Dawn of Science

15. The Affairs of the Heart

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Previous parts:
Resonance, Vol.15: p.498, p.590, p.684, p.774, p.870, p.1009, p.1062. Vol.16: p.6, p.110, p.274, p.304, p.446, p.582, p.663.

From Nei Ching to Harvey, it took almost four thousand years to probe the mysteries of the heart and blood circulation.

As the Chinese text below shows, men of medicine, since antiquity, knew the heart played an important role in the human body and that it was 'somehow' connected with the flow of blood. Ignorance as to what this connection was remained for long a stumbling block in the advance of physiology.

"*The blood current flows continuously in a circle and never stops. The heart regulates all the blood of the body. (The flow of blood) may be compared to a circle without beginning or end.*"

– Nei Ching, ancient Chinese medical treatise (about 2500 BC)

Early Greek scientists, with their blind devotion to Aristotle, believed that blood vessels contained blood and air. It was Galen, the second century Greek physician, who conclusively proved that arteries contained only blood. But he believed that air entered the right side of the heart (from the lungs) and that the flow of blood in the vessels was like tides in the sea – ebbs and flows moving back and forth. The force that prodded this flow came from the contractions of the arteries, the heart playing no significant role. Blood, it was thought, was produced in the liver from where it passed to the right auricle (one of the two upper chambers of the heart) and then to the right ventricle (one of the two lower chambers) and then somehow made its way to the left side where it met blood from the arteries which contained air coming from the lungs. These notions about blood circulation and the heart held sway for nearly fourteen centuries.

Keywords
Galen, blood circulation, Vesalius, Fabricius, Harvey.

The first indication that this picture was far too inadequate came

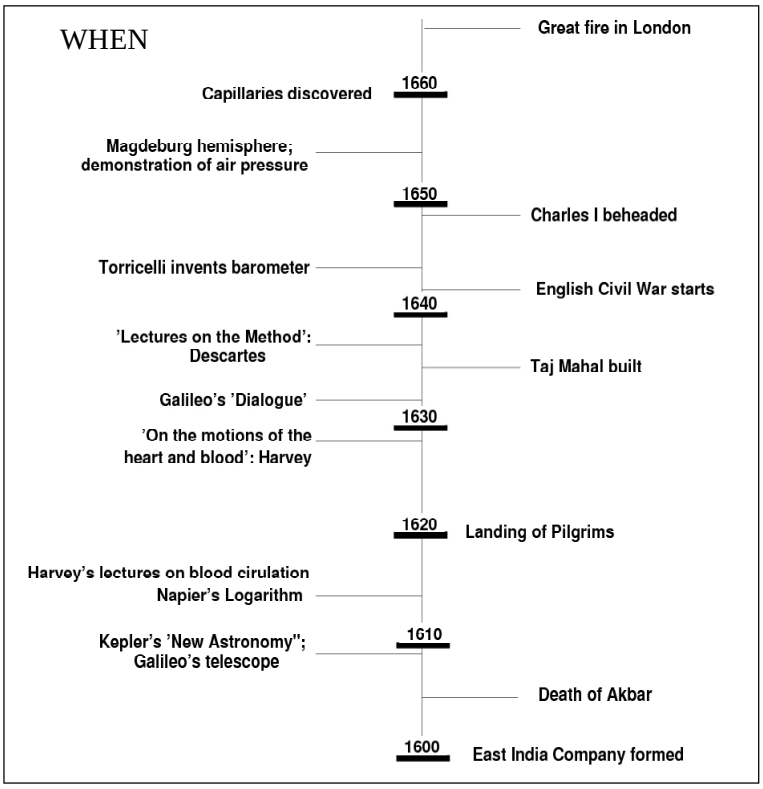

Figure 1.

Figure 2.

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in the sixteenth century. The anatomical works of the Italian physician, Vesalius, and others showed that there were no holes in the partition of the heart, and how the blood flowed from the right side of the heart to the left became even more of a mystery.

