Alice: There’s no use in trying. One can’t believe in impossible things.

The Queen: I dare say you haven’t had much practice. When I was your age I always did it for half an hour a day. Why, sometimes I believed in as many as six impossible things before breakfast.

Lewis Carroll was not the only philosopher who has observed, if in this case obliquely, that scepticism of received wisdom is important to the advancement of knowledge. Indeed, it could be argued that significant advance in understanding rarely occurs without an obstinate refusal to accept what one has been taught. Such behaviour is hazardous, as Galileo discovered when he proposed that the Earth was not the centre of the universe. Today it may lead, at least, to difficulty in getting grants and publishing.

Most of us start out in life believing what we are told, be it fairies, Father Christmas, or God. Soon enough we learn scepticism, discarding at least two of these and perhaps rationalizing the third. But after a decade or two of education filling our heads with facts some of us begin to lose our habit of questioning; it takes a bold student to challenge authority. Later, we start to realize that much we were taught is incomplete or wrong. Only the most adventurous will start to test this for themselves; it is easier and safer to swim with the current.

Some years ago, while I was preparing a lecture in commemoration of William Harvey,¹ I spent some time looking at the 15/16th century drawings of Leonardo da Vinci and wondered why such an extraordinary scientist had failed to conclude from his studies that the blood circulated but had rather tried to fit his drawings to the received first century AD theories of Galen. He seemed to have made all the necessary observations from his dissections, and I simply concluded that he must have been distracted by his other pressing interests. I have now had the opportunity of seeing a new exhibition of his anatomical drawings and a fascinating publication that is available as an on-line app.² My conclusion was only half right.

In brief, Galen’s concept was based on the Platonic doctrine that the soul comprised three spirits, vegetative, animal and rational, and these were dependent on air, the life force. Galen had some understanding of anatomy as he dissected animals and had studied the wounds of gladiators, but dissection of humans was forbidden in his era. Nevertheless, a forceful teacher and writer, he would have achieved top ratings on Google Scholar for his publications, particularly as they held sway until the time of Vesalius and then Harvey in the late 16th and 17th centuries. He taught that blood was formed in the liver from food and passed through the body via the veins. Some of it nourished the lungs and some passed to the heart where it went through invisible pores from right to left ventricle, mixing with air derived from the pulmonary veins to become vital spirit. This in turn was distributed round the body in the arteries, being consumed in the organs and allowing them to do their work; some of this vital spirit went to the brain where it was endowed with animal spirit that passed round the body in the nerves. Thus blood did not circulate but passed back and forth, was consumed by being burnt up in the tissues and organs and was constantly remade in the liver.

This then was what Leonardo knew to be the truth but, driven by an artist’s curiosity about what lay under the skin, he made many dissections of both man and animals, starting about 1489 with a project to produce a comprehensive atlas of human anatomy. His work on this continued, if interrupted by many other projects, to 1513; his drawings and notes are now available for all to study. Whilst his most beautiful observations are on the bones and muscles, it is his studies of the heart and circulation that I am considering here. His first drawing illustrative of this, made about 1489/90, is a schematic representation of what he believed and shows a large vessel taking blood from the liver to the heart and through veins to all other parts of the body. However his grand atlas project was interrupted in 1494 by war and commissions to paint (initially, The Last Supper) and to design engineering and
hydrodynamic projects, and he did not take up his anatomical studies again until around 1503. At this point he made his first break with Galen when considering the mechanics of reproduction, showing that there was no direct connection that would allow passage of the soul from brain to the testes; here observation took precedence over theory. After a period of animal and human dissection and drawing he produced a more detailed depiction of the heart, main organs and vascular system of a woman in 1507/08, a compilation from his many previous drawings and notes. This still showed the same Galenic arrangement of vessels as in his 1488/90 drawing. Nevertheless, he had recognized, by inflating excised lungs, that it would have been impossible for air to flow out of them into the blood as Galen had theorized; a second break with tradition. He then embarked on a period of intense observation and dissection and in 1510 anticipated that he would soon finish his anatomical atlas. In this period, he broke for a third time with Galenic teaching by showing that the muscles could not contract as a result of inflation by air passed through nerves.

In 1511, plague followed by war and fires came to Milan and his anatomical collaborator in human dissection, Marcantonio della Torre died. Forced to move and his dissection confined to animals, he abandoned his great atlas. His anatomical work was not published until the late 18th century. But he still had one further ground-breaking discovery to make. In 1511/13, he dissected ox hearts and studied the mechanisms of the valves. He designed an experiment in which he showed in a glass model of the root of the aorta, using injected water containing grass seeds, how the valve was closed by turbulent eddies of blood. He now knew that the heart had one way valves, took in blood from the veins and pumped it out but was never able to take the next logical step, and state that the blood must therefore circulate between veins and arteries. That was left to William Harvey in 1628.

Old concepts die hard. It is not clear why Leonardo, having already challenged Galen three times, never made this final leap. Certainly, he was an old man for his era, had partly recovered from a right sided stroke in 1517 (he was fortunately left handed) and was to die in 1519, aged 67. He was unable to continue dissecting after his final move to Rome though he continued drawing and other projects. It seems likely that in the context of the time and possible conflicts with religious beliefs it was just too difficult for him to square what he knew with what he had observed. This is the lesson for all of us; if our observations have been meticulous and are repeatable, trust them over what we read in the textbooks. In a broader context, if something we find in a patient doesn’t fit with our preconceptions, put them aside and think afresh. And remember—even Leonardo could be wrong.

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References