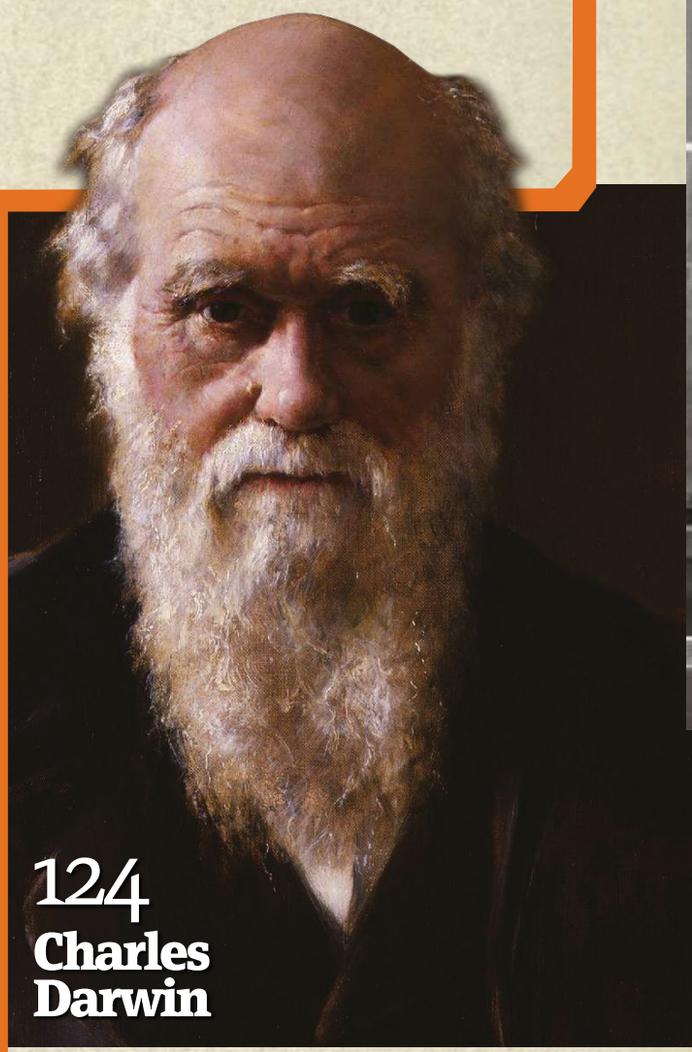
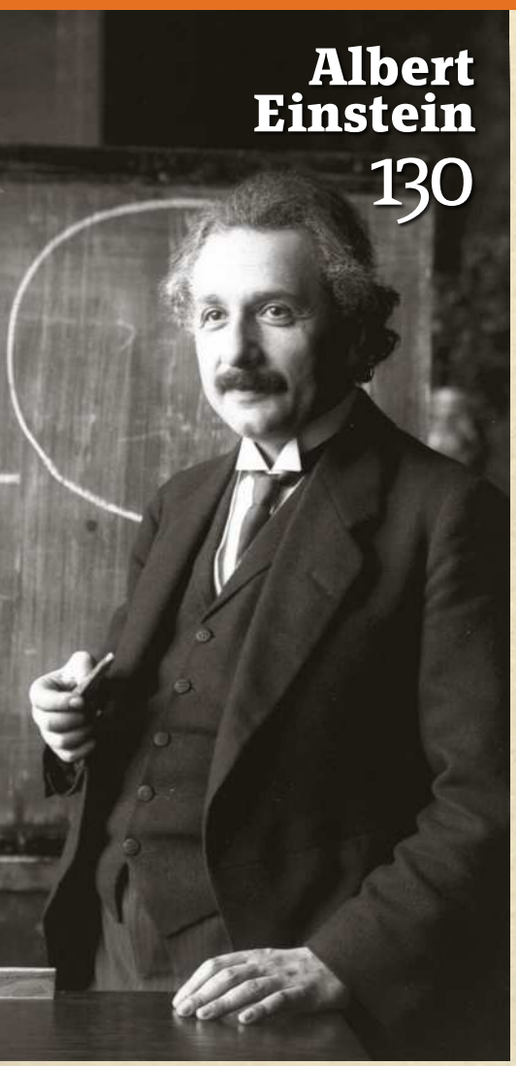
INFLUENTIAL FIGURES

110 Record-breaking royals



124 Charles Darwin

Peter Higgs 132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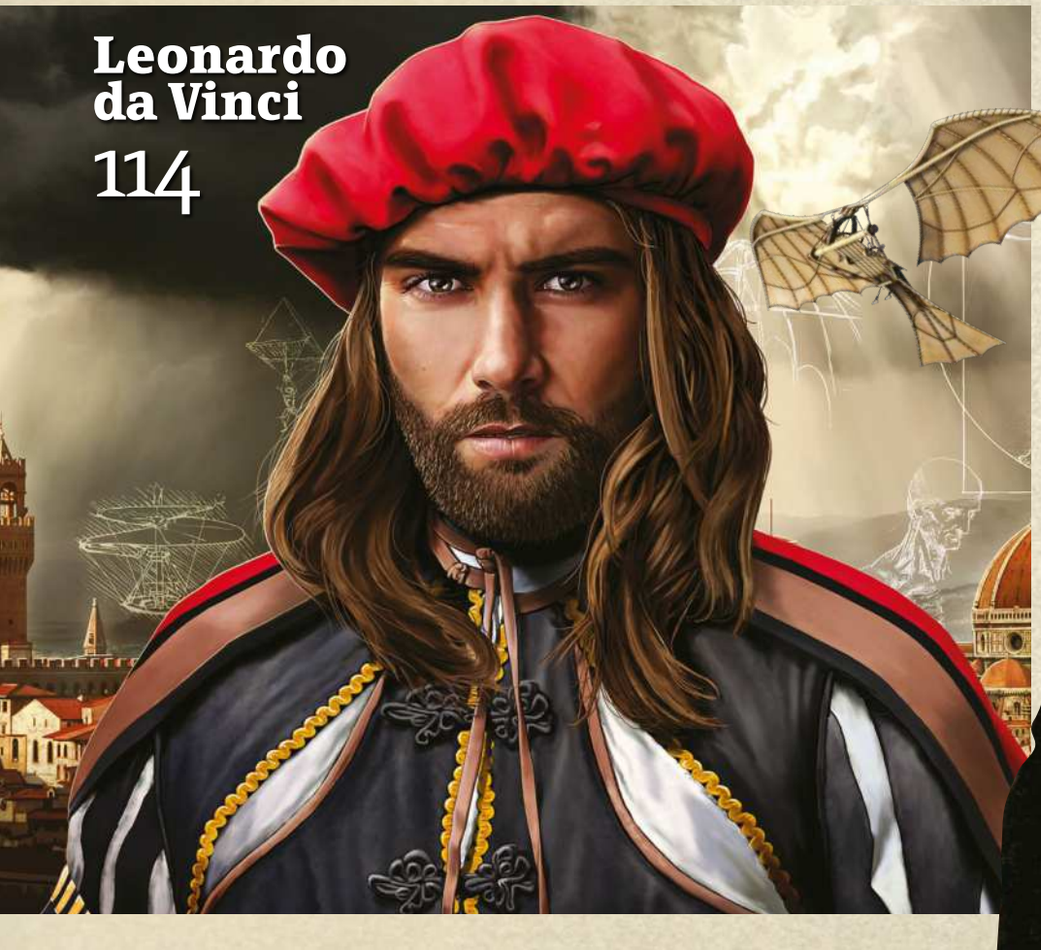
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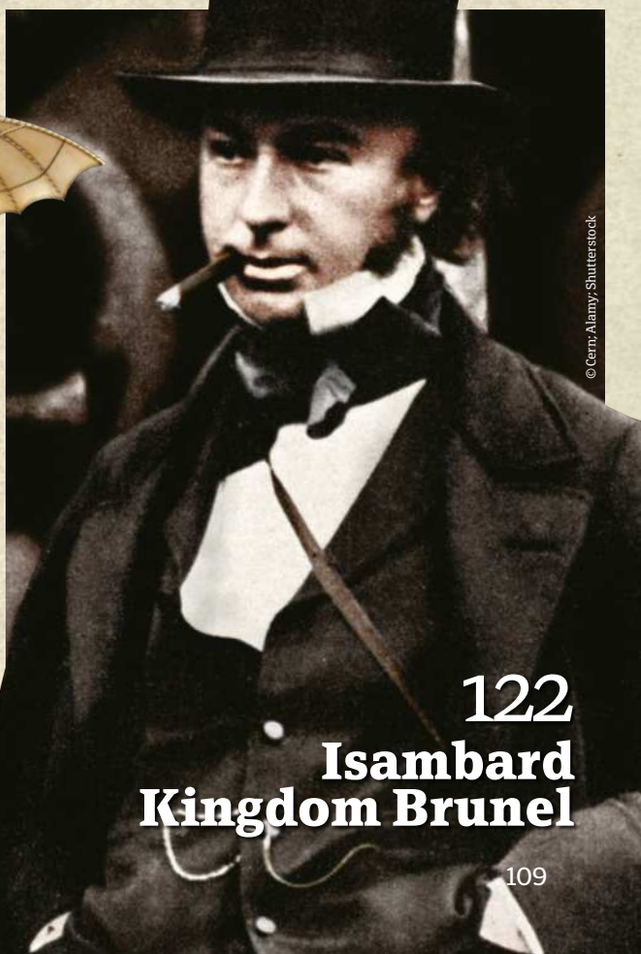
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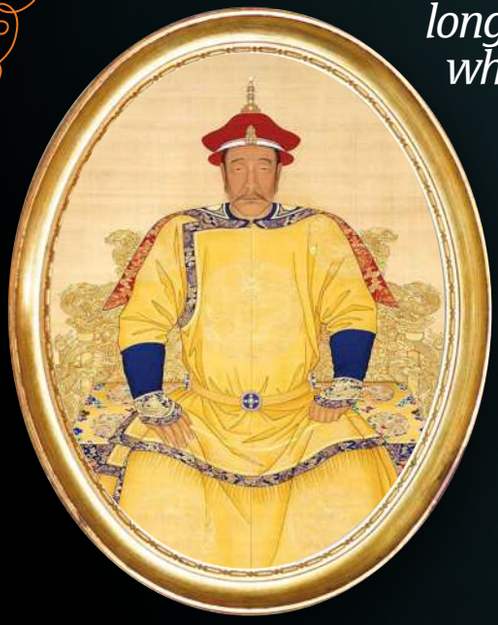
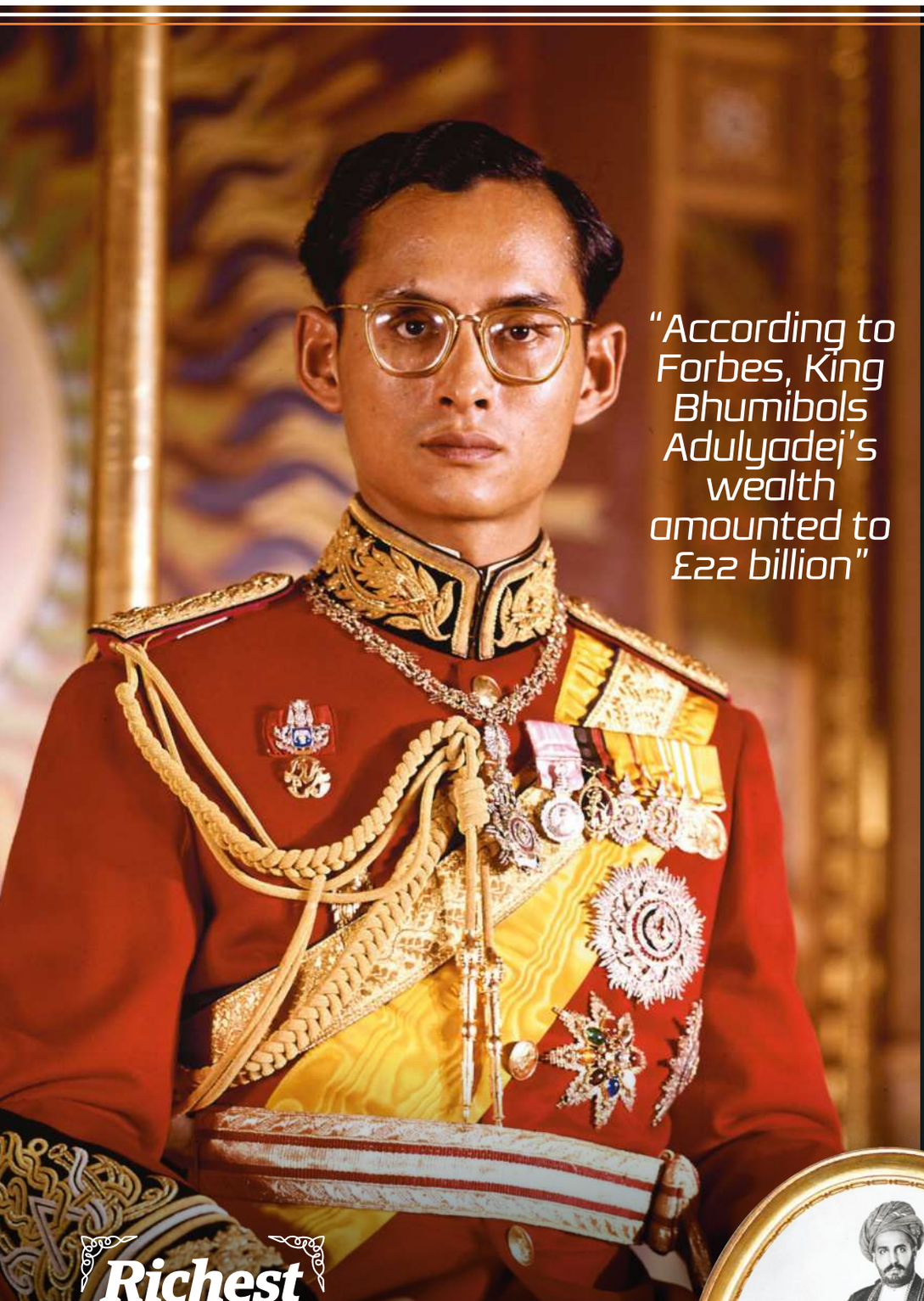
Isambard
Kingdom Brunel

Record-breaking ROYALS

Meet the richest, deadliest and longest-lived monarchs and find out who had the most wives, the most money and the most heirs





"According to Forbes, King Bhumibols Adulyadej's wealth amounted to £22 billion"

Richest

King Bhumibol Adulyadej

1946–2016 / Thailand

In 2012, the Guinness World Record holder for the richest royal was King Bhumibol Adulyadej, King Rama IX of the Chakri dynasty of Thailand. According to Forbes, his wealth amounted to £22 billion ($30 billion), and his riches included the largest cut diamond in the world, a 545-carat jewel known as the Golden Jubilee Diamond.

