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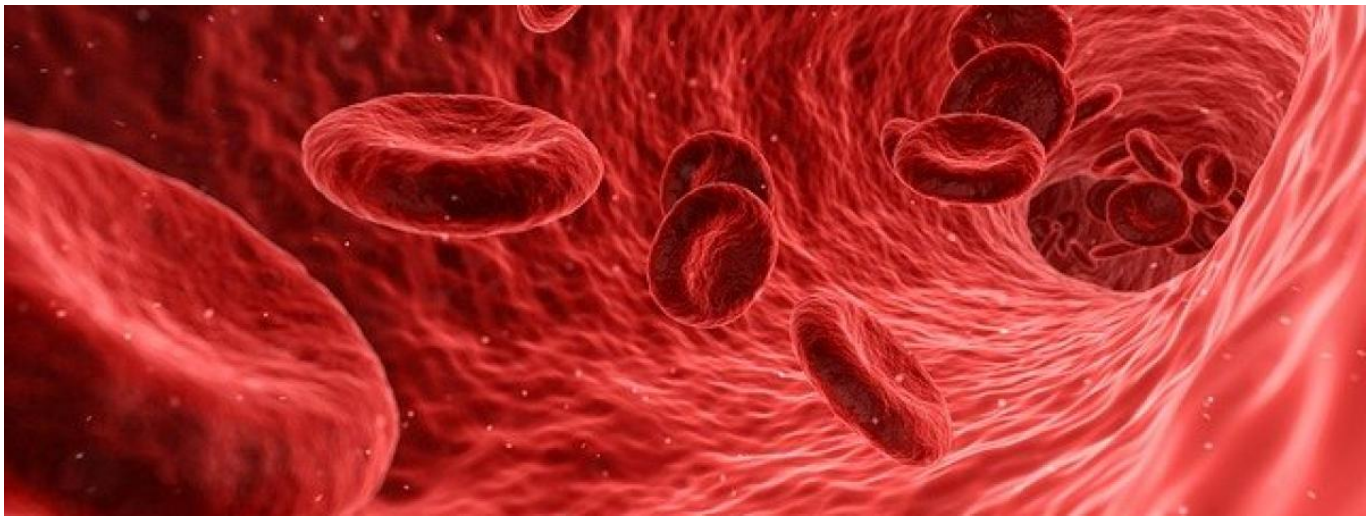

Do you ever feel like you are going round in circles? Well, your blood is continuously going round in circles, in the pulmonary and systemic circulations. Less than 400 years ago, however, these life-giving, life-sustaining circles were not known about. The heart was undervalued, and the liver was thought to be key, just as it was once claimed that the earth was at the centre of the solar system (Harris, 1916).

It was the obsessive, relentless work of one Folkestone farmer's son, called William Harvey, which demolished centuries of understanding about the human circulation, revolutionising our understanding of the human heart. Today, the fact that the heart's contraction is the cause of the arterial pulse is understood by primary school children. Yet without the work of Harvey and others, who dared to question traditional thinking, such fundamental truths would not be known about; building on his foundation, however, we are now able to stent, bypass, dialyse and medicate the circulatory system to human benefit.

Let us take a walk back in history, then, to the prevailing ideas pre-Harvey, before taking a look at the man himself: his influences, the threats to his work, and the great discovery itself.

Early ideas: Galen (AD 129-c210)

Galen, a Greek-Roman physician and master of animal dissection was the first to correctly define the differences between arterial and venous transport, noting the relative thickness of arterial walls and the redness of the blood (Gordon, 1991). He was, however, fixated on the importance of the liver in the movement of blood, describing how all blood was made here before being carried by the venous system to all the organs of the body, as they somehow 'attracted' the blood to themselves and 'consumed it'. The heart, in particular, fascinated Galen, as he saw it 'swell during filling before collapsing in on itself and 'spilling' some blood into the aorta'. Diastole was, therefore, the important part of the cardiac cycle in Galen's view, with the heart seen as a 'set of bellows' (Gordon, 1991).

