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A FORGOTTEN CHAPTER IN THE HISTORY OF THE CIRCULATION OF THE BLOOD *

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THE discovery of the pulmonary circulation is an interesting and debated subject. At least five[1] discoveries are reported and statues have been erected in honor of the authors.

Erasistratus of the Alexandrian School believed that the arteries and the left side of the heart were empty and served to convey the spirit of life to the body. This teaching persisted until Galen disposed of it in the second century A.D., for he showed that by pricking any artery of a living mammal blood gushed forth. He taught that most of the blood from the right side of the heart went through invisible pores in the septum to the left side of the heart. There it mixed with air to create spirit and was distributed to the body. A small portion of this blood in the left side passed back to the lung with each systole to be cleansed of its "soot." He indicated, however, that a small portion of the blood from the right side passed through the vena arteriosa and then by way of the arteria venosa reached the left side. We see, therefore, that Galen had a vague idea of the pulmonary circulation. His errors were a belief in the permeability of the septum and in the systolic reflux.

In 1553 A.D., Michael Servetus[2] described the pulmonary circulation and denied the permeability of the septum but upheld the Galenic theory that the blood in the arteria venosa was mixed with the inspired air and cleansed of its "soot" by expiration.

Fourteen centuries—from Galen to Servetus—pass in silence. During most of this period Arab civilization, besides preserving Greek medicine, made valuable contributions. A manuscript in our possession shows that in the thirteenth century a clear conception of the pulmonary circulation was contributed by Ibn Nafīs,[3] dean of the Mansoury Hospital in Cairo, Egypt.

* A few days ago our attention was called to a valuable article by Dr. Max Meyerhof of Cairo entitled "Ibn An-Nafīs (XIIIth Cent.) and His Theory of the Lesser Circulation," published in the June issue of Isis (No. 65, vol. XXIII. I, pp. 100-120). We had corresponded with Dr. At-Tatawi Bey and in his answer he stated that he had turned over his data to Doctor Meyerhof and had referred our letter to the latter. In his second letter dated March 26, 1935, At-Tatawi Bey stated that he had received an answer from Doctor Meyerhof in which he gives reference to two manuscripts but no mention of any publication or article on the subject.

[1] Michael Servetus, Realdus Colombus, Carlo Ruini, Andreas Cesalpinus, François Rabelais. They all lived in the sixteenth century.

[2] In his Christianismi Restitutio.

[3] Abū-l-Ḥasan Alā-ŭd-Dīn Ali ibn Abi-l-Ḥazm (known as Ibn Nafīs). Brockelmann calls him Abu-el-Harm. The *z* and *r*, in Arabic, look very much alike with the exception that the *z* has a dot over it. Evidently Brockelmann overlooked the dot over his *r*.

Ibn Nafīs studied medicine in Damascus. The famous biographer and bibliographer, Ūsaibi'ā,[4] was his contemporary. They both studied under the same teacher[5] in Damascus and worked together in the Mansoury Hospital of Cairo, and yet the latter made no mention of the former in his biography. Ūsaibi'ā left Cairo and came to Sālkhăd—from the fleshpots of Egypt to the border of the Syrian desert. We wonder if Ibn Nafīs was responsible for that departure and whether the omission was intentional. It is unfortunate that Ūsaibi'ā has failed to give us what would have been valuable first-hand information about one of the brilliant characters of the thirteenth century. However, we are not left totally in the dark for several other biographers[6] have given us a fairly complete record of the life and work of Ibn Nafīs.

