UNDERSTANDING PHILOSOPHY OF SCIENCE

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London and New York

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Introduction

In many ways, our age is no different from any other: most people work hard merely to survive, while a few live in the lap of luxury; many perish in wars and conflicts, the causes of which they have no control over; the cycle of birth, reproduction and death is fundamentally the same for us as it was for our distant ancestors. Yet certain features of the contemporary world are quite new: for example, I can pick up the phone and speak to a relative on the other side of the globe, and I can see that it is indeed a globe that I inhabit by looking at a photograph taken from space; many people's everyday lives are enhanced by, and unimaginable without, computers, televisions and music systems; medicine can treat forms of illness and injury that would have brought certain death for earlier generations. On the downside, but equally unprecedented, the nuclear weapons that many countries now have are sufficient in number to wipe out almost all life on the planet, and our skies and oceans are polluted by substances that only exist because we make them in chemical factories.

Whether good or bad in their effects, none of these technologies would exist without science. It is possible to develop ploughs, wheels, bandages and knives without much in the way of theory, but without the scientific theories and methods developed mainly in the last few hundred years there would be no electronic devices, spacecraft, micro-surgery or weapons of mass destruction. The products of science and technology have a huge effect on the way we live our lives and how we shape our environment; if you are in any doubt about this try and imagine going through an average day without using anything powered by electricity or containing plastic.

The importance of science does not only derive from its use in technology. Science enjoys unparalleled prestige in society compared with other institutions, and everyone is likely to agree about the need to fund and understand modern science while many may deride modern art or literature. Furthermore, most people are likely to trust the word of a scientist much more than they do that of a journalist, lawyer or politician (although that may not be saying much). Rightly or wrongly, science is often thought to be the ultimate form of objective and rational inquiry, and scientists are widely regarded as being able to gather and interpret evidence and use it to arrive at conclusions that are 'scientifically proven' and so not just the product of ideology or prejudice. Courts do not convict or acquit someone of a crime on the say-so of a priest or a novelist, but they do routinely rely to large extent on the evidence of an expert witness who is a scientist of some sort; if a ballistics expert says that a bullet came from a certain direction, or a pathologist says that a person had a certain drug in their system when they died, their testimony will usually be taken as establishing the facts of the case. Most of us consult a doctor when we have something wrong with us and if the doctor prescribes some drug or other therapy we take it assuming that it will help with our symptoms and not itself cause us harm. Often, modern medicine is explicitly claimed to be 'evidence-based' and hence scientific. Similarly, if the scientists appointed by the government say that a particular food or chemical is unsafe, its use and sale will be banned.

The examples above concerning justice, health and safety could readily be expanded to cover activities from engineering and construction to fishing and farming. Hence, in almost all areas of modern life, people are likely to seek or rely indirectly upon the scientific evidence and the opinions of scientists before making important decisions. Whether or not we as individuals share this faith in science and scientists, our lives are enormously affected by it, and this is one reason why understanding and thinking about science is important. Of course, most of us know very little science, and the degree of specialisation within particular sciences is now so great that no individual could possibly know all there is to know about any one scientific field let alone all about science in its entirety. For this reason, we have no choice but to rely upon co-operation and co-ordination between many individuals in order to develop further and apply

scientific thought. However, there are some features of science that are more or less universal and which we can investigate philosophically without needing to know much about the cutting edge of scientific research.

Before thinking about what philosophy of science is about, it will be helpful to say what it is not about. Obviously, there are important ethical questions raised by scientific research, such as whether it is morally acceptable to conduct experiments on animals that cause them suffering, or to give psychiatric patients treatments when they may be incapable of giving their informed consent. Similarly, there are important social, political and economic questions about what research to fund and what not and, for example, whether or not to build nuclear power stations, and whether the genetic engineering of plants and animals is ethical or practically advisable. Although science policy and the ethics of scientific research ought to be informed by the philosophy of science, and indeed are part of the philosophy of science broadly conceived, they are not addressed here. Furthermore, as philosophers, we are not primarily concerned to make progress in any of the particular sciences (although philosophical thinking has often affected how work in the particular sciences is carried out and philosophical inquiry sometimes overlaps with theoretical science).

