2

INTRODUCTION TO THE PHILOSOPHY OF SCIENCE

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Chapter Contents

This chapter attempts to explain what science is by discussing competing answers from philosophers of science to six different questions.

- The first question deals with *the foundations of science*, namely, the nature of its underlying premises. We shall see that science rests on premises which are not scientific at all, in the sense that they are grounded in belief rather than experience. This conclusion raises the possibility that science and belief are somehow linked to each other and that the divide between them is, if not fictional, then at least bridgeable.
- The second question deals with *the nature of the things which science explores*. Here we shall encounter the possibility that science actually studies abstract objects, not concrete ones. If this is so, then its claims can actually be tested in theory only.
- The third question deals with *the objectives of science*. We shall see that science produces testable generalisations about its objects. However, it cannot establish their veracity with certainty.
- The fourth question is about *the evolution of scientific knowledge*. We shall notice that some philosophers take a normative position in relation to the question (how science ought to evolve) and others a descriptive one (how science actually evolves).
- The fifth question deals with *the distinction between science and other knowledge systems* as well as *between the natural sciences and the social ones*. Regardless of the answer, we might discover a tension between the philosophical and the political importance of the question itself.
- The sixth and last question deals with *the relationship between science and morality*. Here we shall examine two competing ways of ensuring that science remains moral.

By the end of the chapter, you will be able to:

- identify some of the philosophical premises upon which science rests
- outline the three main philosophical conceptions concerning the origin of objects, and describe the controversy about the nature of a scientific object
- distinguish between scientific and non-scientific explanations
- recognise the impossibility of verification or falsification of scientific claims
- describe and explicate the conflict between normative and descriptive positions regarding the evolution of science
- outline the major philosophical views about the distinction between science and non-science and between the natural and the social sciences
- explain the impossibility of drawing moral conclusions from scientific statements and describe two competing approaches to protecting science from abuse.

You may rightly wonder why a book that deals with social research should have a chapter on philosophy of science, when even books on physics or chemistry are not inclined to dedicate space to philosophical contemplations. If, as physicist Richard Feynman apparently said, 'philosophy of science is about as useful to scientists as ornithology is to birds' (unsourced), then it must be even less useful to those who study society. After all, some forms of social research do not associate themselves with science at all, others have been accused of pretending to be scientific, and even the incontrovertibly scientific ones have rarely received nearly as much respect as the 'hard' natural sciences.

Yet it is social research which teaches us that Feynman was wrong: humans are different from birds because they can reflect on themselves. Moreover, they can use such reflections to transform themselves and in doing so come to realise that they can become authors of the play in which they act.

But why does it have to be philosophy of science? Can't we just consult our experience and common sense? After all, they teach us quite a lot about science. For instance, they tell us that the term 'science' (from the Latin *scientia*, meaning 'knowledge') refers to a wide variety of knowledge-producing practices, to the community that engages in these practices, and the body of knowledge thereby produced. Experience and common sense tell us that scientific explanations differ somehow from explanations given by other knowledge systems such as everyday experience, intuition, religion, mysticism, philosophy, and perhaps even literature and poetry. Science may be fallible, but also has an unrivalled capacity to produce technology and transform our economies. Yet from time to time we may also question the morality of science.

Philosophy of science tries to go deeper than these considerations. It is the branch of **epistemology** that reflects on the particular nature of science (epistemology is the philosophy of knowledge in general; it explores the possibility of knowing, the generation and evolution of knowledge, and its validity). The classical questions it has been dealing with are:

1. What are the fundamental premises of science?
2. What is the kind of reality it could in principle explore?
3. What are the objectives of science?
4. How does it evolve?
5. What distinguishes it from other knowledge systems? What distinguishes its disciplines, particularly the natural and the social ones, from each other? In which sense, if any at all, can science claim to be superior to any other knowledge system?
6. Can it become immoral? And if so, how could we ensure that this does not happen?

This chapter has been written particularly for readers who are interested in the social sciences, although it deals with social science only as part of the wider discussion about science in general. The chapter offers a brief introductory overview of some of the most influential philosophical perspectives on each of these questions. By no means is it exhaustive; it should be seen rather as an invitation for further reading and discussion. Nor does it intend to take a position on any of the competing perspectives. On the contrary, it wishes to expand the debate, not to restrict it.

The metaphysical basis of science

Science and philosophy are different. Science is in essence an explanatory enterprise, whose explanations are said to be 'testable' (the meaning of testability and its very possibility shall be discussed later on). Philosophy may produce explanations, but it is essentially justificatory. Whatever the case, its assertions are untestable: this is what is meant when we say that it is **metaphysical**. This does not mean that scientific assertions are necessarily true. Nor does it mean that philosophical assertions are necessarily false. One thing should be clear, however: the validity of science is grounded in *experience*, whereas the validity of philosophy is grounded in *belief*.

Philosophers and scientists commonly assert that science is or ought to be (which presupposes that it can be) completely non-metaphysical (**logical positivism**, a pro-science modern epistemology, goes farther, saying that *any* assertion that is not testable by contact with an external reality is meaningless).

Others, though, take the view that science actually rests on metaphysical premises and that it could not do without them. As philosopher Daniel Dennett (1942–) put it, 'there is no such thing as philosophy-free science; there is only science whose philosophical baggage is taken on board without examination' (Dennett, 1996: 21). Box 2.1 shows some examples of premises, fundamental to science, which are essentially metaphysical.

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BOX 2.1

SOME METAPHYSICAL PREMISES OF SCIENCE

- *Ontological realism* – the belief that reality and its components exist independently of any consciousness. (**Ontology** is the branch of philosophy that attempts to answer questions regarding the existence/non-existence of things and their nature).
- *Epistemological realism* – the belief in the 'knowability' of things, which presupposes that propositions about reality must be either true or false, regardless of which is which.
- Belief in the principles of *formal logic* (A = A; A = either A or non-A; A cannot be both B and non-B) including *deductive reasoning* (**deduction** involves working out that something will follow necessarily from given premises, i.e. if A then B).

The belief in some sort of *causality*, i.e. a generative rather than accidental link between successive states of affairs (A as a result of B).

The view that science rests on metaphysical foundations has significant implications. It means that science cannot claim to be superior to metaphysical arguments, such as those based on religion. Contrary to what both atheists and religious people often maintain, science and religion are not necessarily contradictory. The two could indeed be reconciled under certain conditions. For example, the religious belief that God created an evolving world with misleading apparent traces of an infinite past and the scientific belief that this world was not created at all and really has an infinite past are equally metaphysical. Moreover, both are perfectly compatible with evolutionary explanations.

The object of scientific inquiry

Science explores reality, but not the whole of reality. It focuses on particular *objects*. Most generally speaking, the objects of science are the things it wants to explain. Philosophy of science raises some important questions about the nature of such objects and how scientists and social scientists define and study them.

The first question is about objects in general. It concerns what makes them intelligible and open to any inquiry. Another way of putting this is to say that philosophers are interested in the *epistemic possibility of objects.*

The epistemic possibility of objects

There are three main positions on this within epistemology: the empirical, the rationalist and the transcendental. Each in turn will be considered.

