

Review

Ibn al- Nafīs and Servetus laid the foundation of circulation of the blood and Harvey discovered it

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Abstract

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Concerning the anatomy, physiology, pathology, and the circulation of the heart, since Hippocrates (460-377 BC) until William Harvey (1578-1657) practically nothing was known. At a later period the first person in the European tradition to propose a separate transit of the blood through the lungs (pulmonary circulation) was Italian theologian and physician, Michael Servetus (1511-1553). A much earlier than Servetus was Ibn al- Nafīs (c.1210-1280) a Syrian born Egyptian physician, who described the pulmonary circulation, but there is no evidence that Servetus knew his description. Matteo Realdo Colombo (1516-1559) Italian anatomist and surgeon outlined the pulmonary circulatory system solely on the basis of physiological reasoning. Andrea Cesalpino (1519-1603) another Italian physician affirmed that the heart was the origin of blood vessels, and perhaps he was one of the most important precursors of William Harvey. Andreas Vesalius (1514-1564) outstanding Belgian anatomist and surgeon who is considered the father of anatomy who revolutionized the study of medicine with his detailed description of the anatomy of human body showed that the intraventricular partition is impermeable. Nevertheless, it was the English physician William Harvey (1578-1657) whose experiments actually proved for the first time that blood was pumped around the body in a closed system. For the proof of the circulation of the blood, he argued that the rapidity with which the veins refill and the sheer amount of blood passing through were the documentary evidence of its circulation. Eventually, Harvey brought the circulation of the blood into effect.

Keywords: Circulation of the blood, Ibn al- Nafīs, Michael Cervetus, and William Harvey.

INTRODUCTION

Until William Harvey (1578-1657), English physician who discovered the circulation of the blood, practically nothing was known about the heart, pump of the circulation of the blood, so essential to life.

Hippocrates (460-377 BC), Greek physician known as the father of medicine who lived during the Golden Age of Greece and was a contemporary of Pericles, Socrates, Plato, Aristophanes, and other famous figures, had rudimentary ideas about the heart and the circulation of the blood. He likened the movement of the blood to a coming and going similar to the ebb- tide and flow of the sea (Boyadjian, 1985).

Aristotle (384-322 BC), philosopher and scientist from Stagira in northern Greece who was for 20 years a member of Plato's Academy, was more concerned with the philosophy of heart and its circulation. For Aristotle, heart was "the organ of the feelings and the emotions." During that period, the physiology of the circulation might be resumed "the air coming from the lungs reaches the heart, the blood is fabricated by the liver from the food we eat."

Greek physicians in the School of Alexandria (Egypt) brought out new facts about the circulation and the heart. Herophilus of Chalsedon (c.335-280 BC) a Greek



Figure 1. Ibn al- Nafis described the movement of blood through the pulmonary transit, explicitly stating that the blood in the right ventricle of the heart must reach the left ventricle by way of the lungs and not through a passage connecting the ventricles, as Galen had mentioned.

anatomist from Asia minor who, while working in Alexandria, pioneered the study of anatomy, and described the brain as a center of the nervous system and seat of intelligence³. He dissected the heart and found several cavities in it, also noted that by observing the pulse it was possible to evaluate the seriousness of diseases. (Figure 1)

Erasistratus of Geos (300-250 BC), early Greek anatomist and one of the first anatomists at the School of Alexandria where he dissected cadavers. In the history of medicine, he is regarded as the founder of physiology and is noted for his studies of the circulatory and nervous systems and accurate descriptions of the convolutions and ventricles of the brain (Ibid).

As a disciple of Herophilus of Chalcedon, he continued his research and showed that the arteries contain blood, but did not manage to shake off previous theories: “for Erasistratus, too, the air from the lungs came into the left of the heart through the arteries; the veins and the right side of the heart contained blood. The blood was set in motion by flux and reflux, and then again Erasistratus acknowledged, as did his predecessors, that the septum which separates the two cavities contains pores (Boyadjian, 1985).” But he was the first physician to make use of psychosomatic medicine, and the first rhythmologist (Seleucus I, called Nicator (“Conqueror”), (c.358-280 BC), the King of the Syrians, Summoned Erasistratus to attend to his son (the crown prince) who was severely sick. After a complete medical examination, Erasistratus asked all the women living in

the court to file past around the bed of the crown prince. When Antiochus saw his step mother, Stratonice, his pulse began to beat rapidly and irregularly. Erasistratus gave his diagnosis to Seleucus I who was 70 years old. The old king, wisely, separated from his young and beautiful wife and married her to his son, who was completely cured. Thus, for the first time, at a patient’s bedside, the link between cardiac rhythm and the emotions of love was revealed. (Boyadjian, N. The Heart.P.118)). (Figure 2)

