

Ibn al-Nafis and the discovery of the pulmonary circulation

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ABSTRACT

Ibn al-Nafis was an Arab physician, scientist, and philosopher who was born in 1213 in Damascus and died in 1288 in Cairo. He studied medicine in Damascus and moved to Egypt to practice medicine where he became the chief physician in the Mansouri Bimaristan. Ibn al-Nafis wrote in a wide array of fields, including physiology, medicine, ophthalmology, embryology, psychology, philosophy, law, and theology. He is famous for providing the first description of the pulmonary circulation. He was the first person to challenge the long-held theory of the Galen (129-207 AD) School that blood could pass from the right to the left side of the heart through small pores in the interventricular septum. He believed that all the blood that reached the left ventricle passed through the lungs. The work of al-Nafis on the pulmonary circulation predates the much later work of William Harvey (1578–1657).

Keywords: Ibn al-Nafis, Islamic medicine, pulmonary circulation, William Harvey

SCIENCE IN THE MEDIEVAL ISLAMIC WORLD (8TH TO 16TH CENTURIES)

During this time scholars translated Indian, Iranian, and Greek books into Arabic, and these translations became the source for scientific advances throughout Muslim-ruled areas during the Middle Ages. Some scholars prefer the term “Arab science” because most of the documents were written in Arabic, which was the language of the region. However, not all the scientists were Arabs; indeed, some of the most distinguished, such as Avicenna (980–1037), were Persians. In addition, although most of the scholars were Muslim, this was not uniformly true.¹ During this era numerous scientific institutions, libraries, and academic hospitals were developed in Baghdad, Damascus, and Cairo; some of these institutions still exist and claim to be the oldest universities in the world.²

MAJOR WORKS BY IBN AL-NAFIS

Arab scholars wrote thousands of books during this era. Ibn al-Nafis wrote one of the largest books (*Al-Shamil fi al-Tibb, The Comprehensive Book of Medicine*), which he planned as an encyclopedia with 300 volumes but did not finish.³ He also wrote a book on ophthalmology and a book on the effects of diet on health *Kitab al-Mukhtar fi al-Aghdhiya*. His most famous work is *The Summary of Law (Mujaz al-Qanun)*.

He wrote several commentaries on books written by other scientists and philosophers. These included *A Commentary on Hippocrates’s Nature of Man (Sharh Tabi’at al-Insan li-Buqrat)* and *A Commentary on Avicenna’s Anatomy books I and II (Kitab al-Qanun)* in four volumes, including *A Commentary on Generalities, A Commentary on Materia Medicine and Compound Drugs, A Commentary on Head-to-Toe Diseases, and A Commentary on Diseases Which Are Not Specific to Certain Organs*.⁴

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THE DISCOVERY OF PULMONARY CIRCULATION

In the thirteenth century during the time of Ibn al-Nafis, Galen’s theories on physiology had

dominated medical thought for a thousand years. Avicenna studied Galen's writings extensively and elaborated on them to some extent. According to Galen, food in the gut undergoes "concoction" and is then transported to the liver where blood is formed and acquires "a natural spirit". Blood then flows to the right ventricle where some flows to the lungs through the pulmonary artery to provide nutrition, and some enters the left ventricle through "invisible pores" in the interventricular septum. The existence of these "pores" puzzled anatomists for centuries, but they were a necessary feature of Galen's physiology because he did not consider the possibility that a large amount of blood flowed from the lungs to the heart. In the left ventricle, blood is mixed with "pneuma" from the inhaled air, and this resulted in the formation of "a vital spirit," which was distributed throughout the body by arterial blood. Some blood reaches the brain, receives "animal spirit," and is then distributed throughout the body in the nervous system. The formation of "a vital spirit" in the left ventricle products waste products that travel back to the lungs through the pulmonary veins and are exhaled with each breath.²