Philosophers who subscribe to **empiricism** regard any object as a distinct class of observable phenomena. Most (though not all) empiricists maintain that objects exist regardless of whether we have any sense or consciousness of them – they are 'out there' – quite apart from whether we know about them. Empiricism assigns cognition (i.e. our thought processes) a passive role similar to that of a camera film: our brain does not produce the object, but rather records its image. Since the object is concrete, the image is concrete too. Yet to be thought about, an object must be regarded as, at least potentially, one of many such similar things, and this requires us to use a *concept*. The idea of the general object, the corresponding *concept*, is therefore formed by a logical process known as *induction*, on the basis of repeated observations of concrete objects. **Induction** is a process of reasoning whereby a generalisation is inferred from a series of specific cases that either makes the whole group (strong induction) or is just part of it (weak induction).

Philosophers who subscribe to rationalist epistemology, in contrast, give no role whatsoever to the senses or to any external input. Rationalists regard reason as the active producer of concepts *ex nihilo* (out of nothing). They maintain that concrete objects are deduced from the general concepts that describe them, *deduction* being the logical process of drawing specific conclusions from generalisations.

Transcendental philosophy makes a synthesis between empiricism and rationalism. Invented by philosopher Immanuel Kant (1724–1804), it maintains, like rationalism, that a concrete intelligible object (also called 'the thing for us') is deduced from a general concept. However, it rejects the rationalist claim that the concept is a product *ex nihilo*. Transcendentalists argue that concepts are formed in our consciousness through a senses-mediated interaction between previously existing empty templates of reason (also called 'transcendental/a priori categories') and some unintelligible raw material of the external reality (also called 'the thing in itself'). The interaction is dialectically constructive, meaning that the templates of reason and the sense data transform and retransform each other reciprocally ad infinitum. In short, the transcendental mechanism of this interaction produces perpetually evolving concepts and objects. Contrary to what both empiricism and rationalism imply, concepts and objects are therefore not fixed. The history of science bears this out, showing that almost all the concepts and objects of science have changed over the years: how scientists think, and what they think about, has never been fixed for all time.

The role of reason in the construction of knowledge and the nature of its interaction with reality are subject to considerable dispute among transcendentalists. Logical positivists and neo-Kantians, for example, tend to assign reason a *passive* role in the construction of concepts: it simply lets itself be transformed by reality. From this follows the conclusion that the construction of knowledge is a fundamentally *individual* (non-social) process. Marxists, on the other hand, maintain that passive exposure to reality would not yield any conceptual knowledge whatsoever. They assign reason an essentially *active* role, meaning that to produce concepts it has to manipulate and transform reality. Marxists regard reality as social and natural at the same time. For this reason, they take the construction of knowledge to be a *social* process in essence.

Box 2.2 describes what empiricists, rationalists, neo-Kantian transcendentalists and Marxist transcendentalists think would happen to the cognitive development of baby A growing outside of society, but in front of a television screen that shows exactly the same content as what his social counterpart, baby B, is exposed to in real life. Note that baby A maintains a totally passive position vis-à-vis the reality to which he is exposed. Unlike baby B, he cannot transform it in any way. Does this difference matter?

BOX 2.2

PHILOSOPHERS AND COGNITIVE DEVELOPMENT: AN EXAMPLE

The question: Baby A grows up outside of society, but in front of a television screen that shows exactly the same content as the reality that Baby B, born at the same time, experiences – what would happen to the cognitive development of each baby?

- **Empiricists, neo-Kantians:** if given sufficient time, both babies will acquire similar cognitive skills and knowledge.

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- **Rationalists:** If given sufficient time, both babies will acquire similar cognitive skills and knowledge, and would do so even if they were not exposed to either television or particular experiences in real life.
- **Marxists:** Baby A will fail to develop any conceptual thinking whatsoever regardless of how long it is exposed to the television. Baby B will develop conceptual thinking, but the specific content will depend on the particular social circumstances experienced by the baby.

The nature of a scientific object

The second set of questions that philosophers ask about scientific objects concerns their nature. Can any object be studied by science? Do the objects of science have to be 'natural' (e.g. chemical compounds, physical masses, cellular membranes etc.), or can they also be 'social' (e.g. religion, psychology, economy, identity etc.)? Do they have to be material (e.g. stars, waves, particles, forces etc.), or can they be theoretical as well (e.g. language, wars, nationalism etc.)? Do they have to be general and abstract (e.g. Canis lupus familiaris) or can they be concrete (e.g. Fido, Abraham Lincoln's dog, at the moment of the President's assassination)?

Empiricists regard an object as a potential candidate for scientific inquiry if it could give rise to a testable explanation, namely, one that makes predictions which could be verified or falsified by observation. This means that objects must have some observable regularity in order to be studied by science. At any rate, science will deal with *concrete* objects only. After all, for an empiricist only concrete objects expose themselves to observation.

But there is a different way of looking at this question, particularly so for transcendentalists. In this view, science cannot and does not explore concrete objects at all, since they are universally complex, contingent, erratic and hence essentially untestable. Instead, it studies their simplified theoretical models, which, as opposed to their concrete counterparts, are absolutely predictable. The objects of science are thus general, abstract, isolated and closed. In short, they are imaginary.

Box 2.3 contains two examples which illustrate this, one from the natural sciences and one from the social sciences.

BOX 2.3

A SCIENTIST AND A SOCIAL SCIENTIST WHO STUDIED 'IMAGINARY' RATHER THAN CONCRETE OBJECTS

Johannes Kepler's (1571–1630) astronomical theory claimed to explain the orbital motion of planets, moons and other satellites around a 'sedentary' body. Did Kepler derive his laws from the *concrete* solar system, a system consisting of oddly shaped, three-dimensional, erratically behaving planets, placed in a particular point in space and time, each affected by an infinite number of vectors from all corners of the universe? Probably not. He had to clean it from its concrete observed properties before he could say anything general about it. Indeed, only a system containing dimensionless planets that revolve in perfect elliptical tracks around the only object with which they interact, a dimensionless sun, could give rise to the strict geometrical laws that make up his theory.

Karl Marx (1818–1883) invented the *labour theory of value*, which claims to explain the origin of profit. His theory pertains to a closed, abstract and isolated system in which buyers and sellers maintain perfectly symmetrical positions vis-à-vis each other. Such a system does not exist in reality.

If science tested its explanations on concrete objects, then the likelihood of *any* of its predictions to *ever* be perfectly successful would be virtually zero. Meaningful tests, so it seems, can only take place on abstract models. The controlled experiment (described in Chapter 8) – perhaps the quintessential tool of science, although social scientists do not use it very often – may thus turn out to be nothing but a physical attempt, and never a fully successful one, to abstract the concrete object from its concrete properties. Actually, the physical experiment becomes absolutely controlled only in the 'ideal laboratory' – the scientist's mind. Indeed, thought experiments universally complement physical experiments. Moreover, the former often replace the latter altogether, especially where these cannot or ought not to take place. Aren't thought experiments perhaps the only really scientific experiments there are? Isn't it in our thought where theories are ultimately tested? Again, these considerations question the extent to which scientific knowledge differs from metaphysical knowledge.