King Bhumibol Adulyadej passed away in 2016, but no royal yet comes close to taking his title. The nearest is Hassanal Bolkiah, the Sultan of Brunei, who was reportedly worth £15 billion ($20 billion) in 2011.

Longest reign

Sobhuza II

1899–1982 / Swaziland

Queen Elizabeth II became the longest-reigning British monarch in 2015, outstripping the record set by her great great grandmother, Queen Victoria. But this doesn't yet match global records.

The longest reigning European monarch was Afonso I of Portugal, who racked up an impressive 73 years and 220 days between 30 April 1112 and 6 December 1185. However, the longest verifiable reign in history belongs to Sobhuza II, Paramount Chief and King of Swaziland, who assumed his position at just four months old and remained on the throne for 82 years.

Even longer reigns are rumoured but challenging to confirm. It's believed that ancient Egyptian pharaoh Phiops II ascended his throne at the age of six in 2281 BCE and remained there for 94 years, and Min Hti, King of Arakan (now part of Myanmar), reigned from 1279 to 1374, a total of 95 years.

Shortest reign

Sultan Khalid bin Barghash

25–27 August 1896 / Zanzibar

There are two Guinness World Record holders for the shortest reign of a monarch, each spending less than half an hour on their thrones.

Louis-Antoine of France was heir apparent when Charles X abdicated after the July Revolution in 1830. He quickly abdicated too, passing the throne to Henry, Duke of Bordeaux, before fleeing to Britain.

Crown Prince Luís Filipe of Portugal also lost his throne to a revolution. His father Dom Carlos I was assassinated in the Lisbon Regicide of 1908, and Luis died 20 minutes later.

Neither of these princes actually had time to rule. The shortest reign of a ruling monarch goes to Sultan Khalid bin Barghash, who lasted just two days after taking the throne in Zanzibar. The British sent warships to siege his wooden palace, defeating him in the shortest war in history, the hour-long Anglo-Zanzibar War.

© Getty

Most travelled

Queen Elizabeth II

1952–present / United Kingdom and the Commonwealth

Modern monarchs have the upper hand when it comes to global travel, and Queen Elizabeth II has visited more countries than any other royal. In her time on the throne she has racked up more than 1.6 million kilometres, despite, amazingly, not having a passport.

As of 2012 The Queen had made state visits to 116 different countries, including all 53 Commonwealth nations, and by 2016, she'd made 256 official trips in total. But there are some places that remain off-limits. The Queen has not visited Israel, Egypt, Argentina or Greece, the homeland of Prince Philip.

ABOVE: Queen Elizabeth II during a 1975 visit to Hong Kong
RIGHT: The Queen and Prince Philip in Canada, July 1970

Face on most currencies

Queen Elizabeth II

1952–present / United Kingdom and the Commonwealth

Queen Elizabeth II appears on coins in more than 35 different countries, including Australia, Bahamas, Belize, Bermuda, Canada, Cayman Islands, Cyprus, Dominica, Falkland Islands, Fiji, Gibraltar, Guernsey, Hong Kong, Jamaica, New Zealand, Nigeria, Mauritius, Papua New Guinea, Rhodesia, Seychelles, South Africa, St Helena, and the UK.

Queen Elizabeth II's portrait has appeared on banknotes all over the world

Most heirs

King Abdulaziz Al-Saud

1932–1953 / Saudi Arabia

King Abdulaziz Al-Saud founded Saudi Arabia in 1932 and had 45 sons, from whom every Saudi king is descended. The number of daughters he fathered is not known, but Saudi Arabia's royal family now has over 15,000 members. His eldest son, King Saud, had 52 sons and 54 daughters.

Deadliest

Nurhaci, Tianming Emperor

1616–1626 / Liaoning, China

Nurhaci, the Tianming emperor, spearheaded the overthrow of the Ming dynasty. He was leader of the Manchu people of northern China, who were fed up with the famine, silver shortages and tax rises of the early 1600s. He put together a declaration of war known as the 'seven grievances', and the result was one of the bloodiest conflicts in recorded history. The Ming dynasty was replaced with the Qing dynasty and, in the process, an estimated 25 million people died. In the battle of Yangzhou, lead by Nurachi's son, Prince Dodo, 800,000 died.

Most wives

King Ibrahim Njoya

1886–1933 / Bamum (now western Cameroon)

Henry VIII is renowned for having six wives, but he doesn't come close to the record for royal spouses. King Ibn Saud of Saudi Arabia reportedly had 30; King Sobhuza II of Swaziland is rumoured to have had over 100; and King Ibrahim Njoya of Bamum had over 600.

Longest marriage

Takahito, Prince Mikasa Japan

This hotly contested record is currently held by Takahito, Prince Mikasa of Japan. He married Yuriko, Princess Mikasa, in 1941 and they were together for 75 years until his death in 2016. However, Queen Elizabeth II and Prince Philip are fast catching up: they married on 20 November 1947.

Takahito served in China during WWII, becoming a harsh critic of Japan's Imperial Army

"Queen Victoria's empire was the largest in history"

Widest rule

Queen Victoria

1837–1901 / United Kingdom of Great Britain and Ireland, India

The British Empire has its roots in the 16th century, but it wasn't until the reign of Queen Victoria that it reached its peak. Her empire was the largest in history, covering more one-fifth of the world.

Competition with other European countries had driven the formation of British colonies, trading across the globe in tobacco, sugar, tea, silk, cotton, indigo dye and slaves. The first were set up in North America in the 1600s, then in Jamaica in 1655, and northwestern Canada in 1670. By 1661, the British began moving into Africa, settling an island in the Gambia River, and in 1788 the first settlements sprang up in Australia.

At the start of Victoria's reign colonies had appeared in South Africa, and during her time on the throne New Zealand and Egypt were added to the vast trading empire. In 1877 Victoria became Empress of India.

THE GENIUS OF DA VINCI

So much more than just a painter, the famous Renaissance polymath invented a plethora of marvellous machines

Leonardo di ser Piero da Vinci was the epitome of a Renaissance man. While renowned as an artist, da Vinci was also a brilliant scientist and engineer. Beyond his famous paintings, such as *The Last Supper* and the *Mona Lisa*, da Vinci's journals reveal a range of studies and observations, from anatomy to astronomy, and palaeontology to philosophy.

The Renaissance ('rebirth') was a period of cultural revival, which began on the Italian Peninsula in the 14th century as the Middle Ages came to an end. Da Vinci was born in 1452 into a world that had become more accommodating to new ideas. A year after his birth, the capital of the Byzantine Empire, Constantinople (now Istanbul), fell to the Ottomans. As talented scientists and artists escaped the war-torn Bosporus to seek safety in Italian city-states, the country became a hub of learning. One city the fleeing scholars settled in was Florence.

Here they were encouraged to study and invent by the ruling Medici family, who happily bankrolled learning centres all over the city. An intellectual and cultural revolution began; new technological and scientific ideas were spread with help from the recent invention of the printing press, as Europe began to catch up with academics from the Islamic world. It is likely that the inventions and creations of other Renaissance men like Mariano di Jacopo (also known as Taccola) and Filippo Brunelleschi influenced da Vinci, who revelled in the idea of Renaissance Humanism, a notion that encouraged learning and built on critical thinking methods that had stagnated in the Medieval period.

Da Vinci's most famous works are his paintings, but he was also a creative and talented engineer and inventor. The rediscovery of his codices in the 19th century revealed plans for an array of contraptions, from battlefield tanks to flying machines. His ideas were influenced by classical antiquity and observations of the natural world. For example, a tortoise shell was the inspiration for his armoured car, while observations of birds, bats, flying fish and even plants contributed to the designs of his various flying machines.

His ideas were ambitious, but they were grounded in logical calculations based on scientific theories and mathematical principles. For the most part, these designs were only held back by the technological restrictions of the time. While many of da Vinci's manuscripts were inadvertently destroyed after his death, over 5,000 pages of his journals still exist today, providing us with a glimpse into the mind of a man ahead of his time. Leonardo da Vinci may have died nearly 500 years ago, but the legacy of his creativity and innovation lives on.

FLYING MACHINES

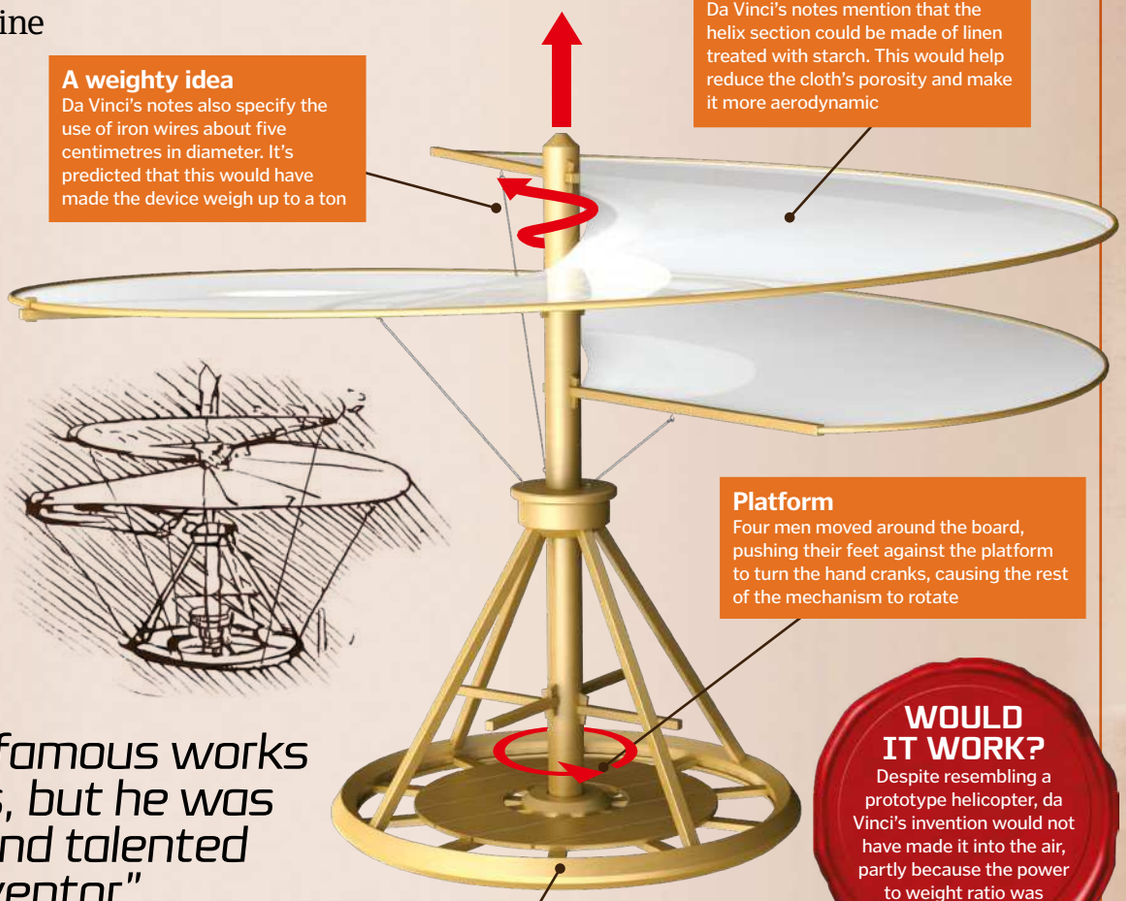
Da Vinci dreamed of mechanisms that would enable humans to soar through the sky

Aerial screw

An ambitious flying machine that helped inspire the modern helicopter

Scribbling in his notebook circa 1489, da Vinci envisioned a spiral-shaped contraption that could take to the skies. Possibly powered by hand cranks turned by four people, his writings suggested that the aerial screw could achieve flight by rotating quickly around a central shaft. Da Vinci believed that air could be compressed, so just as a screw bores into the ground below, his machine could 'bore' into the air above to lift his machine up off the ground.

Unfortunately, materials that were strong and light enough for the device to work were not available at the time. What's more, it would not have been able to fly for long, as once it was off the ground, the screw would no longer have a support structure to press against in order to keep spinning. It may never have made it off the ground, but da Vinci's innovative aerial screw design was the first to study the potential of a rotating spiral for flight.