After Hippocrates, Galen (129-200), famous Greek physician and prolific writer, doctor to de gladiators in Rome who founded the Galenic system of medicine, which was followed for 15 centuries until Renaissance when it was questioned by Andreas Vesalius (1514-1564) outstanding Belgian anatomist and surgeon and Paracelsus (1493-1541) Swiss physician and alchemist, studied anatomy and physiology and described blood circulation. His conception of blood circulation was near to the truth but incomplete. “According to Galen, the blood is formed in the liver, then in the course of the diastole, it passes into the right ventricle; during this same diastole, the air from the lungs reaches the left ventricle through the pulmonary artery to feed the lungs, and into the left ventricle, through the openings in the intraventricular septum. In this ventricle, the “vital spirit” irrigates the body through the arteries (Ibid).” In a nutshell Galen “had argued that blood produced in the liver was all used up as nutriment and its residues excreted (Porter, 1998).” But according to authentic scientific



Figure 2. Erasistratus diagnosing the sickness of Antiochus as the result of his passion to Stratonice (his stepmother).

sources until the third century not one could give a clear and consequent account concerning the blood circulation.

Ibn al- Nafis who laid the foundation the blood circulation

In the argumentation of the blood circulation we must mention Ibn al- Nafis (d.c.1288) outstanding physician from Syria but lived in Egypt. Ibn al- Nafis wrote a detailed commentary on the canon of Avicenna. Of this commentary, he arranged a book in four techniques, on diseases, spices, nutrition, and on treatments, and named it “mūjiz al- Qānūn” (Abridged Canon).

The Mūjiz al- Qānūn an extract from all parts of the Canon of Ibn Sīnā, but omitting anatomy and physiology; it is a concise manual of the whole of medicine particularly useful for the practitioners, and among the works of Ibn al- Nafis it has met with the greatest success in the oriental medical world: it exists in numerous manuscripts, was printed or lithographed a number of times, was the subject of a series of commentaries and glosses, the most reputed of which, by Nafis bin Iwaḍ al- Kirmānī (completed 1437), was lithographed in India for the last time as recently as 1910; it was also translated into Turkish and into Hebrew.

In mūjiz al- Qānūn “on the anatomical portions of the Canon, Ibn al- Nafis described the movement of blood through the pulmonary transit, explicitly stating that the blood in the right ventricle of the heart must reach the left ventricle by way of the lungs and not through a passage connecting the ventricles as Galen had mentioned. This formulation of the pulmonary circulation, sometimes called the “lesser” circulation, was made three centuries before those of Michael Servetus (d.1553) and Realdo

Colombo (d.1559), the first Europeans to describe the pulmonary circulation (Loudon, 1997).

All in all, Ibn al- Nafis discovered the pulmonary circulation about three centuries before Michael Servetus and about four centuries, before William Harvey discovered the circulation of blood.

The commentary of Ibn al- Nafis on the last part of the Canon concerned with compound drugs, was translated into Latin by the Renaissance physician Andrea Alpago (d.1522), who had also prepared a new translation of Avicenna’s Canon. The translation of Ibn al- Nafis on compound drugs was not published until 1547, when it was printed at Venice, but the possibility remains that other parts of the commentary of Ibn al- Nafis might have been transmitted through unpublished translations (Ibid).

Ibn al- Nafis as well as “Commentary of Canon” wrote several other works which are:

1. The “Kitāb al- Shāmil fi ‘l- ṭibb” (consisting medical techniques), an encyclopedia of medicine which was to have consisted of three hundred volumes (this word to be taken in the conventional meaning of some ninety folios), of which only eighty volumes were completed; several volumes exist, partly in the autograph of the author.
2. Kitāb al- Muhadhdhab fi‘l- Quhl, a comprehensive but not every original record of the whole knowledge of the Arabs in ophthalmology; it was used by several later authors. (Figure 3)
3. Among the medical commentaries written by Ibn al- Nafis the most widely disseminated one is on the Aphorisms (Fuṣūl) of Hippocrates. He also wrote commentaries on Hippocrates’s prognostics, Epidemics, and “De natura hominis.”
4. He further commented upon the Masā’il fi ‘l-ṭibb of Ḥunayn bin Iṣḥāq.