The objectives of science

Historians of science have succeeded in showing that science has had more than one objective at a time and that its objectives have changed over the past three centuries or so. In our society, for example, scientists generally try to solve practical and theoretical problems, but science is also recruited by politicians and others in attempts to save money, attract funding, generate profit, and, occasionally, to promote certain political and other institutional ends. Things were somewhat different in the seventeenth century, prior to the Industrial Revolution, when science had not attained the prestige that it now occupies in the minds of the powerful. It is unfortunate that philosophers have appeared unaware of these historical changes. Instead, philosophers fluctuate between the *view* that science *has* an inherent and immutable objective and the view that it *ought to have* a certain objective. In general, however, both approaches agree that science aims, or ought to aim, to *produce 'scientific' explanations*. But what counts or ought to count as 'scientific' explanation is often disputed.

Philosophical debates on the nature of scientific explanation rest on two assumptions. The first one holds that all explanations, whether scientific or not, have something general in common that distinguishes them from other propositions about the world, such as explications (clarifications of vague propositions), descriptions (characterisations of things), predictions (telling what is or is not to happen under certain conditions), judgments (evaluations – e.g. moral or aesthetic), and justifications (arguments that support judgments). The second assumption holds that all scientific explanations have something general in common that distinguishes them from other explanations. It is this general essence that philosophers of science are seeking.

Explanations in general

In terms of form, all explanations contain two elements: an explanans (the thing that explains) and an explanandum (the thing to be explained, i.e. the object of the scientific inquiry or, in other words, the scientific question). In terms of function, an explanation is supposed to expose the essence behind the appearance. This conclusion follows from philosopher Georg Hegel's (1770–1831) understanding of the relations between the essence of a thing and its appearance: they do not necessarily coincide, but they are not independent of each other either: the essence gives rise to appearance; hence it explains it (Hegel, 2010). This Hegelian conception is implicit in Marx's claim that '[all] science would be superfluous if the outward appearance and the essence of things directly coincided' (Marx, 1967: 817).

Box 2.4 demonstrates how this conception would view the difference between the Aristotelian geocentric model of the solar system (all planets and the Sun revolve around Earth) and the Copernican heliocentric model thereof (all planets including Earth revolve around the Sun)

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BOX 2.4

APPEARANCE AND ESSENCE IN THE GEOCENTRIC VERSUS THE HELIOCENTRIC MODEL

For both models the appearance of things is the same: the Sun rises in morning and sets in the evening.

According to the *geocentric* model, the essence behind this appearance is as follows: the Sun moves around the Earth. This is a convincing explanation. However, it is intuitive: it regards the essence to be coinciding with the appearance.

According to the *heliocentric* model, the essence behind this appearance is as follows: the Earth moves around the sun. This explanation is equally convincing. However, it is counterintuitive. Is this perhaps what makes it scientific?

Explanations can be classified according to general categories, each containing several subcategories:

- **Scope**: universal (pertaining to all cases in the category in question), particular (pertaining to some cases only); abstract (pertaining to objects that are abstracted from their contingent features); concrete (pertaining to real objects); overly general; general; specific.
- **Form**: causal; statistical; **teleological** (regarding purpose as cause).
- **Structure**: **reductionist** (seeking the explanans in another, more basic system); non-reductionist (seeking the explanans in the same system to which the explanandum belongs).
- **Testability**: metaphysical, non-metaphysical; **idealist** (ideas explain matter); **materialist** (matter explains ideas).
- **Validity**: true; false; meaningless.

For the moment, do not worry if some of the terms in the above list (e.g. 'truth) have not been defined as yet. Later in this chapter they will be discussed in more depth. Box 2.5 gives examples of several explanations together with some of their properties, and the text that follows will discuss these in a way which will help you understand what these terms mean.

BOX 2.5

EXPLANATIONS WHICH VARY ON PARTICULAR DIMENSIONS

- God created man: metaphysical, idealist, universal, overly general, abstract.
- Man created God: metaphysical, materialist, universal, general, abstract.
- I hit him, because he annoyed me: non-metaphysical, non-scientific, particular, specific, concrete.
- $E=MC^2$ explains the interchangeability of matter and energy: non-metaphysical, scientific, universal, general, abstract.
- Nuclear fission of 1 kg of uranium releases huge amounts of energy, because $E=MC^2$ and 1 kg of uranium is a certain mass: non-metaphysical, scientific, universal, specific, abstract.
- Giraffes developed a long neck in order to be able to feed on leaves that grow on top of trees: metaphysical, teleological, universal, specific, abstract.
- Men are more intelligent then women, because their brain is bigger on average: statistical, non-metaphysical, scientific, biological, reductionist, universal, general, abstract.

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Scientific explanation

Philosophers of science believe that, to be scientific, an explanation must meet certain criteria. Some of the pertinent debates about these criteria are discussed below.

Scope

A scientific explanation must be based on a universal law. Put differently, this law must apply to *all* particular cases in the category in question. An explanation that does not rest on a universal law (ad hoc explanation) may or may not be true, but it is not scientific. Here is a commonly cited example of an ad hoc explanation:

> *I was healed from cancer by God!*
>
> *Really? Does that mean that God will heal all others with cancer?*
>
> *Well … God works in mysterious ways.*

In this example, God is the explanans and the fact that 'I' was healed from cancer is the explanandum. God is said to explain *my* healing *only*. This is therefore an ad hoc explanation: God is not obliged by any law to heal *all* cancer patients. Ad hoc explanations may be true or false, but they are not scientific. Science is not interested in them.

A scientific explanation can be either general or specific. An explanation that pertains to a general explanandum is general, whereas one that pertains to a subspecies of that explanandum is specific. The difference between general and specific explanations is only relative, however. For example, an explanation for the rise of nationalism, say, in post-Tito Yugoslavia is *specific* relative to an explanation for the rise of nationalism is general. However, it is *general* relative to an explanation for Bosnian, Serbian or Croatian nationalism, for example.

Scientific explanations maintain a certain hierarchy in relation to their generality. The explanans in the most general explanations is referred to as a principle. Below this level is a scientific law and below this is a theorem. Different laws may obey the same principle, but they cannot be deduced from it. In contrast, theorems are deduced from laws. A set of laws that pertains to a composite explanandum, namely, one that gives rise to diverse phenomena – the universe, the atom, society, for example – is called a theory.

It should also be emphasised that not every generalisation is a law, and that a generalisation that is not law is not explanatory. For example, the generalisation 'all American presidents in the nineteenth century were bald' would not explain why any one of them was bald even if it were true. It is purely accidental.

Whereas scientific explanations must be general in some sense, they must retain some degree of specificity. Overly general explanations – the attribution of *everything* that happens to God's will, for example – cannot be scientific. Such explanations may or may not be true, but they are non-informative and hence useless.