Ibn Nafīs is portrayed to us as one of the greatest physicians of his age, equal to Avicenna and even surpassing the latter in treatment. Besides medicine, he excelled in language, philosophy, Moslem canon law and traditions. He was a free thinker and one of the chief exponents of unitarianism. Unlike most of his predecessors he was a keen observer and a careful recorder of facts. His love for truth and his logical mind made him refuse to follow accepted authority blindly. He was a voluminous writer, writing fully and intelligently from memory without reference to any book. He wrote at least

Several letters of the Arabic alphabet have no equivalent in any of the European alphabets. Hence in translating Arabic manuscripts into any European language, certain proper nouns cannot be properly spelled to convey the exact Arabic pronunciation. Several systems have been adopted empirically—mostly by Orientalists—to overcome this difficulty, but none of these have been found satisfactory, as the same word may be pronounced differently by a Britisher, a Frenchman, an American, a German, or an Italian.

We must also bear in mind that the same word may be pronounced differently in the various Arabic speaking countries, and even in different sections of the same country. An American living and studying in Syria may pronounce the same word differently from one living in Egypt, Mesopotamia or Arabia.

In this article we have used the spelling that would convey to an English speaking reader the most nearly correct pronunciation.

[4] Mūwaffăq-ŭd-Dīn Aḥmad Ibn-il-Qasīm Ibn Abi Ūsaibi'a, the author of Ūyūn-ŭl-Anbā fi Tabăqāt-il-Atibbā, which contains, beside a brief history of Greek medicine, a complete biography of over 400 Arab physicians.

[5] Mūhăth'thăb-ŭd-Dīn Ad-Dakhwār.

[6] As-Safadi (695–764 A.H.), the first volume of whose book is already printed in Germany, and Moḥammad ŭl-Baqir in his Rowdāt ŭl-Jānnāt, have both given us excellent records of Ibn Nafīs. Five other biographers: Ibn-us-Sabki, Tabaqāt-us-Sabki; Tash Kubri Zadā, Mūtah-ŭs-Sa'adāh; Siyouti, Hosn-ul-Mohathara; Al-Hanbali, Sha'tharat-ŭth-Thāhab; Hajji Khalifā, Kashf-ŭz-Zūnūn, have also given us portraits of him.

[7] The following is a list of his known medical books:

(1) Ash-Shāmil, an encyclopedia of medicine which would have exceeded 300 volumes if it had been completed. He wrote only 80 volumes, most of which have been lost, only a few fragments being found in the Bodleian Library (Nos. 536–539).

(2) Al-Mūhath'thab f-il-Kuḥl, a treatise on eye diseases.

(3) Al-Mūkhtār min-al-Agthi'ya, a book on diet.

(4) Sharh Fūsūl Abicrāt, a commentary on the Aphorisms of Hippocrates.

(5) Sharḥ Taqdimat-ŭl-Ma'rifā, a commentary on the Prognostica of Hippocrates.

(6) Sharḥ Masā'il Ḥunein Ibn Ishāq, a commentary on the Questionary of Hunein Ibn Ishāq.

ten books[7] on various medical subjects and a book entitled the "Perfect Man."[8] This latter expounds the author's unitarian belief and teachings, such as that for which Servetus suffered martyrdom. There is a striking parallelism in the fact that both described the pulmonary circulation in the course of a theologic discussion and made the same mistakes in practically the same phraseology.

In the manuscript in our possession[9]—Commentary on the Anatomy of the Canon of Avicenna—Ibn Nafīs clearly and repeatedly[10] describes the pulmonary circulation. The following are literal translations of some of the passages in which he describes it.[11] ". . . Our purpose now is to set forth what we have been able to find of the discussions of the Sheikh, the Rais, Abi Ali al-Husein Ibn Abdallah Ibn Sina, on anatomy in his Canon, and that by collecting what he wrote in the first book of the Canon and the third book of the same, and so arrange properly all that he wrote on anatomy. What has deterred us from engaging in dissection is the authority of the law and our inherent compassion. So we see fit to depend, for the description of the internal organs, on the words of those who have preceded us—of those engaging in dissection —especially the honorable Galen, as his books are the best books that have come down to us on this subject. . . . We have relied chiefly . . . on his sayings, except in a few details which we thought might be mistakes of copyists or the fact that his description had not been given after a thorough observation. In describing the use of these organs we have depended on true observation and honest study, regardless of whether or not these fit the theories of those

(7) Sharḥ-ŭl-Hidayā f-it-Tĭbb, a commentary on Avicenna's Hidaya.

