Medicine in London, 1600 to 1900 - Dr William Harvey and the seventeenth-century medical revolution

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In this series of three lectures, I am going to be looking at medicine in London over effectively three century periods: the 17th century is the period for this evening; the 18th century is next week; and the 19thCentury in two weeks' time.

But before I start, I would like to read a short poem, which some of you may know, about Gresham, and which, in many ways, gives a sense of the novelty of the College, at least as it was perceived in the 1660s. We do not know quite who wrote this poem. It was a broadsheet ballad and it has been dated from internal evidence to circa 1663, simply because that is what the Royal Society was getting up to at the time it had been written, and it says this:

'If to be rich and to be learned

Be every nation's chiefest glory

How much are Englishmen concerned

Gresham to celebrate in story

Who build the Exchange to enrich the City

And the College founded for the witty.'

The 'witty' of course not meaning the comical, but rather in the Anglo Saxon sense of those who possessed acute senses - in other words, the study of the natural world.

Now, I would like to start off tonight in 1597, which is the year in which the will of Sir Thomas Gresham came into action and the College came into existence. So it was that the Welshman, Matthew Gwinne, became the first Gresham Professor Physic.

I want to have a look initially at what was the general state of medicine and medical understanding at the time of the founding of Gresham and a little bit later at the time of the death of Queen Elizabeth I in 1603. Medicine was profoundly different from what it would become even two centuries later. The one thing which is surprising is how essentially classical medicine was at this period, and I think it is important to say initially how they conceived that the body worked in 1597.

It was considered that the body was a sovereign territory - it is not for nothing that the analogy of the body as 'the body politick' was often used in political discourse as well as medical and theological discourse. For instance, Shakespeare, in his play King John, speaks of England as having 'distempered humours', where of course, in the early 13th Century, anarchy and Civil War was active. Of course even earlier, in the letter to the Corinthians, St Paul speaks of the body as having different parts, all of which have a sovereign combination. This strikes at the heart of how Elizabethan and early Jacobean people imagined medicine worked.

Effectively, the assumption was that there were four humours, four properties, and these were: yellow bile, black bile, blood and phlegm. They were generally associated with certain organs, but not particularly organ-specific. More particularly, they represented characteristics of conditions: hot, cold, moist and dry. It was believed that the way in which these were mixed together in an individual governed, first of all, your basic temperament - whether you were melancholic, saturnine, phlegmatic and so on - and also what kind

of diseases you were likely to be inclined to. For instance, a person born under Saturn with a considerable amount of black bile in their make-up was likely to be much more inclined to depression, perhaps violence, and erratic behaviour. When a doctor therefore looked at a patient, before you even started to get round to diagnosing the disease, you would type them, and would therefore say what kind of susceptibility they had, based on these four classical humours.

Medical training at that period, in either Oxford or Cambridge or any of the great universities of Europe, especially Bologna and Padua, would also have focused on a classical humoural tradition. This included such figures as Galen, the Prince of Physicians, who had lived around 150AD; Hippocrates, the first systematiser of medicine, around 400BC; and lots and lots of others including Dioscorides. In fact, if you were a medical student in 1597, you would be reading cases of people who had been in their graves for over 2,000 years. These formed part of the general process of diagnosis. Hippocrates' Airs, Waters and Places, his Diagnostics and Prognostics, his book on the King's Evil, and various other diseases, classified illness in a way that was, first of all, comprehensible in the Greek world, and was equally comprehensible in the world of Queen Elizabeth I. Therefore, medicine was, unlike today, a profoundly classical art. It was also a deeply conservative art, where the conservatism of the doctor was more important than innovation, in many ways.

I think the biggest single quantum shift in medical understanding in the intervening four centuries is how we regard medical authority: the idea that a young doctor was not as good as an old doctor; the fact that a man who was concerned with modern learning was not as reliable as a man who was concerned with old learning. Indeed, when William Harvey published his first major fundamental studies on the circulation of the blood in 1628, it virtually slaughtered his practice in London, because who would go to a doctor, especially a Fellow of the Royal College of Physicians and a Royal Physician, who was so mad enough to suggest that the blood circulated around the body?! A number of Harvey's rivals, particularly Dr Primrose, made great fun of this and effectively tried to harry Harvey off the scene, because he innovated in physic, as opposed to following the great traditions of classical medicine. So this is one very, very important area of difference between then and now.