Form: models of scientific explanation

Following philosopher David Hume (1711–1776), empiricists have consistently rejected the idea of causality (i.e. a 'necessary' relation between events) as utterly metaphysical (untestable), hence unscientific. They maintained that the objective of science was merely to describe regularities in relation to successive or co-existing events.

Carl Hempel (1905–1997) and Paul Oppenheim (1885–1977) were the first to formalise this conception of scientific explanation. Their model is known as the deductive-nomological (D-N) model. 'Nomos' means 'law' in ancient Greek, so 'deductive-nomological' refers to the capacity of the law to generate deduction. (This model has also been called the *covering law model*.) According to this model, a scientific explanation contains two elements: (1) the specific explanandum (the sentence describing the phenomenon to be explained) and (2) the explanans (the sentence containing explanation), the latter being the logical conclusion of (a) a general law, plus (b) initial conditions pertaining to the specific explanandum.

Box 2.6 illustrates this, with explanations taken first from natural science and second from social science.

BOX 2.6

THE DEDUCTIVE-NOMOLOGICAL MODEL OF SCIENTIFIC EXPLANATION IN GALILEO GALILEI'S (1564–1642) THEORY OF FALLING BODIES AND IN SOCIOLOGIST ÉMILE DURKHEIM'S (1858–1917) THEORY OF SUICIDE

		Galileo: falling objects	Durkheim: suicide rates
Explanandum		Object x falls.	Suicide rates among Catholics are lower than among Protestants.
Explanans	Law	Objects with mass attract each other.	Suicide rates vary inversely with the degree of social cohesion.
	Initial conditions	Body x and Earth are objects with mass.	Catholicism is associated with greater social cohesion than is Protestantism.

The D-N model purports to describe all scientific explanations. However, it has been criticised for being overly abstract. In particular, it does not tell us which generalisations could count as laws. As we saw earlier, generalisations that merely describe regularities are not explanatory. In the absence of a consensus on the criteria of lawhood the D-N model is unclear.

The model raises yet another difficulty. It describes an explanation as a deduction from deterministic laws. But what about the explanatory status of statistical laws, laws that speak of probabilities? Do they explain anything and if so, what do they explain? Hempel himself distinguished between two varieties of statistical explanation. The *deductive-statistical (D-S) explanation* involves the deduction of a statistical uniformity from a more general statistical law. For example, the law that describes the 1:4 chance of two parents each carrying one gene of cystic fibrosis to give birth to a baby with this condition can be deduced from the law pertaining to the heredity of heterozygote conditions in general. Clearly, this model conforms to the same general pattern of the D-N model. The *inductive-statistical (I-S) explanation*, on the other hand, involves the subsumption of individual events under a statistical law. This kind of explanation takes the following form, for example: 25 per cent of babies born to parents who carry the gene for cystic fibrosis will have the condition; X's parents carry the gene for cystic fibrosis.

Philosopher Wesley Salmon's (1925–2001) *statistical relevance (S-R) model* attempts to capture the 'causal' essence of a scientific explanation as a *conditional dependence relationship*. To illustrate this model, let us consider the following example. Women and men who are taking birth control pills are unlikely to conceive. If you are a male, taking the pill is statistically irrelevant to whether you become pregnant. However, if you are a female, it is relevant. In this way we can grasp the idea that taking birth control pills is explanatorily irrelevant to pregnancy among males but not among females.

Salmon eventually abandoned the attempt to characterise explanations or causal relationships in purely statistical terms. Instead, he developed another account, which he called the *causal-mechanical (C-M) model* of explanation. We may think of this model as an attempt to capture the 'something extra' involved in causal relationships over and above facts about statistical relevance. The C-M model employs the idea that a causal process is a mechanical process that is characterised by the ability to transmit a mark in a continuous way. A collision between snooker balls is a simple example. This model does not reflect many scientific laws, if any. One cannot argue, for example, that Isaac Newton's (1643–1727) classical mechanics contains laws that are the cause of the particular motion of bodies. Nor can one argue that Karl Marx's (1818–1883) historical materialism contains laws that cause the transition from one economic formation to another. At best one can say that bodies and economic transitions obey their respective laws.

A **teleological** explanation is an explanation that appeals to purpose/end. Some teleological explanations appeal to purpose only. They take the form of 'A in order to B' – the chair has four legs in order to be stable, for example. Such explanations may make sense. Other teleological explanations confuse the purpose for the cause. They take the form of 'A because of B', when in fact they should at best take the 'in order to' form – cats have come to exist because they prey on mice. In any case, teleological explanations are not scientific. Science is not interested in purposes.

One of the more recent accounts of scientific explanation is the *unificationist model*. It holds that a scientific explanation aims to provide a unified account of a range of different phenomena previously thought to be unrelated. A typical example is physicist James Maxwell's (1831–1879) unification of electricity and magnetism.

The question whether there is or ought to be just one model of scientific explanation is still open. We shall later attempt to find out whether explanations in the natural sciences differ in principle from those in the social sciences.

Structure: reductionism versus non-reductionism

It is commonly accepted that the foundations of some fields of study are rooted in another field: chemistry in physics and microbiology in chemistry, for example. There is also wide agreement that some 'basic' fields can affect and inform 'higher' ones:psychology in the case of economics and biology in the case of psychology, for example. Scientific **reductionism** takes a more radical approach, however. Taking a complex system to be no more than the sum of its parts, this literally mechanistic approach attempts to explain the former in terms of the latter. Reductionist conceptions and practices can be found in all areas of science, including medicine, social sciences and psychology among many others.

Scientific-reductionist explanations are often criticised merely because they happen to be reductionist. For example, sociobiologists, who seek to explain the social world as if it were entirely the product of biological forces, such as evolutionary competition, are often dismissed by critics as 'reductionist'. This is not justifiable. Scientists are under no obligation to produce reductionist explanations, but there is no reason why they should not try. Reductionist explanations should be judged on a case-by-case basis according to the same criteria that apply to non-reductionist explanations. For example, scientists who propose reductionist explanations have the onus of showing that the explanandum can be reconstructed from the explanans. Their success would be our gain, their failure our loss. In some cases they could possibly succeed. Perhaps eye colour could one day be reduced to proteins and genes, for example (so far we have only come up with regularities, not explanations). Yet it seems that some objects could never receive plausible reductionist explanations. For example, it seems highly unlikely that we will ever see a plausible explanation of the history of humankind that rested on quantum physics. Scientific reductionism can take a subtler but no less contentious form. In this version, the explanation is not reductionist in itself. It is reductionist only in relation to an alternative explanation that frames the explanandum and the explanans in terms of a more complex system. For example, the conception that a particular disease is a biological phenomenon that requires a biological explanation does not seem to be reductionist in itself. Of course, cancer is caused by a mutation of cells. However, it transpires to be reductionist in relation to the conception that regards the same disease as a social phenomenon that requires a social explanation. Cancer occurs with differing regularity in people occupying different social classes. The traditional (reductionist) tendency of modern medical science to focus on biological explanations to the relative neglect of social ones has had profound, often disturbing, social implications.

