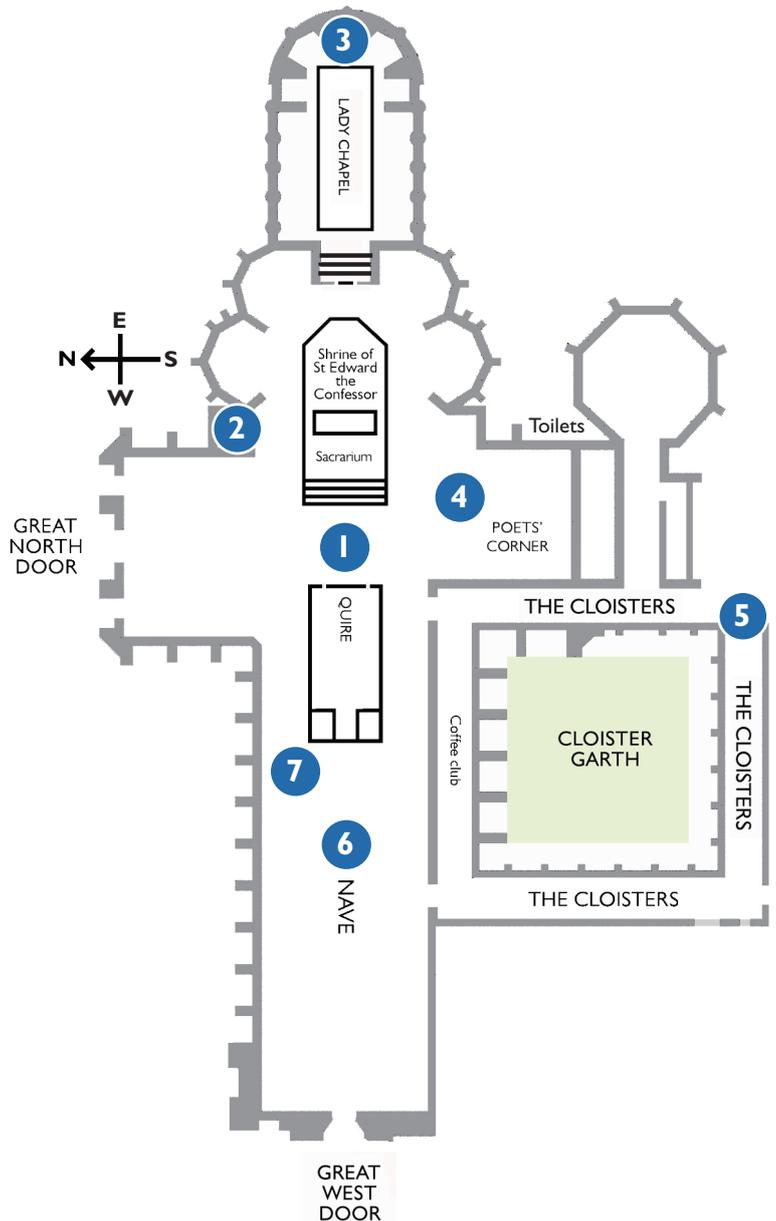


The Royal Society Science Trail Guidance Notes



The Royal Society celebrated its 350th anniversary in 2010 with a year-long programme of events and activities. As part of this celebration, the Society collaborated with Westminster Abbey to produce this exciting science trail, highlighting the discoveries made by past Fellows of the Royal Society, now buried within the Abbey.



This is a simplified map of Westminster Abbey, your trail starts at number 1 in the middle of the Abbey. Follow the blue dots in numerical order.

History of the Abbey

The earliest evidence we have for a church on this site is AD960, when St. Dunstan established a monastery here. A hundred years later, Edward the Confessor re-founded the abbey. He also built his palace here and from then on, Westminster has been the seat of power in Britain.

The current building was mainly built by Henry III. He was particularly devoted to Edward, who was canonised in 1161. Henry created a fabulous golden shrine for the saint and commissioned the Cosmati Pavement upon which Coronations take place. Further building work was done over the centuries and restoration work still takes place today.

