WILLIAM HARVEY (II) "DE MOTU CORDIS". ANALYSIS (first part)

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Harvey's exceptional book is titled *Exercitatio anatomica de motu cordis et sanguinis in animalibus*. It was written in Latin and published in Frankfurt am Main. On its cover it reads: William Harvey, English, Royal Physician and Professor of Anatomy at the London Medical College, Frankfurt, William Fitzeri, 1628.

To reach a full knowledge of blood circulation required innumerable steps, which like fragments, sometimes staggered, sometimes superimposed, took place to achieve a total understanding of the system through Harvey´s work.

The scholars who contributed to the effort of observation and investigation, sometimes even with tragic events such as the death of the Spaniard Miguel Servetus, constituted a prestigious group. We have seen in the development of the previous articles, that, from the earliest ancient times, blood and its movement generated a deep debate that lasted until the 17th century, when Harvey and Malpighi demonstrated the reality of such movement through its anatomical steps.

Not a few authors have seen in this historical development of knowledge, the intention to glimpse the understanding of the major blood circulation, in times prior to the appearance of *De Motu Cordis*. Thus Galen, de la Reyna and Cesalpino were catapulted to this an honor, aspiring to find in them such a discovery.

In fact, an abbreviated course of events tells us that Ibn an-Nafís, despite being the first to demonstrate minor circulation, suffered the misfortune of oblivion until the distant 1924. The Spanish Miguel Servetus was the author of the first print in which pulmonary circulation (1553) was demonstrated, on a manuscript that he had sent to Calvin in 1546. Due to the Inquisition, his work remained "secret" until another Spaniard, Juan Valverde in 1556, and the famous professor of Padua, Realdo Colombo in 1559, correctly exposed the minor circulation.

In 1546, Francisco de la Reyna, a veterinarian by profession, was the author of a paragraph in his work the Book of Albeytería, where some saw erroneously described the major circulation, by stating that in the limbs blood passes from the arteries to the veins. For his part, Andrea Cesalpino exhibits in his text *Quaestionum peripateticarum* (1593) an interesting knowledge about circulation. He shows that blood can be moved centripetally in the peripheral veins, dethroning the liver of Galen as the center of blood and placing Aristotle's heart in its place.

By using the word "*circulatio*", it was thought that Cesalpino had found the real circulatory physiology, but his belief in the continuous peripheral consumption of blood, cancels such a concept. He foresaw the function of heart valves, which in his concept prevented the return of blood from the heart towards the vena cava. He also mentioned the arteriovenous anastomoses. In short, the "*continuus motus*" described by him would displace the blood from the vena cava to the right heart, then part of its amount would pass through the lung to the left ventricle and from there to the parts of the organism, with acceptance of the pores of the septum. He spoke of the "*in capillamento resolvuntur*", which represented the thin venous and arterial terminal ducts.

Using all this background, even of details such as the true function of venous valves, Harvey applied not only observation but also experimentation to definitively dismantle the theory that had prevailed during fourteen centuries. In a patient methodological work, based on reasoned explanation and research on different animals he was able to distort the concepts that opposed the correct movement of blood. The appearance of the microscope would enable Marcelo Malpighi in 1661, to close the gap between the arteries and the veins by discovering the capillaries.

Dedications

From the first page Harvey seeks to have no weaknesses in his work, not even at the level of dedications. Thus, the first of them is addressed to the "Most serene and undefeated" Charles I, king of Great Britain, France and Ireland, and defender of the faith, comparing him with the "main engine" of the heart and to whom he reports the "news about the heart."

The second dedication is to the president of the London College of Physicians, Dr. Argent. In it he speaks of a work "of nine years or more" on the sub-

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ject, since in 1616 the manuscripts prepared for the *Praelectium anatomiae* referred to the circulation. In these first pages he shows great respect for his colleagues by treating them as "most learned and most expert", and then categorically sustains "the blood runs and returns along the same path."

The search for support in the College of Physicians is evidenced when he denotes extreme prudence in his work: "whatever we know, is only a small part of what we ignore." There is a clear concept of a Renaissance experimenter when expressing: "philosophers...cannot bear to be enslaved or lose their freedom to the point of believing their own eyes", and later "...I am not pursuing anything else but the truth".