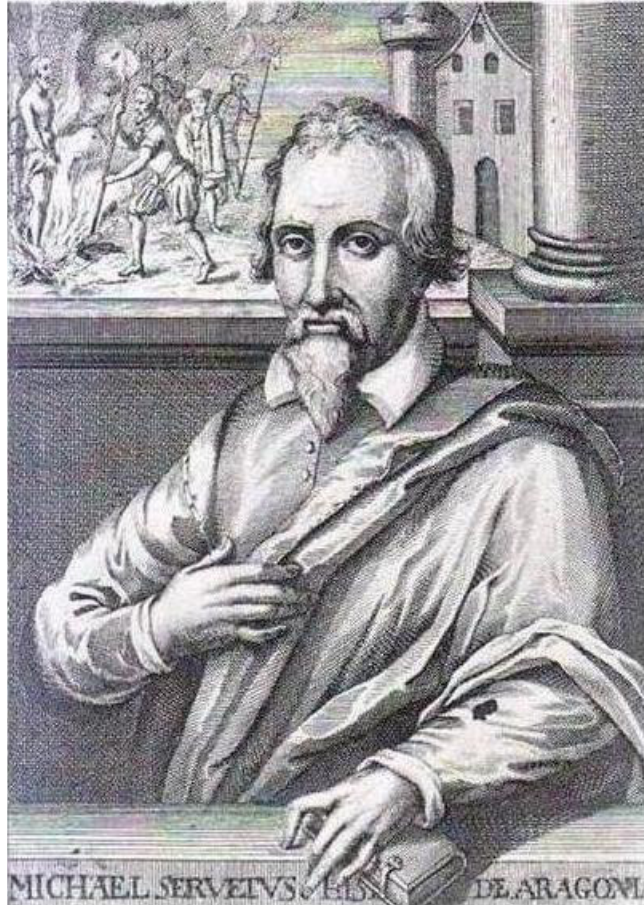


Figure 3. Michael Servetus (1511-1553) Spanish physician and theologian who discovered the pulmonary circulation.

5. And he wrote an extensive commentary on the Canon of Ibn Sīnā which exists in numerous manuscripts, improving the arrangement of the subject-matter and in particular, collecting the passages relating to anatomy from the first three sections of the Canon and commenting on them in a separate section, which was often copied as an independent book; in this section, Ibn al- Nafīs sets out his theory of the lesser circulation of the blood; his commentary on the fifth section of the Canon was translated into Latin by the Renaissance physician and scholar Andrea Alpago and posthumously printed in Venice 1547.

6. Of Ibn al- Nafīs' writing on logic there exists his commentary on his own Kitāb al- Wurayqāt, a summary of the contents of Aristotle's Organon and Rhetoric...

7. "Al- Risāla al- Kāmiliyya fi'l- sīra al- nabawiyya" which can be freely translated as "The Theologus Autodidactus" (Brill, 1986).

But his must achievement in medicine is the theory of the "lesser" or pulmonary circulation of blood. Ibn al- Nafīs is opposition to Galen and Avicenna (980-1037) Iranian great physician wrote: "When the blood has been refined in the right ventricle, it needs be that it pass to the

left ventricle where the vital spirit is generated. But between these two there exists neither a visible passage, as some writers have thought, nor an invisible passage which will permit flow of blood, as Galen believed. But on the contrary the pores of the heart are shut and its substance there is thick. But this blood after being refined, must of necessity pass along the pulmonary artery into the lungs to spread itself out there and to mix with the air until the last drop be purified. It then passes along the pulmonary veins to reach the left ventricle of the heart after mixing with the air in order to become fit to generate the vital spirit. The remainder of the blood, less refined, is used in the nutrition of the lungs. That is why there are between these two vessels (i.e. the pulmonary arteries and veins) perceptible passage (Elgood, 1951)." Ibn al- Nafīs with these words as we realize today, combated Galen, Haly Abbas (d. 994) Iranian famous physician, and Avicenna.