Galen's description of what happened to the blood in the heart is fascinating: the heart is seen as a furnace, 'boiling the blood' so that it changes from purple to red as it heats up. Blood is explained to pass across the

septum into the left heart, through tiny pores (Harris, 1916). The importance of the pulmonary circulation in changing the colour of deoxygenated blood or in allowing blood to move from the right heart to the left heart was unknown: the lungs were judged simply to be consuming blood for their own need, as all other organs did (Wright, 2013).

Out of interest, blood made in the liver was only one of 4 ‘body humours’ that Galen was interested in: he also recognised phlegm from the lungs, yellow bile from the gallbladder and black bile from the spleen. All health and illness were attributed to a balance or imbalance of these humours, and so most medical therapy aimed to redress this balance, perhaps by bloodletting or leech therapy (Gordon, 1991).

Galen’s ideas were accepted as fact, and even in Harvey’s time, students at the College of Physicians in London had to swear never to speak disrespectfully of his work. It was going to take a lot to undo these incorrect ideas.

Early ideas: the Church

Despite prevailing academic ideas about the importance of the liver in the circulation, the church has always recognised the importance of the heart in spiritual and emotional matters. It has been thought of as the ‘residence of man’s soul’ and images of the ‘Sacred Heart of Jesus’ adorned church interiors throughout Europe. Saint’s hearts were often removed, embalmed and worshipped (Dobson, 2007).

In the Bible itself, the heart is frequently seen as a source of sin in the Psalms, whilst the unyielding Pharaoh in the book of Exodus is said to have a hardened heart. In John Bunyan’s Pilgrim’s Progress, the heart is pictured as a dusty room which cannot be cleaned by human effort, only by divine intervention (Bunyan, 2003).

Later ideas: Mondino, da Vinci, Vesalius and Colombo

Anatomists, meanwhile, clung to Galen’s ideas despite advances in dissection and the gifting of supreme artistic skills. Mondino, carrying out the first public human dissection in the University of Bologna in 1315 (Galen’s work had all been performed on animals), continued Galen’s theories. Da Vinci, despite his eye for detail and his ability to understand the human form, made Galen’s theories fit his intricate drawings of the human body (Wright, 2013).

One brave Belgian anatomist, however, described more than 200 errors in Galen’s work. Andreas Vesalius (1514-64) lectured students on surgery and dissection at the University of Padua, and produced his ground-breaking, beautifully illustrated ‘De humani corporis fabrica’ (‘On the structure of the human body’) in 1543, addressing such points as the lack of pores in the septum of the heart (McMullen, 1995). Despite being ignored and ridiculed at the time, a copy of his book is at the Oxford University Science Library today.

Colombo, an Italian anatomist (1515-1559) extended Vesalius’ work, further confirming the non-porous nature of the septum, and also realising that blood changed colour in the lungs, not in the heart. A supremely important revelation was that systole, rather than diastole, was the ‘active’ part of the cardiac cycle: blood didn’t just ‘spill’ out of the heart after diastole, but there was a forced ejection of blood from the heart during systole, and this drove the whole circulation (Ruoff, 2012). With such fundamental findings, why are the names of these men not better known today? And what of William Harvey?

William Harvey: the circles

“I will demonstrate to you today, how blood is sent from the heart throughout the body via the aorta by means of the heartbeat. Having nourished the remotest parts of the body, the blood then flows back to the veins from the arteries, then returns to its original source, the heart. The blood moves in such a quantity around the body and with so vigorous a flow that it can only move in a circle, continuously. This is an entirely new theory but, as you will learn, numerous arguments and our senses confirm that it is true”. (Wright, 2013, p xvii)

This was how Harvey’s famous circles of blood circulation would be introduced to packed lecture theatres as he would skilfully dissect dogs and humans (often the bodies of executed criminals or even those stolen from hospitals and graveyards). The presentations would usually be in Latin and accompanied by lutes. The supporting text was

his weighty ‘Exercitatio anatomica de motu cordis et sanguinis in animalibus’ (‘Anatomical exercises concerning the motion of the heart and blood in living creatures’) published in 1628 (Leake, 1929).

