3. Modern Natural Philosophy

For several centuries after the 6th, the bulk of scholarship in Western Europe was done by Christian monks. All of what survives (as far as I know) concerns history or religion. Most of it seems to be copying or commenting on the Bible. Philosophy seems to have succumbed to the pressing need to serve God through unswerving faith in scripture.

On the other side of the Mediterranean however, scholars in the Islamic world preserved Aristotle's cosmology. Muslims reached and captured the Iberian peninsula in the 8th century, and by the 12th century, some of their cosmological ideas crept North and West. This was a time when the European money economy was reviving, Cathedrals and monasteries were expanding and the first Universities were established. There was even an order of monks called the Dominicans set up in 1216, which sought to defend the Church by examining, teaching and preaching new ideas.

When Aristotle's idea reached the Universities, the effect on students was profound. The Church continued to insist on the superiority of faith over reason, but the best of its scholars gradually adapted to the mood. One of those was Thomas Aquinas, who at first opposed Aristotelian reason, but then incorporated them into his thinking. In 1277, three years after Aquinas' death, the Church issued the last of its condemnations of Aristotle.

Over the next three centuries, Aristotelian cosmology was not only accepted by the Church, it became almost as sacred as scripture. Church scholars now talked positively about reason and spoke in favour of testing ideas with arguments. When arguments were settled however, the Church gave its verdict, the power of authoritative opinion took over. For this philosophical method, which is sometimes referred to as “scholasticism”, the old habit of deference to authority was hard to break.

Church authority however, did eventually weaken and crumble, beginning in earnest from the 16th century. In 1543, the orthodoxy was hit by Copernicus' model of the solar system with the Earth at its centre. Then Kepler's version of 1609 added more mathematical accuracy and spoke only of free moving planets in space. Aristotle's universe of rotating crystalline spheres began to look like a fantasy, and with it the whole scholastic method would fall.

The New Instrument

In 1620, an English intellectual and politician wrote a book called *Novum Organum*, which means new instrument (or method). The title alludes to Aristotle's original book on method, which was called the *Organum*. The new method aimed to break through the limits of scholasticism, which had become associated with long, fruitless discussions of trivialities.

The book's author, Francis Bacon, was Lord Chancellor in the court of King James I of England. The following year, when he was 60 years old, he was found guilty of corruption and retired from public life. As a skilled and perhaps cynical social climber, Bacon had a pessimistic view of human nature. He thought that people were gullible, vane and self-serving. That is really why, when it comes to the pursuit of knowledge, a strict method of enquiry is needed. It minimises the effect of personal flaws.

Novum Organum is the culmination of a fresh idea. The cover illustration on its early editions has an interesting metaphor. A ship is sailing through the Pillars of Hercules (which mark the boundary from the Mediterranean to the Atlantic) while another is returning in the opposite direction. In his political life, Bacon represented that part of England that turned away from Europe and looked to the new world. He had been an inspiration for the founding of colonies in America. Now he is playing on the philosophical parallel. He is turning away from classical European ideas to a new world of discovery.

Like the ventures that crossed the Atlantic, Bacon's method would require big investment for big rewards. It was also considered to be practical. He argued that science would bring technological advances, which would add to the prosperity of the nation. While Philosophy seeks knowledge for its own sake, knowledge itself can be put to other uses. Bacon is reported to have said “Knowledge is power”.

Novum Organum describes a model for a community of scientists, with data gatherers at the bottom, and different kinds of theorist arranged hierarchically. It is all about observation first. To study a subject properly, Bacon argued, you must interrogate nature, by observation and experiment. Once you have the information you can begin the task of making sense of it. His ideal community of scientists worked like an efficient business, with data coming in and knowledge coming out.

There were several aspects to Bacon's method. One for example, was that of designing crucial experiments, whereby if you had two possible explanations of something you would design an experiment that would prove one and disprove the other. Another aspect of his method was listing qualities and examples. For example, if you want to study heat, you make a list of all the hot things you can think of, then all the cold things, and then systematically compare them.

The first of these, designing crucial experiments, has become the ideal standard of the scientific method, the second, that of comparing lists, is rarely if ever used. For this reason it is usually said that the Baconian method was short-lived, which is true if you are talking about the specifics and the package as a whole. I think however, that this slightly misses the point.

In reaching for Bacon's ideal, many scientists, like those of the Royal Society, developed the practical method we know as science today. What defines it is not this or that particular procedure, but the idea of empirical research followed by measured, defensible advances in knowledge.