While there are other disciplines that study the sciences, the types of questions they address and their means of trying to answer them are different from those in the philosophy of science. Questions about, for example, the development of particular scientific disciplines and theories need to be addressed by historians of science, not philosophers. On the other hand, questions like, 'what sort of personality makes for a good scientist?' or 'what role do journals play in the communication and assessment of theories in physics?' are matters for the psychology or sociology of science, respectively. Philosophical questions about science, like philosophical questions in general, cannot be answered by going out in the world and gathering information, and finding out what happened, or how a particular scientific community is, as a matter of fact, organised; rather, philosophical inquiry proceeds by analysis, argument and debate.

This characterisation of history, sociology and psychology as empirically based and distinct in both subject matter and method

from philosophy is itself philosophically controversial. Many philosophers think that the traditional conception of philosophy as a subject based on armchair reflection is untenable and that philosophy is really continuous with empirical inquiry and science itself (this view is known as *naturalism*). On this view, questions about scientific methodology and knowledge in philosophy of science are really continuous with questions in cognitive science about how human beings reason and form beliefs. However, one need not imagine an absolute distinction between philosophy and empirical forms of inquiry to appreciate the broad differences between the latter and the study of philosophical questions that arise when we reflect on science.

Of course, this characterisation is of little use unless we know what science is, so perhaps the most fundamental task for the philosophy of science is to answer the question, 'what is science?'. Given the status of science, this question is of great importance and many philosophers have sought to provide an answer so that it can be used to assess whether beliefs that are claimed to be scientific really are. The problem of saying what is scientific and what is not is called the **demarcation problem**. Some people have claimed scientific status for beliefs and practices, such as those of astrology, creationism (the doctrine that God created the Earth a few thousand years ago as stated in the Bible), Marxism and psychoanalysis, and some philosophers have wanted to be able to show that they are not scientific, that they are in fact merely pseudo-scientific. It is usually thought that if there is anything of which science consists it is a method or set of methods, so the study of scientific method (known as **methodology** of science) is at the centre of the philosophy of science.

We may not yet know how to define science or how to tell whether certain contentious activities or beliefs count as scientific or not, but we certainly have lots of examples of sciences. It is usual to divide the sciences into two types, namely the natural sciences and the social sciences. The former have as their object of study the natural world and include physics, chemistry, astronomy, geology and biology; the latter study the specifically human or social world and include psychology, sociology, anthropology and economics. Because the social sciences study the behaviour and institutions of human beings, they must deal with meanings, intentional actions and our apparent free will; hence, the philosophical questions they raise are often quite

different from those raised by the natural sciences. Furthermore, it is an important issue in the philosophy of the social sciences whether or not a subject such as sociology is, can, or should be, scientific. Such questions do not arise for the natural sciences – if anything is a science then physics certainly is. For the purposes of this book (and here I follow standard practice) the philosophy of science is the philosophy of natural science, although many of the topics to be discussed are of concern in the philosophy of social science as well.

Philosophy of science as epistemology and metaphysics

Apart from any philosophical interest that we may have in science because of its status and influence on our lives, science is important to philosophy because it seems to offer answers to fundamental philosophical questions. One such question is 'how can we have knowledge as opposed to mere belief or opinion?', and one very general answer to it is 'follow the scientific method'. So, for example, whatever any of us may believe, rightly or wrongly, about whether smoking causes cancer or traffic fumes cause asthma, a government will not act unless there is scientific evidence supporting such beliefs (of course, they may still not act even when there is evidence). Similarly, in all the examples mentioned above, respect is accorded to the views of scientists because their conclusions are supposed to have been reached on the basis of proper methods of gathering and assessing evidence, and hence are supposed to be justified.

The branch of philosophy that inquires into knowledge and justification is called **epistemology**. The central questions of epistemology include: what is knowledge as opposed to mere belief?; can we be sure that we have any knowledge?; what things do we in fact know?. The first of these is perhaps the most fundamental epistemological question. Each of us has many beliefs, some true and some false. If I believe something that is, as a matter of fact, false (suppose, for example, that I believe that the capital city of Australia is Sydney) then I cannot be said to know it. In logical terminology we say a **necessary condition**, that is a condition that must be satisfied, for somebody knowing some **proposition** is that the proposition is true. In other words, if somebody knows some proposition then that

proposition is true. (The converse obviously does not hold; there are lots of propositions that are true but which nobody knows, for example, there is a true proposition about how many leaves there are on the tree outside my window, but I presume nobody has bothered to find out what it is.) Where someone believes something that turns out to be false (no matter how plausible it seemed) then we would say that they thought they knew it but that in fact they did not.