Over 3500 people are recorded as being buried in the Abbey and there are many more whose names we do not know. Wherever one digs in the site, remains are found. They are always reburied if they have to be disturbed.

The Abbey Today

The Abbey is still first and foremost a church. As a Royal Peculiar, it is directly responsible to the monarch and plays an important part in the life of the Royal Family. As well as being used for all Coronations since that of Edward II in 1307, more recently it has been used for the marriages of Princess Anne to Captain Mark Phillips in 1973 and Prince Andrew to Sarah Ferguson in 1986. In 1997, the Abbey held the funeral of Diana, Princess of Wales, and in 2002 that of Queen Elizabeth, the Queen Mother. Every year, key events such as Remembrance Day and Commonwealth Day are celebrated and the Queen is a regular visitor. In 2010 she opened a new Education Centre at the Abbey and viewed important restoration work.



Write down three things that had to be discovered or invented for people to build Westminster Abbey.

e.g. Tools which could cut stones.

- 1. How to make glass.**
- 2. How to build foundations to support a high tower.**
- 3. How to carve stone.**



Leave this area and turn right into the North Ambulatory. Turn left to enter an area which was once three chapels. At the far end you will see a large tomb.

On the wall behind the tomb, there are a number of memorials to great scientists:

Thomas Telford, Sir Humphrey Davy, Matthew Baillie and Thomas Young.

On the North Wall find the memorial to:

John W. Strutt (1842-1919) Lord Rayleigh

Lord Rayleigh worked on many different subjects in physics. He experimented with light, sound, electricity, magnetism, gases and waves. He received the Nobel Prize in 1904 with another scientist called William Ramsey for discovering argon gas. Argon gas makes up nearly 1% of the air we breathe.

Have a look out of the window in this section. You might see some blue sky. Lord Rayleigh was the first person to explain why the sky is blue. Sir Isaac Newton showed that white light, like the light from the Sun, is really made up of all the colours in a rainbow.

Lord Rayleigh explained that when light travels through air some of the light is scattered in different directions, and then scattered again and again. Without the scattering the sky would look black and starry. Not all light is scattered easily: blue light is scattered more than red light and so the sky seems blue.



Take time to go into the side chapels which have many highly decorated tombs and monuments. Go up the stairs to the Lady Chapel and you will find the RAF chapel at the end behind the large railings of the tomb of Henry VII and Elizabeth of York. The memorial to Sir Frank Whittle is on the right, on the ground, just by the altar rail.

Frank Whittle was the pioneer of the jet engine. His design allowed aeroplanes to fly higher and faster than the old propeller planes allowing people to travel faster around the world. He was born in 1907 and later joined the RAF college at Cranwell. The first test run of his prototype jet engine took place in 1937. In 1941 the engine had its first flight and the Meteor I jet aircraft was in service with the RAF by spring 1944. Whittle retired from the RAF in 1948 and was knighted. He moved to the USA in 1976. In 1986 he was awarded the Order of Merit and he died on 9 August 1996. His ashes are buried at RAF Cranwell.

Who made the first flight in 1903?

Concorde's supersonic jet engines allowed it to cross the Atlantic in half the time of a normal aeroplane. To do this Concorde flew at what height?

For an aeroplane to lift off the engines and wings give it an upward thrust. What force is acting downwards, pulling it back to earth?

Solar powered aeroplanes are powered by sunlight. Some can fly overnight because...

The Wright brothers

17 km

Gravity

They have batteries which charge up during the day

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Leave the Lady Chapel and follow the main route round to Poets' Corner. There are toilets in Poets' Corner. The Memorial to Stephen Hales is on the west wall of Poets' Corner, high up, the fourth from the left.

Stephen Hales (1677-1761)

In the south transept of Westminster Abbey is a monument to Stephen Hales, eminent botanist and inventor of the ventilator, to help people breathe. Hales studied many different subjects: he found a way to extract fresh water from sea water and he was the first person to measure blood pressure. A large portion of his work involved plants. He worked out that plants need something in air which they use to grow. We now know this is carbon dioxide. He also studied how plants take up water and then release some of this water through their leaves. For this work he has a group of plants named after him, called Halesia.