A weighty idea
Da Vinci's notes also specify the use of iron wires about five centimetres in diameter. It's predicted that this would have made the device weigh up to a ton

Materials
Da Vinci's notes mention that the helix section could be made of linen treated with starch. This would help reduce the cloth's porosity and make it more aerodynamic

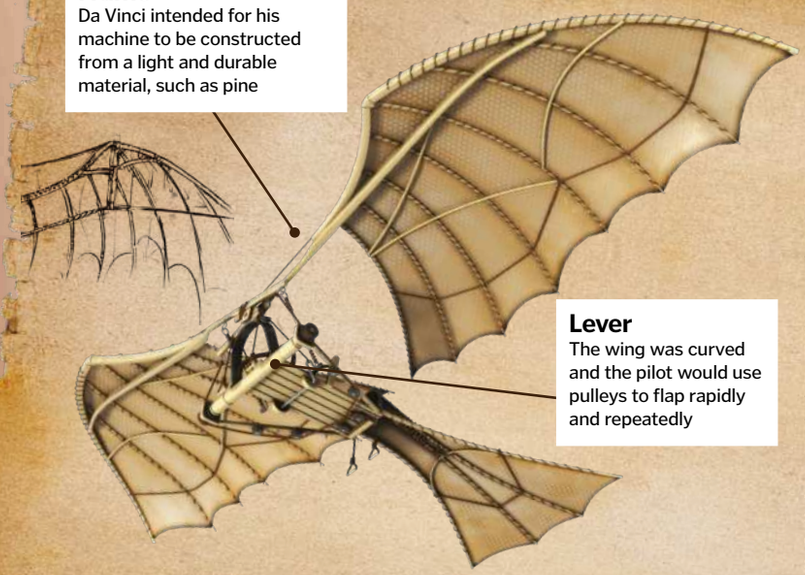
Platform
Four men moved around the board, pushing their feet against the platform to turn the hand cranks, causing the rest of the mechanism to rotate

Lift off?
One hurdle encountered in this study was to figure out how to produce high enough speeds to generate the required lift

"Da Vinci's most famous works are his paintings, but he was also a creative and talented engineer and inventor"

WOULD IT WORK?
Despite resembling a prototype helicopter, da Vinci's invention would not have made it into the air, partly because the power to weight ratio was so low.

Frame
Da Vinci intended for his machine to be constructed from a light and durable material, such as pine



Lever
The wing was curved and the pilot would use pulleys to flap rapidly and repeatedly

Ornithopter

Enthused by birds soaring in the air, da Vinci drew some inventive designs for mechanical wings

Da Vinci observed birds and other animals in flight, and became obsessed with the idea of a contraption that would allow humans to do the same. One of his ideas was an ornithopter, which was powered by flapping mechanical wings. Da Vinci wrote over 35,000 words and drew 500 sketches on flying machines. He understood that birds relied on both lift and propulsion to maintain flight, and that they balanced themselves with both wings and tail. He hinted at the idea of gravity and understood that flying machines had to be as lightweight as possible. His sketches demonstrate knowledge of aerodynamics, showing how airflow could be streamlined and how aircraft produce drag. The only drawback was the human body, which is simply not built to achieve flight on its own, nor muscular enough to power a mechanical engine for flight.

WOULD IT WORK?
Ornithopters with flapping wings have been built, both manned and unmanned. They can work with the help of an engine.

WAR MACHINES

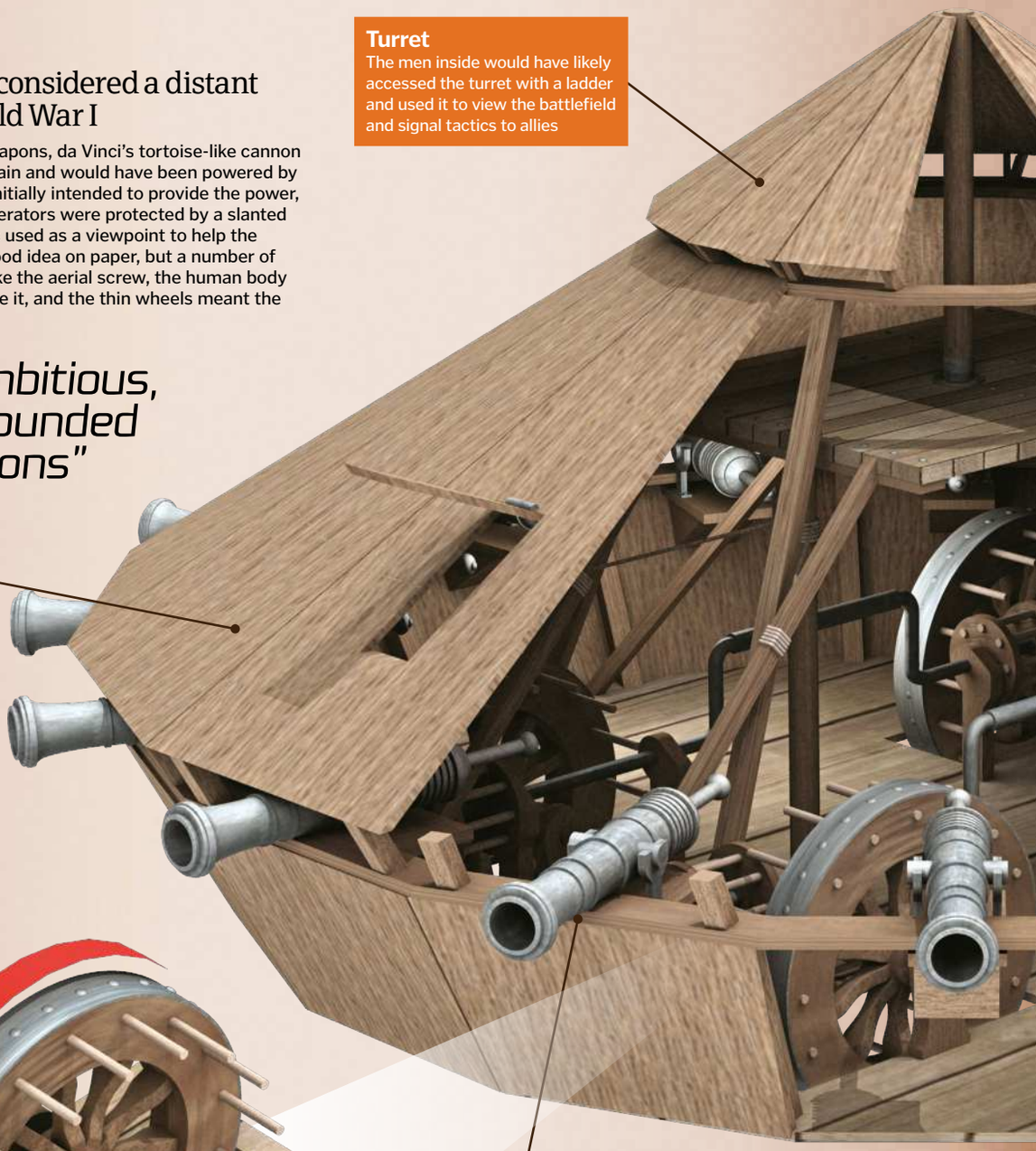
Da Vinci devised a number of military mechanisms that could have revolutionised the battlefield

Armoured car

Da Vinci's concept could be considered a distant ancestor of the tanks of World War I

Incorporating past designs for armoured weapons, da Vinci's tortoise-like cannon system had the ability to move over flat terrain and would have been powered by an eight-man team. Oxen and horses were initially intended to provide the power, but space inside the car was limited. The operators were protected by a slanted and sturdy covering, and a turret on top was used as a viewpoint to help the drivers navigate. The armoured car was a good idea on paper, but a number of issues meant it could never have worked. Like the aerial screw, the human body simply didn't have the muscle power to move it, and the thin wheels meant the tank would easily sink in mud.

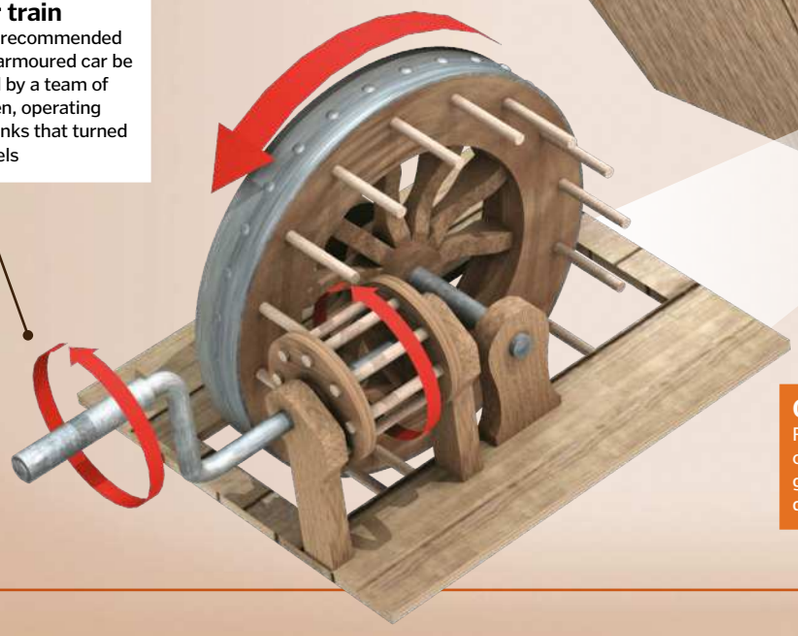
"His ideas were ambitious, but they were grounded in logical calculations"



Turret
The men inside would have likely accessed the turret with a ladder and used it to view the battlefield and signal tactics to allies

Armour
The plated sloping design proposed by da Vinci was possibly superior to WWI tank armour, as the 45-degree angle would help deflect the impact of enemy projectiles

Power train
Da Vinci recommended that his armoured car be powered by a team of eight men, operating hand cranks that turned the wheels



Cannons
Regularly placed around the car's circumference, the guns could fire in any direction on the battlefield

WOULD IT WORK?
If da Vinci's illustration was followed, the shafts would turn the wheels in opposing directions, preventing the car from moving. It's thought this was a deliberate error in case his designs fell into enemy hands.

The bombard
Another weapon that da Vinci depicts in his notebook is a bombard that launched fragmenting ammunition

Rain of metal
Once it was fired, the cannonballs would separate into several pieces, raining down lethal shards of metal on enemy infantry

Wheels
Despite including studs on the wheels to add friction, it is likely the armoured car would have got stuck in boggy and uneven ground

Machine gun

A multi-barrelled weapon that could unleash rapid-fire projectiles at hordes of enemy soldiers

Cannons were important in Renaissance-era artillery. Da Vinci aimed to add maneuverability and extra firepower with his concept of a multi-barrelled war machine that could fire a dozen cannonballs at once. With wheels on its side, the portable muzzle-loaded cannon had a rotating body with up to three revolving rows of guns. One could fire while the other two cooled and were reloaded. The recoil would have been fierce, so the machine was equipped with a support bulkhead that held the main body in place. In one of da Vinci's sketches, the barrels are arranged in a fan shape to give the weapon a wider firing range.

Recoil
The cannon was encased in a wooden structure to hold it in place. Although it was heavy, accurate firing was not difficult

Springald

A cannon intended to eliminate specific targets from the battlefield

The springald was an artillery device that existed before da Vinci, but like many of his other creations, he built upon the idea. His version had the ability to fire in many directions both horizontally and vertically. An elevating arc moved the springald up and down, and when the desired height was achieved, it was held in place by a cylindrical peg. It could then be aimed to the left and the right. Iron and stone cannonballs, and even metal-tipped arrows were fired from the breech-loaded cannon.

Protection
An angled wooden slope would have protected the men operating the cannon

HYDRAULIC MACHINES

Da Vinci's notebooks feature several ideas for complex yet workable devices powered by water

Paddleboat

This reciprocating-motion vessel was a huge advance on the oar-powered boats of the age

With the absence of internal combustion engines, boats and ships in the 15th century were powered either by wind or by oar. Writing between 1487 and 1489, da Vinci reasoned that a paddle-based mechanism that used reciprocating motion (repetitive back and forth movements) would be far more effective. By replacing the oars with paddle wheels, it would be easier for the boat to travel upstream.

The paddleboat wasn't an original da Vinci idea; Italian inventors Taccola and Francesco di Giorgio had both looked into the concept before, but this was the most realistic and workable proposal yet. The operators would push down on alternate foot pedals, which powered a reciprocating-motion system, which in turn was transformed into rotary motion to turn the paddle wheels and propel the boat forwards. The principle was the opposite of a water mill, with the machine moving the water rather than the water moving the machine.