Testability: verificationism versus falsificationism

To be scientific, an explanation has to be testable. An explanation that is untestable is unscientific regardless of any other considerations. Metaphysical explanations, such as theistic explanations for the creation of the world (as well as atheistic explanations for the invention of God), are unscientific, because they cannot be tested. In general, empiricism regards an explanation as testable, if it entails rigorous and specific (i.e. conditional) predictions that, if successful, can reveal its truth value. What these predictions are supposed to predict (events which are compatible with the explanation or events that are incompatible with it) and what exactly they should reveal about the truth value of the explanation (its veracity or its falsity) is debatable, however.

Verificationism, a traditional empiricist conception, maintains that a scientific explanation should entail predictions that are compatible with the explanation. Thus if successful, these will validate, which is to say confirm, its veracity. Relatively modest predictions required a relatively large number of confirmatory observations before the explanation is declared true, whereas for exceptionally bold ones even a single successful observation may suffice. For example, a single observation of light bending around the Sun made in 1918 as predicted by Albert Einstein's (1879–1955) general theory of relativity is said to have confirmed this theory. The justification for this position and its shortcomings warrant a brief discussion.

Verificationists regard generalisations as the basic units of any genuine knowledge, let alone scientific knowledge. However, they differ from others in their explanation of the origin of generalisations. They maintain that these are derived from consistent observations of cases or individual facts, a thought process called **induction**. For example, it is a fact that when a stone is dropped it falls to the ground, and we will find that it does so again and again if we keep on trying this. Verificationists would argue that the law of gravity is scientific because its prediction that things will fall under certain circumstances could in principle be found consistently successful. Verificationists would regard the law as scientific even if these predictions were eventually to be found unsuccessful; the verificationist would then simply conclude that this (scientific) law is false.

There is no doubt that the predictive capacity of scientific explanations, more than anything else, makes science socially useful: it instructs the engineer, the technologist, the astronaut, the doctor and a host of others. But do consistently successful predictions imply veracity? This is not clear. Induction may perhaps be a necessary thought process and no doubt it plays a role in the formation of some generalisations. But it is *not* a logical process. There is no necessity that the next observation will yield the same result as the previous ones, no matter how consistent and numerous they have been. The Sun may have risen since time immemorial, but this is no guarantee that it will rise tomorrow. Besides, the number of actual observations is always infinitesimally small compared to the infinite number of possible observations, so that it is always possible that an event has occurred that contradicts the law, but which has not been observed. Any generalisation that is based on induction is thus fallible: its veracity cannot be established with certainty. Known as the problem of induction, this had already been recognised by ancient philosophers. It was reintroduced by David Hume in the eighteenth century and then again by philosopher Karl Popper (1902–1994) two centuries later on.

An empiricist himself, Popper agreed that an explanation must be testable in order to be scientific. However, he rejected the verificationist assumption that explanations could be validated by successful predictions. He maintained, instead, that a scientific explanation should entail predictions, which, if successful, will falsify (i.e. refute) it. Popper's **falsificationism** regards an explanation as scientific if it is able to describe conditions in which it would be proved false by observation. Accordingly, the generalisation 'all swans are white' is scientific not because it can be confirmed – in fact, it cannot be confirmed – but rather because it can be refuted. Indeed, one observation of a non-white swan will falsify the generalisation.

Yet falsificationism itself is problematic no less than verificationism. (Interestingly, Popper was aware of that. He had other reasons for embracing the conception. These will be discussed later on.) Whatever their number, observations of an allegedly law-refuting prediction may be faulty in themselves. Moreover, there is no procedure or criterion that could guarantee their soundness. A swan may appear to be non-white just because it is dirty or because it has been painted black.

A student of Popper, philosopher Imre Lakatos (1922–1974) attempted to overcome the problems of both verificationism and falsificationism. He maintained that the nature of the predictions which an explanation entails has nothing to do with its truth value. It is merely a rational measure allowing us to compare competing explanations. Explanations that make many, new, and bold predictions are stronger than those that do not, regardless of whether they are 'confirmative' or 'refutative'. Lakatos seems to have saved the requirement of testability from emptiness by assigning it a functional, rather than epistemic role.

Yet the question could be tackled from a different direction. Let us note that the empiricist practice of observations presupposes that explanations are being confirmed and falsified on the basis of predictions about concrete reality. Think back, though, to the early part of this chapter where the nature of scientific objects was discussed and you will recall that it is debatable as to whether these objects can be considered concrete or abstract entities. If the object of scientific inquiry is abstract, then such predictions are purely theoretical. They succeed or fail in theory only, and it is theory and not observation that confirms or refutes them.

Validity: truth and objectivity

Following philosopher Pierre Duhem (1861–1916), **instrumentalists** maintain that scientific theories are useful conceptual constructs that have no truth value. **Realists**, in contrast, regard them as explanatory constructs that do have a truth value. Excluding naïve realists, most realists are fallibilists, which is to say that they regard scientific theories as hypothetical and always corrigible in principle. They may happen to be true, but we cannot know this for certain in any particular case. But even when theories are false, they can be closer to the truth than their rivals. But what is truth? Can it be identified? Does it play any role in science? If so, should it?

One 'true' thing that can be said about *truth* is that it has received many definitions (see Box 2.7). Against this backdrop, it would be absurd to ask which one of them is true. Although the box shows many such definitions, just three will be discussed here. The first definition is known as the **correspondence theory of truth**, which goes back at least to some of the classical Greek philosophers including Socrates, Plato and Aristotle, and is still the most popular theory of truth. It posits a superposing (sometimes called 'matching' or 'corresponding') relationship between thoughts and objects. In other words, a judgment is said to be true when it conforms to the objective reality. According to this theory, the terms truth and **objectivity** seem to be interchangeable. However, the relation between them is not straightforward, and it would be sensible here to divert the discussion of truth definitions to consider this matter of objectivity.

Empiricism defines objectivity as the property of knowledge designating its independence of any consciousness. Accordingly, objective knowledge is true knowledge. If Newton's classical mechanics is false, then it is cannot be objective. If Einstein's special theory of relativity is true, then it is objective. But there are those who would argue against this. Transcendentalists, for example, regard objectivity as the property of knowledge designating its independence of any individual consciousness, but not of any consciousness. In fact, they regard it as an inter-subjective or social artefact. Newton's theory and Einstein's theory were thus both objective (referring to different objects, though), but only one of them, at most, can be true.

The second definition of truth is known as the **coherence theory of truth**, which maintains that truth is primarily a property of whole systems of propositions, and can be ascribed to individual propositions only according to their coherence with the whole. Coherence theories have been embraced by rationalists and logical positivists because they considered them as non-metaphysical in contrast to correspondence theories.