Also, we have to bear in mind how the medical profession was structured in 1597. London is the easiest place to describe it because of various statutes that applied to London. Most obviously of all, King Henry VIII had established the Royal College of Physicians. This had been a body which had not only governed London, but had an administrative remit for the practice and teaching of physic within a radius of seven miles of St Paul's Cross, which was the whole of what we would now call Greater London. How far this remit applied to Bristol, Norwich, York, and so on, became a matter of endless legal wrangling in the 17th Century, because it duly became what you might call a medical closed shop.

The physicians were the doctors who dealt with the inner workings of the body and they would be the ones who applied a variety of therapies which were broadly purgative in character. You would first of all diagnose which particular humour - black bile, phlegm or so on - was at the cause of this person's disease, and then you would try to shift it. You would do this by moving or coaxing it by bleeding, purging or powerful emetics etc. When you look at the general armamentarium of doctors of circa 1600, most medicines were effectively intended to move something inside you. It was a sort of sophisticated system of metaphysical and physical plumbing. The physicians were the ones who had the legal right to diagnose and to prescribe.

On the other hand, you had the surgeons. These also operated under a Charter of 1540 given by Henry VIII. However, this Charter clearly put surgeons as distinctly second class citizens to doctors. For instance, they did not have a Royal College at that date - that dates from 1800 - they had a Worshipful Company. They were grouped with the Dyers and the Salters and the other, traditional commercial trades of London and did not to have an academic foundation behind them. They were not to deal with the internal parts of the body. They were to deal with scabs, ulcers, with shaving if necessary, amputating limbs, dressing wounds, and things of this sort. On the other hand, it was often amongst the surgeons that you found some of the most extraordinary radical technical innovation, because 16th Century Europe was absolutely beset with war, and if you wanted to learn your trade as a surgeon, you did not stay in London. You went off and followed the Army or you enlisted with Drake or Frobisher or someone like that. In doing this you had access to lots and lots of badly injured men who were not going to complain, and you would learn a great deal. Surgery, by 1600, was light years ahead of where it had been in 1500 in terms of technical manipulation and understanding of the body.

Then you have what I suppose one would consider as the lowest branch of medicine, and these would be the apothecaries. These were the people who would 'compound drugs', as the phrase used to be. They were not supposed officially to prescribe, although when you have a situation where only a relatively small number of people could afford the services of a formally trained physician, the majority of people would go into an apothecary's shop, describe their aches and pains, and something would be given to them over the counter. This became another source of endless legal wrangling, as the College of Physicians tried constantly to restrict the apothecaries in prescribing.

These are the three branches of the profession as they would have been in 1597. They would also have been relatively ineffective in treating any major disease. The only people who would have had what you might call a radical capacity to cure were well-trained surgeons. For instance, the surgeon for with Sir Francis Drake wrote a major treatise on surgery, in particular how to deal with gangrenous limbs, how to amputate with new techniques, and so on, but this was a conservative business.

On the other hand though, when you look at the nature of care in London, there was only two hospitals in 1597. There was St Bartholomew's which was allegedly founded by Rahere in 1123; and there was Bedlam, or St Bartholomew's, both of course on the northern part of the City, dating from around 1200. These would be for every kind of illness at Bart's and for those referred to as 'the poor distracted' in Bethlehem or Bedlam. On the other hand, it would only have had a small capacity. For instance, Bedlam only had 25 beds until 1676, when Robert Hooke completely redesigned the hospital for the governors and provided facilities for 120. The idea through much of this period was not that the sick would go to hospital, but they would simply be treated at home. They would be treated by irregular practitioners if you could afford no one else at all, or if you could afford it, you would have a surgeon or a physician or, illegally, an apothecary to visit you at home.

On the other hand, we do have the vast and murky diaspora of what I suppose one would call irregular practitioners, people who were already by this time becoming to be called 'quacks.' This was, of course, largely because they have a great penchant for mercury-based drugs, and hence of course quicksilver, quack-salver, quack, becomes the linguistic derivation by which we often refer to them. I will be looking more at quacks next week, but in addition to the more overt, quack-ish, practitioners I want to say something to you about the use of astrology in medicine in 1597.

It was widely used, because we have to bear in mind that these people lived within a geocentric cosmos. This was a period when Copernicanism has had relatively little impact in the West, and really until Galileo, you do not have a lot of evidence that really suggests the Earth moves in space. Therefore, astrology makes sense in that world. If we have four humours in our bodies, and we are on the Earth, which is at the centre of a series of spheres, and all the planets of heaven go around us, describing the variety of complex geometrical configurations, then all of these things will beam in on us and affect our humours. So therefore, very often, if a perfectly reputable physician was making a diagnosis, he would often request of the patient of the hour at which you went to bed - in other words, when did the disease become intolerable, because that is the birth of your disease. In addition to looking at your humours and everything else, very frequently, he would calculate from this a prognosis of how you were likely to fare in the future.