Bacon died in 1626. Just six years later, in Italy, Galileo published a book called “Dialogue concerning the two chief world systems”. The two systems in question were the Copernican model of the solar system, with the Sun at the centre, and the Ptolemaic model, with the Earth at the centre. One is defended on the grounds of empirical evidence, the other, through the character of Aristotle, is defended with supreme confidence in pure reason.

Galileo was a member of a group of thinkers in Rome called the Academy of the Lynxes, founded in 1603. The Lynx is an animal reputed to have excellent eyesight, and this is a clue to how Galileo and the Academy thought. Knowledge must be based on observation. Even if your first observations are good, over-indulging your rational mind can construct grand systems that are highly likely to go wrong. You must always return to observation, and if there is a conflict between reason and observation, it is observation that must prevail.

A sign that the Church was now tightly wedded to the Aristotelian model of the universe is the fact that Galileo was subject to the “Inquisition”. Over the previous century opposition to the Church had become so strong that it responded with a system of courts and punishments. Now even Galileo, who made no arguments about religion, was attacked for questioning Aristotle. He was forced to publicly renounce his views and kept under close guard for the last nine years of his life.

When the Royal Society of London was created in 1660, it cited Bacon as its inspiration. This was the first significant group of scientists to break away from the Aristotelian orthodoxy, which still dominated the Universities of Oxford and Cambridge. It is symbolically significant that it broke from these centres of Medieval thought and was born in London, the heart of the new economy. Its early members include monumental figures in the early history of science like Robert Boyle and Isaac Newton.

Newton's *Principia Mathematica*, published in 1687, gave the world its first great breakthrough in understanding how the physical universe actually works. Whereas Aristotle and the ancient cosmologists had great faith in their rational imaginations, Newton followed Bacon. His motto was “I do not hypothesise” (*Hypotheses non fingo*). His book describes mathematical relationships between observable things and makes empirically testable predictions.

Idealism

Rene Descartes loved the new ideas about the world. It's thought that as a 14-year old in 1610, he wrote a poem for a school performance celebrating Galileo's discovery of the moons of Jupiter. He went on to study all the sciences, particularly mathematics. He is commonly credited as the inventor of “analytic geometry”, the use of coordinates to describe movement in space.

The question of whether any of this knowledge was actually true, bothered Descartes. He wanted certainty. In 1641 he wrote what he called his “meditations”, which some say is the foundation of modern Western philosophy. These are his “epistemology” (see essay 5 in this series), but in the process he produced an important metaphysical idea called “Dualism”.

From Aristotle to the New Method, the assumption was that the universe was nothing but matter in motion. This is “materialism”. You can see it as a kind of Monism because only one substance, matter, exists. Descartes said that we have ideas about the material world, but the ideas themselves are crucially different. They are made of an entirely different substance. The universe is made of two things. This is Dualism.

It is two objections to Dualism that are important for the development of modern natural philosophy. The first of these is associated with a man called Berkeley, an accomplished and respected academic who went on to become a Bishop. The second is associated with a man called Hume, who we will come back to later.

To understand Berkeley's response to Dualism it is helpful to understand a commonly held distinction at the time, between “primary” and “secondary” qualities. Primary qualities are things like the shape and size of material objects. They stay the same whether or not anyone is observing them. Secondary qualities are things like smell and colour, which vary according to experience. Dualism held that primary qualities belong to the material world, while secondary qualities belong to the mental world.

Berkeley attacked the distinction. If you see a red triangle he said, you can't separate its redness, a secondary quality, from its shape, a primary quality. You see that it is red, and you see that it is a triangle. It is one experience and all its qualities are experienced in exactly the same way. If we get rid of this distinction between primary and secondary qualities, we have to decide which way to go. Berkeley decided that all our experiences are what the conventional wisdom would call “secondary” qualities. They depend on the observer.

Our words, according to Berkeley, label bundles of sensations, which we imagine have corresponding physical objects. There is no good reason to believe that these objects we imagine have anything in common with these bundles of sensations nor any role in causing them. So the most reasonable response is what he called “Immaterialism”, or what is commonly called “Idealism”.

While its true that Berkeley was religious, his ideas should not be thought of as belonging to religion. It's true that he disliked the way that the new scientific method distanced people from God. Its also true that he believed Idealism was the best argument for God. To explain this point: Idealism left one question unanswered which is this: if ideas don't come from the material world, where do they come from? Berkeley found “God” the best and most satisfying answer to this question.