Proem

Harvey mentions the need to use prior knowledge, but modifying it in relation to experience, dissection and observation. He promptly establishes a separation between the function of pulse and respiration, pointing out that the structure and movement of the heart are different from those of the lung. He contrasts his idea to that of Galen and of Fabrizio d' Acquapendente, who in his work *De respiratione et eius instrumentis libellos duos* (Venice, 1615) stated that the lungs surrounded the heart to cool it, since the arteries were not enough to ventilate it.

In the proem, through successive questions he dismisses the prevailing Galenic physiology. He emphasizes that the arteries carry heat rather than ventilation and refrigeration to the parts.

"How can diastole simultaneously attract spirits of the heart to heat the parts and air from outside to cool them?" According to Harvey there are mixed opinions among the precursors. Against Erasistratus and in favor of Galen he states that arteries contain only blood. To demonstrate this, he mentions Galen's experiment: "If, having placed ligatures in two places of an artery, the segment that remains between them is longitudinally cut, it is found that it only contains blood." Later he declares "spirits and blood are intrinsically linked" whereby we can glimpse a certain approximation to the blood oxygenation process.

He denies Galen's "pulsific" jump originating in the heart, claiming "that blood pulse distends the arteries." In his controversy with Jean Riolano, after the release of *De Motu Cordis*, he incorporates a clinical case referring to this topic, which implies the use of pathology to explain circulatory physiology. So, in the "Second Epistle" (1649) he literally replies to Riolano, who was firmly against the circulatory theory, with the following experience in a patient he treated: "the descending aorta had turned into a bone tube, but nonetheless, the arterial blood reached the lower extremities and made their arteries pulse... Where it was changed into bone it could not expand or contract like a bellows; nor transmit the pulsating power from the heart to the lower vessels; nor propagate a force that was incapable of receiving through the solid matter of the bone. However, I frequently noticed the pulse in the legs and feet of this patient, while he lived, since I was his most caring doctor and his very special friend." Let us remember that, in opposition to Harvey, Riolano wrote first his text *Encheiridium anatomicum* (1648) and later his *Opuscula anatomica nova* (1649).

Another question he poses to himself corresponds to the analogous constitution of both ventricles: "how could it be claimed that the function of this [the left ventricle] is to draw out and prevent the return of the spirits and that of the right ventricle is to draw out and prevent the return of blood?", if both are similar in their constitution. The same requirement corresponds to the "*vena arteriosa*" in relation to the "*arteria venosa*", wondering why they have the same size for different functions.

There is also concern in this reasoning: "How can we assume that so much blood is necessary for the nutrition of the lung?", if the "*vena arteriosa*" is larger than the vena cava. When studying the right ventricle, Harvey wonders why would this cavity, so close to the lung, have a nutritional function for the latter only, when expressing: "to nourish the lung,...add another ventricle to the heart?"

The next question refers to the left ventricle and the "*arteria venalis*". Why do they have two functions? a) to remove fuliginous matter towards the lung and b) to transmit spirits to the aorta, shrewdly expressing "what... prevents the spirits from mixing and confusing with the fuliginous matter?" Furthermore, in a series of questions on the capacity that the atrioventricular valves would have to prevent the exit of air, and to allow the fuliginous matter to pass, he exposes the most fragile structure of the Galenic system. With the same reasoning he investigates the possible mechanism for the semilunar valves to prevent the "spirit" from returning to the left ventricle. Faced with the topic of various uses for the "*arteria venalis*" -he answers- "nature does not manufacture a single vessel for opposite functions."

He confirms that there is no air in the "*arteria venalis*", but blood. If there were air, its constitution would not be that of a vein, but "the path...should be ringed as that of the bronchi, in order to remain always open without collapsing." He denies the porosity of the interventricular septum, a concept that, as we know, was previously expressed by Servetus, Vesalius, Valverde and Colombo, of whom he does not make direct reference. When expressing that in the fetus blood passes through the foramen ovale, he assumes that it could not do so easily through the septum of the adult, if it is understood that it is of a denser composition.

Harvey concludes his excellent proem, pointing out with methodological success that the paths to reach the truth are vivisection and "*ob oculo*" observations.