Scientific Theories

A theory is an imaginative leap to what is really going on behind what we observe. A theory may be no more than a proposal for a hidden mechanism or process, but scientific theories have become increasingly complex and formal, especially in those sciences dominated by precise measurement and mathematics. Philosophers are interested in how theories are true, the criteria applied to produce good theories, whether there are unique correct theories, and whether theories can be accurately compared.

Theory **construction** has several different aims, which can come into conflict. The best known aim is prediction, but theories are also meant to fit the known data, to explain and illuminate, and possibility reduce something baffling to something that is known. Theories also differ in how deep they are allowed to dig, and how speculative they can be. Conservative theory-making just aims at 'empirical adequacy', which is giving an account that fits only what has actually been observed. Bolder theories either speculate about hidden mechanisms, and then infer what else those mechanisms might do, or they follow the mathematical patterns found in the observations, to deduce further areas of reality that are beyond our reach. Most theory-making dreams of converging on something very simple, such as a universal mechanism, or one or two equations which fit all of the phenomena.

A close relative of scientific theorising is the construction of **models**. The aim of modelling is in some way to copy or 'map' an area of reality. Models differ in how abstract or idealised they are – that is, how close to or far away they are from their target. Thus a photograph models its reality quite closely, but a set of graphs is much more abstract. Good models are usually held to be 'successful', 'accurate', 'useful' or 'illuminating', but they are rarely described as 'true'. This may be because they only offer a parallel to the real structure, but without offering the deeper reasons why the model functions as it does, whereas scientific theories try to show what 'makes the model tick'. Mathematical models are sets of descriptions, which are described in formal model theory, but 'semantic' models more directly represent their target. The best models aim to embrace all of the available data, with no misfits, and to then predict behaviour that has not yet been observed.

It would be absurd to expect perfect **truth** from scientific theories. They are abstract, and linguistic or formal, while the world is largely concrete and speechless. The world is endlessly complex, but theories are concise and suited to human thought. The possible truth of a theory will partly defend on what view of truth we hold. If we hold a 'robust' view of truth, we will expect a good theory to directly report how the world is. If we hold a more 'minimal' view of truth we may just look for internal criteria to judge the theory, such as its consistency. The more robust view likes successful predictions, because they offer a tangible reward for the theory's truth. There may also be a feeling that a true theory 'cuts nature at the joints', or latches onto the natural kinds of entities that we encounter, where a false theory may seem to be inventing the world's structures and categories. The minimal approach to truth more quickly focuses on the sentences expressing the theory, along with sentences expressing the observations, so that more formal criteria can be applied. The 'instrumentalist' view of theories says that the only truth there is consists of patterns in the observations. One important difference of opinion is over whether individual sentences of a theory can be true, or whether the correct picture is 'holistic', with truth applying only to complete theories. Theories need observations, but holists say that useful observations need theories, so they hang together in a single system.

If perfect truth is not available, there are other criteria we look for within a theory to indicate success. We expect a theory to have 'building blocks', the **basic ingredients** of its ontology, which are used to tell the story. Early theories were based on pure ideas, or on the concept of objects or 'substances', with intrinsic natures. The emergence of modern science introduced the idea that there are 'laws of nature', often mathematical in character, and that the 'matter' that composes nature might be revealed and understood (as atoms, and fundamental physics). Hence the security of a theory partly depends on the trust we have in its components, and theories from different 'levels' of science are expected to fit together. In modern times, the more minimal approach works with descriptions as building blocks, and so the building blocks are 'terms' and 'predicates'. We can't give up on reality if we want true theories, so these linguistic ingredients are taken to have 'ontological commitment'. That is, your belief in what is out there arises from what terms you insist on using in your theory. A recent emphasis has been on the relations and structures of the theory, rather than its objects and predicates.

If the building blocks are trusted, then theory building can begin confidently, but the possibilities are so vast that **values** are always invoked in the later adjustments that refine a theory. The best known of these is an appeal to simplicity. It is a traditional principle to prefer what is simpler (all things being equal), but reality may be complex, and it is hard to say exactly what a 'simple' theory looks like. Other virtues a theory should meet are accuracy, internal consistency, consistency with other theories, wide scope, and fruitfulness in explanations and predictions. In addition to these requirements, a theory has to fit into the background of common sense, and qualify as 'coherent'.

The optimistic view that there is one true theory for each aspect of nature has lost support in modern times. In formal theories the best that can be achieved is 'isomorphism' – many successful theories that map onto one another. Given the dependence of theories on the limitations of human language and concepts, this should not surprise us. A tougher challenge comes from questions about the **comparison** of theories. If two theories offer different proposals about the same set of concepts then comparison seems fine, but most new theories introduce new concepts, or adjust the old ones, and then there can be radical doubt about whether any comparison is possible. This problem (of the 'incommensurability' of two theories) raises questions about how you can evaluate any theory, and for some people it undermines confidence in scientific progress. Much thought in theories about language has indirectly addressed this difficulty, and the logic of how you translate language systems is a key issue. One strategy for evading big question about what a theory says is to paraphrase it, using variables instead of terms, so that it retains its general claims, without making controversial and untranslatable claims about what is fundamental.