His demonstrations would involve cutting the pulmonary artery in a dog whose heart had been exposed, showering the audience with blood as the right ventricle contracted; ligating the pulmonary artery and filling the right ventricle with water until it might burst – yet the absence of any water in the left ventricle proved the non-porous nature of the septum; and watching the subsequent passage of water from the right heart once the pulmonary artery was opened, through the lungs and into the left ventricle to prove the pulmonary circulation (Wright, 2013).

Further demonstrations involved ligating the vena cava of a dog, and seeing the subsequent emptying of the pulmonary circulation and the aorta; meanwhile, ligating the aorta and then releasing it (or even piercing it) showed blood forced out of the heart into the systemic circulation. That systole was an active contraction of the heart muscle, rather than it simply ‘collapsing’ after diastole was proven by watching the beating heart in situ: first on transparent cold-blooded fish, whose heart naturally beat more slowly, aiding observation, and then on a young man with a chest injury, exposing his beating heart (Silverman, 2007).

To complete the circuit back to the heart, blood must enter the venous system and Harvey studied this with delight, affectionately calling the valves in veins the ‘little doors’ that prevent backflow. He would ligate human forearms and show that blood would not pool in the hand despite the added pressure, owing to these strong little membranes (McMullen, 1995).

The two circles of man’s circulation had thus been demonstrated beyond question. That the blood moved in a continuous circuit, not being ‘consumed’ but ‘recycled’ was a revolutionary idea.

William Harvey: the odds stacked against him

It is nothing short of a miracle that Harvey discovered what he did, and that his work received acceptance even in his lifetime since many factors seemed to work against him. There was the shipwreck in 1600 when, as a young Cambridge graduate, he headed to Padua University, Italy, to continue his studies. All onboard the ship died, yet Harvey had been the only man prevented from boarding – he saw it as God’s providence (Wright, 2013).

He had also been steeped in the teachings of Galen: his copy of Galen’s work is highlighted, annotated and marked throughout. Galen’s work was held as truth, and Harvey had absorbed it all – yet this did not prevent him from thinking independently, and allowing himself to challenge general opinion (Silverman, 2007).

Gaining acceptance for his work amongst Galen supporters was probably aided by his esteemed role as physician to King James I and King Charles I. Such a position commanded respect, though, as with all healthcare workers, he occasionally gave the wrong diagnosis and treatment, losing respect and therefore acceptance from his peers (see the famous case of Sir William Smith’s bladder stone (Wright, 2013)).

A final threat to the dissemination and acceptance of Harvey’s work came when many of his works were destroyed in the Great Fire of London in 1666, and by wilful vandalism during the English Civil War (Silverman, 2007).

William Harvey: all things working together for good

Despite the setbacks and threats to his work, Harvey’s ideas succeeded in demolishing theories that had stood for nearly a millennium and a half. This must have been, in part, to Harvey’s tireless, unquenchable drive to pursue his experiments. At school and university he would regularly work an 18 hour day, in his spare time he would explore and investigate nature, in his later life, he would often dissect in his study at home, reconfirming his theories. He even performed the autopsy on his own father in 1623 (Wright, 2013).

Being the firstborn son of nine children and marrying the daughter of the Queen’s physician ensured that he received the best education and mixed in wealthy circles – his father-in-law helped him to become a member of the College of Physicians.

Finally, his faith in God helped him to view man as the summit of creation and worthy of scholarly investigation. The following is a quote from his work, “We acknowledge God, the supreme and omnipotent creator, to be present in the production of all animals, and to point, as it were, with a finger to his existence in his works” (Leake, 1929). Few have investigated human anatomy as thoroughly as Harvey did.

Concluding remarks

William Harvey changed the face of cardiology when he proved the existence of the double circuit, comprising the pulmonary and systemic circulations, that delivers blood to the whole body.

Remarkably, another English physician, Thomas Willis, was proving the existence of the Circle of Willis at the base of the brain in the same century as Harvey (Martini, 1998). These three circulatory circles really do give new meaning to the phrase ‘circle of life’, being life-sustaining in their design.

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Links
[1] http://pastmedicalhistory.co.uk/going-round-in-circles-the-discovery-of-the-bodys-circulatory-system-by-william-harvey/