However, the point of Idealism itself, has nothing to do with God. The argument is that we can say nothing about anything unless it is perceived. Ideas are bundles of qualities we experience. Where they come from is entirely a matter of belief, and there is no absolute way to rationally judge such beliefs. We have no good reason to believe they are caused by anything material.

Samuel Johnson, the celebrated English writer, while talking to his biographer about Berkeley's idea, kicked a rock, declaring “I refute it, thus”. Both men agreed that Berkeley philosophy was wrong, however, they both agreed that it was irrefutable. The rock kicking incident makes it clear that Samuel Johnson believed in the physical world. The point however, is that this is a belief. There is no way to judge whether it is true or not. You are free to believe in the physical world, but you have to admit, there is no more valid reason to believe in it than not to.

Later philosophers, such as Kant and Hegel, accepted and reiterated this point. In the 20th century the schools of thought known as Phenomenology and Pragmatism, also followed this argument. These 20th century schools argued that there *is* a physical world, but we can say nothing meaningful about it, so to avoid unsubstantiated arguments, it is generally safer to ignore it.

Modern Science

The second response to Dualism was made by David Hume. To understand it, it is helpful again to think about the distinction between primary and secondary qualities. Berkeley collapsed the distinction making everything, so to speak, secondary qualities. What if we went the other way?

In his book *A Treatise Of Human Nature*, published in 1740, Hume argues that humans are products of nature, and this includes the ideas in their minds. He collapses the distinction between primary and secondary qualities in favour of primary qualities. If we think of the mind as made of matter in motion, it can, in theory, be explained by science. Hume is not just talking about describing the rules of logic (a common pursuit of the ancient and scholastic philosophers), he believed science could explain things like perception, causation, morality and beauty.

Having absorbed this idea, what happened next to modern natural philosophy is best understood through the instructive debate, which began in the 1840s, between William Whewell and John Stuart Mill.

Whewell argued that observation alone gives us very little knowledge. Consider the fact that every event is unique, no two apples will fall identically, even their separation in time and space is a difference. In order to even think of them as the same we must be using our rational minds. This idea of identity, like causation and all the rules of logic must exist before we observe anything. Without some ideas in our minds we would be simply unable to make sense of our observations.

Mill defended the idea that observation is the source of knowledge (an idea sometimes called “empiricism”) but couldn't refute Whewell's argument. Our minds must make sense of observations, he argued, so the point was to understand how and so constrain our imaginations to produce reliable knowledge. He developed rules to test the validity of an observation, for example, if two events have only one potential causal factor in common, then that factor can be assumed to be the cause of the events.

Whewell and Mill were really not so far apart. Their debate has been described as about the relative powers of “inspiration” and “observation”, respectively. The differences of degree can be used to illustrate the value of a distinct and productive balance that produced an explosion of discovery over the following decades. In 1832, Whewell had first used the word “scientist” to describe the pioneers of the new spirit of systematic enquiry. The 1840s-50s saw an explosion of research and scientific publications.

The method in practice can be seen to owe something to both Mill's and Whewell's arguments. Science starts with an initial idea. It doesn't really matter where this idea comes from (although if it comes from sound observations it is more likely to be worth pursuing). We can call this idea the “hypothesis”. By applying reason to the hypothesis it is possible to make testable predictions.

As science softened its disdain for “hypotheses”, the connotations of the word changed. While for Newton it meant allowing the imagination to run wild, it now simply meant the generation of ideas prior to testing. The new method is often now described as “Hypothetico-deductive”. It is not concerned for the source of a hypothesis, only for the predictions that can be deduced from it. It is the constraints of testing that are important, and allow the accumulation of knowledge to proceed steadily.

This is how many people saw science until 1917. It elaborated an ever richer and ever more reliable picture of the world. Above all this picture was, as far as most people were concerned, simply true. This belief was not based on epistemological theory, so much as growing confidence created by the quality of the ideas science produced. The materialist basis of science seemed to be confirmed by the enlightening power of its products.

Following Hume and the Whewell-Mill debate, there was no reason to think science could not be used to explain anything, including human ideas and behaviour. By the end of the 19th century, the work of Wundt, James and others, had given rise to Psychology. There were also prominent theories of group behaviour, such as the Sociology of Durkheim and the Political Economy of Marx. Looking back, it seems that confidence in science was at all all-time high.