(8) Al-Mūjaz, a compendium on Avicenna's Canon.

(9) Sharḥ Qanūn Ibn Sīna, a commentary on Avicenna's Canon.

(10) Sharh Tashrih-il-Qanūn, a commentary on the Anatomy of the Canon.

[8] Risālat Fadil ibn Nātĭq (The Epistle of Fadil Ibn Natiq) on Ar-Ragul-ŭl-Kāmil (The Perfect Man).

[9] This book has been mentioned by most of the Arab bibliographers. Brockelmann gives reference to four copies: Berlin No. 6272, Paris No. 2939, Bodleian II.178, and Escurial I.267.

We know of two other copies—one in the Zāhiri'yā Library, Damascus (No. 20), and the other in the private library of one of us obtained by purchase from Persia. We have had the opportunity to study and compare these two manuscripts and compare them with the Paris manuscript No. 2939. These three manuscripts are practically identical.

[10] This is repeated at least five times—in his description of the pulmonary vessels, of the heart, of the lung, of the portal circulation and liver, and of the brain.

Our attention was first called to this by Sarton. In his Introduction to the History of Science he credits Doctor Muhhy-id-Din At-Tatāwy of Cairo, as being the first to call attention to Ibn Nafīs's description of the pulmonary circulation. From personal communication with Doctor At-Tatawy we have learned that he made a translation into German from the Berlin copy and that only five typewritten copies were made. He also stated that he has turned over all his data to Doctor Meyerhof of Alexandria.

[11] In translating these passages we tried very hard to give as literal a translation of the original as possible—sometimes at the expense of good English. A literal translation of Arabic books is always difficult as a whole chapter is one continuous sentence. The photostatic reproductions are taken from our manuscript and they have been carefully checked with photostatic reproductions from the Damascus and the Paris copies.

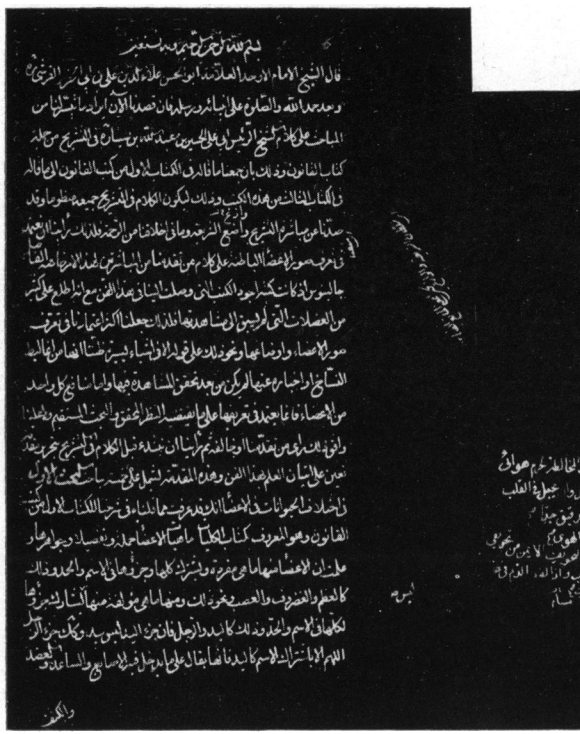

FIG. 1.—The introductory page of Ibn Nafis's Commentary on the Anatomy of the Canon.[11]