This remarkable theory, perhaps because of its unorthodox character, was almost completely ignored by the later Arab medical authors, excepting only an anonymous commentator of the Canon who agrees with it, and an otherwise unknown al- Fāḍil al- Baghdādī in

his commentary on the Qānūncha, an extract from the Canon by Maḥmūd bin Muḥammad al- Chaghmīnī (d. 1344), who made it his object to refute Ibn al- Nafīs criticisms of Ibn Sīnā. A theory of the lesser circulation, identical in all essential respects with that of Ibn al- Nafīs and expressed in terms strangely reminiscent of those used by him, was formulated by Michael Servetus in his "Christinaismi Restitutio", and an exposition of the same doctrine by Realdo Colombo or Columbus (c. 1516- c. 1559) Italian physician in his *De re anatomica libri* XV forms a close parallel to this. Detailed philological analysis has made it probable that Servetus (and perhaps Colombo, too) had direct knowledge of the theory of Ibn al- Nafīs, and it is likely that this knowledge was transmitted by Andrea Alpago, who spent more than 30 years in Syria, travelled widely in search of Arabic manuscripts, and is known to have translated from the Arabic numerous medical texts not all of which were printed posthumously (he died about 1520) (Musavi, 1989).

Leonardo da Vinci (1452-1519), a Renaissance artist, inventor, engineer and anatomist from northern Italy who produced some 750 detailed and accurate anatomical drawings based on his own dissections. He prepared useful illustration of the heart, muscles, bone and even the fetus in the womb (Encyclopedia International, 1975), and studied heart, but could not break away completely from Galen's 12 century's theories. In his anatomical works of the heart, the partition between the left and the right of heart still contains a communication, an opening.

Servetus, the Second Contributor of the Blood Circulation Discovery

Michael Servetus (c. 1511-1553) Spanish physician, and theologian, described the pulmonary circulation of the blood from the right chamber of the heart to lungs in his "Christinaismi Restituto", published in 1553. He wrote that the blood did not pass through the central septum of the heart, as had previously been believed, but did not suggest that there might be a systematic circulation. He says the connection between the cavities of the heart is not established through the median partition of the heart; a wonderful track conducts the blood, which flows in a long detour from the right of the heart to the lung, where it undergoes the action of the lung and becomes red; at the moment of relaxation (diastole) it reaches the left cavity of the heart. The publication *Christinaismi Restituto* led him to be burned at the stake for heresy. But there is no evidence that he knew of Ibn al- Nafīs' discovery of pulmonary circulation (Muḥyo al- Din Altawī, an Egyptian physician, in 1924, while studying the history of Arab (Islamic) medicine at Albert Ludwig's University in Germany, he discovered a script, "Commentary on Anatomy" in Avicenna's "Canon of Medicine" in the Prussian state Library in Berlin. It was the earliest

description after Galen's incorrect description in second century, Michael Servetus's correct description in 6th century). Although Alpago translated the commentary of Ibn al- Nafīs in the Renaissance, he apparently failed to deal with the writings pertaining to pulmonary circulation. According to the Encyclopedia International though Servetus was friendly with several reformers, his theological studies led him to reject the dogma of the Trinity and the Divinity of Christ. These views were expressed fully in his "Christinaismi Restituto", published anonymously in 1553. Servetus, still a nominal Catholic and physician to the archbishop of Vienne, was denounced as the author of the anonymous work to the inquisition at Lyon, probably at the inquisition of John Calvin. He was taken into custody, but soon escaped and eventually arrived at Geneva, only to be arrested there and charged with heresy, refusing to recant, he was burned alive (Encyclopedia International, 1975).