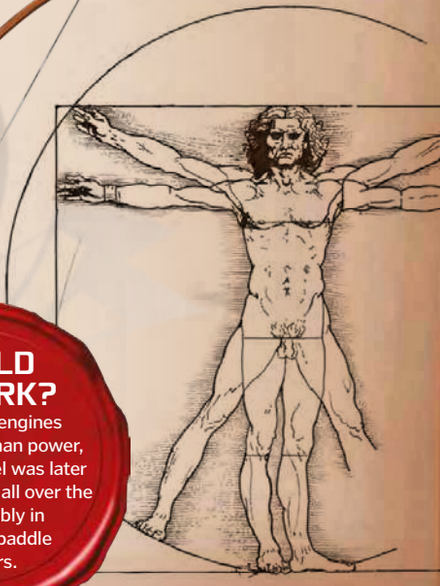
1 Pedal
The mechanism starts with the operator pushing down on one of the two pedals

2 Motor
The reciprocating motion produced by the pedal is transformed into rotary motion by a series of cranks, springs and gears

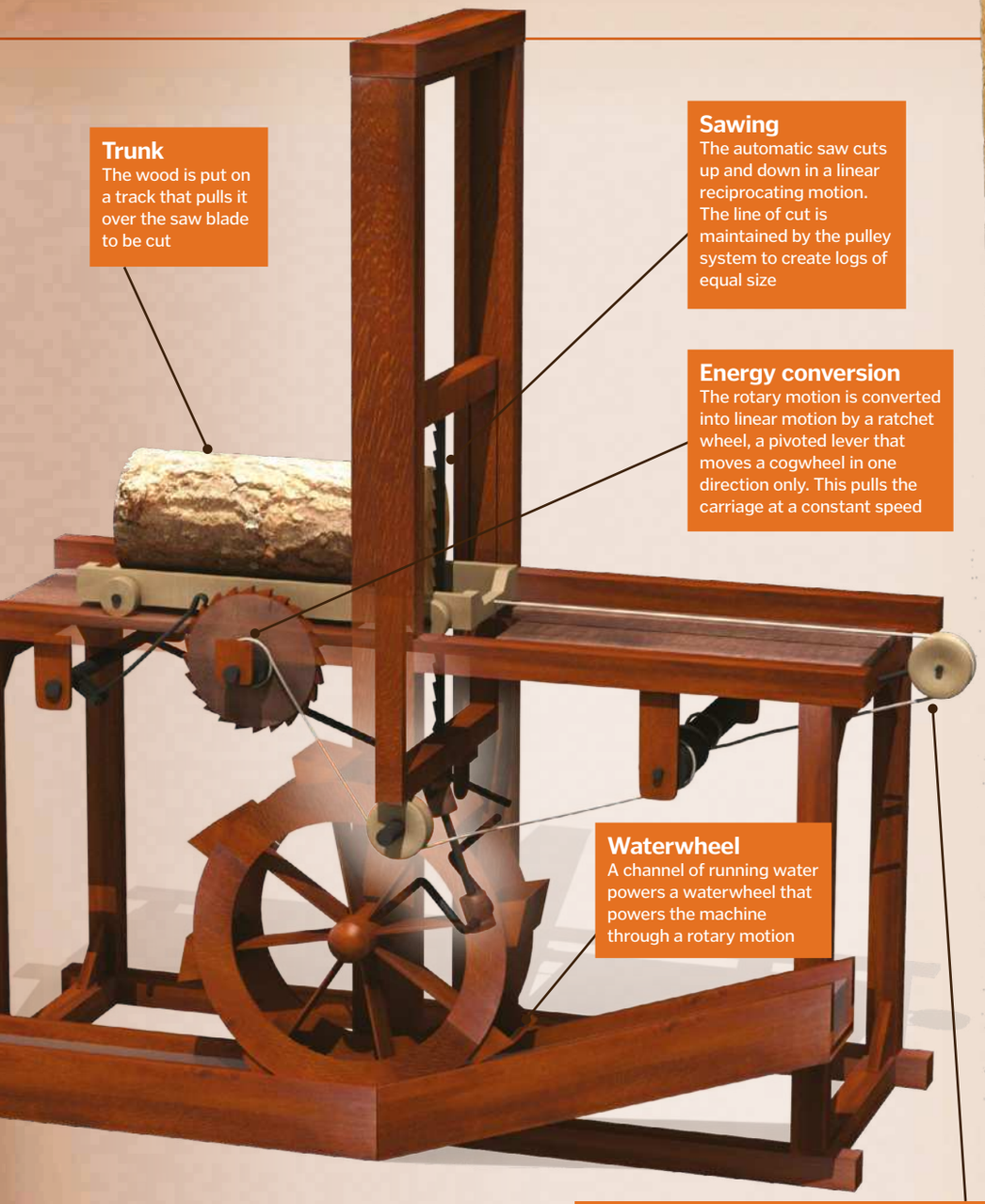
3 Paddles
The rotary motion produced by the motor turns the paddle wheels to propel the boat forwards

4 Reciprocation
The operators alternately press on the left and right pedals to keep the paddle wheels spinning

"The inventions of other Renaissance men most likely influenced da Vinci's own ideas"



WOULD IT WORK?
Using steam engines rather than human power, the paddle wheel was later used extensively all over the world, notably in Mississippi paddle steamers.



Trunk
The wood is put on a track that pulls it over the saw blade to be cut

Sawing
The automatic saw cuts up and down in a linear reciprocating motion. The line of cut is maintained by the pulley system to create logs of equal size

Energy conversion
The rotary motion is converted into linear motion by a ratchet wheel, a pivoted lever that moves a cogwheel in one direction only. This pulls the carriage at a constant speed

Waterwheel
A channel of running water powers a waterwheel that powers the machine through a rotary motion

Pulleys
The mechanism is run using pulleys that gradually move the carriage as the wood is sliced

Mechanical saw

Another hydraulic invention that was designed to cut wood quickly and efficiently

Noted down circa 1478, da Vinci's mechanical saw was a rapid cutting device. The saw utilised the energy of a water mill to power the slicing of logs into wood. The wood would then be used for construction, particularly in war time, where it would be used to quickly build military bridges (these bridges were easy to transport and could be rapidly assembled across a body of water to allow troops to cross).

The saw's mechanism was relatively simple: a channel of running water turned a mill, and this rotary motion was transformed into linear reciprocating motion that powered the up and down sawing movement. The mechanism also powered pulleys and crankshafts that kept the log moving towards the saw. Like the paddleboat, the mechanical saw had been thought of before but not in this level of detail. Once again, da Vinci took a clever concept and improved it.

WOULD IT WORK?

The mechanical saw was one of da Vinci's least innovative but most workable concepts. Its automatic cutting system worked using the same principles as a standard water mill.

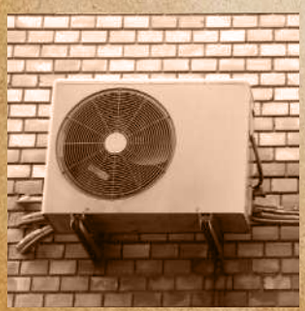
DA VINCI INVENTIONS USED TODAY

Ball bearings
First seen in a drawing in 1497, da Vinci based his idea on ancient Egyptians rollers that were used to transport huge stones up ramps to construct the pyramids.

Double hull
Da Vinci proposed the idea that a double hull would stop ships from sinking if its first was pierced by an enemy ship's ram, a weapon commonly used in naval battles.

Parachute
Da Vinci devised this combination of linen cloth and wooden poles 300 years before the first parachute test. His design was tested in 2005 and was proved to work.

Robot
Using a system of pulleys, weights and gears, da Vinci's robot was a moving suit of armour that could move its limbs, turn its head and sit down and stand up.



Air conditioning
After being asked to help ventilate a boudoir, da Vinci developed a mechanical water-driven fan in 1500 that can be seen as a precursor to modern cooling systems.

Michael Faraday

The scientist behind electromagnetic induction who played a key role in inspiring Einstein…

Faraday was a chemist as well as a physicist, who investigated liquefied gases, optical glass and electrolysis

Michael Faraday was born in 1791 to a poor family who couldn't afford to educate him. Few could have guessed that he would go on to massively advance our understanding of electricity and more. He learned to read and write at Sunday school, and subsequently became a bookbinder's apprentice in his teens.

Faraday loved to read and he worked his way through the books that he was binding, developing a keen interest in chemistry, electricity and magnetism. His newfound interest in science led him to attend a series of four lectures by chemist Humphry Davy, where he took extensive notes in the hope of securing employment at the Royal Institution. Eventually, his persistence paid off and he managed to get a job working as a laboratory assistant to Professor Davy.

Faraday worked for Davy for several years, during which time the pair travelled to Europe for their research. While with Davy, Faraday made several discoveries in the field of chemistry, including identification of the ring-shaped hydrocarbon benzene. He also made two new chemical compounds: hexachloroethane, which now forms the basis of military smoke grenades, and tetrachloroethylene, which is widely used to dry-clean clothes even to this day.

Faraday's major breakthroughs were not in chemistry though, but in physics. In 1820, Hans Christian Oersted discovered that an electrical current could produce a magnetic field. Faraday was convinced that the opposite must also be true, and began his most influential work on electromagnetic induction. His first discovery came shortly after, when he showed that by wrapping two insulated coils of wire around an iron ring a current could be transferred from one coil to another in a process known as mutual inductance.

Keen to further this research, Faraday continued investigating the electromagnetic properties of materials, and this led to his greatest achievement of all in 1831 – the discovery of electromagnetic induction (see 'The big idea' for more information).

Faraday's work on electromagnetism sparked the interest of other scientists and

A life's work

We highlight some key events from Faraday's electrifying career in the 19th century

1791
Michael Faraday is born in Surrey, UK, to James Faraday and Margaret Hastwell.

1805
Faraday starts work as a bookbinder's apprentice. During this time he develops an interest in science.

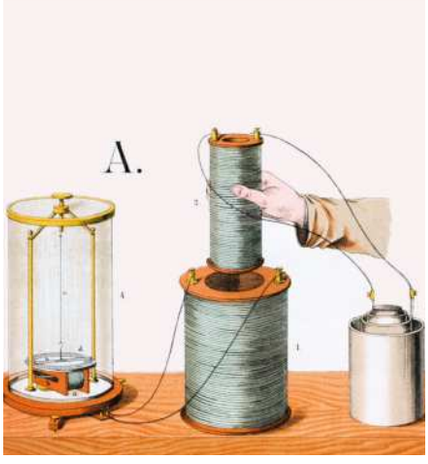
1813
He works as assistant to Professor Humphry Davy, making several advances in the field.

1821
Faraday discovers the principle behind the electric motor, using the idea of electromagnetic rotation.

1824
He is elected a fellow of the Royal Society.

The big idea

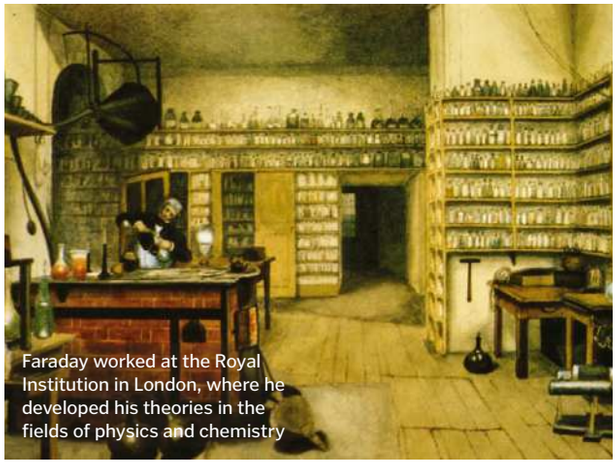
Faraday was a prolific scientist, but is best known for his work on electromagnetic induction. Faraday's Law states that a change in the magnetic environment near to a coil of wire will induce a voltage in the coil. Faraday developed a spinning copper disc, which rotates next to a static magnetic field (provided by a bar magnet). As the disc spins through the magnetic field, a potential difference is generated between the centre and the edge of the disc, creating a steady direct current. Faraday's disc was inefficient, but it provided the basis for the development of transformers, inductors, electrical motors and generators.



Faraday declined knighthood and presidency of the Royal Society twice

mathematicians, which led to William Thomson writing to him, suggesting that it was mathematically possible for magnets to alter the plane of polarised light. Faraday had been interested in this idea himself for a very long time, conducting experiments to show how light and magnetic fields interact with each other. This was one of the first steps towards the realisation that visible light is actually electromagnetic radiation.

Later in life Faraday's health declined, but even so, he stubbornly continued his lecturing at the Royal Institution. His incredible scientific contributions were officially acknowledged by the royal family and, in 1858, Faraday moved to a home in Hampton Court, granted to him by Queen Victoria. He died in 1867 and, having previously refused a burial site at Westminster Abbey, he was buried in Highgate Cemetery instead.



Faraday worked at the Royal Institution in London, where he developed his theories in the fields of physics and chemistry

Five facts: Michael Faraday

1 No one-trick pony
Faraday developed an early version of the Bunsen burner and also discovered the laws of electrolysis.

2 Nanoparticles
Faraday was the first to report nanoparticles' properties, noticing that gold colloids (sub-micrometre-sized gold particles dispersed in a liquid) have different properties to solid gold.

3 Modest man
He declined a knighthood offered by Queen Victoria, and refused to accept presidency of the Royal Society twice.

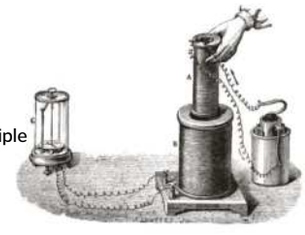
4 Christmas Lectures
Faraday founded the Royal Institution's (RI) Christmas Lectures. To this day, fun science demonstrations for children are broadcast every Christmas in the UK by the RI.

5 Competition
The Italian priest Francesco Zantedeschi and US scientist Joseph Henry were both working on electromagnetic induction too. Which of these men came up with the idea first is still contested to this day.

