William Harvey (III)
De Motu Cordis (Second Part)

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We continue with the analysis of De Motu Cordis, and each of its chapters

Chapter I. "The Author's Motives for Writing"

Harvey describes the difficulties he encountered in proving his theory. "*I came to think,* [he says] *with Fracastoro,* [a Renaissance epidemiologist], *that the motion of the heart was only to be comprehended by God.*" Because the heart moved so fast, Girolamo Fracastoro (Verona, 1478-1553) had expressed this concept in his book *De sympathía et antipathía* rerum (Venezia, 1546).

His own words certify that Harvey had been teaching the concepts of circulation since 1616, in the lectures of anatomy of Praelectiones Anatomiae of the London Medical College, a fact that is recorded in the manuscripts made for those classes. He explains that he wrote De Motu Cordis due to conflicting views on this circulatory description. His teacher, Fabrizio d'Acquapendente, did not cover this topic in depth in his work, making it necessary for him to do so.

Chapter II. "The Motion of the Heart as Seen in the Vivisection"

To better understand cardiac motion, he observes the motion of the heart in cold-blooded animals (toads, snakes, frogs, and fish) because their heartbeats are slow. Here, he demonstrates the different phases of the organ's function, providing an understanding of systole and diastole. With this view he opposes the doctrine of Galen, who believed that the activity of the heart was manifested in dilatation, by means of the "*vis pulsifica.*"

Chapter III. "Of the Motion of Arteries as Seen in the Vivisection"

He considers that the arterial pulses are directly related to the activity of the heart that pushes the fluid. Therefore, once again, Galen's theory of *"vis pulsifica"* is disproved. Harvey spoke of the synchrony between cardiac systole and peripheral pulsation, but he did not notice the delay in the arterial pulse, which was related to the location of the vessel being examined. It is important to remember that during that time, clocks only had one hand that marked the hours. It was not until 1707 that the Englishman John Floyer (1649-1734) published *Physicians*' *Pulse Watch* where he described the use of a watch to measure the pulse. The first to refer to this time difference was Weitbrecht in 1734. In 1834, E. H. Weber found a delay in the submaxillary artery of 1/6 or 1/7 seconds, corresponding to an average velocity of blood propagation of about 8.5 meters/second.

Regarding this topic, he refers to Aristotle who mentions in his books *De animalibus* and *De respiratione* the simultaneous occurrence of arterial pulsation and cardiac activity.

Chapter IV. "Of the Motion of the Heart and its Auricles as Seen in the Vivisection"

Harvey made distinctions between the atria and the heart, which is why this chapter is titled as such. This differentiation was a legacy of Galen, who considered the atria to be mere dilatations of the vena cava, while the ventricles formed the structure of the heart.

Rebutting Jean Riolano, author of *Anthropographia* (1649), and Gaspar Bauhin (Switzerland, 1550-1624), he mentions that there are two movements of the heart and not four, emphasizing that the heartbeat is initiated in the atria. In one paragraph, he states: "*Dividing them into fragments is also futile as each fragment continues to contract and relax even after being separated*". This concept constitutes a description of what was later called cardiac automatism. He also mentions that the atrium is the first to beat, *"primum movens",* and the last to die, *"ultimum moriens"*.

Chapter V. "Of the Motion, Action, and Function of the Heart"

In this chapter, Harvey explains how blood circulates

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due to the movements of the heart and mentions that the "*vena arteriosa*" is an artery in both function and structure. Regarding the heart sounds, he explains that "*each time the heart delivers blood from the veins to the arteries, it produces a pulse that can be heard within the chest*". Many detractors denied this sound. Later, although these sounds were not disregarded, they were considered to be unimportant. It was not until 1819 that the Frenchman René Téophile Hyacinthe Laennec (1781-1826) interpreted this semiological finding, in his text *Traité de l'auscultation*.

He argues that the lack of understanding of the close relationship between the heart and the lungs "has been the main cause of doubt and error" in the understanding of cardiac physiology. He refutes the idea of blood passing through the septum "*as I have previously disproved*".

Chapter VI. "Of the Course by Which the Blood is Carried from the Vena Cava into the Arteries, or From the Right into the Left Ventricle"

He admirably describes fetal circulation, mentioning the "*ductus arteriosus*" and the foramen ovale. He provides a reasonable explanation based on the fact that the obliteration of fetal passages coincides with the initiation of pulmonary function and relates this fact to blood flowing from the right ventricle to the left ventricle through the lungs.

