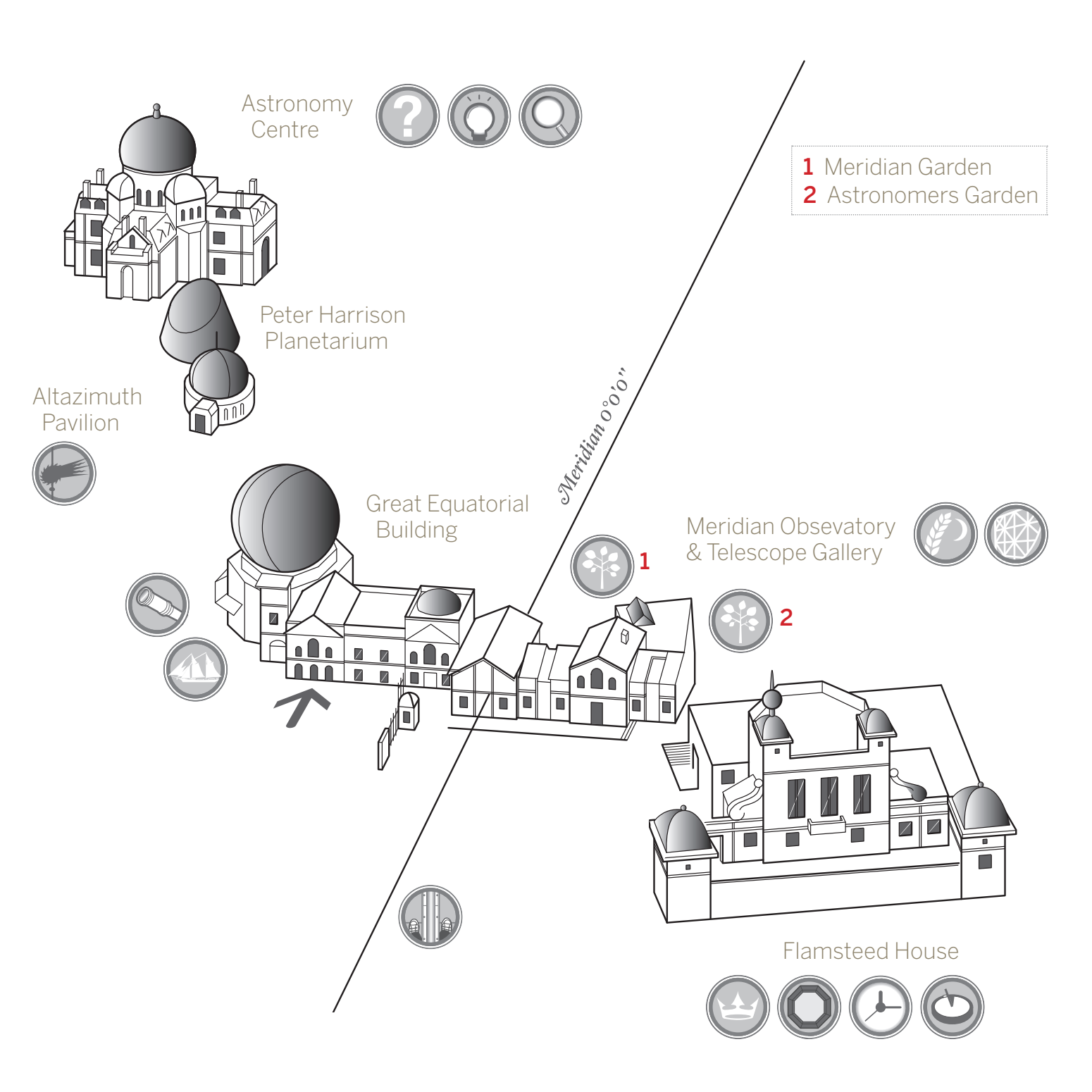
THINK Look for Newton's optics publication – he was the first person to study the nature of light along with gravity.

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?


Astronomy Centre
Peter Harrison Planetarium
Altazimuth Pavilion
Great Equatorial Building
Meridian 0°0'0"
1 Meridian Garden
2 Astronomers Garden
1
Meridian Obsevatory & Telescope Gallery
2
Flamsteed House

ACTIVITIES LIST SECONDARY (ASTRONOMY CENTRE)

ACTIVITY	KEY STAGE	GALLERY	DESCRIPTION
Different Types of Light	3 (ages 11 – 14)		Learn about the importance of using all types of light to explore the Universe.
Exploring the Universe	3 (ages 11 – 14)		Find out how astronomers investigate space.
Space Probes	3 (ages 11 – 14)		Build a space probe to investigate a planet, moon or comet.
Multi-Wavelength Astronomy	4 (ages 14 – 16)		Learn about why astronomers use the whole electromagnetic spectrum to explore the Universe.
Elements in the Universe	4 (ages 14 – 16)		Discover the origin of the Solar System and how we know what stars are made of.
Space News	4 (ages 14 – 16)		Become a science journalist and write about a chosen topic.

ACTIVITIES LIST SECONDARY (HISTORIC OLD OBSERVATORY)

ACTIVITY	KEY STAGE	GALLERY	DESCRIPTION
Observing with the telescope	3 (ages 11 – 14)		Think like an astronomer with the Great Equatorial Telescope.
Communicating Time	3 (ages 11 – 14)		Find out about time zones and how they work.
Forces & Harrisons Timekeepers	3 (ages 11 – 14)		Learn about John Harrison's special sea clocks and how they regulated time.
Mapping the Night Sky	4 (ages 14 – 16)		Explore the link between time and the stars.
The Power of the Sun	4 (ages 14 – 16)		. Discover the nature of the Sun and calculate its properties.