14.A: the ***PhilosophyIdeas*** overview of

The Basis of Science

Philosophers want to understand everything, which requires knowledge, and science has triumphantly generated a lot of that. Hence philosophers are interested in how it was done, since science offers a model of successful rational thought. Practitioners tend not to be interested in their presuppositions, but that is the first port of call in philosophical study. We will consider some basic concepts on which science is built: observation, evidence, demonstration, experiment, falsification, anomalies, prediction, and accommodation to data.

A simple model of science prevailed for a long time, saying that we first observe things, then spot a pattern, then predict, then check the prediction, and this confirm a theory. The earliest doubts about this arose when the nature of **observation** was considered. We quickly see that what people observe depends on what they expect to see, which depends on prior knowledge, presupposed theories, language, habit, and downright prejudice. People 'saw' stars as equidistant from us, but now we 'see' galaxies and huge variations in their remoteness. We observe colours according to the conventional divisions used in our culture. We fail to observe fine gradations of snow, if our language doesn't cater for that. We tend to treat modern observation as numerical measurement, but this works less well for biology. Achieving true objectivity in observations is either hopeless, or needs a huge extra effort, to take account of all of these problems. Maybe we need a 'holistic' view, which sees theory and observations as a single united system.

We are familiar with the arrival of scientific methods in the seventeenth century, but a key part of this was the arrival of the modern idea of **evidence**. This accompanied a new interest in probability, because that could be increased or decreased by evidence, without arriving at certainties, which had been the previous aim (often achieved by appeals to authority). Law courts became more scientific at the same time, when they sought solid evidence, rather than accusations. Thus science became more empirical, but the same problems arise that we find with observation. If you believe a daft theory, you will interpret evidence in a daft way to fit it. We talk of 'weighing' evidence, and build the fragments into a single whole that could be 'flimsy' or 'overwhelming' – which needs the rather vague idea that evidence is 'coherent'. Observed evidence also 'points' to what is not observed, and even to what is unobservable, so the interpretation of evidence becomes even more important than its initial observation. Especially challenging is an apparent conflict between pieces of evidence, and appropriate weight must be given to negative evidence, and evidence from 'thought experiments'. One suggestion is that *all* beliefs should rely on evidence, but some of our most general beliefs (of laws of nature or morality or politics) far outrun the available evidence.

Once we have achieved a set of observations, and interpreted them as evidence for some coherent picture (battling to achieve objectivity by weeding out presuppositions and prejudices), we must then build on them in the quest for understanding. Nowadays we build 'theories' (a separate topic) but the earliest idea was that you aim at a **demonstration**, which proceeds from a secure starting point, and shows how things in general must be. The idea is to track the links (of inclusion or causality) among your discoveries, and if you can deduce the intrinsic nature of each thing, then you can show what must follow from it. Hence you start from comprehensive definitions, and hope to arrive at a set of necessary truths about nature. The obvious difficulties with this are to know the true 'nature' of each thing, and the excessive optimism of hoping that we can logically deduce the whole picture. The arrival of fragmentary evidence and probabilities has pushed us away from this view.

The big discovery of the scientific revolution was the idea of an **experiment**. This is not completely novel, because we all experiment in daily life (when we try things in cooking), and we take things apart to see how they work, but five ingredients made scientific experiments both new and successful. The key first step is that we don't just observe nature, but *intervene* in it. The next is that we apply great *rigour* to the intervention, attending to small details. This leads to exact *measurement*, which quickly suggests the introduction of mathematics. The big advance then comes when *controlled conditions* are set up, which isolate some one feature of nature which interests us. The culminating ingredient, resulting from the precision and rigour, is that the experiment is then *repeatable* by other people. 'If you don't believe it, look for yourself'. Although we can list the ingredients of experiments, a studious attempt to precisely define the 'experiment method' has not been so successful. Science seems to be too diverse (between physics and biology, for example).

The dream of science is to understand nature by precisely identifying its universal truths. A universal truth can be destroyed by a single contrary observation, so **falsification** is an interesting pillar of scientific thought. One suggestion is to base the whole of science on it, by hunting for the one falsifier, rather than innumerable verifiers, and only believing what is still left standing. These seems too drastic, though, because a profusion of verifiers might outweigh any apparent falsifier (if that was deemed a 'miracle', for example, or it wasn't repeatable). If the truth we are proposing is widespread but not universal (that smoking causes cancer), then we will actually expect occasional falsifiers. Nevertheless, the appearance of **anomalies** in some area of study (observations that don't fit the theory, even if they don't directly falsify it) is now seen as crucial to scientific developments. Some anomalies lead to wonderful discoveries, but others eat away at our current science. A successful picture of nature can be gradually undermined as the anomalies accumulate, and a whole new picture is then needed.

Many saw confirmation of **predictions** as the key achievement of science, and the main test of its success. The famous landmarks in science are often confirmations of bold predictions (about the existence of planets, elements or particles – though no one has yet predicted a new species!). It is tempting to see science as a continuous cycle of prediction and confirmation, but the rival requirement is that good science should be an **accommodation** with the data that is already discovered. Evolution, for example, seems hopelessly unpredictable, but offers a story intended to fit what we have long observed. Prediction may be no more than coming to realise important gaps in the data that needs to be explained. Both procedures are responses to the detection of patterns, in daily and experimental experience. The strength of accommodation is that it explains, which mere prediction may fail to do.