The solution, though, existed in a book by an Arabic scholar, Ibn-an-Nafis, published around AD 1242. There he had suggested that blood was pumped from the right ventricle into the arteries which led to the lungs; having picked up air from the lungs, the blood was brought back to the left ventricle from which it was further pumped to the entire body. (This circular flow of blood from the heart to the lungs and back is now called the 'lesser circulation'.) But this book was not known to the later western scholars. So the 'lesser circulation' was to be independently discovered by a Spanish physician, Mignel Serveto (1511–1553), who published a book on anatomy and blood circulation in 1553.

Unfortunately, the book also carried strong unitarian theological views which got Serveto into trouble with John Calvin, who preached a much more extreme version of Protestantism than even Martin Luther did. After publishing the book, Serveto had travelled to Geneva, which at the time was under Calvin's rule. Calvin had Serveto arrested and burnt at the stake with all the copies of the book. However, the concept (of lesser circulation) surfaced again soon and spread when an Italian anatomist, Realdo Colombo (1516–1559), discovered it independently again and gave it prominence in his lectures.

Meanwhile, these 'new' ideas as well as the fact that there were no perforations in the walls of the heart were proving difficult to reconcile with Galen's views that dominated. And the dogmatists persisted.

The next disturbing piece of evidence against Galen's ideas came from the work of Fabricius (1537–1619), who was the professor of medicine at the University of Padua in Italy. Fabricius studied the veins in detail and found that they contained a series of valves, the function of which was unclear. (Fabricius was the student of

Fallopius, who discovered the Fallopian tubes; Fallopius himself was the student of Vesalius, thereby maintaining the strong medical tradition of Padua.) Fabricius was close to discovering the circulation of blood but, being a strong Galenist, didn't push his observations to their logical conclusion.

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That honour finally went to William Harvey (1578–1657), the English physician. Harvey was the son of a very prosperous businessman and had the best of education. He received his first degree in medicine in 1597 at the University of Cambridge. Determined to study medicine further, he went to the best school at the time, at the University of Padua. He spent about two years at Padua working with Fabricius. Returning to London, Harvey climbed very fast on the social and professional ladder. In quick succession, he became a fellow of the College of Physicians, a practising physician at St. Bartholomew Hospital, personal physician to King James I and later to King Charles I. Very courteous and dignified, he was held in affection and respect by his colleagues. He was successful in every way.

In spite of active medical practice, Harvey found time to pursue scientific research over a long period (1604–1642). The two years with Fabricius had convinced Harvey that the flow of blood in the body was not well understood and he started a series of simple experiments and dissections to get to the bottom of this problem. By actual dissection, he noticed that there were valves separating the auricles from the ventricles so that blood could flow only from the auricle to the ventricle. He had earlier learnt from Fabricius about the valves in the veins. Combining these observations, he could easily arrive at the full and correct picture of blood circulation.

Figure 3. William Harvey. Courtesy: http://en.wikipedia.org/wiki/William_Harvey.

That a fixed volume of blood circulated through the blood vessels and the heart in a definite direction was quite a revolutionary idea. Harvey also found simple and elegant arguments to demonstrate the fact that blood flowed only in a definite direction in the body. For example, he showed that when an artery was tied off, it bulged on the side towards the heart; when a vein was held the same way,

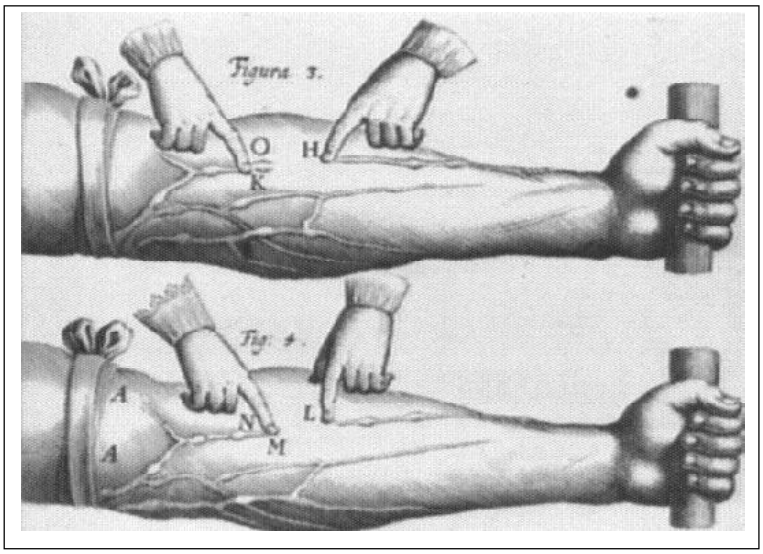

Figure 4. Harvey demonstrating that blood flowed only one way in the veins by pressing blood up from a section of the vein and releasing his fingers. If he releases the upper finger, blood would not flow down. Courtesy: http://www.comptonhistory.com/compton2/blood.htm

it bulged on the side away from the heart. He also found, by a simple calculation, that the quantity of blood pumped out by the heart in one hour was about three times the weight of a man.

