

LEONARDO DA VINCI'S

Codex on the Flight of Birds *Codice sul volo degli uccelli*

Smithsonian's National Air and Space Museum
Washington, DC

SEPTEMBER 13, 2013 - OCTOBER 22, 2013



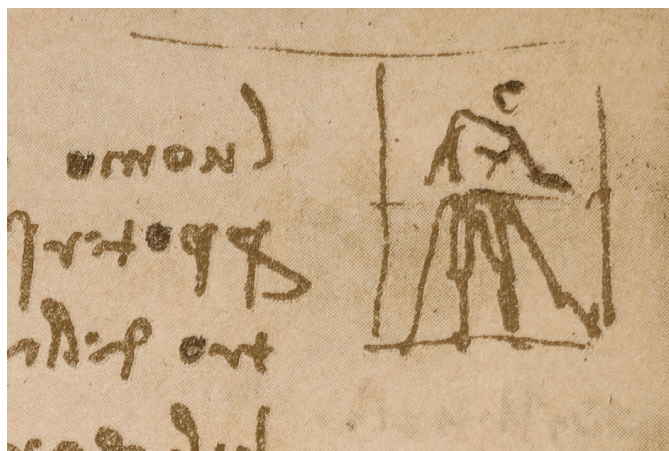
Leonardo da Vinci remains history's universal genius. The great figure of the Renaissance, he is the very definition of what it is to be a renaissance person. His aggregate achievements in art, engineering, mathematics, anatomy, geology, physics, music, military technology, aeronautics, and a wide range of other fields not only stood without peer in his own time, but were strikingly prescient for the distant future. Leonardo's ideas were rich with insight and creativity, but also daring. In nearly everything he approached, he challenged conventional thinking and established a new framework for innovation.

As deeply embedded as this characterization of Leonardo da Vinci is today, for three centuries after his death the world's grasp of his legacy was far more narrow. Leonardo was generally known only as a painter until the nineteenth century. Little or nothing of his sculpture or engineering works survived, and his notebooks, the only remaining evidence of his insatiable curiosity and fertile mind, were long hidden away, dispersed in private hands. It was only after 1800 that the record of his intellectual and technical accomplishments, the thousands of pages of writings and drawings that we collectively refer to today as Leonardo's codices, began to surface, be studied, and published. With the rediscovery of the Leonardo codices, the artist who painted the *Mona Lisa* and *The Last Supper* was recast as the Renaissance visionary who saw the modern world before it was realized.

Codex on the Flight of Birds

Among the many subjects Leonardo studied, the possibility of human mechanical flight held particular fascination.

A proposed pilot's position in a flying machine. Leonardo talked about how the pilot shifts body position to balance the machine, much like in a modern hang glider.



He produced more than 35,000 words and 500 sketches dealing with flying machines, the nature of air, and bird flight. These investigations of flight are scattered throughout the many da Vinci codices and manuscript collections, but he did produce one short codex almost entirely on the subject in 1505-1506, the *Codice sul volo degli uccelli* (*Codex on the Flight of Birds*). The document is written in Leonardo's famous "mirror" script, written backward and reading from right to left. The loan of the *Codex on the Flight of Birds* from the Biblioteca Reale in Turin, Italy, to the Smithsonian's National Air and Space Museum could not be more appropriate. The Museum holds the world's premier collection of aviation and spaceflight artifacts, the centerpiece of which is the Wright brothers' original first successful airplane of 1903. To mark the centennial of the Wrights' invention of the airplane in 2003, the Museum mounted *The Wright Brothers & The Invention of the Aerial Age*, a special exhibition featuring this seminal aviation artifact that changed the world in profound ways. The *Codex on the Flight of Birds* is on display in this gallery, just a few feet away from the Wright Flyer. For the first time in history, the work of da Vinci and the Wright brothers share the same space. Genius meets across the centuries. Wilbur and Orville would be honored. Visitors to the exhibition collect a once-in-a-lifetime experience.