The third definition is that of **social constructionism**, which holds that truth is constructed by social processes, is historically and culturally specific, and is in part shaped through the power struggles within a community. Constructionism denies that our knowledge reflects any external realities. Rather, perceptions of truth are contingent on convention, human perception,and social experience. Constructionists maintain that representations of physical and biological reality, including race, sexuality and gender, are socially constructed.

BOX 2.7

DIFFERENT CONCEPTIONS OF TRUTH

- *Correspondence theory:* A statement is true if it describes reality accurately.
- *Coherence theory:* A statement is true if it makes sense in the context in which it is made.
- *Social constructionism:* A statement is true if society constructs it as true.
- *Consensus theory:* A statement is true if it has been agreed upon.
- *Epistemological subjectivism/relativism:* A statement is true for those who take it to be true.
- *Epistemological nihilism:* Truth is a meaningless concept; nothing is knowable.
- *Pragmatic theory:* A statement is true if it works.
- *Performative theory:* Truth assertion is a speech act signalling one's agreement with the assertion.
- *Redundancy theory:* Asserting that a statement is true is equivalent to asserting the statement itself. Thus truth is a redundant concept; just a word that is used for emphasis, nothing else.

The plurality of definitions of truth reflects disagreements about the meaning of truth. Yet even if we embraced, say, the correspondence theory, we would still need some foundational criterion by which the veracity and the falsity of statements could be established. Unfortunately, philosophical inquiry has failed to uncover such a criterion. One view is that it is impossible to prove any truth even in the fields of logic and mathematics, since the very assertion from which the truth of the statement is deduced must be proved true by another assertion in a process requiring infinite regression. Another view holds that it is impossible to test a scientific hypothesis in isolation, because any empirical test of the hypothesis would require one or more background assumptions (auxiliary assumptions) whose own test requires other assumptions ad infinitum. According to these arguments, there is no point in looking for the truth in science or in any other knowledge even if it exists. Whatever it is, we shall never be able to identify it (ironically, even the truth of this assertion must be taken with a grain of salt).

This has therefore led many philosophers to argue that **nonfoundationalism** is the only way we can really think about science and social science. This position has several important implications. First, we could conclude that science is not superior to other forms of knowledge in any way. This possibility was discussed at the outset of this chapter when arguments for the metaphysical basis of both religion and science were discussed, and will be considered again in what follows. Alternatively, we could conclude that if science is indeed superior to other forms of knowledge, then this is not because of its veracity. To support this argument, then, we would need to come up with other points, such as the willingness of scientists to abandon scientific explanations that are in irremediable conflict with experience (a much trumpeted feature of science according to some who support it), or the systematic attempt by scientists to construct stronger explanations or of course, the practical usefulness of science in instructing the production of various technologies. We might also compare the strength of competing scientific and non-scientific explanations based not on epistemic criteria, but rather on aesthetic ones, asking, for example, whether an explanation seems 'elegant'. Taken together, we might then argue that explanation P will be stronger than explanation Q, all other things being equal, if:

1. P accounts for more phenomena, or predicts a larger number of events.
2. P is simpler (more 'parsimonious').
3. P is more elegant.
4. P persists in the face of new knowledge, whereas Q does not.
5. P can explain why Q cannot explain the phenomena which it can.

The nonfoundationalist premise could take us to yet another place and help us realise that we must have chosen to embrace some scientific assertions and reject others under circumstances that had nothing to do with their 'real' truth value. These circumstances, for example, might include our psychological preferences or our social position, which predispose us to want to accept one scientific idea above some other idea. In other words, these are the conditions of our ideological choices, which under this view should concern us much more than the truth value of the knowledge which we accept. Philosophy cannot reveal this because it is unable to tell us why we find some of its assertions more attractive than others. This task belongs to social scientists who may study the way in which scientific (and social scientific) communities decide on what to count as true or false, and why some segments of the general population agree with them and others disagree. In fact, the sociological study of science, and of the public understanding of science, is a flourishing area.

Methodology and progress

Philosophical accounts of the evolution of science are partly **normative** (how science *ought* to evolve) and partly **descriptive** (how it *actually* evolves). At any rate, philosophers regard its evolution to be the direct result of its particular methodology or the lack thereof. In this section five different accounts of the evolution of science will be considered.

The first is known as the **hypothetico-deductive method**, sometimes also known as the *cumulative model* of scientific progress. This was first proposed by the philosopher William Whewell (1794–1866) as a seemingly descriptive model, although it in fact contains normative elements. According to this clearly empiricist model, the scientific process starts with hypotheses. These are then tested: positive predictions corroborate them and negative ones refute them. Hypotheses that are corroborated thus add up to the existing aggregate of positive knowledge in an infinitely progressive process, which is why the model is also known as the cumulative model. In line with this model, some historians have argued that the acquisition and systematisation of scientific knowledge are the only human activities that are truly 'cumulative' and 'progressive'.

Second, associated with Karl Popper, is the **falsificationist** view of scientific progress. This is very much a normative view, which accepts the hypothetico-deductive method but holds that science ought only to try to falsify its hypotheses and, when successful, replace them with new hypotheses, which ought themselves to be falsifiable on other grounds. Popper regarded this process as a critical-rational condition for approximating to the truth, even without ever being able to know how close to it we are.

Third, are the ideas of philosopher Thomas Kuhn (1922–1996) who was influenced by historical study of how communities of scientists actually seemed to work, so might be considered to provide a descriptive rather than a normative view of scientific progress. He took a transcendentalist point of view in proposing that science progressed via a series of **scientific revolutions**. He maintained that scientific observations are always embedded in some broad context consisting of the theoretical premises, methods and practices used by a particular community, or generation, of scientists as a backdrop, or set of largely unquestioned assumptions, to their scientific work. This collection of background assumptions Kuhn called a **scientific paradigm**. Thus corroborations and refutations of hypotheses do not take place in the realm of observation, but rather in the reciprocal interface between observation and paradigm. According to this view, the evolution of science oscillates between periods of normal science – a routine, cumulative, 'puzzle-solving' work involving experimentation within a paradigm without actually challenging it – and a paradigm shift or a scientific revolution, namely, a critical situation where an irresolvable tension between normal science and paradigm results in a change of paradigm. Kuhn maintained that competing or consecutive paradigms are incommensurable, and that the choice between them is made on the basis of partly logical but also partly sociological reasons.

Fourth in the list of accounts of scientific progress is the idea that science proceeds by means of research programmes. Attempting to reconcile the differences between Popper and Kuhn, Lakatos suggested that research programmes are sets of theories which share a certain 'hard core'. Scientists involved in a programme will attempt to shield the theoretical core from attempts to falsify it behind a protective belt of auxiliary hypotheses. Whereas Popper regarded such ad hoc measures as unacceptable, Lakatos argued they rather reflected rationality (within limits).

