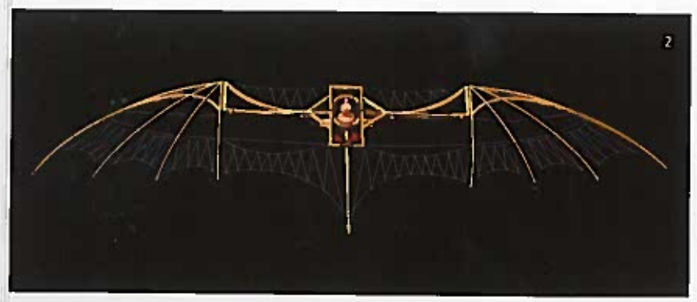
The father of *invention*

Universally regarded as an artistic genius, Leonardo da Vinci was also an ingenious and prolific designer of machines inspired by his observation of natural phenomena – as a fascinating new exhibition on show at the Science Museum in London reveals, reports **Lindsay Fulcher**

Universally acknowledged as a genius, the man who painted the most famous picture in the world, Leonardo da Vinci (1452-1519) was also a scientist, architect, mathematician and engineer. He was also a visionary inventor. The epitome of the Renaissance Man, he made detailed sketches of hundreds of innovative devices but, after his death, his notebooks were 'lost' from public view. As a result, these extraordinary designs have received far less attention than his better-known artistic output.

Now his ingenious ideas for improving almost every type of machine – from weapons of war and flying machines to water systems and industrial machinery – are being celebrated in the UK premiere of an international interactive touring exhibition entitled *Leonardo da Vinci: The Mechanics of Genius*. Devised by Universcience, Paris, in association with Museo Nazionale della Scienza e della Tecnologia Leonardo da Vinci in Milan, after opening in the French capital the exhibition went on to Munich and São Paulo. Now it has arrived at the Science Museum in London.

The exhibition includes 39 prototype models of flying machines, weapons and diving equipment built according to Leonardo's designs in Milan and exhibited there in 1953 to celebrate the 500th anniversary of his birth. A number of objects, made for the same reason in the same year for an exhibition staged at the Royal Academy in London, are in the Science Museum's own collection. A selection of these, relating to Leonardo's ideas in the areas of mechanics, manufacturing and flight, are on display at the entrance to the current exhibition.



1. Oil pigment print from an engraving made by Benjamin Thomas Pouncy in 1864 showing Leonardo da Vinci *circa* 1500. © UIG/Science and Society Picture Library.

2. Model of the glider designed by Leonardo, inspired by his observation of the wing structure of birds. 345cm x 52cm x 115cm. © Alessandro Nassiri/ Museo Nazionale della Scienza e della Tecnologia Leonardo da Vinci.

Leonardo was born, out of wedlock, to a notary named Ser Piero da Vinci and a peasant woman called Caterina on 15 April 1452, in a small town called Vinci near Florence. He was educated in the studio of the renowned Florentine painter Andrea del Verrocchio. At the age of 20, he was employed in a workshop on the site of Florence cathedral. Influenced by such eminent artists, engineers and mathematicians as the architect Brunelleschi, one of the creative giants of the Renaissance, Leonardo started to make drawings of cranes and other machinery, often trying to improve on the efficiency of existing designs and processes.

The exhibition takes the machines that Leonardo drew and reinterprets them in three-dimensional form, alongside interactive games and multimedia installations. Through his drawings he demonstrated a unique ability to recognise solutions to engineering problems in the world around him, and translate these into remarkable new concepts for machines that foresaw many aspects of the modern world.

The legendary painter of the *The Last Supper* (1495-98) and the *Mona Lisa* (1503-17) was an extraordinary draughtsman, and this set his work apart from that of his contemporaries. But Leonardo did not publish the drawings of his miraculously inventive designs during his lifetime and, after his death on 2 May 1519, they were stored and forgotten for several centuries. So the fruits of all his acute observations, long-term research and brilliant draughtsmanship were for a long time lost to the world and unable to influence the scientists and engineers who followed him.

3. The *Imagining Flight* section of the exhibition shows how Leonardo observed the flight of birds and used what he saw to design flying machines, including a glider and one with wings that could be flapped manually. © EPPDCSI/Ph Levy.

4. Designed by Leonardo, a model of a flying airship, with wings that could be flapped by the use of levers. 273cm x 137cm x 86cm. © Alessandro Nassiri/ Museo Nazionale della Scienza e della Tecnologia Leonardo da Vinci.

According to Giorgio Vasari (in his *Lives of the Most Eminent Painters, Sculptors, and Architects*, published in 1550) Leonardo not only had extraordinary powers of invention, but '*outstanding physical beauty*', '*infinite grace*', '*great strength and generosity*' and a '*regal spirit and tremendous breadth of mind*'. The artist also had a great respect for life. He was a vegetarian and often, Vasari tells us, purchased caged birds in order to release them. But he may have had a more selfish interest in this seemingly charitable act, as it allowed him to observe

closely how birds actually flapped their wings and flew.