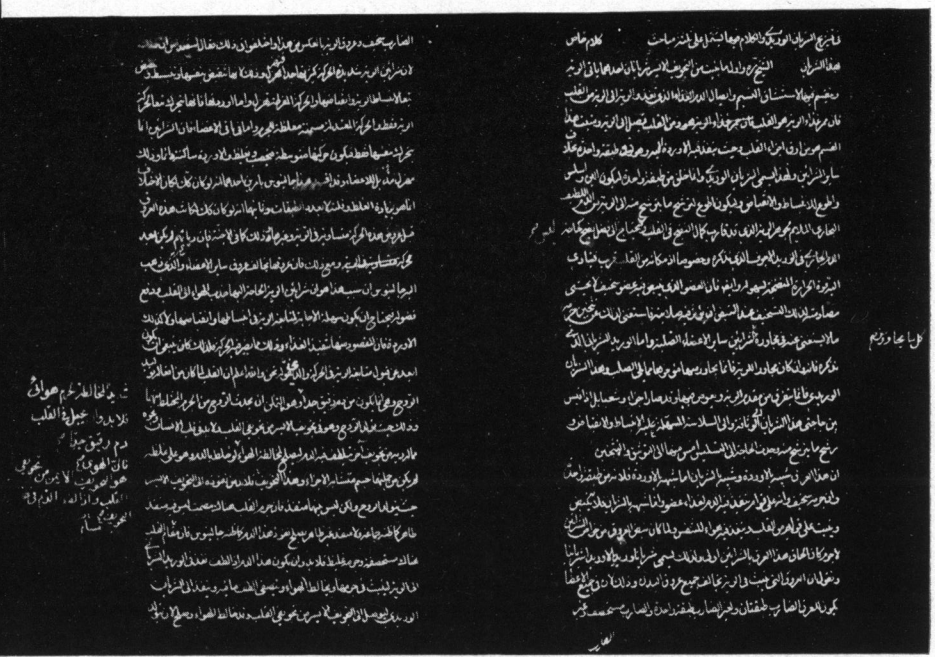

FIG. 2.—Description of the pulmonary vessels.

who have preceded us. . . . We see fit, before starting the discussion of anatomy, to write a preface that will help us to understand this science. The preface contains five discussions. The first is on the difference that animals show regarding their organs. . . ."

In describing the pulmonary vessels and their structure Ibn Nafīs disagrees with Galen and his predecessors as to the cause of the difference in structure between these vessels and the vessels in the other parts of the body. ". . . And we say, and God is the All-Knowing, whereas, one of the functions of the heart is the creation of the spirit from very thin blood strongly miscible with air, and air, so it is necessary to make, in the heart, very thin blood to make possible the creation of the spirit from that mixture. The place where the spirit is created is in the left cavity of the two cavities of the heart. Therefore, it is necessary, in the heart of man and his like—of those who have lungs—to have another cavity where the blood is thinned to become fit for mixing with the air. For if the air is mixed with the blood while it is still thick, it would not make a homogeneous mixture. This cavity (where the blood is thinned) is the right cavity of the two cavities of the heart. If the blood is thinned in this cavity it must of necessity pass to the left cavity where the spirit is created. *But between these two cavities there is no passage as that part of the heart is closed and has no apparent openings as some believed and no non-apparent opening fit for the passage of this blood as Galen believed.* The pores of the heart there are obliterated and its body is thick, and there is no doubt that the blood, when thinned, *passes in the vena arteriosa to the lung to permeate its substance and mingle with the air, its thinned part purified; and then passes in the arteria venosa to reach the left cavity of the two cavities of the heart; having mixed with the air and* become fit for the creation of the spirit. What is left of this mixture, less attenuated, the lung uses for its own nourishment. This is the reason why the vena arteriosa is made of thick walls and of two coats, so that what passes through its pores be very thin, and the arteria venosa thin and of one coat."