Contributions of Two Italian Physicians from Padua

Few doctors and scientists paid any attention to Servetus's exact description of the lesser circulation. It seems quite probable that his great discovery was in a theological work and its author was burned at the stake. After-wards, two Italian physicians from Padua (Italian Padua; ancient Patavium), historic city in Veneto, northern Italy (22 mi. west of Venice), Colombo and Cesalpino restated the exact description of lesser circulation without quoting Michael Servetus. Matteo Realdo Colombo (1516-1559) Italian anatomist gave one of the earliest de-scription of pulmonary circulation, who wrote "De re anatomica" showed that pulmonary veins contain blood made "spiritous" by lung. Andreas Cesalpino (1519-1603) Italian botanist and physician who described the circulation and theorized on the systematic and pulmonary circulation (that blood passes from the right side to left side of heart via lungc (Lee, 2000)). He indeed has the merit of having been the first to create the term "pulmonary circulation". He is also noted for his contribution to plant classification and to the theory of blood circulation. Andreas Vesalius (1514-1564), Belgian anatomist and the greatest single figure in the history of anatomy, does not attack on Galen's long- termed theory, but in his anatomical drawings he corrects many of the latter errors. In his famous book "De humani corporis fabrica libri septem" (On the Fabric of the Human Body"), (7 vols.) which appeared in Basle (1543), he shows that the intraventricular partition is impermeable, but he does not draw any physiological conclusions from this. (Figure 4)

Of Paramount Importance, Harvey's Discovery of the Circulation of the Blood

Of paramount importance was Harvey's discovery of the



Figure 4. (131-201) who gave an incorrect description of the circulation of the blood.

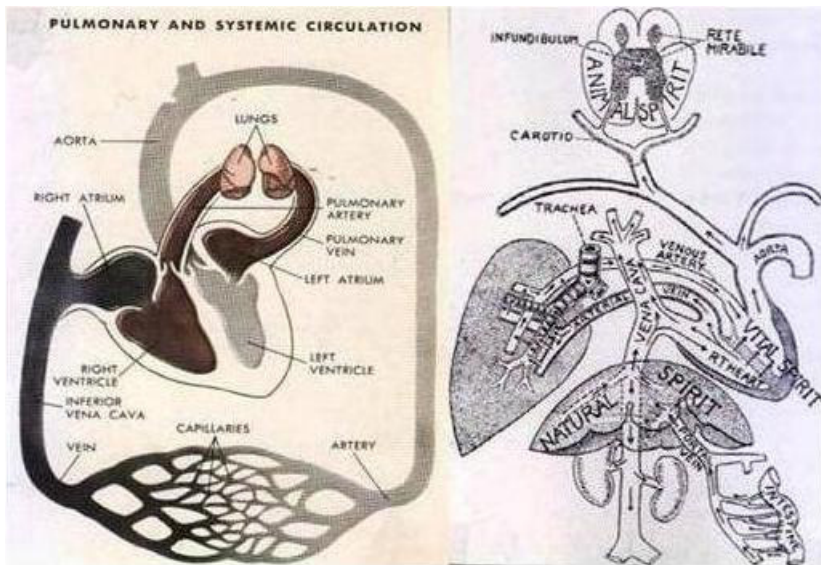


Figure 5. The pulmonary and systemic circulation of the blood.

Galen's physiological scheme as interpreted in 1946.

circulation of the blood. By demonstrating his findings, which were published in 1628, Harvey effectively established the science of physiology. (Figure 5)

After careful experimentation and observation on pigs,

dogs, fishes, and other animals, Harvey published his slim volume but the greatest treatise in the history of physiology on circulation, "Exercitatio anatomica de motu cordis et sanguinis animalibus" ("On the Movement of



Figure 6. William Harvey. Of paramount importance was Harvey's discovery of the circulation of the blood which was published in 1628.

Heart and Blood in Animals") in Germany in 1628. In this important work, considered the greatest medical treatise of all time, William Harvey "detailed the flow of blood from the right side of heart through the lungs, into the left side of the heart, then through the arteries into the veins, and finally back into the right side of the heart." This argument required Harvey to take a bold deductive leap from the arteries into the veins, sine minute blood vessels (the capillaries), which carry blood from the arteries to the veins, could not actually be seen until the microscope had been perfected.

Marcello Malpighi (1628-1694) Italian anatomist known for his pioneer work in the microscopic study of plants and animals tissues discovered the capillary vessels postulated by Harvey. It was indeed Malpighi's greatest contribution, and his achievement, accomplished independently by the Dutch microscopist and father of proto-zoology and bacteriology Antoni van Leeuwenhoek, completed the missing link in the circulation of the blood as described by William Harvey (Ibid).