I have done quite a lot of work on the popular almanacs of the period, which were replete with the astrological knowledge of that day, and perhaps the most famous of all of these medical astrologers was William Lilly. He was to become Chief Astrologer to Cromwell, and it was said that in the Civil Wars a positive prognosis from Lilly for the outcome of a battle was better than an extra six regiments of dragoons for the King. This gives you the idea of the sheer moral force that Lilly had the power to bring up. But Lilly was also a man who practised astrology extensively in medicine, although of course often on the fringes and never quite liked by the Royal College of Physicians.

I want to go on to say something about the illness patterns now, what actually people suffered from in England around 1597. But, first of all, I think it is important to just ask what size London was at that time. We do not have any exact returns, but people who have studied things like tax returns and so on from the period have led to the expectation that at around 1600, at the end of the Queen's life, there were probably 200,000 people living in what is now the City, in Westminster, Southwark and that area. By the time that you get to 1700, it has been estimated to around 600,000 - well over half a million. That is a substantial increase in people.

What you also have to bear in mind though is what the age structure of that was. One of the first people to ever study that was William Petty, one of the early Fellows of the Royal Society, a man who knew Gresham College very well indeed. In 1663 he produced a little tract which basically looked at the structure of

population in London. It is not for nothing that Petty is considered the father of scientific demography. He studied the Bills of Mortality particularly, which had been started in 1603, in which every parish in the city had to do a weekly return of the number of people who had died and what they had died of (which, as you might be able to guess from what I have said so far, was often a bit of a guess). From this, Petty calculated that of every hundred children born in London sixty would be dead before they reached the age of five. Also, the average life expectancy of a Londoner was in their thirties. Then you come across figures like Robert Hooke, Sir Christopher Wren, Sir Isaac Newton - a number of the leading figures of the age - who got to decent ages between 68 for Hooke and 92 for Christopher Wren, but they were very much the tips of the demographic icebergs. One has not got to look very far, for instance flipping through John Aubrey's Brief Lives, that great collection of 17th Century lives, will simply tell you, so-and-so and so-and-so, great scholar, St John's Cambridge, Inns of Court, fought in the Civil War, died 42 - and it is very common, and of course not dying in battle, just simply dying. So most people did die much younger.

This would also have meant that London had a much younger average population than today. Alms houses were not the problem. The real problem is what to do with the apprentice gangs, the large number of unruly fourteen to sixteen year olds, and of course a much younger general population group. Of course, this affects disease patterns, because many diseases which of course we are particularly concerned with today - let us say cancer or heart disease - would not have been statistically that significant. Essentially, these are diseases of aging, in the broadest sense; they tend to be more effectively biting into people over forty than people over ten. In consequence therefore, it is not for nothing that when you look at disease patterns in London for this period, you tend to find a relative paucity of what you would consider as modern diseases.

One reason for that is a totally different explanation of what a disease was. For instance, the concept of a heart attack did not exist in the 17thCentury. You might have a palsy, you might have an imposthume, you might have a man who was, let us say, 62 years old, very fond of food and drink, had a red nose and was often out of breath - he might have a spasm, which is what we would now call a heart attack. We can recognise these there in the right groups, but statistically, they are much, much smaller.

The case is similarly for cancer. You always find cancer on the Bills of Mortality, but generally speaking, these are confined to visible cancers. Indeed, breast cancer was the almost entire reference to this. Concepts such as internal cancers and definitely things like blood cancers were totally unknown within the purview of medical knowledge of the 17thCentury.

Therefore of course, when you have a reference to what someone died of, you have to ask who gave the diagnosis. For instance, the people who had to give the diagnosis for the Bills of Mortality each week within the 109 parishes of the city were two old women and not a doctor. They had the title of Searchers of the Parish, the intention being that they would have been old enough to have seen a lot of disease in their time; so therefore, when they went to see a body lying on its bed or on a board in a house, and they asked a few general questions of the family such as whether they died of a great pain in the head or if they had died, very commonly in the case of children, of teeth, exactly what that means, and then you have other familiar diseases such as fever, a flux, or something of this sort. By today's standards this is all, clinically, spectacularly imprecise! These Searchers were looking for one illness particularly - plague - and if they saw the tokens of plague, the buboes of plague on a body, then of course that house had to be shut up and left for forty days and forty nights, usually with disastrous consequences for the inmates.