In describing the anatomy of the lung Ibn Nafīs states: "The lung is composed of parts one of which is the bronchi, the second the branches of the arteria venosa and the third the branches of the vena arteriosa, and all of these are connected by loose porous flesh. . . . *The need of the lung for the vena arteriosa is to transport to it the blood that has been thinned and warmed in the heart, so that what seeps through the pores of the branches of this vessel into the alveoli of the lung may mix with what there is of air therein and combine with it, the resultant composite becoming fit to be spirit when this mixing takes place in the left cavity of the heart. The mixture is carried to the left cavity by the arteria venosa.* What is left of that blood in the inside of the branches of the vena arteriosa and passes through its apertures to the body of the lung, would be thicker than the blood that seeps through and more watery, and fit for the nourishment of the lung. This vena arteriosa while it brings to the lung its nourishment, also brings the blood that is very thin and that is fit to become animal spirit when mixed with the air. The use of arteria

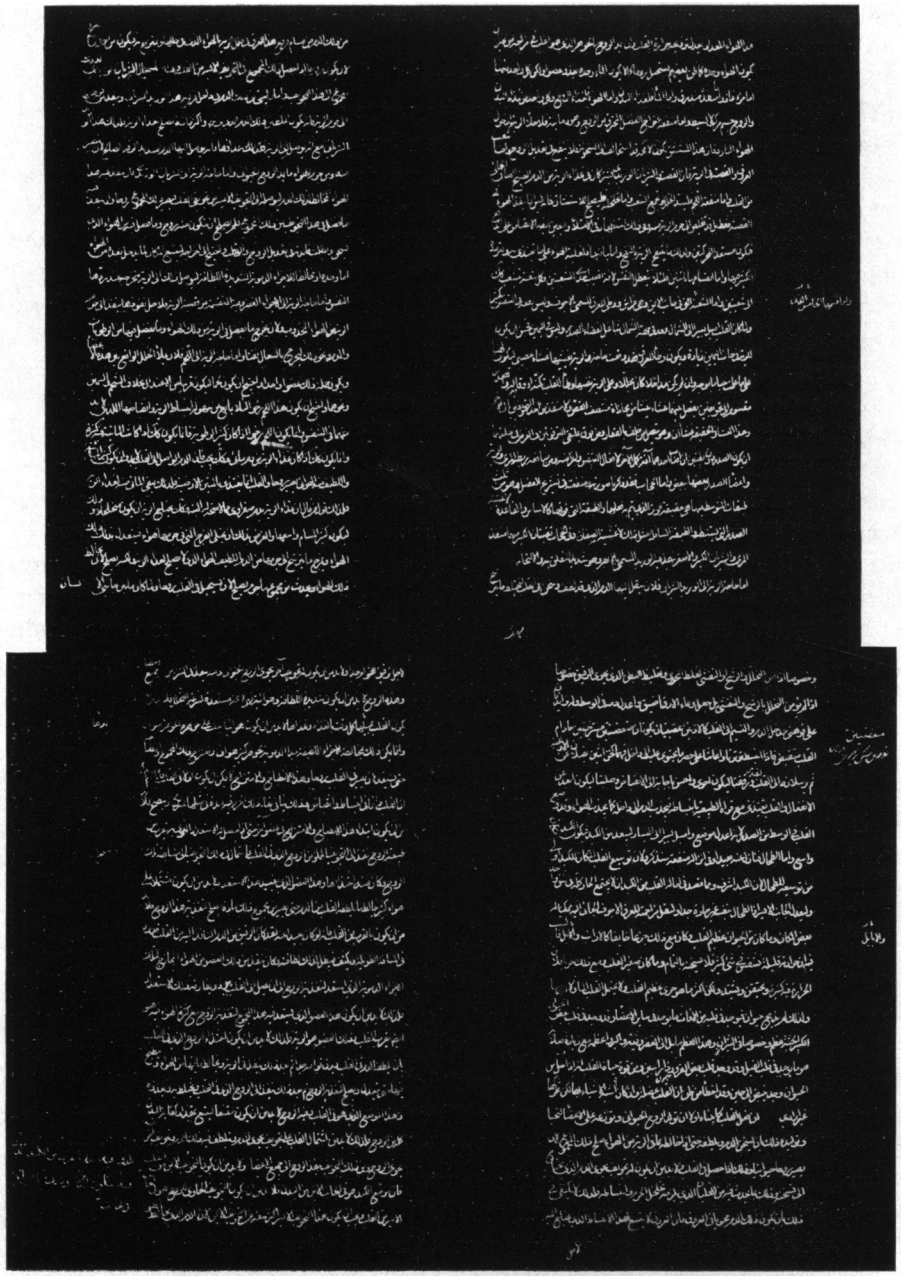

FIG. 3.—Description of the anatomy of the lung.
FIG. 4.—Description of the anatomy of the heart.

venosa is to transmit this air that is mixed with the thinned blood to the left cavity of the two cavities of the heart to become spirit. Another use is for the passage of what is left in this cavity of that mixture which was not fit for the creation of the spirit and of what is left in it of air that is overheated and useless. Both of these must come out of the cavity to make space for what comes afterwards of air alone or of air mixed with greatly thinned blood. So this vessel carries back these things to the lung to be discharged with the returning breath (expiration)."

In describing the anatomy and function of the heart Ibn Nafīs states further: ". . . The function of the heart, as we have shown, is first, the creation of animal spirit and its distribution to the organs in order to animate them. This creation comes about by heating the blood and making it thin so that when it is mixed with what there is of air in the lung, the mixture becomes fit for the production of the animal spirit. . . . *Therefore, for the nourishment of the spirit that is in the heart, it is necessary for the blood to become attenuated in the heart and its consistency very much thinned, then pass to the lung and mix with what there is of air there and be cooked in it until it is tempered and become fit for the nourishment of the spirit, and afterwards pass to the spirit that is in the heart and mix with it and nourish it.