Flying machines, diving apparatus and weapons are among 39 historical models from Milan that are displayed across different sections of the exhibition, which each focus on a specific area of Leonardo's knowledge and expertise: *Transforming Movement, Preparing for War, Drawing Inspiration from Nature, Imagining Flight, Improving Manufacturing* and *Unifying Knowledge*.

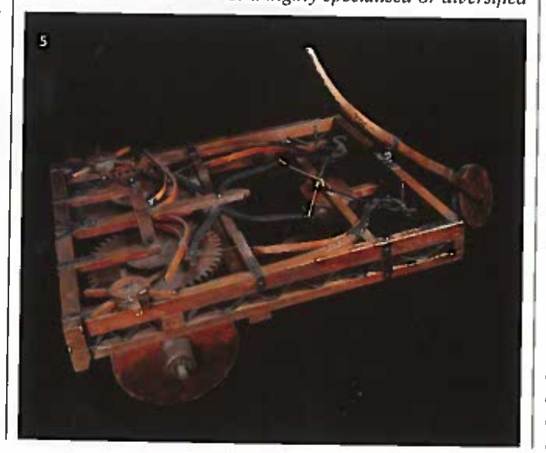
But was Leonardo really an inventor? Did he intend the machines that he drew to actually be constructed and used? In his essay *The birth of a collection in Milan: from the Leonardo Exhibition of 1939 to the opening of the National Museum of Science and Technology in 1953*, Claudio Giorgione of the Museo Nazionale della Scienza e della Tecnologia in Milan urges us to exercise caution when describing the artist as a practical inventor.

He writes: '*...With respect to the age-old issue of the practical execution of the machines Leonardo designed, it is important to emphasise that the inadequacy of motive powers and available materials, as well as the question of friction, made the actual operation of many of the sophisticated sequences of gears essentially impossible. Furthermore, Leonardo could not avail himself of the sum of collective experiences needed for the practical execution of his ideas, as he did not oversee a laboratory or a highly specialised or diversified workshop with all the essential professionals, such as carpenters, metalworkers and foundry men. Last but not least, it is important to note that Leonardo himself showed little interest in proceeding beyond the intellectual and graphic development of an idea to its practical implementation.*

'*Very often Leonardo's drawings constitute, rather, infinite variations on a given theme, reaching the proportions of a refined but impossible game. Examples of this can be seen in the series of frightful, visionary weapons, exercises of fantasy that re-elaborate the warfaring traditions from the Romans on to the Middle Ages, without any sort of practical finality, as in the ballistae or the fantastical idea of a covered war carriage.*

'*Many of Leonardo's ideas contained instances of great intuition, and can be considered precursors of inventions that would be refined only centuries later. The technical abilities then existing, the engines and materials available in that epoch often were inadequate for realising his ideas, even if this limitation does not make them appear any less ingenious, on account of their anticipatory power.*

'*The risk... is that of attributing to Leonardo mental mechanisms or ideas contemporary to ourselves, and of considering him, improperly, to be an inventor of machines that were realised only centuries later.*'