I would like to now say something about diseases coming and going at this period. For instance, without any medical interference whatsoever, one disease which had benighted a lot of medieval Europe had gone by the time of Elizabeth's time, and this is the disease of leprosy. We can chart leprosy's course throughout European culture in the Middle Ages, simply because of the number of leper houses or lazar houses that were built to accommodate the lepers. By 1550, these lazar houses were being given over to other things - schools, charities, general hospitals - because simply there are no lepers to go in them anymore. Exactly why this disease died out, we simply do not know. It dies out from England; it does not die out from Scandinavia; Scotland has a bit of leprosy too; but in fact, Bergen in Scandinavia had its last leper death in 1952. Why this peculiar change of this disease pattern happens, frankly, we do not know, but it had gone from England by 1600.

On the other hand, you have the appearance of the new disease of syphilis. This came in from the New World in around the 1490s, traditionally in the wake of Columbus' landfall in the Americas. Sixty years later its mode of transmission and its basic gross aetiology had been worked out by Giorlamo Fracastoro in Italy, and it was known to be a sexually transmitted disease. This was now beginning to ravish Europe, and one

comes across numerous references to the generic use of pox, or syphilis, or of course the one that it was most commonly called in this country, the Morbum Gallicum, the French disease. When you look of course across Europe, syphilis is often given the name of the country you do not like - it is the 'Morbum Gallicum', the 'German disease', the 'Spanish disease', and various others. But it is fascinating to see where that disease came from and how it established itself in the English population by the middle of the 17th Century.

Then you have diseases which are episodic, and the most obvious of these is the great terror disease itself, Bubonic Plague. Bubonic Plague probably was known in biblical times. The second book of Samuel has an account of an illness, suffered first of all by the Philistines, and then by the Children of Israel, which some epidemiologists have suggested is Bubonic Plague. This of course is the famous series of wars between the Children of Israel and the Philistines, when the Ark of the Covenant is stolen by the Philistines and God strikes them down with buboes in their secret parts and there are rats and mice plaguing them as well. Whether this was plague, we do not know, but it certainly could well be.

We do know too that it was likely to be around in the late Roman world - the Plagues of Justinian have been suggested to be Bubonic Plague. But it comes and goes. But then in 1346, it appeared in Italy, out of the Byzantine world, and shot across Europe in a period of two years. It got to England in the early months of 1348, and it was in Scotland a few weeks later. The disease then took up residence. At first, it came about every two or three years, absolutely ravishing the population. Then it settled down to a much more what you might call congenial pattern, of a really bad epidemic about every 20 or 25 years.

The year in which Queen Elizabeth died, 1603, saw one of the worst ever epidemics on record. 1644, at the height of the Civil Wars, saw another; and then came 1665, the plague year of Samuel Pepys, when at least 68,000 people died. I say 'at least' because that is what the Searchers declared, and as many people had a very clear interest in not having their houses shut up, so they were very careful in many cases to cross palms with silver to have the disease put down to something else.

But then, after 1665, it went away and it never reappeared. And then of course, there has been endless speculation as to whether perhaps changes in the rat population or better nourishment may have been at the heart of the fact that it never came back. It was certainly in Egypt in 1798, because Napoleon Bonaparte's army encountered it, and it was also in other parts of the Middle East, but why it left Europe, we simply do not know.

Doctors of the day tended to have a strong historical sense, after all, if you had been educated on Greek philosophers, Greek doctors, and Arab doctors, such as Avicenna, you would have a strong historical perspective. So it was that they were aware of and were, frankly, baffled by these comings and goings of diseases and their episodic nature. This is one of the reasons of course why astrology often had a strong profile in medical explanation, because you could normally tie up these manifestations to things happening in the heavens.

I think this shows us something of the nature of the profession, the way in which the approach to medicine operated, but what I want now to look at is the way in which changes take place in the growth of what might broadly be called scientific medicine, which began to slowly appear in the 16th and 17th Centuries.

If you live in a world where you see the Ancients as lying at the heart of all truth, innovation becomes fundamentally unacceptable. Like Harvey found, if you start to innovate, you are doing something which is going against the wisest of the past. Why therefore did people begin to innovate in medicine? Also, why did they innovate in astronomy - people like Copernicus and Tycho Brahe and Galileo - and why did we have also this challenge to ancient learning? This is an issue that I believe many historians simply duck. They talk about the Renaissance or the New Learning and things of this sort, but what fascinates me as a historian is why things happen. Looking at a lot of the general scientific literature of the 16th and early 17th Century, there is one event which screams out with regular reference to the way in which they saw their world changing. This was the discovery of America by Columbus in 1492. Why this is so crucial is that it shows the ancient geographers had utterly and completely got it wrong.