"Faraday worked his way through the books that he was binding, gaining interest in chemistry, electricity and magnetism"

1825
Faraday is appointed director of the laboratory at the Royal Institution, beginning the Christmas Lecture series.

1831
He discovers the principle of electromagnetic induction and invents the electromagnetic generator.



1858
Faraday moves to Hampton Court, awarded to him by Queen Victoria for his services to science.

1867
Faraday dies, aged 75, at his home in Hampton Court. He is buried in Highgate Cemetery.

Isambard Kingdom Brunel

Though not always successful, Brunel's designs revolutionised transport, and he is now remembered as one of the greatest engineers of all time

Isambard Kingdom Brunel revolutionised rail and water transport not just in the UK but all around the world

"SS Great Britain laid the foundations for a new era of transatlantic travel"

While an era of progress, the Industrial Revolution was also a time of trial and error. Those leading the way in technological advances attempted to make huge leaps forward, often resulting in failure, but sometimes incredible success. One of the greatest of the innovators of this time was Isambard Kingdom Brunel, born at the start of the 19th century. His father, Marc, was a French civil engineer, and encouraged his son to learn arithmetic, scale drawing and geometry. At 16, he became a watchmaker's apprentice.

In 1824 Marc was appointed chief engineer of a project to construct a tunnel under the River Thames. He hired his son as an assistant engineer, who later became resident engineer. The project was fraught with disaster, witnessing several incidents of flooding, as well as financial difficulties. At one point the operation was halted for several years and the tunnel bricked up. It was eventually opened in 1843 and is still in use today as part of the London Overground network.

The project transformed the young Brunel into a full-fledged engineer. In 1830 he entered a competition to design a bridge that would span across the River Avon in Bristol, and although rejected initially, he eventually persuaded the panel to appoint him as project engineer. Work on the Clifton Suspension Bridge commenced in June 1831, but just four months later the Queen Square riots drove investors away. Once again a project ground to a halt.

In 1833 Brunel was made chief engineer of the Great Western Railway, which would run from London to Bristol. It was then that he developed one of the most controversial ideas of his career – to use a 2.1-metre gauge (distance between the tracks) rather than the standard 1.4-metre gauge. He believed that this would allow the trains to run at much higher speeds, as well as provide a more stable and comfortable journey without as much rocking back and forth. For the

A life's work

Brunel made his mark on history – but what were the defining moments in this innovator's career?

1806
Isambard Kingdom Brunel is born in Portsmouth, UK, to French civil engineer Marc Isambard Brunel and Sophia Kingdom.

1827
Brunel is appointed resident engineer of the Thames Tunnel project in London, taking over from his father.

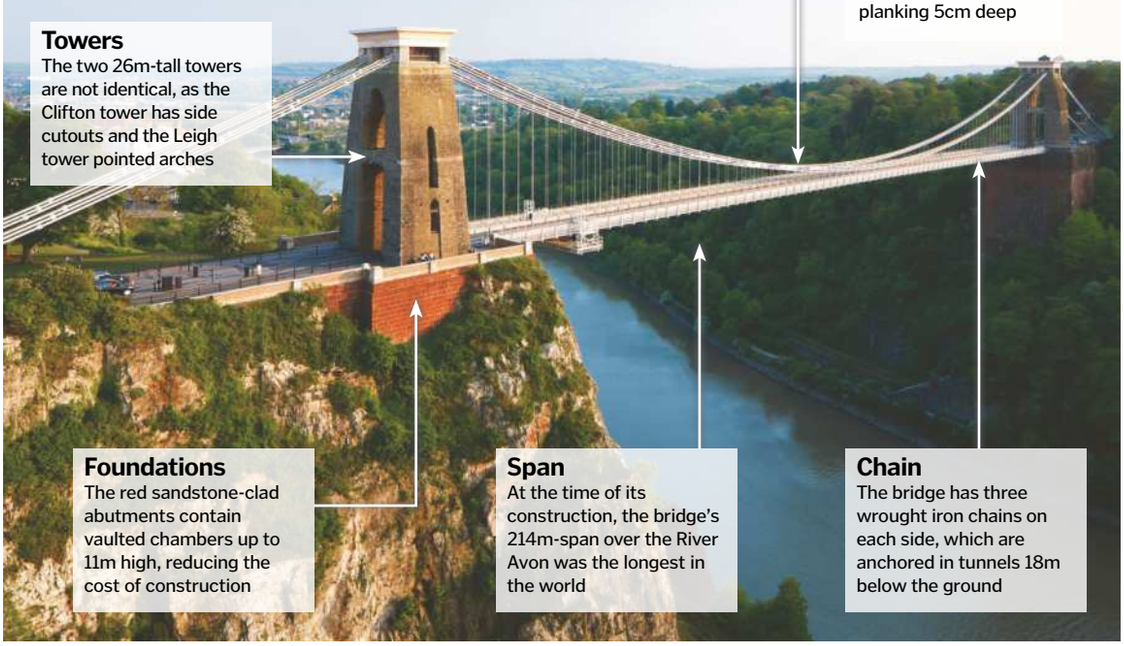
1830
He enters a competition to design a bridge to span the River Avon and is awarded first place.

1831
Work on the Clifton Suspension Bridge begins but financial difficulties bring the project to a halt.

1833
Brunel becomes chief engineer of the Great Western Railway, developing his idea for a wider track.

Clifton Suspension Bridge in focus

What feats of engineering ensured the bridge's survival to the modern day?



Deck
The deck is made of timber sleepers some 13cm thick overlaid by planking 5cm deep

Towers
The two 26m-tall towers are not identical, as the Clifton tower has side cutouts and the Leigh tower pointed arches

Foundations
The red sandstone-clad abutments contain vaulted chambers up to 11m high, reducing the cost of construction

Span
At the time of its construction, the bridge's 214m-span over the River Avon was the longest in the world

Chain
The bridge has three wrought iron chains on each side, which are anchored in tunnels 18m below the ground

rest of his life the efficiency of this design was heavily contested.

But none could contest the efficiency of his Great Western Steamship, which transported passengers from Bristol to New York. It was thought a steamship would not be able to carry enough fuel for the trip and have room for cargo. However, it completed its maiden voyage in 15 days, with a third of its coal remaining. Brunel was also a fierce proponent of propeller-driven ships and incorporated a propeller on his second ship, SS Great Britain. Considered the first modern ocean-going ship, it was made of metal, powered by an engine rather than wind, and driven by a propeller rather than a paddle wheel. Indeed, this vessel laid the foundations for a new era of transatlantic travel.

Brunel's personal life was a series of ups and downs too. Many say the stress of the Great Western Railway led to his early death in 1859. Soon after it was decided all railways in the country should revert to using the standard gauge. However, funds were also raised to complete the Clifton Bridge, which was opened five years after Brunel's death and is still in use.

The big idea

The Clifton Suspension Bridge in Bristol spans 214m between two 26.2m towers, which at the time was the longest bridge span in the world. In its design of chains and rods, Brunel had made a near-perfect calculation of the minimal weight required to provide maximum strength. The abutments contain a honeycomb of chambers and tunnels, some of which are 11m high, which reduced the cost of construction without compromising strength.

Brunel trivia

1 French connection
During his teenage years, Brunel attended school in France, but surprisingly his application to the renowned French engineering school École Polytechnique was unsuccessful, owing to the fact that he was a 'foreigner'.

2 River party
In 1827, after several incidents of flooding, Brunel held a lavish banquet inside the Thames Tunnel to help convince people that it was perfectly safe.

3 Beating the competition
Brunel's submission to the Clifton Bridge competition was initially rejected by the judge, Thomas Telford, who instead put forward his own design for the bridge.

4 Flip of a coin
In 1843, while performing a magic trick for his children, a coin became lodged in Brunel's windpipe. In order to remove it, he was strapped to a board and turned upside down.

5 Commissioned by the lady with the lamp
In 1855 Brunel responded to a request from Florence Nightingale, known as nursing icon 'the lady with the lamp', to design a new hospital that would replace the unsanitary British Army Hospital in Scutari, Turkey, which he did successfully.

1838
The Great Western Steamship sails from Bristol to New York in just 15 days.

1843
The Thames Tunnel is opened to the public and the propeller-driven SS Great Britain is launched.

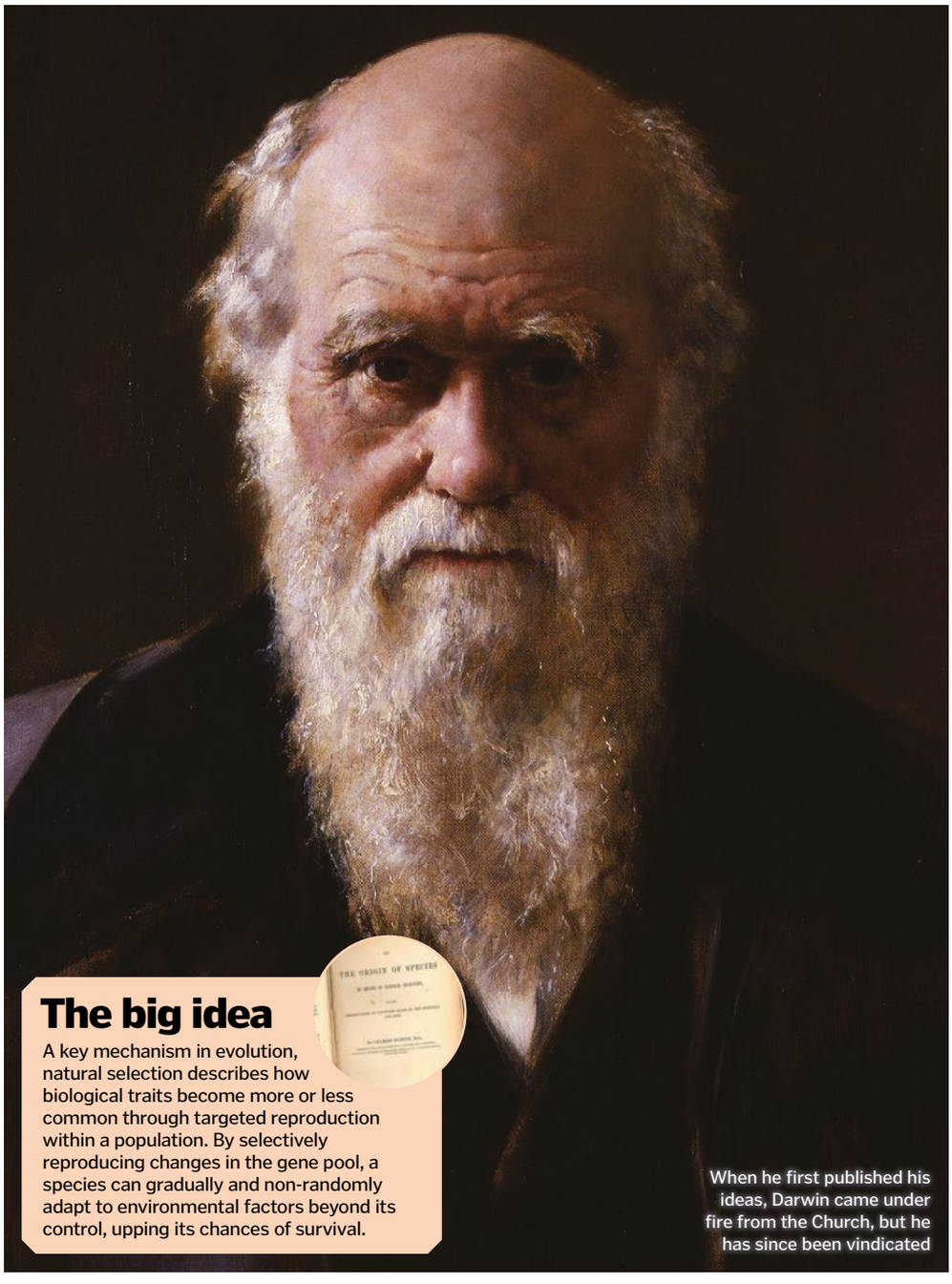
1852
Brunel's design for Paddington Station is constructed.

1859
Brunel dies on 15 September, ten days after suffering a stroke.

1864
The Clifton Suspension Bridge is finally completed as a tribute to Brunel by the Institute of Civil Engineers.

Charles Darwin

The father of evolutionary biology, Darwin is the most famous naturalist of the Victorian era, if not all time



The big idea

A key mechanism in evolution, natural selection describes how biological traits become more or less common through targeted reproduction within a population. By selectively reproducing changes in the gene pool, a species can gradually and non-randomly adapt to environmental factors beyond its control, upping its chances of survival.

When he first published his ideas, Darwin came under fire from the Church, but he has since been vindicated

Charles Robert Darwin was an English naturalist renowned today for his theories of evolution and natural selection, both of which were introduced in his seminal work *On The Origin Of Species*. The book was both lambasted and celebrated on its publication. Early controversy stemmed from its apparent undermining of religious scripture, but it would become one of the most influential works of Western society, with the entire field of evolutionary studies arising from it.

Though *On The Origin Of Species* was published in 1859, Darwin originally conceived of evolution by natural selection shortly after an around-the-world tour starting in 1831. He embarked on the journey to expand his newly formed interest in natural history, spending the trip collecting specimens and analysing many interesting species, when not suffering from seasickness. During the expedition on HMS Beagle he collected over 5,436 skins, bones and carcasses of various creatures. His experiences and findings led him to question many of the accepted beliefs at the time concerning life's origins.

In 1838 he pinned down his theory of natural selection proper – see 'The big idea' boxout for more details. Over the next 20 years, he continued to refine it until he received a letter from fellow British naturalist Alfred Russel Wallace proposing a collaboration. The fact that both men shared the same ideas led to the joint publication of their research. While Wallace's hypotheses on the subject were detailed, his hands-on research was lacking and Darwin's extensive fieldwork won out, with history since attributing the theory largely to the latter.