The monument shows a pyramid with a portrait profile of Hales. On either side are figures representing Religion and Botany, holding a cornucopia. A globe displays winged heads, representing winds, referring to his greatest invention. His ventilators were used in the House of Commons, in ships, prisons and hospitals. He died on 4 January 1761 and was buried with his wife at St Mary's church, Teddington. Charles Wesley called him 'a truly pious, humble Christian'.

Which of these scientists has **a unit of force, a space telescope, laws of motion, a crater on the Moon and a crater on Mars** named after him?

One of these scientists has **a mountain in the Andes, an island in the Galapagos, a frog, a beetle and many other animals** named after him?

Which of these scientists has **a mouthwash and a type of bacteria** named after him?

This scientist has **a crater on the Moon, a crater on Mars, a mountain in Tasmania, and a moss** named after him.

Isaac Newton

Charles Darwin

Joseph Lister

Charles Lyell

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Leave the Abbey and go out into the Cloister. This is where the monks used to spend most of their time. There is a coffee shop on the right. In the South Cloister is a monument to:

Edmond Halley (1656-1742)

The famous astronomer Edmond Halley made maps of stars in the southern hemisphere. He also calculated the orbits of 24 comets, and realised that one particular comet seemed to keep returning roughly every 76 years. The comet is now called Halley's Comet.

It was last visible from Earth in 1986 and will next appear in 2061.

The memorial plaque was installed in 1986 and was designed to represent the comet that bears Halley's name. His achievements are listed on its tail, and its head is a small depiction of the Giotto spacecraft that intercepted the comet during its transit in 1986. Halley is actually buried at Lee, Kent.

When did Halley's comet last return to Earth? 1986

If the comet is to return again in 76 years, when will we next be able to see it? 2061

What was the name of the spacecraft that studied the comet? Giotto

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Re-enter the Abbey in the Nave. Walk towards the altar and look on the floor in the middle for a large stone covering the grave of:

David Livingstone (1813-1873)

David Livingstone, the famous Scottish missionary and explorer, was born on 19 March 1813 and died at Ilala in the centre of Africa in May 1873.

Livingstone was an explorer who worked to abolish slavery, and who mapped out areas in central and southern Africa which were unknown in the West. He crossed the Kalahari Desert, and traced the Zambezi River to the coast and the Indian Ocean. He found and named the Victoria Falls which we now know to be the largest waterfall in the world. David Livingstone died trying to find the place where the Nile starts.

Livingstone's heart had been buried under a mpundu tree but his faithful attendants enclosed his embalmed body in a cylinder of bark which was wrapped in sailcloth and carried it to the coast and then sailed to London, arriving the following year. As he had been away from England for so long a correct identification of the remains was required and this was verified by the badly set broken arm which had been crushed by a lion. There was also the fact that only Dr Livingstone could have inspired the Africans to overcome their natural superstition of carrying a dead body for so many months in order to reach the African coast with all the dangers that journey entailed. The location for the grave was eventually chosen in the centre of the Nave, near to James Rennell, founder of the Society for African Exploration.

Which of these animals might David Livingston have faced on his search for the source of the Nile? Hint: Think about where the Nile is.

Lion Giraffe Hippopotamus Rhino

On the North side of the nave, by the third pillar, find the grave of:

Charles Lyell (1797-1875)

Lyell was born in Scotland, the eldest of ten children in a wealthy family. He is best known as the author of *Principles of Geology*, which popularized uniformitarianism – the idea that the earth was shaped by slow-moving forces still in operation today. He felt that you could understand the past by a close examination of the present and realised that the world had taken many millions of years to reach its present form. He greatly influenced Darwin who also studied change over time. He was a devout Christian who did have some trouble accepting some of Darwin's theories.

Lyell's tombstone in the abbey is made from Carboniferous Limestone, and contains hundreds of crinoid fossils. It is a sedimentary rock, formed over many millions of years on the sea bed.