We have to bear in mind of course nobody in 1492 believed the Earth was flat - this is only a piece of American history legend going back to Washington Irvine and the Legend of Sleepy Hollow and tales of that sort. No educated person with three brain cells believed the Earth was flat in 1492. Ptolemy had shown it was a sphere and Aristotle and various others even made good guesses as to its size. The key thing of course was that all the ancients had worked on the assumption that it had actually more land on its surface than it had water, so effectively, the European and Asiatic landmass occupied a much bigger part of the Earth's surface. In their reckoning the entire sovereign part of the world, terra-incognito Australis, the

Southern part of the globe, and the known oceans - the Atlantic, the Mediterranean, the Indian, and by legend, what bits of the Pacific there were around China and Japan - were simply small pieces of water. On the whole, water occupied about one-seventh of the Earth's total surface, this was believed. So, when Columbus discovered the Americas, and shortly afterwards, Magellan discovered and navigated the Pacific, it showed that Strabo and Ptolemy and various other ancient geographers have made fundamental errors.

There is another central feature that you have to bear in mind here as well. If you looked at the broader assumptions that lay at the heart of where the human race was going in the 16th Century, you have an essentially declinist approach to culture. You had, first of all, longevity in the days of the Old Testament patriarchs. After all, Methuselah lived to the age of 986 years, and in fact Thomas Paynell, a medical doctor and close friend of the court of Henry VIII, wrote a little book in 1518, where he commented on the fact of how puny modern man are: 'Not only are we not the size of the giants, do we not compare with Goliath or with King David, but we are just runts when it comes to longevity.' Clearly, the human race is running out, dying out, and conking out, broadly speaking. Why therefore did we discover things that the wisest men of the ancient world had not known?

In this respect I think the discovery of the Americas was a tremendous re-orientation of Western culture. They saw we could find things out that they never knew of, and not only did they find it out, they found it out by a particular method. They did not do it by collecting - I am speaking here of Columbus et al, Drake and so on - they didn't do it by philosophising; they did it by taking ships and finding places - they did it by physical discovery. It is very hard to reconcile this approach to physical discovery, with let us say the philosophy of Plato, which held that that essentially intellective knowledge, deductive, philosophical knowledge is of the highest kind (and it was in Plato, of course, that the neo-Platonists of the universities would have been trained). Now you have a pack of navigators finding continents and oceans not known. This I think therefore is a shot in the arm.

There is also a biblical parallel again which comes into this. Francis Bacon, in the introduction and on the title page of his Advancement of Learning of 1620 has a Latin quote from the Book of Job, which of course was extremely powerful within that culture. The English translation of this Latin quote says effectively, 'Many shall run to and fro and knowledge shall be increased. Before the end of the world, before God wraps up the world like a curtain, many shall run to and fro and knowledge shall be increased.' Geographical discovery, scientific discovery, investigation of new things seem to fit that prediction beautiful. So the rise of their science, and the medical knowledge which they start to see as part of that science was not just simply discovery. It was seen as fulfilment of biblical prophesy; it was seen as the last new vigorous gasp of a dying human race before the world is wrapped up as a curtain; and of course we have to bear in mind that, to most people living in the Renaissance, they were not living into a new wonderful time of the birth of culture, but rather to what you might call the last act of the drama before the celestial curtain came down. So therefore we have to see this as taking part of what they thought of medicine.

At the same time, you also find Vesalius in Italy doing something never done before, certainly since the time of Galen, and this is the dissection of human bodies on a systematic scale. It is true that the Royal College of Physicians had been permitted bodies to lecture on in London - four criminals a year to lecture on to medical students in London. But of course you have to bear in mind that this kind of dissection, in let us say 1500, had been largely theatrical. You would have had a corpse placed up on a table, you would have had a professor on a high dais, reading from an appropriate passage of Galen or Hippocrates or so on, and you would then also have had a reader who would have assisted in the reading, and then down there, you would have had the corpse on its slab, a man with a knife, probably who did not understand the Greek or the Latin, who was told, 'Get the heart,' 'Now get the liver,' he would saw away and out it came, it would be put it on the platter and he would show it round. That is theatrical dissection.

What you start to find though with Vesalius is the idea of the painstaking taking to pieces of a corpse bit by bit, where the professor does not merely work on his dais; he closes the book, he comes down, and cuts up the body with his students. This starts a radical new approach to dissection. It also finds that ancient doctors have got a lot of key things wrong. For instance, the uterus does not have the structure that Galen said it did, the breastbone is not serrated in the way that Galen said it was, and the heart simply does not have the required plumbing facilities that Galen said it should have had. What of course too Vesalius, who was not only cutting up humans but cutting up virtually any creature he could lay his hands on, had realised was that what the ancients were doing was often dissecting apes, monkeys, pigs, cows, and creatures of this sort. In other words, the great inheritance of classical anatomy was a veterinary.