* . . . So of necessity the heart should have one cavity to contain the blood and thin it and another cavity to contain the spirit, and from this latter cavity the spirit passes to the different organs. And of necessity the cavity which contains the blood should be near the liver where the blood is made and so must be on the right side of the heart as the liver is on the right side of the body; and the cavity which contains the spirit on the left side of the heart. . . . And his (Avicenna's) statement that the heart has three ventricles . . . is not correct as the heart has only two ventricles, one filled with blood on the right side and the other filled with the spirit on the left side, *and between these two there is absolutely no opening for if there were, the blood would pass to the place of the spirit and spoil its essence. Also dissection gives the lie to what they said, as the septum between these two cavities is much thicker than elsewhere, lest some blood or spirit pass through and get lost.* . . . Again, his (Avicenna's) statement that the blood that is in the right side is to nourish the heart is not true at all, for the nourishment to the heart is from the blood that goes through the vessels that permeate the body of the heart. . . . *The benefit of this blood (that is in the right cavity) when it is thinned and attenuated is to go up to the lung, mix with what is in the lung of air, then pass through the arteria venosa to the left cavity of the two cavities of the heart and of that mixture is created the animal spirit."*

SUMMARY

From the above literal translation of Ibn Nafī's description of the pulmonary circulation and from a careful study of his biography and books we can draw the following summary.

(1) He advises the study of comparative anatomy as an aid to the understanding of human anatomy.

(2) On several occasions he hints that he performed dissection—which was very rare among Moslem physicians—despite the fact that he denies this in his introduction. He mentions dissection as a basis for his claim.

(3) He was not a blind follower. He has his own convictions and after careful observation and recording he states these regardless of accepted authority.

(4) He classifies man as an air-breathing animal.

(5) He uses logic where observation does not suffice.

(6) He declares that blood is aerated in the lung and gives a definite description of the alveoli.

(7) He states that the heart is nourished by its own vessels.

(8) He gives a clear and definite description of the pulmonary circulation and repeats this more than five times in the text.

(9) Three manuscripts show clearly that Ibn Nafīs, a prominent Arab physician, gave a classic description of the pulmonary circulation in the thirteenth century.

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