

## Leonardo Da Vinci. Investigations on the Heart

*Leonardo Da Vinci. Investigaciones sobre el corazón*

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Leonardo synthesized the spirit of the Renaissance more than anyone else, without settling for the superficial study of anatomy, like the artists previously cited, but reaching the depth of the body to know “*l’uso*”, “*l’ufficio*”, “*il giovamento*”. He not only cultivated painting and sculpture, but was also an engineer, physicist, mathematician and astronomer.

He was born in Vinci, 30 km from Florence in 1492. He was the illegitimate offspring of the notary Piero Antonio da Vinci and Caterina, a servant, who immediately disappeared from the scene. He received his artistic training in the workshop of the Renaissance artist Andrea Francesco Verrocchio (1435-1488) when he was an adolescent. He lived in Milan, Florence and Rome, spending his last years under the tutelage of Francis I at the Chateau of Cloux (near Ambroise, France), where he died on May 2, 1519, at the age of 67.

Leonardo, “*il pittore anatomico*”, worked in anatomy for about twenty years and dissected 30 human cadavers, and made depictions of the anatomical specimens at different angles and with different sections. Let us recall that it was not until circa 1315 that Henri de Mondeville and Mondino di Luzzi, in Bologna, were authorized to perform autopsies on executed inmates. His work remained unknown until it was accidentally found in the Windsor Castle in the late 19th century. In 1898, F. V. Sabashnikov and G. Piumati published a reproduction of the original drawings in Paris. Thanks to his work, Leonardo can be considered as one of the initiators of comparative anatomy and iconography. He was a craftsman in detailed anatomical drawings of the human body as an architectural structure that was later fully developed by Andreas Vesalius.

Among the 750 anatomical drawings made by Leonardo, an important group is about the heart. Leonardo made drawings of the circulatory system, highlighting the structure of the valves, and understanding that they directed the blood flow in only one direction. He also described the interatrial foramen which was later called foramen Botalli. His studies on the cardiovascular system can be divided into two periods. The

first period corresponds to the end of the 15th century (circa 1490) in which he describes the classical scheme with the influences of Galen, Mondino and Avicenna. The second period (circa 1513) is based on the practice of dissection. He made great efforts to understand the mechanism of aortic valve closure and blood flow in the heart. For this purpose, he used studies similar to those he had carried out as a hydraulic engineer, with an “*in vitro*” model of the aorta made from a wax cast of a bull’s artery. In contrast to Galen, who considered the atria as mere dilatations of the vena cava, Leonardo recognized the four cardiac chambers, but he made the same mistake as the Pergamene by admitting and drawing nonexistent pores in the interventricular septum. In the right ventricle he described the arched trabecula, later called “*moderator band of distention*” (Ring, 1837), ansiform band (Poirier), arched fascicle (Testut) and septomarginal trabecula (Tandler).

Experimentally, when he insufflated the lungs, he found that the air did not reach the heart through the “*arteria venalis*”, as Galen asserted; instead, the air ended up in the terminal parts of the bronchial system. He conferred muscular structure to the cardiac pump. He also injected wax into an ox heart to make a cast. His description of the blood vessels demonstrates unclear knowledge, preventing him from getting a glimpse of blood circulation.

Together with Nicholas of Cusa or Nikolaus Chrypffs (Germany, 1401-1464), Leonardo introduced the mathematical method into scientific knowledge. This is evidenced by his statement “*no human investigation can be called real science if it cannot be demonstrated mathematically*”. Leonardo’s intention was to carry out a work of anatomy in collaboration with his friend Marc’ Antonio Della Torre (Verona, 1478-1511), Professor of Anatomy in Padua, with whom he had studied in 1510. It is generally believed that if his manuscripts had been published at that time, Vesalius’ text “*De humani corporis fabrica*” (Basel, 1543) might not have been written or would have remained in the background