You can understand the shock force of the realisation that we, from this runt end of human history, have discovered structures in the human body that no one had ever known were there before. It is not for nothing that Padua in Northern Italy became the greatest centre of this radical dissection, and it is not for nothing of course that William Harvey, discoverer of the circulation of the blood, was a student in that University from 1601 to 1603.

What you start to find therefore, with this new radical approach to knowledge, is the suggestion that new things can be found. In another dimension of course, Copernicus was suggesting that the Earth moves around the Sun, backed up very powerfully by Galileo's realisation in 1610 with the telescope that many of the things he saw - the moons of Jupiter, the craters on the Moon, the phases of Venus, and so on - fit much better with the Copernican heliocentric theory than they fit with the classical geocentric theory. So in other words, knowledge was in ferment and this is why we were starting to get new discoveries - not because people are just discontented with antiquity, but because, starting from the geographers onwards, you are finding that a new style of learning - empirical, hands-on, comparative, and in the astronomical sciences, mathematical studies - are bringing out truths never known before.

Undoubtedly the greatest of all of these discoveries in the period that we are concerned with is William Harvey of London. Harvey was born in 1578. He was a Kentishman, went to Gonville and Caius in Cambridge, and then went off to Padua. There he took a Doctorate in Medicine and learned the new radical techniques of dissection and the study of the human body.

On the other hand, people sometimes give the impression - and this is part of an approach to the history of science which I personally strongly find erroneous - that somehow all of these great scientific innovators were, on the one hand, radical, discontented and difficult men, and also, they were trying to prove the Church to be somehow wrong. This is a thing which simply fails to stand up to scrutiny. For instance, we find that so many of these discoveries were made by men who have no particular axe to grind. It is true that Galileo is an exception to this, but many others were remarkably conservative. They were also often deeply devout as well, as Galileo was as well. But what you start to find is that they were realising that, against all of their instincts, what they are finding in their respective profession - astronomy, medicine, or whatever - simply did not quite match up to what they had been told it should. This tended to mean that you also used the ancients creatively, and I think Harvey was an immensely conservative doctor who also used the ancients creatively to produce radical conclusions.

For instance, one of the central tenets of the medical writings of Aristotle is effectively that structure and function were connected; a body of any creature should not have a part that is overworked or under-worked. Why therefore, when you look at the function of the heart in classical Galen physiology, is the aorta overworked and vena cava under-worked? Harvey started to look at how you can rethink the body in terms of the heart, and I will quickly say here how he came to the conclusions of the circulation of the blood, here in London, just down the road.

He studied in Padua and learned the business of how to cut things to pieces with a number of leading Italian anatomists and dissecting anatomists. He had found that the Italian anatomists in the wake of Vesalius had been puzzled by one phenomenon: why in the great trunk veins of the body were there valves, unknown to the ancients, and why do these valves all open and close toward the heart?

According to classical medicine, the heart was a furnace that heated the blood, and it caused the blood to effervesce and froth. The lungs were seen as bellows that blew air, through the pulmonary artery and the pulmonary vein they thought, into the heart and frothed and bubbled it up, and this then caused it to sort of effervesce into the veins, where there was a tidal flux and reflux through the veins. This meant that you had something like that vena cava that was overworked, in and out, and others that were under-worked.

Harvey started to ask whether this could really be quite the situation. For instance, if all of the blood goes into the veins and goes down the body, why do all the veins have what he calls 'clacks' or 'mock gates', as in a pump, which close? He spoke of the mechanical analogies - the clacks of a pump that stops the reflux of water when you have done a pumping action. Why does the body clacks against the flow? Could it be that the blood is supposed to go up the vein rather than down it? He had a long way to go.

He then started to do another brilliant piece of experimentation, and although, he was a conservative doctor, Harvey was an instinctive experimentalist - he had picked that up in Italy. For instance, the idea was in classical medicine that your food produces your blood, pretty well directly, in the spleen and the liver. 'Why is it,' he then asked, 'if you measure a person's pulse and, in dissection, you determine the internal volume of the heart, and how much blood a systolic heart can hold, then multiply that by the

number of beats per minute, why is it that in the course of about twenty minutes to half an hour, the person's entire body weight passes through their heart?' No glutton in Christendom eats his or her body weight in twenty minutes in food. Where therefore do you have what you might call the missing mass of the blood? This was another of his problems.