The publication of *On The Origin Of Species* the following year was therefore a landmark moment for Darwin – and for science as a

A life's work

Famous for describing the evolution of humanity, we chart Darwin's own evolution through the 19th century

1809
Charles Darwin is born in Shrewsbury, England. His parents are Robert (above) and Susannah Darwin.

1818
In June, Darwin goes to Shrewsbury School as a boarder, where he studies for seven years.

1825
Darwin signs up for medical courses at the University of Edinburgh with elder brother Erasmus.

1827
He is admitted to Christ's College Cambridge to study not science but divinity.

1831
Accepts an offer to join a voyage on HMS Beagle which sets sail on 27 December.

HMS Beagle spent just five weeks in the Galápagos Islands, but that was long enough for Darwin's research purposes

whole. To a degree it was a bringing together of various ideas that had already been mooted by other biologists but unproved. While Darwin did not supply concrete evidence for evolution, the work's lucidity and logic meant that, towards the end of the 1870s, the scientific community, and society as a whole, had accepted his views.

Darwin followed up this groundbreaking title in 1871 with *The Descent Of Man, And Selection In Relation To Sex*, where he applied his own evolutionary theory specifically to human's evolution from apes. This book was incredibly popular from the word go, with a reprint ordered within just three weeks of publication. Three months after its release, 4,500 copies had been sold – a testament to his rising fame.

Darwin died on 19 April 1882 from heart disease and, after a request by his colleagues, was granted a state funeral at Westminster Abbey, buried alongside other famous scientists John Herschel and Isaac Newton.

Although some claim the significance of Galápagos finches to Darwin's theories has been overblown, more recent research indicates they are a good example of micro-evolution

Perhaps the most famous resident of the Galápagos, the giant tortoise

Five facts: Charles Darwin

1 Family guy
Darwin had ten children, though two died while still young. Three of his sons went on to become members of the Royal Society themselves.

2 On the money
Darwin is commemorated in the UK with his portrait printed on £10 banknotes, alongside a hummingbird and the ship HMS Beagle.

3 School of thought
The school that Charles Darwin attended as a boy, Shrewsbury School, still exists, but it is no longer in the same building, which has since become a library.

4 Name gets around
Due to Darwin's great achievements in the field of natural history, more than 120 species and nine different genera have been named in his honour to date.

5 No sea-lover
HMS Beagle took five years to circumnavigate the globe, but Darwin only spent 18 months on board. From the day it set sail, he was afflicted with terrible seasickness throughout.

"The publication of On The Origin Of Species *was a landmark moment for Darwin – and for science"*

1836
Lands back in England on 2 October and returns home to Shrewsbury.

1839
Marries Emma Wedgwood and has his first of ten children.

1858
Receives a letter from Alfred Russel Wallace who shares many of his ideas about the theory of natural selection.

1859
Publishes *On The Origin Of Species By Means Of Natural Selection, Or The Preservation Of Favoured Races In The Struggle For Life*.

1864
Receives the Copley Medal, the highest accolade from Britain's Royal Society.

1882
Darwin dies, aged 73, and is buried at Westminster.

Wilbur (right) and Orville attend the Belmont Park Aviation Meet, NY, in 1910

The Wright brothers

These siblings played a pivotal role in the evolution of powered flight and radically altered the path of aviation history

Wilbur and Orville Wright are two of history's most famous aviation pioneers who, through a series of experiments in the late-19th and early-20th centuries, created the first controllable, powered, heavier-than-air aircraft. Named the Wright Flyer, the plane was the culmination of over a decade's worth of research and trials that saw the brothers progress from custom-built kites, through to gliders and finally on to engine-powered aeroplanes. Together these talented siblings are generally credited with launching the age of powered flight.

Wilbur and Orville Wright were the sons of Milton Wright, an ordained minister of the Church of the United Brethren in Christ, and Susan Catherine Koerner Wright. The family lived in various locations including Richmond, Indiana; Cedar Rapids, Iowa; and Dayton, Ohio – the latter for the majority of the brothers' lives. Orville later explained that his father had encouraged both of them from an early age "to pursue intellectual interests and to investigate whatever aroused curiosity."

This encouragement led Orville and Wilbur into a diverse range of interests and expertise including printing, bicycles – which the pair sold and repaired for several years – and the construction of various machines from wood and metal. Both engineers and inventors, the brothers became well known for their academic and practical application of modern engineering, with Wilbur especially spending much time in his father's and public libraries.

One of their heroes was German gliding pioneer Otto Lilienthal, who up until his death in 1896 had built and flown a series of aircraft to varying degrees of success. His death, however – which was the result of a glider crash – oddly spurred the brothers' interest in flight, with them writing to the Smithsonian Institution for suggestions on other aeronautical manuscripts. One of the museum's recommendations was the engineer Octave Chanute, a leading authority on aviation and civil engineering at the time.

With Chanute's help the brothers began conducting a number of aeronautical experiments. Crucial to their approach was the focus on control of the aircraft, advancing previous designs that could only fly in a straight line by introducing a helical twist across the wings in either direction. The brothers tested this configuration in 1899 and, after discovering that it allowed the acute control of a kite, began working on a full-scale model: the first Wright Glider. It was tested in October 1900 at Kitty Hawk, North Carolina, where although lifting off the ground, it produced disappointing results.

The Wright brothers refined their glider and tested it in 1901, then again in October 1902 after spending the summer undertaking a vast series of tests into more efficient wing designs. This third model was the breakthrough, with the glider performing exactly as predicted. The pair – who each piloted the glider in turn – racked up almost 1,000 flights between them over a two-month period, covering distances at Kitty Hawk of up to 190 metres.

Realising they had cracked both the aerodynamic and control issues that all of

The big idea

Prior to the Wright brothers' successful flight (pictured below), many other scientists and engineers had dreamed about and, to varying degrees of failure, attempted to build machines that could not only defy gravity, but do so in a controlled manner. Their failures left the idea of a non-dirigible method of flight as mere fancy, with materials, aerodynamics and energy supplies all seeming insurmountable obstacles.

What is testament to the Wright brothers' expertise is that they addressed each one of these issues with their aircraft in turn, solving in years what countless minds had failed to address in centuries. Examples include the testing of hundreds of wing designs in a custom-built wind tunnel to determine which shape best granted lift, designing and building their own four-cylinder internal combustion engine that was adapted for air travel, and recognising that propeller blades could be understood as rotary wings.

A life's work

The main milestones that led to the Wright Flyer taking off...

1867
Wilbur is born, with Orville arriving four years later.

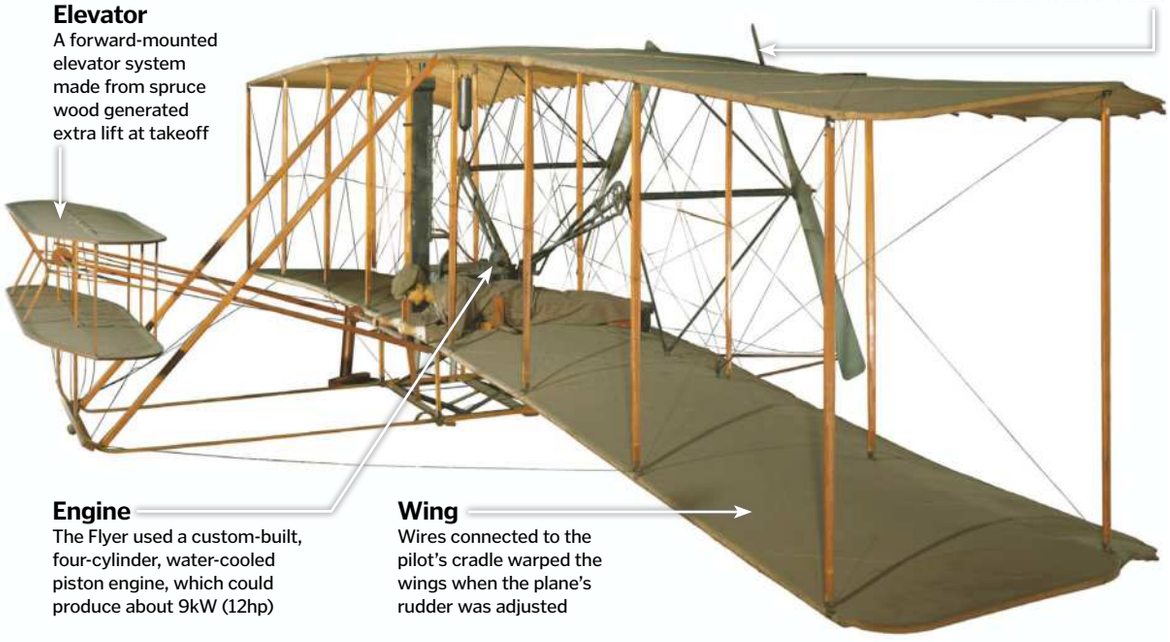
1869
The Wright family move to Dayton, OH, due to the father's work commitments.

1892
Both brothers team up to open a bicycle repair shop. They begin building bikes a few years later.

1900
Years of research lead to the brothers testing the Wright Glider (right), an unpowered biplane with a forward elevator for pitch control.

The Wright Flyer in focus

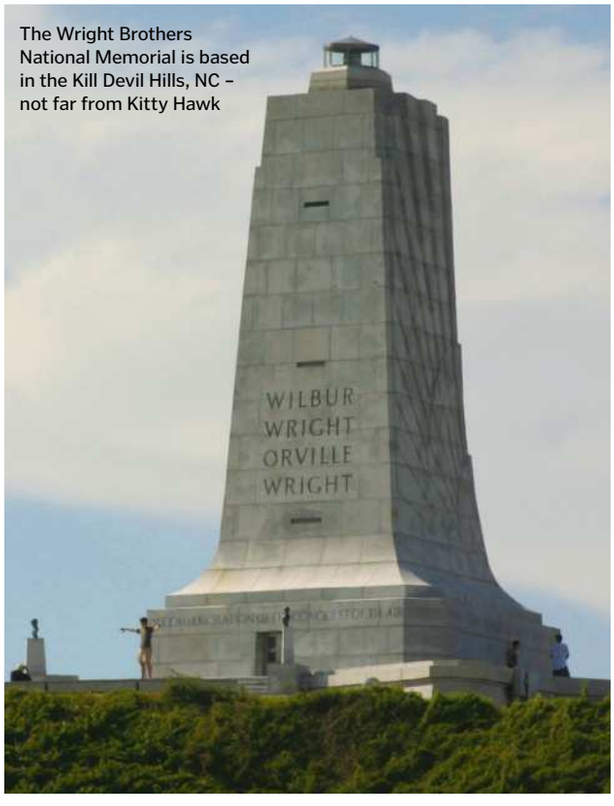
Take a closer look at the pinnacle of the Wright brothers' aviation careers



their predecessors had struggled with, the two brothers turned their attention to a power plant for the glider. In 1903 they built their own four-cylinder internal combustion engine and returned to Kitty Hawk to trial it. Unfortunately the first attempt ended in the engine stalling during takeoff and the front of the plane getting damaged, but after a couple of repairs, the second flight ended in resounding success.

Lifting off at 10.35am on 17 December 1903, the Wright Flyer flew 36 metres, then 53 metres, followed by 60 metres before finally achieving a distance of 259.7 metres. This series of flights heralded a new era of aviation and propelled the Wright brothers and their aeroplane to worldwide fame.

"The brothers became well known for their academic and practical application of modern engineering"



The Wright Brothers National Memorial is based in the Kill Devil Hills, NC – not far from Kitty Hawk

Five facts: Wright bros

1 No college
Wilbur and Orville were the only members of the Wright family who didn't attend college. Orville spent the years learning the printing trade, while Wilbur helped out at the local church.

2 Lifelong bachelors
Neither of the Wright brothers married throughout their lives. Wilbur is recorded as once saying that he "did not have time for both a wife and an airplane."

3 Child's play
In their later lives, the Wright brothers attributed their fascination with flying machines to a small toy helicopter which their father had brought home one day from his travels.

4 Luminaries
Both of the brothers extensively catalogued their aviation experiments on paper, leading to Wilbur Wright delivering an official talk at the highly prestigious Western Society of Engineers in Chicago in 1901. The speech he gave was entitled, fittingly, 'Some Aeronautical Experiments'.

5 Hobby to business
In 1909 the Wright Company was incorporated with Wilbur as president and Orville as one of two vice-presidents. Orville sold the company three years after Wilbur's death in 1912.

1903
The brothers successfully fly the Wright Flyer in sustained flight at Kitty Hawk, NC. Its fourth flight covers 259.7 metres in just 59 seconds.

1909
The Wright Company sells the first-ever military aircraft, the Wright Military Flyer (right), to the US Army Signal Corps.

1912
Wilbur dies of typhoid fever on 30 May at 45 years old.

1915
Orville ends his leadership of the Wright Company by selling his shares to a group of financiers.

1920
Orville joins the board of the National Advisory Committee for Aeronautics – a precursor to NASA.

1948
Orville suffers a heart attack on 27 January and dies three days later in Dayton, OH, aged 76.

Guglielmo Marconi

Sometimes called the father of radio, this resourceful inventor's practical telegraphy system led to the widespread use of wireless communications

Marconi developed his radio equipment in the attic of his parents' home in Italy, with the help of his butler, Mignani

"The Marconi room aboard the RMS Titanic and its two Marconi wireless operators transmitted the most famous radio signals of all time"

Guglielmo Giovanni Maria Marconi was a famous and widely respected Italian inventor who pioneered the development of wireless communication and long-distance radio transmission.