Leonardo da Vinci: Artist, Engineer, Visionary

Leonardo da Vinci (1452-1519) is one of the most recognized names in history, yet biographical details about him are few and his personality remains an enigma. Despite the survival of approximately 7,000 pages of an estimated 13,000 pages of notes he produced, references to his views on the issues of the day, personal reflections, or even basic facts of his life are only infrequently scattered among his voluminous writings on the broad array of topics that interested him. Leonardo the person is largely mute in what he left behind. We can, however, say something about the age in which he lived and environments that shaped him.

Born in the village of Vinci, Leonardo was the illegitimate son of a notary, Ser Piero da Vinci. Ser Piero spent much of his time in Florence, leaving Leonardo to be raised primarily by his grandparents and his uncle, Francesco. A pivotal moment in Leonardo's life came in the 1460s, when as a teenager he left Vinci for Florence to apprentice in the



Top: Leonardo addressed the importance of light-weight structures and illustrated the structure of a mechanical wing.
Right: Leonardo discussed maneuvers birds make to maintain flight, foreshadowing those of future airplane pilots.



workshop of Andrea del Verrocchio. Ser Piero may have been an absent father, but he could not have done better by Leonardo than to enlist Verrocchio to take him under his creative wing. Verrocchio was something of a one-man university of the arts. At the time Leonardo joined him, his workshop was quickly becoming a meeting place of all the artistic youth of Florence—a crucible for new ideas, techniques, and philosophies of art. Most importantly, Verrocchio fostered a new approach to art that was emerging during the period that focused on mastering nature in its reality, compared to the more inspirational works of the past. One learned to draw from nature under Verrocchio's tutelage. He was a pioneer, not satisfied with imitating the works of previous masters that was the tradition of the time. He experimented, improved, challenged, and innovated. The scientific spirit of the Renaissance was at work in Verrocchio's shop as well. Leonardo and the other students were grounded in the scientific principles of observation, analysis, deduction, and experiment, and infused them in their approach to art. Indeed, the distinction between art and science was blurred. This was the environment in which the young mind and talents of Leonardo matured. Art as a foundation of engineering and engineering as an expression of art; this approach was nurtured and expanded by Verrocchio, and pervaded everything da Vinci did for the remainder of his life. Leonardo would later say to his own pupils: "... you will never succeed if you do not have the universal power to represent by your art all the varieties of form present in nature—and indeed, you will find this impossible unless you can first see them and hold them in your mind." "Science is the captain," he wrote, "practice the soldier."

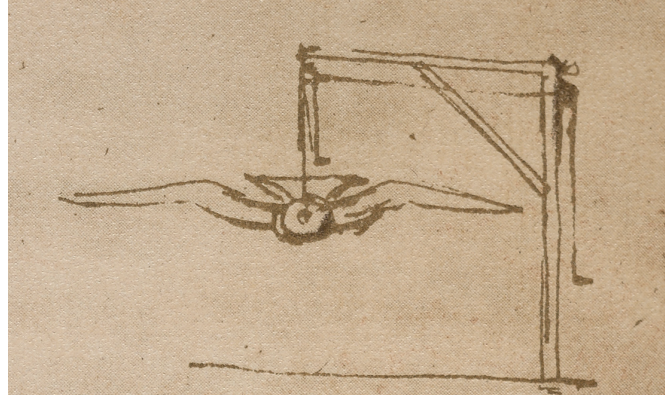
Leonardo and Flight

Leonardo's interest in flight appears to have stemmed from his extensive work on military technology which he performed in the employ of the Milanese court. He filled many notebooks with countless sketches of weapons, military machines, and fortifications. They included a giant crossbow, a tank, and a submarine, to name just a few. However, as far as it is known, none of these inventions were ever built. Leonardo's focus on military technology and tactics led him to the idea of aerial reconnaissance. Once engaged with the notion of a flying machine, it became an obsession. Given his close observance and use of nature as a foundation for his ideas, emulating natural flight was an obvious place to begin. Most of Leonardo's aeronautical designs were ornithopters, machines that employed flapping wings to generate both lift and propulsion. He sketched such flying machines with the pilot prone, standing vertically, using arms, using legs. He drew detailed sketches of flapping wing mechanisms and means for actuating them. Imaginative as these designs were, the fundamental barrier to an ornithopter is the demonstrably limited muscle power and endurance of humans compared to birds. Leonardo could never have overcome this basic fact of human physiology.