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Walk back up the North Aisle. Just before the gates, look on the floor for a large stone covering the grave of:

Howard Florey of Adelaide and Marston (1898-1968)

Howard Florey was born in Adelaide on 24 September 1898, a son of Joseph and Bertha Florey. He attended Oxford University as a Rhodes Scholar in 1922 and later worked in Cambridge, Europe and the USA. In 1933 he was appointed professor of pathology at Sheffield and then at Oxford in 1935. He is celebrated for making Alexander Fleming's discovery of penicillin into a clinically useable product, thus initiating the era of antibiotics. During the Second World War, Florey, with his colleague Ernst Chain, found a way of making penicillin in large enough quantities to be used to save thousands of lives.

In 1960 he was elected President of the Royal Society, the first Australian to hold the office. He was created Baron Florey of Adelaide and Marston in 1965 and was made a member of the Order of Merit. He died suddenly in Oxford on 21 February 1968 and is buried at Marston, near Oxford.

Can you fill in the right word into the blank spaces to complete the story of penicillin?

Alexander Fleming discovered penicillin by accident in the year **1928**, when he found a penicillium mould in a dish of **bacteria** he was studying. Fleming realised the mould was producing something that stopped the bacteria growing. This was the first **antibiotic**. He called it penicillin.

Howard Florey and Ernst Chain started working on penicillin about ten years later. At the beginning they found it hard to grow enough mould to treat people, but just like people come in different sizes, not every penicillium mould grew quickly. They needed to find a super mould that would grow fast and produce lots of penicillin. After a huge search the best mould was found growing on a **melon**.

Penicillin kills bacteria but not **viruses**. Today there are lots of different antibiotics, some of which have been found in nature and some which have been made in a laboratory.

Alexander Fleming, Howard Florey and Ernst Chain have saved millions of lives with their work.

When you are level with the altar, look to the right over the rope and you will see a number of memorial stones on the floor around the altar.

Michael Faraday (1791-1867)

Michael Faraday was the son of a blacksmith. Little is known of his early life but he was apprenticed to a bookbinder. His great interest in science was furthered by his contact with Sir Humphrey Davy and Faraday was employed as a laboratory assistant at the Royal Institution. He investigated chemistry, electricity, magnetism, the composition of steel and the making of optical glass and was elected a fellow of the Royal Society.

Faraday's discovery in 1831 that moving a magnet near a wire makes an electric current was the idea behind many electricity power stations today. Faraday is buried in Highgate cemetery in London.

Paul Dirac (1902-1984)

Paul Dirac was born in Bristol where he was brought up by his strict father, a French teacher. He studied Electrical Engineering at Bristol University but decided that he preferred Maths, so he did a second degree and then went to Cambridge where he spent many years studying a new form of physics: quantum mechanics. He predicted the existence of antimatter. Antimatter is just like real matter (everything that we see around us). However, if a piece of matter touches its antimatter partner both would annihilate each other! He won a Nobel Prize 1933

Joseph John Thomson (1856-1940)

This scientist discovered the electron. It is the electrons moving around inside a wire that we know as electricity. Born in Manchester, the son of an antiquarian book dealer he studied Maths and in 1906 he was awarded a Nobel Prize for the discovery of the electron and did much to research the structure of the atom. He is buried near Newton. His son also won a Nobel prize for Physics in 1937.

Ernest Rutherford (1871-1937)

Rutherford was born in New Zealand and came to Cambridge to study for his doctorate. He is credited with being the first person to split the atom and did much work on radioactivity and the structure of atoms. He is buried at Westminster Abbey.

George Green (1793-1841)

Although he was a miller's son, when his father realised that George was clever, he found enough money to send him to a proper school where he soon excelled in Maths. He was such a great mathematician that his theories are still used today in a range of sciences. His most important work was published in 1828

James Clerk Maxwell (1831-1879)

This scientist combined all the experiments, observations and theories about electricity and magnetism into a single subject. Scientists are still looking for ways to combine all the main theories in physics in a similar way. He published this work in 1873

Fill in the name of the scientist beside their greatest achievements.