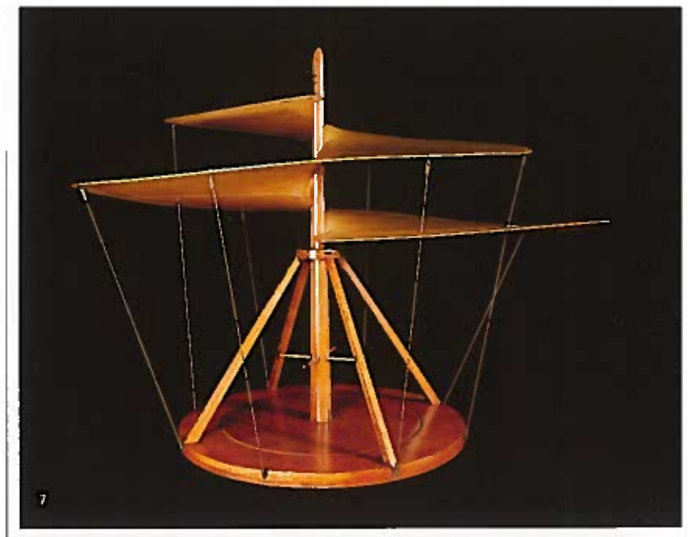


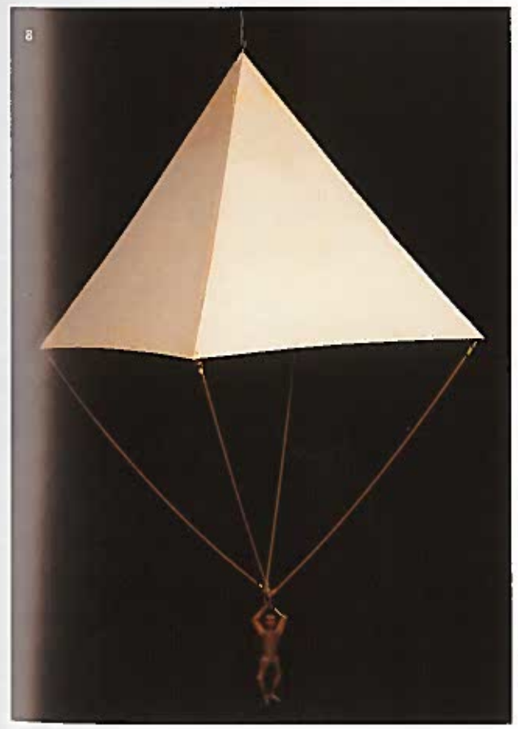
5. Model of Leonardo's self-propelled cart. 198cm x 177cm x 118cm. © Museo Nazionale della Scienza e della Tecnologia Leonardo da Vinci/ Alessandro Nassiri.

6. In the *Improving Manufacturing* section there are examples of textile machinery designed by Leonardo for industrial processes. © EPPDCSI/Ph Levy.

7. This model of the Aerial Screw, designed by Leonardo in the late 15th century, has been seen as the prototype for a helicopter. 167cm x 167cm x 143cm. © Archivio Museo Nazionale della Scienza e della Tecnologia Leonardo da Vinci/Alessandro Nassiri.

8. Model of Leonardo's prototype parachute. 92cm x 92cm x 105cm. © Archivio Museo Nazionale della Scienza e della Tecnologia Leonardo da Vinci/Alessandro Nassiri.





These models include items by other Renaissance figures, including a large-scale crane devised by Brunelleschi. Leonardo's own inventions were a self-propelled carriage, an armoured vehicle, a spinning wheel with mobile wings, gears, a diving apparatus and various weapons. He is also credited with inventing the parachute, the helicopter and the tank.

In discovering how the great inventor was inspired by the natural world, the exhibition examines the influence that biomimicry still has on today's cutting-edge robotics and aeronautics.

Films show examples of modern-day inventions. Visitors can see the SmartBird, an ultra-light, aerodynamic and agile robot, inspired by the flight of the herring gull and developed by the Festo company in Esslingen, Germany. Like the machines that Leonardo designed, it beats its wings, glides and banks in the air like its natural avian model.

Biorobotics specialists design robots with functions inspired by abilities specific to certain animals: perception, mobility, autonomy, adaptation to the environment, and so on. Angels is an aquatic robot that can swim through murky water. It was designed by the biorobotics laboratory of the École des Mines de Nantes, assisted by numerous European partnerships. This robot, which moves like an eel, perceives its environment in a similar way that an electric fish does, and each of its 'vertebrae' is a module that can split off from the others and continue autonomously before joining back up to re-form the 'eel'.

Another idea from nature comes from spider silk. Its high resistance, finesse, elasticity and adherence, are properties that are coveted by scientists and manufacturers. Spider silk is a complex composite material. Its thread is structured in sequences alternating between highly ordered proteins and more disordered zones, which gives it those celebrated properties.

The biomaterials laboratory at the University of Bayreuth in Germany uses the *Escherichia coli* 'host' bacteria to produce the proteins which it then uses to make membranes or fabrics that have medical applications. Producing spider silk in industrial quantities remains a challenge but its potential uses in a variety of situations are numerous.

Analysing the functioning of sight and flight in flies and bees, testing it and reproducing it in bio-inspired micro-robots capable of safe aerial navigation was the multiple challenge facing researchers led by the team at the biorobotics laboratory at the University of Marseille/CNRS, who have produced the Octave robot. It has no need of an altimeter or on-board camera because the robot controls its flight in the way that a fly does, thanks to a special technique of mapping visual clues mathematically, called optical flow. This is all the robot needs to steer clear of obstacles and fly and land safely.

Reduction in energy consumption and noise pollution are two key problem areas for modern aeronautical engineers. Further improving efficiency and safety while reducing the ecological impact of airliners requires a technological revolution. Engineers at the Munich/Toulouse-based company Airbus, which is one

of the exhibition's sponsors, have turned to nature for solutions that can be used in the aircraft of today and tomorrow, including their Airbus A350. They have come up with a bio-inspired Concept Plane to showcase these promising areas of research.