Interestingly, most of these avian mimicking designs predated Leonardo's serious study of bird flight, which we find in the *Codex on the Flight of Birds*, begun in 1505. In this work, compiled during the same period as the *Mona Lisa* was painted, we see some of the ideas and observations by Leonardo about flight that were more forward-looking than his better-known earlier ornithopter drawings. In this *Codex*

da Vinci discusses the crucial concept of the relationship between the center of gravity and the center of lifting pressure on a bird's wing. He explains the behavior of birds as they ascend against the wind, foreshadowing the modern concept of a stall. He demonstrates a rudimentary understanding of the relationship between a curved wing section and lift. He grasps the concept of air as a fluid, a foundation of the science of aerodynamics. Leonardo makes insightful observations of gliding flight by birds and the way in which they balance themselves with their wings and tail, just as the Wright brothers would do as they evolved their first aeronautical designs. He comments on the pilot's position in a potential flying machine and how control could be achieved by shifting the body weight, precisely as the early glider pioneers of the late nineteenth century would do. He notes the importance of lightweight structures that aircraft would require. He even hints at the force Newton would later define as gravity.

In less than 20 pages of notes and drawings, the *Codex on the Flight of Birds* outlines a number of observations and beginning concepts that would find a place in the development of a successful airplane in the early twentieth century. Leonardo never abandoned his preoccupation with flapping wing designs, and did not develop the insights he recorded in the *Codex on the Flight of Birds* in any practical way. Nonetheless, centuries before any real progress toward a practical flying machine was achieved, the seeds of the ideas that would lead to humans spreading their wings germinated in the mind of Leonardo.



Leonardo described the use of flight testing apparatus to understand aerodynamics.

In aeronautics, as with so many of the subjects he studied, he strode where no one had before. Leonardo da Vinci lived a fifteenth century life, but a vision of the modern world spread before his mind's eye.

The death of Leonardo da Vinci in 1519 was the beginning of an odyssey that would bring the *Codex on the Flight of Birds* to the Biblioteca Reale in Turin, Italy, more than four centuries later, after passing through many hands and many places. The Biblioteca Reale in Turin, Italy, was founded in 1831, and holds works by such masters as Michelangelo, Rembrandt, and Leonardo da Vinci. The library holds 200,000 volumes, 4,500 manuscripts, 3,055 drawings, 187 incunabula, 5,019 16th century books, 1,500 works on parchment, 1,112 periodicals, 400 photo albums, maps, engravings, and prints. In addition to the *Codex on the Flight of Birds*, the Biblioteca Reale holds Leonardo's famous self-portrait, dated circa 1512.

Peter L. Jakab, Chief Curator
National Air and Space Museum

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Cover Image: Leonardo da Vinci, self-portrait, ca. 1512, Italian Ministry of Cultural Heritage and Activities; Biblioteca Reale, Turin, Italy.

This exhibit is organized by the Smithsonian National Air and Space Museum and the Italian Ministry of Foreign Affairs, the Ministry of Italian Cultural Heritage and Activities, the Embassy of Italy in Washington DC, the Biblioteca Reale in Turin, thanks to the support of Bracco Foundation, Finmeccanica, and Tenaris. It is part of 2013 - Year of Italian Culture in the U.S., an initiative held under the auspices of the President of the Italian Republic, organized by the Italian Ministry of Foreign Affairs and the Embassy of Italy in Washington DC with the support of Corporate Ambassadors, Eni and Intesa Sanpaolo.