Dirac - He discovered that moving a magnet near a wire makes an electric current. This is the idea behind many electricity power stations today – where we get our household electricity.

Thomson - He predicted the existence of antimatter. Antimatter is just like real matter (everything that we see around us). However, if a piece of matter touches its antimatter partner both would explode in a shower of energy.

Rutherford - Although he was a miller's son, he was such a great mathematician that his theories are still used today in a range of sciences.

Green - He proved that inside each atom is a nucleus, an even smaller part. He studied radioactive decay, and his research has led to building nuclear power stations.

Maxwell - This scientist combined all the experiments, observations and theories about electricity and magnetism into a single subject. Scientists are still looking for ways to combine all the main theories in physics in a similar way.

Faraday - This scientist discovered the electron. It is the electrons moving around inside a wire that we know as electricity.

7

Look at the floor where you are standing and just in front of the blue gates you will find the grave of :

Charles Darwin (1809-1882)

Charles Darwin is known for his *Theory of Evolution*.

Just like a human baby will look a little different from its mother and father, when an animal is born it isn't exactly the same as its parents. It may have darker hair, a bigger nose, or smaller feet. If an animal is born that is more able to find food, or hide more easily, it is more likely to survive and may pass on this feature to its babies. Over many years all of these animals will have 'evolved' this ability.

Darwin came up with his ideas in South America and the Galapagos Islands on the HMS Beagle. Darwin looked very closely at tiny differences between very similar animals to work out his theory of evolution.

Scientists put all living things into different groups - living things which are similar to each other.

Can you sort out this list of animals into three groups of animals which are similar but not the same?

Peacock Chicken Duck Cheetah Tiger Pet Cat Dog Wolf Hyena

.....

Just through the gates into the North Quire Aisle, look on the right wall to find the round memorial to Joseph Lister.

Lord Joseph Lister (1827-1912)

Joseph Lister is famous for making hospitals cleaner safer. He had seen carbolic acid used as a sewer cleaner and realised he could use it to clean instruments, wash wounds and clean the surgeon's hands, killing the invisible 'germs' that caused diseases.

Joseph Lister was famous for stopping diseases, rather than curing them.

This is something we all do every day, and because of this we live much healthier lives.

Can you list three ways you stop yourself from catching germs each day, or ways to keep yourself healthy?

Hint: Think about what you might do to yourself and your food before eating.

1. Wash hands

2. Wash Food

3. Keep food in fridge

It isn't just bacteria which are considered 'germs'. Can you name two other types of germ which can cause diseases?

1. Viruses

2. Fungi

There are also memorials to other famous scientists around here:

Alfred Russel Wallace, John Couch Adams, James Prescott Joule, Sir Joseph Dalton Hooker, Sir William Ramsey. The window at the end of this aisle is to George and Robert Stephenson and James Watt

Return to stand by the rope near Darwin's grave and look at the large memorial which forms the left side of the Quire screen. This is to:

Sir Isaac Newton (1642-1727)

Isaac Newton is one of the most famous scientists of all time. We still use his laws of motion and laws of gravity today. As well as helping us understand gravity, Newton found new ways of doing maths, he experimented with light, invented a telescope, and studied astronomy.

Many great scientists have had their portraits on banknotes in the United Kingdom. These scientists include Isaac Newton (who was on the old £1 note).

		Pictured with	From	Until
£1	Isaac Newton	Solar system, telescope and prism	1978	1988
£50	Christopher Wren	Plan of St. Paul's Cathedral	1981	1996
£5	George Stephenson	The Rocket	1990	2003
£20	Michael Faraday	Electric spark apparatus	1991	2001
£10	Charles Darwin	Magnifying glass and HMS Beagle	2000	
£50	Matthew Boulton, James Watt	Steam engine	late 2010	

Having looked around Westminster Abbey you will see that it is a place where many very important people are remembered. It is also a living church where people worship God every day. Christians believe that God created a very beautiful and special world which science can help us understand. We hope that you have enjoyed your visit to the Abbey today.