When it comes to flying, lightweight construction is of crucial importance, but safety is just as critical. Nature knows about this: the bones of birds grow in a distinctive manner, adding material only where it is absolutely necessary, never too much or too little.

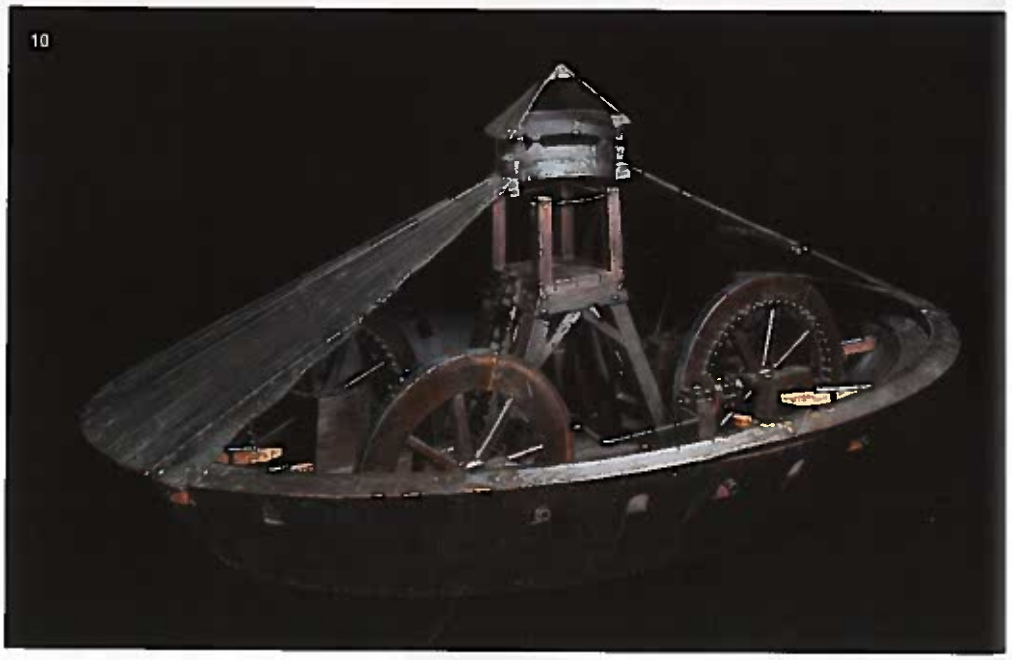
Engineers developing a new wing rib for the Airbus A380 sought to develop the lightest and safest possible structures and found their results were similar to the bone structure of an eagle's wing. Normally hidden from view is the 'skeleton' of the aircraft's wings, the rib that helps to reduce weight, which thus increases fuel efficiency and cuts emissions. By combining maximum strength with minimum weight, the new computer-aided design saves 500kg on each super-sized A380.

Airbus Group's Helicopters division has also developed a specialist composite material with remarkable properties, used as a filler in parts of the blade. This was inspired by the structure of the honeycomb, built by bees to protect honey and eggs. These qualities are reproduced in rigid, lengthwise walls and outstanding lightness.

Nearly 500 years after his death, Leonardo would have been fascinated to see all these new inventions that, like his own work, have been inspired by the observation of natural phenomena.

'*Leonardo da Vinci is one of history's greatest independent thinkers, whose determination to imagine the world anew inspired humankind for generations and will continue to do so for generations to come*,' comments Ian Blatchford, Director of the Science Museum. '*We hope this unique exhibition helps our visitors to understand more about his skilled and innovative approach to engineering and to be inspired to look afresh at the world around them.*'

The crowds that stand in front of the *Mona Lisa* in the Louvre seem hypnotised by her, gazing into her eyes as if they hoped to get a glimpse of the genius who created her. But perhaps a visit to *Leonardo da Vinci: The Mechanics of Genius* would give them a more penetrating insight into the restless and curious mind of this unique polymath. ■



9. The *Preparing for War* section of the Leonardo da Vinci gallery at Cité des Science/Universcience, Paris contains models of Leonardo's designs for weapons for use on the battlefield and an armoured vehicle. © EPPDCSI/Ph Levy.

10. Model of an armoured vehicle, or covered war chariot, made to Leonardo's design. 286cm x 187cm x 144cm © Alessandro Nassiri/Museo Nazionale della Scienza e della Tecnologia Leonardo da Vinci.

• ***Leonardo da Vinci: The Mechanics of Genius*** **is on show at the Science Museum in London (sciencemuseum.org.uk) until 4 September 2016. Pre-booking tickets is advised. This exhibition was designed and produced by Cit des Sciences, a Universcience site, in co-operation with the Museo Nazionale della Scienza e della Tecnologia Leonardo da Vinci and with the support of its industrial partner Airbus Group. This exhibition is supported by players of People's Postcode Lottery.**