Often credited as the inventor of radio, Marconi was actually an astute businessman who combined, and built upon, the work of other scientists to develop a commercially viable method of long-distance communication.

His interest in electricity and physics began at an early age, and he was inspired by the work of scientists like James Clerk Maxwell, Heinrich Hertz and Nikola Tesla, among others.

In 1894, Marconi read the work of German physicist Hertz, who had developed equipment to send and detect electromagnetic waves over short distances. Marconi saw the potential for transmitting information using radio waves and set about developing a longer-range system to replace wire-based telegraphy.

Marconi began his experiments at his father's estate and with the help of his butler, Mignani, built equipment in the attic. Soon he could transmit radio waves over short distances, so he moved his experiments outdoors to develop the technology further. He found that increasing the length of the antennas – and arranging them vertically – increased the range of transmission so much that he was able to send and receive signals over distances of around 2.4 kilometres.

It was at this point that Marconi began to see the potential commercial applications of his experiments. Italy already had a well-established telegraph system though, with networks of wires extending across the country, and his applications for funding were dismissed. Undeterred, Marconi travelled to the UK. Britain had a powerful Royal Navy and was the world's greatest trading empire, and his thinking was that they might have use for his work in maritime communication.

A life's work

Tune in to some of the major events from the lifetime of this astute Italian radio pioneer

1874
Guglielmo Marconi is born in Bologna, Italy, to landowner Giuseppe Marconi and his Scots-Irish wife Annie Jameson.

1894
Begins to develop a method of transmitting telegraph messages without wires, using radio waves.

1896
Travels to London, where he gains the support of engineer-in-chief of the Post Office, William Preece.

1899
Sets up the first wireless link between Britain and France from Wimereux, France, to a lighthouse in Dover, England.

1900
Takes out his No 7777 'Improvements in Apparatus for Wireless Telegraphy' patent to protect his technological developments.

Post Office engineers inspect Marconi's radio equipment before the first-ever transmission of radio signals over the open sea

Marconi gained the support of the engineer-in-chief of the British Post Office and, with his help, demonstrated his technology to the British government. During his first few years in England he gradually improved the distance of radio transmission – first on land and then over sea. His work excited the international community and stations were set up in France for the first radio crossing of the Channel.

As his technology continued to evolve, 'Marconi rooms' were installed in ships, containing a suite of wireless telegraphy equipment which enabled communication with land as well as other vessels. The Marconi room aboard the RMS Titanic and its two Marconi wireless operators transmitted perhaps the most famous radio signals of all time: 'CQD CQD SOS Titanic position 41.44 N 50.24 W. Require immediate assistance. Come at once. We struck an iceberg. Sinking'.

Marconi died in Rome in 1937 at the age of 63. He was given a state funeral and – as a tribute to his massive contribution to wireless communication – every radio station in the world fell silent for two minutes.

"Marconi saw the potential for transmitting information using radio waves"

The big idea

Marconi combined and modified the inventions of other scientists to develop equipment that could transmit radio waves over great distances. He used a spark-gap transmitter to generate radio frequency electromagnetic waves and a coherer receiver to detect them. A telegraph key enabled him to send radio waves in bursts, generating Morse code. Marconi discovered that the maximum distance of radio wave transmission varied according to the square of the height of the transmitting antenna – tall, vertical antennas were key.

Five facts: Guglielmo Marconi

1 Royal connections
Marconi installed radio equipment on Queen Victoria's royal yacht so that she could communicate with the Prince of Wales (Edward VII) while travelling.

2 Educated but unqualified
Marconi had no formal scientific qualifications, but had a keen interest in physics. At the request of his mother, he was mentored by physicist Professor Augusto Righi, who introduced him to radio waves.

3 Are you ready?
The first wireless radio transmission across the open sea was sent on 13 May 1897 over the Bristol Channel. The message travelled a distance of just 6.4 kilometres and read 'Are you ready?'

4 High-speed Morse
To be employed as a wireless operator by Marconi's Wireless Telegraph Company you had to be able to send and receive Morse code at a speed of 25 words per minute.

5 Lucky escape
Marconi was offered free passage on the famous doomed ship RMS Titanic, but decided to travel to America three days earlier on the RMS Lusitania because he had paperwork to do.

1901
Successfully transmits the letter 'S' in Morse code 3,380 kilometres across the Atlantic Ocean to Newfoundland.

1909
Receives the Nobel Prize in Physics – along with Karl Ferdinand Braun – for their contribution to wireless telegraphy.

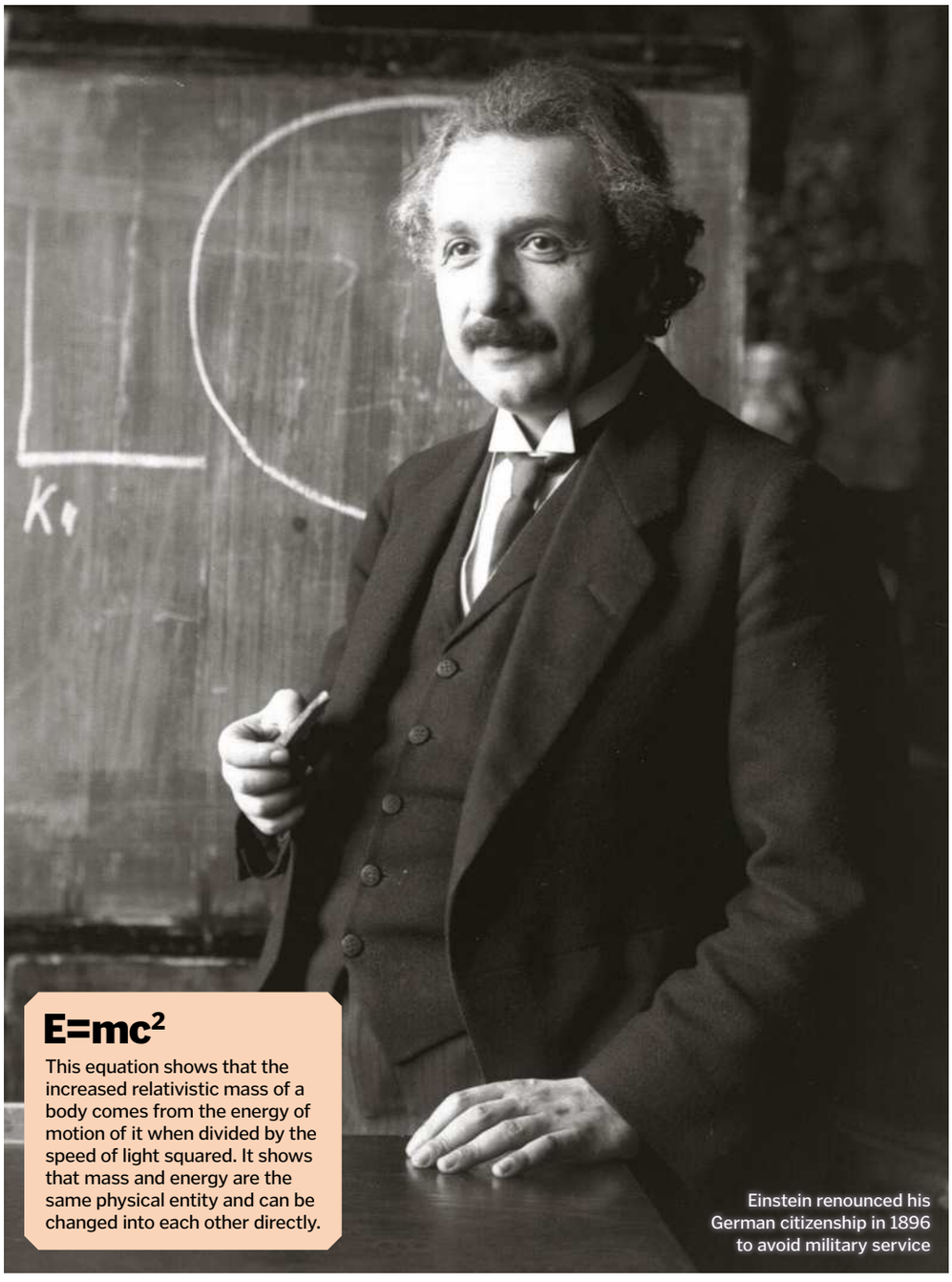
1912
Marconi radio is used to save victims of the Titanic, and passes distress signals from the sinking ship to the RMS Carpathia.

1914
Joins the Italian war effort during World War I, where he takes charge of the military's radio service.

1937
Marconi dies aged 63. He receives a state funeral in Italy and all radio stations hold a two-minute silence in his honour.

Albert Einstein

The foremost scientist of his age, Einstein is considered the most influential physicist of all time



$E=mc^2$

This equation shows that the increased relativistic mass of a body comes from the energy of motion of it when divided by the speed of light squared. It shows that mass and energy are the same physical entity and can be changed into each other directly.

Einstein renounced his German citizenship in 1896 to avoid military service

Albert Einstein was born on 14 March 1879, in Ulm, Germany. He is considered the most influential physicist of the 20th century, formulating both the theories of special and general relativity, concepts that still underpin much in the fields of physics and astrophysics today. In 1921 he was awarded the prestigious Nobel Prize in Physics for his explanation of the photoelectric effect – a process where electrically charged particles are released from a substance when exposed to electromagnetic radiation.

Einstein's first real contact with science came when he was a young boy, instigated by his intrigue with his father's compass. Confused by the invisible forces that seemed to be acting upon the needle, he went through his early years fascinated by such forces. Spurred on by reading the work of Aaron Bernstein, which introduced him to the concepts of electricity and light, Einstein dedicated his later teenage years to the nature of light, writing a scientific paper entitled 'The Investigation Of The State Of Aether In Magnetic Fields'.

Despite a great love for the sciences, Einstein had a troubled education. He skipped classes while attending the Swiss Federal Polytechnic School, and his father's failed business led to much disruption, with Einstein having to move frequently. This led to a period where he was forced to take a position at the Swiss patent office in Bern, a role significantly less prestigious than his desired doctorate.

In hindsight, though, the position at the patent office was ideal, as the work left much time for him to theorise on the properties and nature of light. Then, suddenly, in 1905 Einstein made a breakthrough, starting what is now termed his 'miracle year'. In that time he published four papers: the first on the photoelectric effect, the second on the existence of atoms, the third introducing the

A life's work

We chart Einstein's phenomenal journey to becoming the most influential physicist

1879

Einstein is born on 14 March in Ulm, Germany.

1896

After avoiding military service, Einstein enrolled in a four-year mathematics and physics teaching course in Zurich.

1905

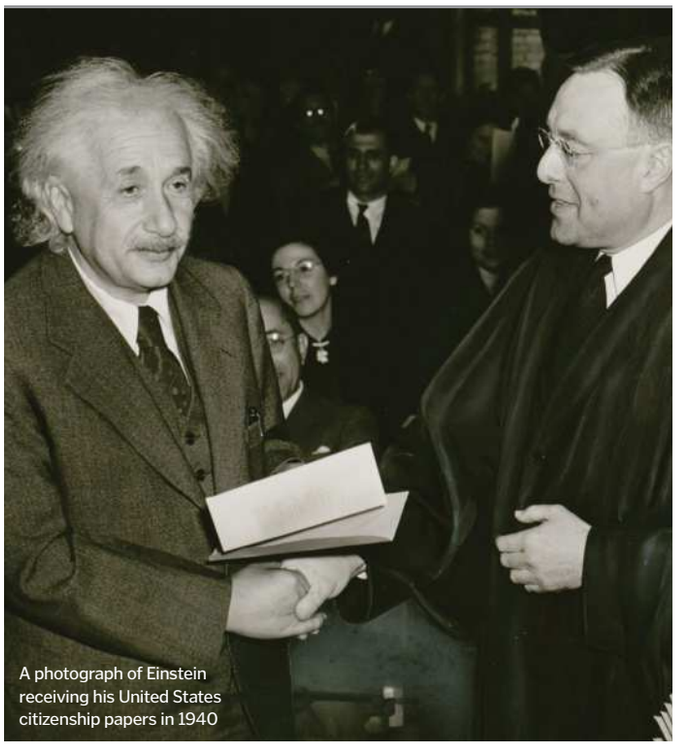
Einstein released four papers on the photoelectric effect, Brownian motion, special relativity and the equivalence of matter and energy.

1906

Einstein receives a doctoral degree from the University of Zurich.

1908

He becomes lecturer at the University of Bern.



A photograph of Einstein receiving his United States citizenship papers in 1940

Einstein's former summer home in Germany was confiscated by the Nazis in 1933

mathematical theory of special relativity and the fourth on the theory of relativity. Famously, Einstein published the last paper almost as an afterthought, despite it containing the key equation for which he is famous: $E=mc^2$.

At first the scientific establishment ignored Einstein's papers. Fortunately, though, they caught the attention of the foremost scientist of the age: Max Planck, the founder of quantum theory. Through Planck, Einstein became a respected member of the international community, attending the prestigious Solvay conferences and being offered important positions at Europe's foremost universities.

After completing his theory of general relativity in November 1915, Einstein's work was interrupted by World War I. Being a life-long pacifist, Einstein opposed the war and spoke frequently on its folly. After its conclusion, Einstein toured the world, but his period away from Europe was soon to be made permanent, with Einstein fleeing Nazi Germany in 1933. He settled in America and was granted US citizenship in 1940.