Harvey asks himself: "*Why does Nature, which always does what is best, [Aristotelian reference] completely close the various open routes after birth which she had formerly made use of in the embryo and fetus, and still uses in all other animals?*". It was necessary to wait until 1660 to understand this problem when Robert Boyle (Englishman, 1626-1691) described the chemistry of respiration. At that time, Harvey interpreted that the blood was sent through the lungs to be tempered according to the prevailing Galenic concept. In any case, his statement "*about the need and uses of air*" left the question open to later knowledge. The chapter ends with an emphatic and clear description of the pulmonary circulation.

Chapter VII. "Blood Passes Through the Lung Parenchyma from the Right Ventricle of the Heart to the Venous Artery and the Left Ventricle"

He categorically affirms that blood passes through the pulmonary tissue. He even reminds the Galenists that Galen himself admitted the circulation of a small portion of blood from the "*vena arteriosa*" to the "arteria venosa". In Harvey's exact words: "*The very words of Galen fully confirm as a truth that blood can be transmitted from the vena arteriosa to the arteria venosa and from there to the left ventricle*". He also acknowledges Colombo, whom he calls "*the most expert and erudite anatomist*", as the discoverer of the passage of blood through the lungs.

In reference to the usefulness of the sigmoid valves, that Galen had already described in *De usu partium,* he wrote: "*If our Maker had not instituted these supplementary membranes [the valves], an inconvenience would result...The valves have all a common use: preventing matter from returning into the opposite direction.*"

The concept of the importance of the right ventricle in animals with lungs is extremely valuable. This represents evolutionary reasoning prior to the development of phylogenetic theories. Literally, he writes: "*Nature, when she ordained that the same blood should also pass through the lungs, saw herself obliged to add the right ventricle.*" By the end of the chapter, he links this idea to that of the pulmonary blood course: "*The right ventricle was made for the sake of the lungs, and for the transmission of the blood through them, not for their nutrition.*"

Chapter VIII. "Of Quantity of Blood Passing Through the Heart from the Veins to the Arteries and of the Circular Motion of the Blood"

From the quote "*Alea jacta est!*" (the die is cast), taken from Julius Caesar, he expresses his concern. This is supported by numerous experiments conducted on circulation to gather the necessary evidence. His statement, "*I began to think whether there might not be a motion, as it were, in a circle*", establishes his concept of the circulation of the blood.

Harvey relates his circular theory of the perpetual return of the blood to Aristotle's cosmology and the motions of the stars, which he mistakenly also considered circular. From the historical process, let us recall that as early as 1609, Johann Kepler (Germany, 1571-1630) described that planets move in elliptical orbits and obey fundamental laws.

Chapter IX. "The existence of a circular movement of blood based on the confirmation of a first hypothesis"

In the search for truth through demonstration, he considers three key items to reach truth:

1) The volume of blood that flows from the vena cava to the right ventricle, then to the left ventricle through the lungs, and finally through the aorta into the body is too great to be solely derived from ingested food, as Galen had imagined.
2) The body sends blood to its various parts in larger quantities than necessary. Therefore, it is incorrect to assume that blood is continuously produced.
3) The veins return this blood to the heart.

Harvey begins his deductive process within this general scheme. Regarding the amount of blood needed, Galen claimed that the blood expelled by the heart was constantly consumed by tissues. To refute this concept, which Harvey calls the "*first hypothesis*", he introduces the "*more mathematico*" method (Desiderio Papp), which involves quantitative reasoning in medicine. He calculates that the heart beats between 1000 and 3000 times - on average 2000 - every half an hour. Considering that the left ventricle has a capacity of one and a half ounces* (47 g) and sends no less than one-eighth of that volume to the aorta with each systole, which is equivalent to one to two drachms* (6 g), we can infer that in that time interval, it ejects 3000 drachms of blood (about 12 kg). This large amount of blood cannot be continuously produced from the food in the liver. As a consequence of this quantitative analysis, he writes: "*Blood could not move if it did not walk out and return making a circuit*".

In a second demonstration of this first hypothesis, he turns to vivisection by means of arteriotomy, stating: "*The whole of the blood may be withdrawn in the course of half an hour, until it is exhausted*". He clarifies that the arteries only receive blood from the heart and not from the veins.

* *An ounce is equal to 8 drachms, and a drachm is equal to 3.89 grams.*