The highlights

- William Harvey was educated at Cambridge and later at Padua (M.D., 1602).

- Harvey first developed his idea concerning the circulation of the blood in lectures given at the Royal College of physicians. At this period it was believed that blood was manufactured in the liver from food, that from there it entered the heart, finally to pass into the vessels of the body.
- William Harvey the discoverer of the circulation of the blood, from Folkstone, Kent, was a physician at St Bartholomew's Hospital, London (Sebastian, 2001).
- For twenty years after the publication of Harvey's important scientific work "On the Movement of the Heart and Blood in Animals" controversy raged over its conclusions. In this initial period many medical men ignored him including those who had observed his demonstrations (Lyons, 1987).
- *Execitatione de Generatione Animalium*, by William Harvey, was published in 1651. It contained descriptions of chick and deer embryology.
- Harvey described the circulation of the blood, heart valves, arterial pulse, pulmonary circulation, venous valves and proposed the existence of the minute vessels which carry blood from the arteries to the veins (the capillaries) (Sebastian, 2000).
- Marcello Malpighi (1628-1694) Italian physician and founder of histology who discovered the capillary vessels postulated by William Harvey (Sebastian, 2000).

- He showed that the heart was a muscular pump which propelled blood through the body, and that the pulse coincided with the heartbeat. Of paramount importance was Harvey's discovery of the circulation of the blood by demonstrating his findings, which were published in 1628, when Malpighi was born.
- Harvey's first major supporter was Robert Fludd (1574-1637), his friend and a mystic philosopher and physi-cian who subscribed to the ancient concept of the human as a microcosmic analogy to the macrocosom (Analogy is generally taken for some kind of argument supposed to be of an inductive nature, but not amounting to a complete induction). Fludd concluded that the heart was the center of universe.
- Jan de Waal (Walaeu) (1604-1649) was also another adherent of Harvey who performed new experiments that supported his findings.
- James Primerose, an extreme adherent to Galenist doctrines was the first to attack Harvey's ideas. He explained away the absence of pores in the spetum of the heart by postmortem changes.
- Caspar Hofmann (1572-1648) was another critic of Harvey.
- Cesalpino believed that blood originated in the heart, and thought of the circulation of the blood in terms of hot blood rising in the arteries and cold blood falling in the veins, but he had no clear conception of the veins as an exclusively centripetal system returning blood to the heart (Ibid). Figure 6

CONCLUSION AND IMPACT

In 1628, William Harvey demonstrated the continuous circular motion of the blood flow conclusively. He showed that blood circulated around the body pumped by the heart. His correct description of the circulation of the blood abounded in radical departures from the firmly established ideas of Aristotle, Galen and other scientific notables. For instance, Harvey's simple experiments contradicted the Galenic tradition of blood being produced from food and drink and consumed in the tissues. Harvey's discovery was the seventeenth century's most significant achievement in physiology and medicine. Although his contributions had enormous importance to anatomy and physiology, their impact on the practice of medicine was limited since the concepts of understandings of causes of disease were little advanced by his demonstrations. Medicine adjusted to the circulation of the blood but still thought in terms of humors and of therapeutics relying on bleeding, purging, and vomiting. His work was a significant confirmation of the new mechanical science and the principles of experimental and quantitative analysis. Harvey's discovery of the circulation of the blood began scientific medicine and formed a common front with that of Galileo (1564-1642) Italian scientist and founder of modern

physic and of telescopic astronomy, Johannes Kepler (1571-1630) German astronomer, Isaac Newton (1642-1727) the greatest figure in the history of the exact sciences, Robert Boyle (1627-1691) British chemist, physicist and theologian, Giovanni Alphonso Borelli (1608-1679) Italian physician who described the neurogenic theory of heart action, Marcello Malpighi (1628-1694) Italian physician, microscopic researcher and founder of histology, and others.

It was his pioneer work on the circulation of the blood, however, which gained him a prime position in the history of medicine. His observations have withstood the test of time and are the basis of the world present knowledge of the circulation of the blood. In addition, his scientific approach has become a central feature of modern mechanical physiology (thinking of the body as a machine), and effectively established the science of physiology. Furthermore, from this period onward anatomical studies became closely meshed with physiological investiga-tion.

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