Fifth and finally, philosopher Paul Feyerabend (1922–1994) argued that there is no single scientific methodology, pointing out that evidence about how scientists actually work shows that all 'scientific' methods have, in practice, been violated by individual scientists at some point in order to advance of scientific knowledge. He therefore embraced the view that science was – and perhaps needed to be – anarchic, so that he embraced scientific anarchism. At one level, Feyerabend appears cynical and dismissive of science. For example, he maintained that hypotheses came to be embraced or rejected not because of their accord or discord with any scientific method, but rather because their proponents and opponents used some tricks, including lies, in order to advance their cause, respectively. But Feyerabend also said that anarchism was, in practice, the source of scientific creativity and the secret of its achievements. Breaking methodological 'rules' has sometimes been necessary for scientific advances.

Problem(s) of demarcation

Boundaries are often drawn between science and other knowledge systems. Moreover, they are drawn within science itself as well: between the natural and social sciences and among individual natural and social disciplines. But where exactly should the boundaries be drawn, what do they imply, and what purpose do they serve?

Science versus pseudoscience

According to empiricists, the difference between science and other knowledge systems rests on the particular methodology which each employs. For logical positivists and verificationists, the scientific methodology, as they see it, reflects the meaningfulness of scientific assertions, if not also their unrivalled validity. For falsificationists, it reflects the difference between science and pseudoscience, practices that purport to be scientific, when in fact they only attempt to capitalise on the reputation of science as the most rational system of knowledge. Indeed, Popper himself used the criterion of falsifiability primarily to reject certain theories to which he also happened to be politically opposed, notably, of deterministic interpretations of Marxist theory of history, which he regarded as unfalsifiable and therefore pseudoscientific. He applied the same critique to the ideas of Sigmund Freud, Alfred Adler and even Darwin.

For Kuhn and Lakatos, the boundary should be drawn between lively and degenerated scientific paradigms or research programmes, respectively. Thus it seems they would regard obsolete scientific theories as non-scientific, at least tentatively (although Lakatos did not preclude the possibility of resurrecting old research programmes). Feyerabend went one step further, maintaining that science does not occupy any special place in terms of its logic or methodology and is an integral part of the larger body of human thought and inquiry in which 'anything goes'. Such views are shared by postmodernists, who criticise any over-arching position, including positions that draw boundaries, as being ideological and at any rate oppressive.

Natural versus social sciences

The relationship between natural science and social research is uneasy, with the suspicion that the application of the label 'science' to the study of social and cultural matters is unjustifiable always lurking behind debates. There are a variety of responses to this, ranging from attempts to make social science adhere to the methods and principles of natural science as closely as possible, to the opposite extreme, whereby social and cultural researchers actively reject the label 'scientific', claiming instead to be pursuing something quite different.

Naturalists hold that all phenomena are natural, thus society can be studied by science just like nature. Some of them, notably positivists like sociologists Auguste Comte (1798–1857), Émile Durkheim, Talcott Parsons (1902–1979) and Robert Merton (1910–2003), demand that social science embrace the empiricist conception of objectivity. Durkheim, for example, required the social scientist to 'embark upon the study of social facts by adopting the principle that he is in complete ignorance of what they are, and that the properties characteristic of them are totally unknown to him, as are the causes upon which these latter depend' (Durkheim, 1982: 245).

Interpretivists, on the other hand, contend that the study of society requires an interpretative approach. Some of them reject the positivist claim that empirical science is the only science. Others, like Alfred Schutz (1899–1959), Hans-Georg Gadamer (1900–2002), Paul Ricoeur (1913–2005), Clifford Geertz (1926–2006), Jürgen Habermas (1929–) and Charles Taylor (1931–), who accept the positivist claim, also accept the positivist conclusion that much of what social science is doing is not really science. As far as they are concerned, the study of society involves a search not for facts, but rather for meaning.

Reconcilers attempt to bridge the divide between naturalism and interpretivism. They typically embrace the transcendentalist perspective that all science, including the natural sciences, is anyway interpretive. Max Weber (1864–1920), for example, regarded detachment (complete conceptual neutrality of the observer) and objectivity that depends on 'pure' observation as utterly inconceivable, but he did not dismissed objectivity as a social construct. Karl Marx and Friedrich Engels (1820–1893) went even farther. They reduced all science, including the natural sciences, to one science that is essentially social: 'we know only a single science, the science of history. One can look at history from two sides and divide it into the history of nature and the history of men. The two sides are, however, inseparable; the history of nature and the history of men are dependent on each other so long as men exist' (Marx and Engels, 2004: 39). It should be emphasised that most reconcilers distinguish between science in general and other knowledge systems. They are aware then that not every knowledge that is produced by science, natural or social, is necessarily scientific.

Determined to challenge any boundary in particular and in fact any positive knowledge in general, **postmodernists** often express attitudes toward science that differ radically from those we have discussed in this section. Their extreme relativism leads them to conclude that science is a 'myth' that does not differ in essence from any other 'narrative'. Moreover, they often claim that since all narratives make positive assertions which necessarily imply some negations, they must be essentially oppressive (ironically, this applies to this assertion as well). Indeed, postmodernists often attack science on this ground. In social science, they have typically targeted Marxism. However, they have attacked the natural sciences as well. For example, the feminist theorist Luce Irigaray (1932–) criticised $E=MC^2$ for privileging the speed of light over other speeds that are vitally necessary for us. Other postmodernists seem to have ridiculed any boundary between natural and social science by importing concepts from natural science into the humanities without any justification. The alternative, allegedly 'subversive' knowledge, which they offer instead, is deliberately fragmentary and incomprehensible. This point was taken ad absurdum in 1996 by Alan Sokal, a physics professor at New York University and a harsh critic of postmodernism. He submitted a quasi-postmodernist article to *Social Text*, an academic journal dedicated to postmodern cultural studies, in attempt to learn whether it would publish an article liberally salted with nonsense. The article, 'Transgressing the boundaries: towards a transformative hermeneutics of quantum gravity' (Sokal, 1996: 217–252), which proposed that quantum gravity is a social and linguistic construct, was accepted for publication.

The moral question

Facts and values

Naturalists sometimes maintain that moral claims can be inferred from the natural properties of the object. The object would thus be inferred as 'good' from the fact that it is, say, 'desirable', 'pleasant', 'more evolved' etc. Think about it – we do it all the time: when someone says 'good boy' this involves inference from the boy's behaviour. Philosopher G.E. Moore (1873–1958) showed, however, that this position ('if it is natural, then it must be good'), called the *naturalistic fallacy*, is logically flawed: no natural property implies 'goodness'. And yet it often seems that people draw moral (ought to) conclusions from descriptive or explanatory (is) statements. David Hume regarded this cognitive leap as utterly illogical. For example, the statement 'Switzerland is a central European country' does not entail that Switzerland is good or bad. Max Weber held a similar view, noting that '[an] empirical science cannot tell anyone what he should do, but rather what he can do' (Weber, 1949: 54). For example, the statement '$E=MC^2$' can tell us that we can build an atomic bomb, but it does not say we ought to do so.