In his *Commentary on Anatomy* in Avicenna's *Canon*, Ibn al-Nafis made three important challenges to Galen's physiology. First, he stated categorically that the interventricular septum between the right and left ventricles was not porous and could not allow blood to travel through it. The English translation by Meyerhof of this section of the book reads: "... but there is no passage between these two cavities [right and left ventricles]; for the substance of the heart is solid in this region and has neither a visible passage, as was thought by some persons, nor an invisible one which could have permitted the transmission of blood, as was alleged by Galen. The pores of the heart there are closed and its substance is thick."⁵ He repeats this forceful denial of the permeability of the interventricular septum elsewhere in the commentary. For example, in the section identified as folio 65 r and v, Meyerhof's translation states, "There is no passage at all between these two ventricles; if there were the blood would penetrate to the place of the spirit [left ventricle] and spoil its substance. Anatomy refutes the contentions [of former authors]; on the contrary, the septum between the two ventricles is of thicker

substance than other parts to prevent the passage of blood or spirits, which might be harmful. Therefore, the contention of some persons to say that this place is porous is erroneous; it is based on the preconceived idea that the blood from the right ventricle had to pass through this porosity—and they are wrong!"^{2,5,6}

Second, since there is no communication between the right and left ventricles through the interventricular septum, the output of the right ventricle can only reach the left ventricle through the pulmonary circulation. In the section of the Commentary identified as folio 46 r, Meyerhof's translation reads, "the blood after it has been refined in this cavity [right ventricle], must be transmitted to the left cavity where the [vital] spirit is generated."⁵ This section also includes, "For the penetration of the blood into the left ventricle is from the lung, after it has been heated within the right ventricle and risen from it, as we stated before." Third, in another short passage, Ibn al-Nafis states that there must be small communications between the pulmonary artery and the pulmonary vein. This comment predicted the existence of the pulmonary capillaries which were not identified until 400 years later by Marcello Malpighi (1628–1694). The translation of the relevant section in folio 46 r is, "And for the same reason there exists perceptible passages (or pores, *manafidh*) between the two [blood vessels, namely pulmonary artery and pulmonary vein]."^{2,5,6}

Three hundred years later scholars in Europe concluded that blood had to pass through the pulmonary circulation and could not move directly from the right to the left ventricle. Michael Servetus (1511–1553) first reached this conclusion and wrote, "However, this communication is made not through the middle wall of the heart, as is commonly believed, but by a very ingenious arrangement the refined blood is urged forward from the right ventricle of the heart over a long course through the lungs; it is treated by the lungs, becomes reddish-yellow and is poured from the pulmonary artery into the pulmonary vein."² He recorded this idea in a theological treatise (*Christianismi Restituto, The Restoration of Christianity*) which was considered heretical by both Catholics and Calvinists, resulting in Servetus being burned at the stake in Geneva. Only three copies of the book survive today.

Later, similar ideas were expressed by Renaldus Columbus (1515–1559), his student Juan Valverde (1525–1587), Andreas Vesalius (1514–1564), and William Harvey (1578–1657).^{2,6}

The physiology of the pulmonary circulation initially puzzled William Harvey. For example, he stated, “It is altogether incongruous to suppose that the lungs need for their nourishment so large a supply of blood, so pulsatorily delivered.”⁷ In fact, only a few years before his death Harvey reported experiments in which he conclusively demonstrated the passage of liquid from the pulmonary artery to the left ventricle. In a letter to a German friend, Harvey described how he had ligated various vessels in the cadaver and demonstrated that water passed freely through the lungs from the pulmonary artery to the left ventricle.

A final interesting question is whether Michael Servetus, whose book was dated 1553, and later Columbus, Valverde, Vesalius, and Harvey knew about the work of Ibn al-Nafis on the pulmonary circulation published over 300 years earlier.⁷ The number of coincidences related to this question is quite unusual. Andrea Alpagus was a teacher at Padua University in Italy and spent 30 years in Syria translating Arabic medical books into Latin.⁸ He translated Ibn al-Nafis’s book describing the pulmonary circulation, and this was printed in Venice in 1547. Servetus included this section verbatim in his book *Christianismi Restituto*. In addition, Servetus and Vesalius were fluent in the Arabic language. Harvey took his doctorate degree at the Padua University in 1602; he gave a comprehensive description of the circulatory system in his lectures in 1616 and published his famous book on this system (*Exercitatio anatomica de motu cordis et sanguinis in animalibus*) in 1628. It is plausible that these European physicians knew about Ibn al-Nafis and his description of the pulmonary circulation.

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