Then also, he started to do experiments on arms. I do not know how far this will be appropriate for Health & Safety at Work, but these were experiments you can simply do on yourselves or on your friends. If you have someone hold a staff or a pole, and someone put a moderately tight ligature around your arm, after a few minutes, you would see your principal veins in your arm starting to stand up as little nodules, and you would see that they were rather like strings of sausages and they have closed gaps between them. Harvey showed that you could push the blood up but you could never push it down, because when you pushed it down, as he said, the pump clacks, closed. This clearly indicated that the flow of blood was towards the heart.

The great problem was, what was the job of the arteries? The ancients had believed that the arteries contained a variety of things - generally speaking, numa, the life force - and this carried some kind of vague, gaseous, sometimes partially liquid, thing through the arteries. On the other hand, Harvey was aware of another thing, and this comes from Galen, and from military surgeons. Why is it that when you are dissecting a cadaver, especially one that has been dead perhaps for quite some time, you find no blood in most of the arteries, but why is it that when a man has an arm injury that it is the artery that spurts blood? Why therefore are the arteries engorged with blood in life and apparently empty of it in death? Do you therefore get the blood in the veins in death because they are trapped between the clacks up the limbs? The great problem facing Harvey though is how the blood gets from the arteries to the veins. He was able to trace increasingly reduced structures and membranes. The problem was he could not see a connection, and Harvey was a very good experimentalist and did not like postulating things he could not be sure of.

He recognised the weakness of his theory and he suggested that there could be connections on such a small level they could not be seen. This was put forth in one of the most important books in the entire history of medicine, De Motu Cordis et Sanguinis in Animalibus, On the Motion of the Heart and Blood in Living Things, published in London in 1628. The book outlines, in detail, everything I have told you. It is an extraordinary piece of experimental physiology. Without it, modern medicine could not exist. Can you imagine any aspect of modern medicine requiring drips, hypodermic injections, experiments, which did not take, as a premise, that the blood circulated around the body, under the mechanical action of the heart? The heart, says Harvey, is not a furnace, but is a pump, and it is a pump which in its systolic and diastolic expansions and contractions makes the blood move through the body.

Harvey's work was utterly fundamental on influencing European thinkers. As I said, it did damage his practice, and a lot of his most fashionable clients will no longer come to him. But on the other hand, in Padua, Paris, Bologna, and all across Europe, people like Rene Descartes and Marcello Malphigi were taking up Harvey's work.

In 1663, Marcello Malphigi, using the newly devised microscope, saw for the first time the circulation taking place in the tail of a fish. Therefore, using the biological experimental analogy that what is happening in one creature can be applied to another, he gave the first proper microscopic determination of the circulation of the blood in living creatures. But by this time Harvey had been dead for five years.

What happened after this was that there was an explosion in fascination with experimental physiology, in England and across Europe. Harvey's work, as I said, was inspiration in a very important degree. That group of men who started to meet in Gresham College, around 1644, which called itself a philosophical club, and part of it migrated to Oxford in 1648 into my own College of Wadham, under the aegis of John Wilkins, the Warden, started to create two experimental centres in England. These centres look at all kinds of things - astronomy, gardening, animal culture, all sorts of things - but in 1660, they came to London at the Restoration, where they became the Royal Society (the Royal Society though, I may say, was always referred to euphemistically as Gresham College, simply because that is where it met). Of course I am sure most of you are familiar with its illustrious curator of experiments, Robert Hooke, who we celebrated last year, and he was one of the great experimental driving forces. But in that world of experimental science at Gresham and at Wadham, we find a number of key new approaches.

The first of these is the study of the physiology of respiration - what is air, what does it do in living creatures, and how does it bond? It was well known that your venus blood in your veins is darker than your arterial blood. Why? Traditionally it was said that this was because one had numa blown into it and the

other did not. Boyle and Hooke, working with an air pump, were able to discover that there seems to be some property in air, which they called generically aerial nitra, which when it is in contact with blood, lightens its colour. They performed a series of experiments, and found that when he had a mouse or a candle burning in the same volume, an upturned vessel with a sealed bottom, that they both expired - the mouse died and the candle went out - when a certain volume of the air had gone. This suggested that the whole of the air was not necessarily used for respiration, only part of it; and it also asked the wider question - why is burning and breathing connected? Could it be perhaps that what causes a fire to burn in the air is also the thing that generates life and makes living bodies warm? Dead bodies of course do not breathe, hence they are not able to generate that kind of reaction.