Hume and Weber were right in arguing that science is morally neutral. But they were only partially right. Science is morally neutral only when it is considered in the abstract, that is to say, out of its social context. In social context, however, the conception that science is morally neutral becomes as absurd as the claim that music is emotionally neutral. Let us not forget that the social context contains general moral laws and concrete interests that are informed by 'is' statements. When this happens, the latter loose their moral neutrality. For example, a society that (a) embraced the general moral law that 'central European countries are bad' and (b) faced the factual statement that 'Switzerland is a central European country' would be bound to draw the conclusion that 'Switzerland is bad'. This deduction would not be illogical at all, as Hume thought.

Good science: conservative versus radical ethics

Like any other social enterprise, science may also be subject to moral criticism. For example, the history of ethics in medical research involving humans in the past six decades can be described as a continuous reaction to moral outrage following revelations about crimes and wrongs committed in the name of science (Chapter 5 discusses research ethics in more detail).

In general, the morality of science can be judged with respect to three areas:

- its attitude to and impact on researchees, consumers and other populations (e.g. whether people participate in scientific studies on the basis of informed consent or not)
- the nature of its agenda, namely, the problems it chooses to deal with and those it chooses to ignore (e.g. scientists may study nuclear fission and contribute to weaponry, and they may ignore the science of global warming, or vice versa)
- the nature of the interests which it serves (e.g. the military-industrial complex or the pharmaceutical industry).

The moral action required in each of these areas has particular political implications. The action pertaining to the first area requires science to offer some protection to the pertinent groups. This is a most important sphere of action; however, without tackling the last two areas as well it is bound to become an ideological smokescreen. The moral actions regarding the last two areas are radical. They demand that we challenge the powers that determine the historical character of science.

Conclusion

This chapter has tried to figure out what science actually is by presenting various answers to several specific questions. For each question, the discussion has raised issues which are pertinent to social researchers.

- First, we saw that science rests on several metaphysical premises, and that it probably cannot free itself from all metaphysics. Critical science, particularly social science, should be aware of its fundamental premises, scrutinise them, and be able to defend or reject them as necessary.
- Second, we saw that philosophers of science differ about the source of the intelligibility of objects in general and about the nature of the objects it can in principle investigate in particular. In view of these perspectives, social researchers should ask whether social objects are really different from 'natural' objects and what the conditions for making them amenable to scientific inquiry are.
- Third, discussing the objectives of science, we learned that science is fallible (interestingly, there is a wide consensus about this point among both scientists as well as philosophers of science). This means that its claims to any superiority cannot rest on its validity. Perhaps it is just *rational* and that is what makes it so special. Can social science be as rational as natural science? There is no reason why not.
- Fourth, we discussed theories that describe how science evolves or how it ought to evolve. This debate has given rise to the question of whether or not science is in fact rational. Whatever the case, we saw again that there is no reason why the proposed models of scientific progress should not apply to social science as well.
- Fifth, discussing problems of demarcation, we came across an extreme conflict between theories that push for a very narrow hence exclusive definition of science and theories that reject any positive assertions, including assertions about demarcation. Social researchers should be aware of the implications of both kinds of theories for their own enterprise.
- Finally, discussing the interface between science and morality, we saw that, in context, science tends to acquire a moral dimension and there are two complementary ways to strengthen its morality. A similar conclusion applies not just to science, natural and social, but also to any other knowledge system.

FURTHER READING

Martin and McIntyre (1994) is a treasury of important articles in the philosophy of science. Hollis (1994) is an exceptionally good introductory text. Smith (1998) has excellent coverage of contemporary developments. Machamer and Silberstein (2002) provide a thorough, comprehensive guide.

Student Reader (Seale, 2004b): relevant readings

3 Emile Durkheim: 'Laws and social facts'
4 Walter L. Wallace: 'The logic of science in sociology'
5 Thomas D. Cook and Donald T. Campbell: 'Popper and falsificationism'
26 Paul Feyerabend: 'Against method'
27 Thomas S. Kuhn: 'The structure of scientific revolutions'
59 Renato Rosaldo: 'Grief and a headhunter's rage'
62 Zygmunt Bauman: 'Intellectuals: from modern legislators to post-modern interpreters'
67 Max Weber: 'Science as a vocation'
71 Sandra Harding: 'Is there a feminist method?'

Journal articles discussing issues raised in this chapter

Mulkay, M. and Gilbert, G.N. (1981) 'Putting philosophy to work: Karl Popper's influence on scientific practice', Philosophy of the Social Sciences, 11: 389–407.

Potter, J. (1984) 'Testability, flexibility: Kuhnian values in scientists' discourse concerning theory choice', Philosophy of the Social Sciences, 14: 303–330.

Web links

Stanford Encyclopedia of Philosophy: http://plato.stanford.edu/contents.html

Routledge Encyclopedia of Philosophy. Social sciences, philosophy of: www.rep.routledge.com/article/R047

Philosophy since the Enlightenment, by Roger Jones: www.philosopher.org.uk

e-Source: Chapter 2 on '"Science" in the Social Sciences' by Jeffrey Coulter: www.esourceresearch.org

KEY CONCEPTS FOR REVIEW

Advice: Use these, along with the review questions in the next section, to test your knowledge of the contents of this chapter. Try to define each of the key concepts listed here; if you have understood this chapter you should be able to do this. Check your definitions against the definition in the glossary at the end of the book.

Coherence theory of truth

Correspondence theory of truth

Deduction

Deductive-nomological (D-N) model

Empiricism

Epistemology

Explanans/explanandum

Explanations (scope, form, structure, testability and validity of)

Falsificationism

General and specific explanations

Hypothetico-deductive method

Idealism

Induction

Instrumentalism

Interpretivism

Law, theorem and theory

Logical positivism

Materialism

Metaphysical

Naturalism

Nonfoundationalism

Normative and descriptive accounts of science

Objectivity

Ontology

Postmodernism

Principle

Rationalist epistemology

Realism

Reductionism

Scientific paradigm

Scientific revolution

Social constructionism

Specificity of scientific explanations

Teleological

Testable explanation

Transcendentalism

Universal law

Verificationism

Review questions

1. Describe in which respects science resembles metaphysics and in which respects it differs from it.
2. Explain why science cannot claim to be superior to other knowledge systems based on the validity of its statements.
3. Describe the problem of induction and suggest an alternative way of producing generalisations.
4. What are the problems which falsificationism purports to address? Does it tackle them satisfactorily?
5. Describe the difference between normative and descriptive theories of scientific progress and give some examples of each.
6. Describe Feyerabend's view on the demarcation problem and compare it to a radical postmodernist view.
7. Give an argument why *all* science is necessarily interpretive and explain on which epistemology it draws.
8. Explain why Hume was right saying that a leap from 'is' statements to 'ought to' statements is illogical. Describe the conditions under which the transition from the former to the latter could nevertheless be done in a logical way.

Workshop and discussion exercises

1. What, in your view, are the major features of a *science*?
2. Explain the arguments for:
   (a) treating social sciences as analogous to natural sciences
   (b) rejecting the notion of the methodological unity of natural and social sciences.
3. What do you understand by the terms *value freedom* and *objectivity*?
4. Are emotions best kept out of social science?