Harvey published these results in 1628 in a small book, *Exerciratio de Motu Cordis er Sanguinis* (On the motions of the heart and the blood), of about 72 pages. It was printed in Holland on very poor paper and was full of typographical errors. Nevertheless, the book became a scientific classic. The Galenists of course ridiculed Harvey but his forceful arguments convinced his colleagues of his new ideas.

The theory of the circulation of blood depended crucially on one question: how did blood flow from the arteries to the veins? Harvey, noting that the arteries and veins branched into finer and finer vessels, had the intuition to guess that the transfer occurred at the finest levels (capillaries) too small to see. This was later confirmed by the Italian physiologist, Marcelo Malpighi (1628–1694), using the microscope.

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Harvey was a good friend of King Charles but stayed clear of politics. Because of this, he escaped the wrath of the parliamentary army when civil war started in England in 1642 and Charles I was arrested. The beheading of Charles, in 1649,

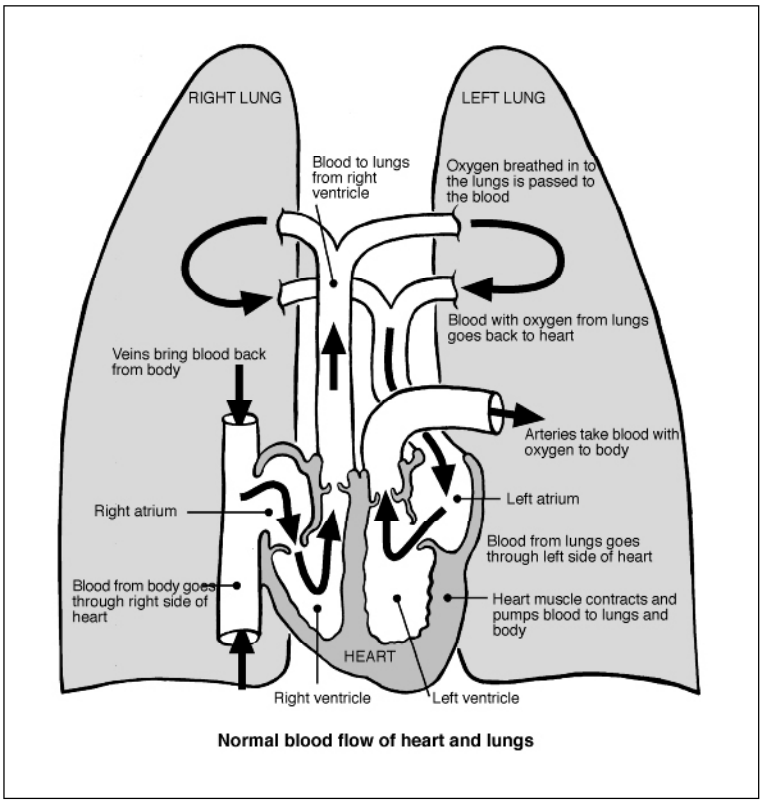

Figure 5. The blood circulation system in the body.
Courtesy:
http://www.patient.co.uk/diagram/Heart/lung-circulation.htm.

however, affected Harvey deeply. This loss, and the fact that Cromwell (the leader of the parliamentary forces) always treated Harvey as a suspect, made Harvey quite unhappy in his later years. He died in 1657 at the age of 80.

Suggested Reading

[1] **Isaac Asimov, *Asimov's Biographical Encyclopedia of Science and Technology*, Doubleday, 1982.**

[2] **I Harrison, (Compiled), *The Book of Firsts*, Cassell Illustrated, 2003.**

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