New and old challenges

The tide broke in 1917, with the publication of Einstein's General Theory of Relativity. This new model of the universe had a different concept of time and space to Newton's. Suddenly, it felt like the philosophical foundations of science, built over the preceding centuries, were weaker than they appeared. If Newton's law-governed universe could turn out to be wrong (or at least not universally true), where did that leave the other products of the new scientific age? Can we have any faith in its method?

In 1934, Karl Popper published an influential book called *The logic of scientific discovery.* It went some way to rebuild confidence in science. He argued that even the hypothetico-deductive method can build grand systems of ideas on weak foundations, unless we put more constraints on our imaginations. The problem, Popper said, was verification. There is a natural human tendency to want to be right. It inclines us to make observations and design experiments to verify hypotheses we already believe in. What scientists should do (as the best already do) is something that seems quite unnatural. They should try to prove their ideas wrong.

It doesn't matter how many times your observation confirms your hypothesis, you can't show that it is true. It only takes one observation to show that it is false. We should believe something only to the extent that we have failed to show that it is not true. “Falsification” is the extra constraint that science needs.

Popper cited Freudian Psychology and Marxist Social theory as examples of “pseudo-science” because their theories are non-falsifiable. That is to say, they are too flexible and imprecise to be tested, so they thrive on faith. In contrast, Popper cites Einstein's theory, which hypothesised the deflection effects of light bent by gravity. It gave predictions of the position of objects in the sky on which the theory would stand or fall. Such predictions are falsifiable and therefore make it true science.

It remains questionable whether modern scientists fully understand and put into practice the constraints of “hypothetico-deductive falsification”. I think there is some evidence that they do not, judging by the way some contemporary physicists talk with great confidence about things which are non-falsifiable and rest on weak evidence, like dark energy and multiple dimensions.

When it comes to serious challenges to the power of science, two big ones stand out. There are, in my view, two questions on which science seems to struggle. To put this another way, modern natural philosophy has told us a lot about how the world works, yet some questions seem to be tricky and persistent. Here are two:

Consciousness

Modern science is based on materialism (this is its “metaphysics”). It depends on the idea that ideas themselves can be explained scientifically. Is this really possible? Perhaps more has been said on this issue than the whole of the rest of Western Philosophy combined. That's one reason why it is usually regarded as a branch of philosophy in its own right, called the “Philosophy of Mind”.

To explain the problem as simply as possible: we humans have a feeling that we call awareness, or consciousness. This includes the feeling of particular things, like colours, sounds, etc., that we can call “qualitative” experience. We also have a feeling that we call “freewill”. These things don't feel like physical phenomena in the way that say, a mountain or a falling apple does. It is far from obvious how a world of nothing but matter in motion could create such feelings.

Two significant ideas have been put forward. “Eliminative materialism” is the idea that mental states don't really exist. This sounds strange but can be grasped if you think about particular examples. Suppose for example, I see a cake and I decide to eat it. Visual perception, neurone firing, changes in brain and blood chemistry and eventually some action of my body will happen. These are all physical phenomena. If I were to think about it afterwards, or if someone was to ask me what I felt, I might say “desire”. This makes the mental state of desire seem like a thing in itself. In fact, it is only that particular bundle of physical phenomena.

Eliminative materialism fits well with an approach to Psychology called “Behaviourism”, which says that human behaviour can be studied scientifically without bothering about the difficult questions of consciousness. Behaviourism was quite strong for decades until the emergence of computing in the late 20^{th} century. That was when Psychologists and Philosophers latched on to computers as a new way of talking about the mind.

In the 1960s, Hilary Putnam, a computer scientist, proposed an idea that became known as “Functionalism”. When I run a program on my computer it interacts with other programs and moves the computer through a series of states. These “machine” states and its overall behaviour can be completely explained in the language of computer programs. In other words, every machine state can be explained by another machine state. Lower level phenomena: bits, switches, microchips, etc., are irrelevant.

Functionalism thinks of the human brain as something like the chips and bits of a computer, while the human mind is like a computer program. Human consciousness is a continuous series of mental states, like the machine states of a computer. The neurones of the brain, like the chips of a computer, exist but are largely irrelevant to explaining its behaviour. In this way, Functionalism can be said to improve on Eliminative Materialism because it does not deny the existence of mental states. On the other hand, it doesn't really explain awareness, qualitative experience and freewill.