Suppose too that another necessary condition for somebody knowing some proposition is that he or she believes that proposition. We now have two necessary conditions for knowledge; knowledge is at least true belief, but is that enough? Consider the following example: suppose that I am very prone to wishful thinking and every week I believe that my numbers will come up on the lottery, and suppose that one particular week my numbers do in fact come up; then I had a belief, that my numbers would come up, and it was a true belief, but it was not knowledge because I had no adequate reason to believe that my numbers would come up on that particular week rather than on all the other weeks when I believed they would come up, but when they did not. Hence, it may be the case that I believe something, and that it is true, but that I do not know it.

So it seems that for something someone believes to count as knowledge, as well as that belief being true, something else is required. My belief about the lottery in the example above did not count as knowledge because I lacked an adequate reason to believe that I would win that week; we would say that my belief was not justified. The traditional view in epistemology has been that knowledge can only be claimed when we have an adequate justification for our beliefs, in other words, knowledge is *justified* true belief. Although recently this 'tripartite' definition of knowledge has been the subject of much criticism and debate, justification is still often regarded as necessary for knowledge. This brings us to the issue of what justification amounts to and, as suggested above, justification is often thought to be provided by following scientific methods for testing or arriving at our beliefs (the word science comes from the Latin word *scientia*, which means knowledge).

So one area of philosophy that overlaps considerably with philosophy of science is epistemology. The epistemological questions that are addressed in later chapters (along with some of the competing

answers to them) include the following. What is the scientific method? How does evidence support a theory? Is theory change in science a rational process? Can we really be said to know that scientific theories are true?

If we accept the idea that science really does give us some sort of knowledge then we must examine what scientific theories tell us about how the world is, and decide what is the scope of scientific knowledge. The modern scientific picture of the world seems to tell us a great deal, not just about how things are now, but how they were millions and even billions of years ago. Astrophysics tells us about the formation of the Earth, the solar system and even the universe, geophysics tells us about the development of mountains, continents and oceans, and biochemistry and evolutionary biology tell us about the development of life itself. Such scientific theories tell us more about familiar things, so, for example, we may learn where a particular river used to flow or how bees pollinate flowers. However, scientific theories, especially those in physics and chemistry, also describe entities that are not part of our everyday experience, such as molecules, atoms, electromagnetic waves, black holes, and so on. Such theories raise particular problems and questions in the philosophy of science; for example, should we believe in the existence of such esoteric and unobservable entities, and if so, what is to count as evidence for their existence and how do we manage to refer to them?

Of course, science does not just describe the world; it also gives us explanations of how and why things are as they are. Often this involves describing unobservable causes of things we observe. Hence, Newton is not famous for discovering that unsupported objects fall to the Earth, he is famous for explaining why they do so (the gravitational force is what causes apples to fall out of trees), and for giving us a law that allows us to calculate the rate at which they do so. Newton's mechanics, like many scientific theories, is formulated in terms of a few fundamental principles or laws. Central to our understanding of science is this idea of *laws of nature*; for example, it is supposed to be a law of nature that all metals expand when heated. So science seems to tell us about the ultimate nature of things, what the world is made of and how it works. It has even been thought that science has replaced **metaphysics** not just by telling us about what exists, and explaining what happens in terms of laws of nature

and causation, but also by answering other fundamental philosophical questions about, say, the nature of space and time. But what exactly is a law of nature, and what does it mean to say that something has caused something else? What is it to explain something?

Many philosophers and scientists take it for granted that the aim of science is not merely to describe what we see, but also to arrive at the truth about the unobservable entities, laws and causes that lie behind the phenomena we observe. On the other hand, there is also a long tradition of disregarding questions about the real nature of things, the laws of nature and so on, and emphasising instead the search for theories that accurately predict what can be observed, without worrying about whether they are true or false beyond that. The question on which this book will focus is, 'ought we to believe in the unobservable entities postulated by our best scientific theories?', or more crudely, 'do electrons really exist?'. You might think this question makes little sense because electrons are, in fact, observable. After all, don't television sets work by firing electrons at a phosphorus screen, and so don't we, indirectly at least, observe electrons all the time? Exactly what is meant by observability will be discussed in the latter part of Chapter 6; however, it ought to be clear that electrons, atoms and the like are not observable in the same way that tables and trees are. Scientific realism is the view that we should believe in the likes of electrons, whereas scientific antirealism is the view that we should stop short of believing in the truth of scientific theories and content ourselves with believing what they say about what we can observe. In trying to decide the issue of scientific realism we will have to address all the epistemological and metaphysical questions mentioned above along the way.