Hooke went on to perform a series of, frankly, rather gruesome experiments, along with Richard Lowell and John King, where they performed experiments called the insufflation on dogs to try to determine the blood/air connection in the lungs. By 1667, the general books of the Royal Society contained a series of experiments where they were asking the question 'What does air do in the lungs? Does it actually invigorate the blood or does it simply cool the body down, as a sort of blast going into the mouth?' They come to the conclusion that not only did it cause a colour change in the blood, but also it seemed to have some kind of chemical bond. This is 1667, thirty odd years after Harvey. - The speed of experimental development was colossal.

Likewise also, Thomas Willis of Oxford, and later of London, Fellow of the Royal Society, started to do fundamental work on the nature of the human brain. He started to dissect brains in about 1658. He tells us how he came to this by a rather bizarre route. He says that his wife had died and, in his mourning, he had looked for intellectual distraction, and he says, 'I took myself upon the opening of heads,' which is hardly what most people would consider as a way of relieving mourning, but it provided him with tremendous intellectual impetus. He was dissecting one man who he seemed to have known in life and known something about the man's prior illness, and found that this man's left carotid artery was completely blocked by a massive and long-standing thrombosis. According to traditional medical belief from Aristotle and Galen, that man should have had half a brain dead, because it was thought that each carotid supplied the left and the right hemispheres respectively. Why therefore was he not dead?

He then tells us that he sent out his servant to find him a dog. This was a common practice, especially at Oxford - you would give your servant sixpence and he would come back with dog on a piece of string. You would then open the dog's neck, he ligatured its carotid, stitched it up again, and kept the dog around for a few weeks. He studied of course that clearly the creature did not seem disoriented, it ate its food, and absolutely witless cur as it was, he said it even licked his hand after all of this. It would not have done had it known what was coming to it!

After about a month, he killed it. He found that the ligature was holding and that the dog's carotid had withered away, but just as in the case of the man, the right carotid had swollen to thrice its normal size and seemed to be putting blood into a great circular vessel at the base of the brain, and from this circular vessel, the rest of the brain drew its blood nourishment. This is now of course immortalised the Circle of Willis. It was the first discovery that one part of the body can compensate for the loss of function of another part of the body, and again, it comes out of this experimental tradition.

The use of the microscope, the air pump, and a variety of experiments at this period all suggest that there was a tremendous new interest in taking the body to pieces, comparing it with animal bodies, and trying to conduct experiments in particular diseases. The establishment of the Philosophical Transactions of the Royal Society became, and remains, a benchmark for articles on all forms of experimental knowledge. If one looks through the early volumes of Philosophical Transactions especially, you find articles on diseases, on monstrous births, as they call them, creatures that were born - a sheep born with six legs and things of this sort. This was at the time when the scientists are trying to define what was normal nature, and therefore how does unnormal nature compares to normal nature, and what you can do to a body. These would occasionally be extraordinary things, such as a story from Philosophical Transactions from the 1580s, of a rather foolish boy playing around with a knife who swallowed the knife down his gullet and could not get it out. Then, a few months later, the side of his stomach became very sore and it became a sort of festering sore and a local surgeon opened it, and lo and behold, he finds a sharp metal point beneath the sore. He then probes and widens the wound and extracts the knife from the lad's stomach wall, and apparently he survived. This is the type of thing that goes into Philosophical Transactions - it is the weird, the wonderful, and the scientific. They were trying to delimit what nature was.

This medical world, you may say, should have started to produce prodigious cures, but it did not. Over the course of the next two lectures, I am going to be looking at the way in which science began to progress in medicine, and so many aspects of illness came to be understood - anatomy, physiology, the classification of disease, and of course alternative practitioners and quacks.

But there were so many things that these people could not do: they could not control pain; they could not control infection; they had no proper understanding of trauma; and they were totally, utterly, and absolutely at sea when it came to understanding the vast plethora of fevers and infectious diseases that simply wiped out that population - smallpox, Phthisis, pulmonary consumption, typhus, typhoid, malaria, all of the rest of them. They could do nothing against these things. It would take a full two centuries of systematic, prodigious experimental research in London, across Europe, and in the burgeoning American colonies, and then the United States, while they started to accumulate this tremendous new body of medical knowledge. And it was not until the middle of the 19th Century that this body of knowledge had reached what you might call a critical mass, where you started to get real innovations in therapeutics emerging from it. I want to be looking, in my subsequent two lectures, on how this critical mass developed, and in my last lecture, the extraordinary fruits that experimental medicine produced in the late 19th Century.