More recently, the physicist Roger Penrose has suggested that these question may be answered at the sub-sub-atomic, or “quantum” level of the physical world. The idea has clearly been lingering in the back of a lot of people's minds given the positive response it got, despite the fact that Penrose himself says it is nothing more than a suggested direction of enquiry. Perhaps we have not been able to understand consciousness because it lies at a physical level we are only just discovering. Perhaps quantum physics can provide clues to the problem.

Indeterminacy

This brings us neatly to the second great challenge for modern natural philosophy. In 1927, the physicist Werner Heisenberg wrote a radical interpretation of an experiment first conducted 18 years earlier. The experiment involved releasing a beam of light from a coherent light source (only one wavelength), which is then split and sent through two slits cut in a screen. A second screen then records the impact of the light as waves passing through the slits cross paths. As expected this produces an interference pattern of dark and bright lines, as waves cancel each other or add to each other, respectively.

Light however is made of particles, or rather quantum units called “photons”. When a single photon is released in this experiment it has a 50% chance of passing through a particular slit, but where it will hit the screen is unpredictable. Except however, when the process is continuously repeated. The probability of a photon hitting one part of the screen is greater than another, in accordance with the interference pattern that would be produced by waves. If repeated often enough the screen will show the particular pattern you would expect from waves according to their angle of interference.

The theoretical problem however, is that photons released at intervals are not waves. How can individual particles separated in time show wave-like interference? Scientists now claim that it isn't only photons that behave in this way, but a host of sub-atomic particles. They seem to effect each others behaviour in a way that defies our idea of time. On top of that, when physicists found a way of detecting which slit the photon had passed through, they found that detecting it prevented the interference pattern from forming.

The Heisenberg interpretation of this is expressed in observational terms. At the quantum level, objects do not have a position *and* a direction of travel, they have one *or* the other. When the screen in the experiment detects the photon it fixes its position. Before this moment the photon does not have a position, it only has a direction of travel. This is not uncertainty, that is to say, it is not that we don't know where the photon is. It is “indeterminacy”, the photon does not have a position.

The idea re-ignites the old metaphysical debate. If where photons are is determined by where we look, then our minds are shaping reality. This sounds like I'm saying that our minds are changing the physical world, but that would be magical. Instead, try to imagine that the physical world has many potentials and our minds construct the one we actually live in. At every moment that we stop a photon we are choosing to be in the world in which it is in that position. Heisenberg saw the split-light experiment as direct evidence for Indeterminacy, which could be thought of as a new form of

Idealism.

Conclusion

The scholastic thinkers of medieval Europe followed Aristotle. Although they were deeply religious, they separated those beliefs from their attitude to the physical world, which they thought of as consisting of real, material things that move, change and bump into each other. In short, they believed that the world is matter in motion. The problem was not their metaphysics but their method. It relied too much on imaginative reasoning and authoritative opinion.

From Bacon to Newton, the advocates of the new method insisted on observation and experiment, driving science forward. Descartes set out on a quest to use his reason to find certainty (*see pedagogic essay 5*) and ended up with an idea of the universe made of two substances. This idea became known as “Dualism”, which can be summarised like this: there is a physical world of matter in motion about which we can do science, and there is an immaterial world of the mind.

It was two responses to Dualism that moved natural philosophy on. The first was from Berkeley, who followed Descartes' initial conclusion that it is only the mental world we can be certain of. He argued that if we can't be certain of the physical world then its existence is a matter of belief. On matters of belief one choice is as valid as another and Berkeley himself chose to reject the physical world. This was Idealism, and was later developed by Kant and Hegel.

The second response to Dualism was from Hume, who argued that there is no immaterial world of the mind, only matter in motion. In fact, as our methods improve the mind itself will be explained scientifically. The question of method peaked in the mid-19th century debate between Whewell and Mill, which helped to crystallise the “hypothetico-deductive” method. Around this time, science bloomed, spreading even into the realms of society and the psyche.

The early 20th century was hit by the unsettling effect of Einstein's revolutionary theory of General Relativity. The collapse of the Newtonian orthodoxy showed that even modern science could generate grand and ultimately false ideas. In response, the idea of “falsification” was put forward and acknowledged, although it remains questionable whether scientific imaginations are really being adequately constrained.

We should also note the tendency for orthodoxies to develop in large scientific communities, which can be conservative and tend to fudge or ignore difficult questions. The two biggest difficult questions, in my opinion, are Consciousness and Indeterminacy. While they linger unanswered there is a tendency for supernatural ideas to creep back, which can undermine philosophy itself.

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