While in America, though he was not immediately convinced that an atomic bomb was possible, Einstein had encouraged the US government, including personally writing to President Roosevelt, to research nuclear chain reactions using uranium in response to German advances in the field. He did not work directly on the project to build a bomb, despite it being heavily based on his own work. According to reports, Einstein was on vacation when the first atomic bomb was dropped on Hiroshima, Japan. This action and its aftermath led to him undertaking anti-nuclear campaigns and lectures for the rest of his life.

Einstein's later years saw him pioneer numerous key theories including wormholes, multi-dimensional models and the possibility of time travel, as well as discovering his unified field theory. The latter was to be an all-embracing theory that would unify the forces of the universe and physics into one framework. The theory was never completed, however, with Einstein dying of an aortic aneurysm in 1955 before being able to finish his work.

Five facts: Einstein

1 Boy of few words
According to reports, Einstein seldom spoke as a child and when he did, it was very slowly. Accounts state he did this until he was nine.

2 Point of inspiration
Einstein's interest in science was reportedly sparked by his father's compass. At the age of five he thought there must be some force in the apparently empty space that acted on the needle.

3 Slow to start
Einstein did not receive outstanding grades while at school, and when he left he flunked the entry exam for the polytechnic institute in Zurich. Instead he went to work in the Swiss patent office first.

4 Nuclear pacifist
Einstein was a pacifist and while initially supporting the use of atomic weapons as a deterrent, he later chose to campaign for nuclear disarmament and world peace.

5 The man with two brains
After his death in 1955, Einstein's brain was removed for preservation by Thomas Stoltz Harvey in an attempt to discover what made him so intelligent.

"In 1905 Einstein made a breakthrough, starting his 'miracle year'"

1911
Einstein moves to Prague, where he acts as professor at the Karl-Ferdinand University.

1912
Einstein moves back to Switzerland, taking up a professorship at his alma mater, the Swiss Federal Institute of Technology in Zurich.

1915
Einstein completes his general theory of relativity.

1919
A solar eclipse provides dramatic observable evidence that his general theory of relativity is correct, making him a worldwide celebrity.

1921
16 years after its publication in 1905, Einstein wins the Nobel Prize in Physics for his work on the photoelectric effect.

1933
Einstein and his family flee from Nazi Germany to settle in the United States. He works at the Institute of Advanced Study at Princeton.

Peter Higgs

Well known in the scientific community for decades, it's only with the suspected discovery of the Higgs boson in 2012 that this physicist shot into the limelight

We can safely say that the 4 July 2012 discovery of a new particle, likely to be the elusive Higgs boson, had to be the biggest scientific announcement of that year. For most, it was enough to know that the Large Hadron Collider (LHC) – that huge, super-expensive particle accelerator in Switzerland – had given real weight to some decades-old but cohesive physical theory. Some impressive figures were released, then impossible speeds and inconceivably small theoretical particles existing for infinitely short expanses of time were mentioned, and our collective imaginations were captured. For its namesake Peter Higgs though, it must have felt like the ultimate validation of his entire lifelong career.

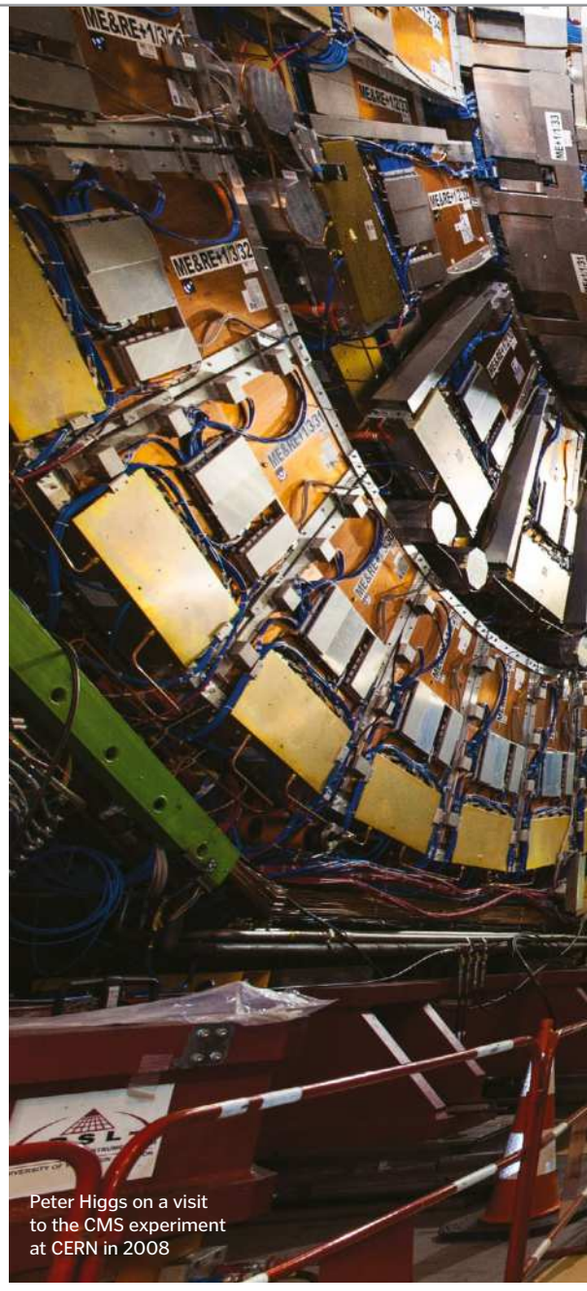
Higgs was born in Newcastle-upon-Tyne, UK, in 1929. He graduated from King's College in the University of London with a first-class degree in Physics then went on to secure a Master's and finally a doctorate in 1954. It was during his work as a research fellow and a lecturer that Higgs began the basis of a paper that would help describe the very nature of mass, even if it was completely disregarded at first. Higgs' work began in quantum field theory – the surreal world of the forces that bind subatomic particles and an exciting new area at the time.

His first paper on the Goldstone boson was picked up and published by a physics journal edited at the only recently founded CERN in Switzerland that same year. To his dismay though, his next paper – finished in 1964 – was rejected on the basis that it bore no relevance to physics. This paper described the radical concept of what became known as the Higgs mechanism, a scalar field present in all points of space, which gives particles mass. The Higgs mechanism was independently discovered by several other leading physicists in the same year, however none of them made any mention of a massive boson, which Higgs had gone on to include in a revision of the same paper.

Higgs' ideas were used to describe the origins of particle mass by physicists Steven Weinberg and Abdus Salam in the late-Sixties – a solution to which had eluded the scientific community for some time.

By 1983 – the same year that Peter Higgs became a fellow of the Royal Society – the only unproven parts of this electroweak theory were the Higgs field and the Higgs boson, but it took him nearly 20 years and physical experiments of an unprecedented scale in the LHC and beyond, to finally draw a line under the Higgs boson.

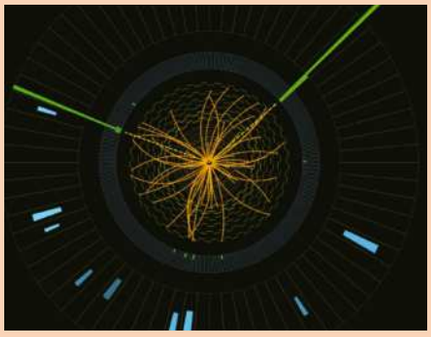
Peter Higgs retired in 1996 from a career that also saw him win the Rutherford Medal and the Dirac Medal. In the wake of 2012's CERN announcement, he has received praise from many notable peers – including Stephen Hawking, who publicly recommended him for the Nobel Prize in Physics.



Peter Higgs on a visit to the CMS experiment at CERN in 2008

The big idea

The existence of the Higgs boson hasn't been proven absolutely, but CERN's experiments did confirm the existence of a new particle that is consistent with Higgs' theory. For most physicists, there's no doubt it's the Higgs boson. What this particle proves is the existence of the Higgs field, which allows the building blocks of our universe to gain mass and form stars, planets, galaxies and everything around us. Currently, it provides the answers to the last few burning questions in the Standard Model of Physics, and in the future it could prove integral to science.



A life's work

The big events that led to the discovery of this tiny particle

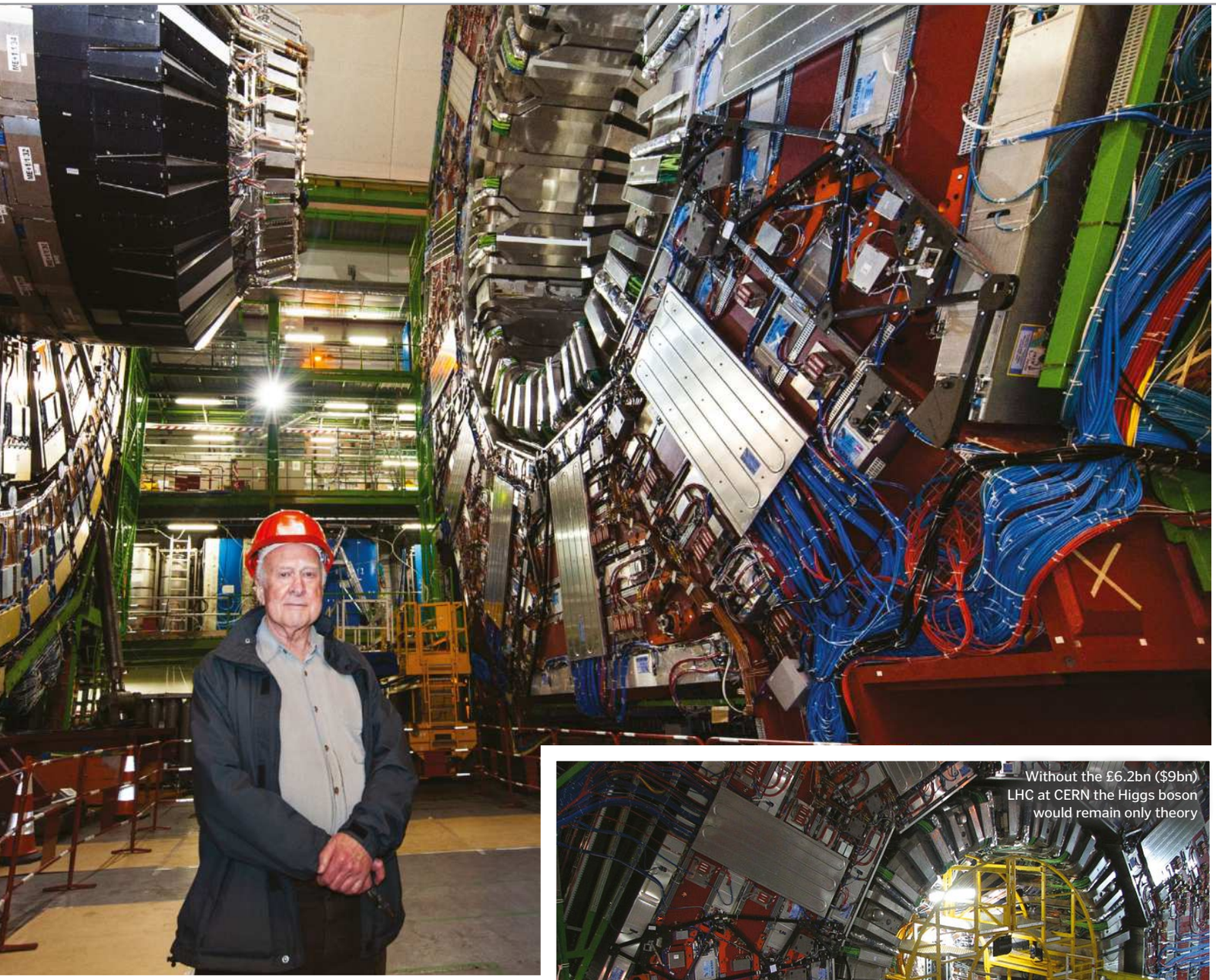
1929
Born on 29 May, the family moves around a lot as Higgs' father is a sound engineer for the BBC.

1954
Finishes his PhD at King's College London (right) and goes on to lecture at the University of Edinburgh.

1964
He describes the Higgs mechanism in a paper, which is rejected. He later revises it to include the Higgs boson.

1983
W and Z bosons are discovered, leaving only the Higgs particle to confirm the electroweak theory. Higgs also enters the Royal Society.

1991
Higgs becomes a fellow at the prestigious Institute of Physics, London.



Without the £6.2bn ($9bn) LHC at CERN the Higgs boson would remain only theory

In their footsteps...

Ken Currie

The celebrated Scottish artist Ken Currie was commissioned by the University of Edinburgh to paint a portrait of Peter Higgs in 2008. He admitted to being inspired by Higgs' work – not claiming to understand his theory, per se, but grasping the sublime and 'beautiful' nature of his solution.

Sir David Wallace

Higgs was Wallace's advisor while he was studying a PhD in elementary particle theory. Formerly a researcher at Princeton University and a lecturer at Southampton University, it's for his work as director of the Edinburgh Parallel Computing Centre that he was awarded a CBE.

"During his work as a lecturer Higgs began the basis of a paper that would help describe the very nature of mass"

1996

Higgs retires and becomes emeritus professor at the University of Edinburgh.

1997

He receives an award for his work in theoretical physics, named after a hero of his: theoretical physicist Paul Dirac (right).

2004

Another award – this time the Israeli Wolf Prize in Physics, though Higgs refuses to fly to Jerusalem to receive it on moral grounds.

2011

The results of CERN's initial experiments with the LHC in December are extremely positive, but more tests are needed to be certain.

2012

The strongest indication of a new particle with significant mass is announced by CERN in July. For his work, Higgs is made a Companion of Honour at the start of 2013.