DID MY GENES MAKE ME DO IT?

AND OTHER PHILOSOPHICAL DILEMMAS

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IS SCIENCE THE ANSWER?

FROM MYTHOLOGY TO SCIENCE

The making of the modern mind begins in the West in the sixteenth and seventeenth centuries with the astronomical discoveries of Copernicus, Kepler, Galileo, and Newton. Their findings completely changed traditional beliefs about mankind's role in the broader scheme of things. For at least a thousand years before the Copernican revolution it was accepted without much dissent that the earth is the center of the universe, that humanity is a special creation of God, and that human beings are radically different from all other living things. Modern science and its close relative, technology, have shaken this outlook to its roots, and it is now widely rejected by many. What has given science and technology such compelling authority? In answering the question, we shall eventually want to distinguish science from technology, but for the moment let us treat them as being more or less the same. At least part of the answer must be the notable success that science, in this broad sense of the term, has attained in the past four hundred years. It has not only produced a clearer and truer picture of the animate and inanimate features of the natural world than any scheme that preceded it, but its achievements have extended the lifespan of humans, multiplied the food supply by orders of magnitude, and revolutionized communication. Many intelligent persons are convinced that, given its distinguished record, science can solve all problems. As mentioned in the Preface, the celebrated Austrian philosopher/physicist, Moritz Schlick, was a typical proponent of this view. In his magnum opus, *Die Allgemeine Erkenntnislehre* (*The General Theory of Knowledge*), he stated: "Since science in principle can say all that can be said there is no unanswerable question left." The idea it expresses is that science can eventually cope with all of mankind's problems.

The major aim of this book is to challenge such optimism. In the chapters that follow, I will present a series of problems that are palpably factual in nature, but that science cannot solve. In fact, my thesis is even stronger. It is that these problems, and others like them, are not capable of decision by anyone – philosophers, scientists, historians, or psychologists. I will also make the case that they are pressing problems, "deep disquietudes" as Wittgenstein characterizes them, that beset ordinary persons and professional philosophers alike. But in order to show that science cannot deal with them, I wish to make the strongest possible case for science, and the rest of the chapter will lay out that case.

Everyone will acknowledge, of course, that large numbers of scientific mysteries still exist. Whether there is extra-terrestrial life in the universe remains an open question. Chemists and biologists generally agree on the criteria of what counts as life – any form of life must be self-reproducing and capable of mutation. Accordingly, we *now* know what sorts of observations would have to be made to answer the question, even if we are not yet in a position to make them. That is what it means to say that the difficulty is solvable "in principle." The practical problem is different; it is how to get to some of those distant places and do the appropriate tests. But once there, the obstacles to discovery would not be much more formidable than they would be in order to find out whether there is life in the deepest trenches of the oceans. In both cases it is a matter of developing the appropriate technological means.

Of course, one should not underestimate the practical impediments. We don't have to leave the planet to encounter such difficulties. Even where the origin and nature of a medical ailment are completely understood, there may be no treatment for it. Sickle-cell anemia is a good example. In 1948 a team of biologists working at Caltech under the supervision of Linus Pauling was able to unravel the molecular basis of this serious blood disease. Nevertheless, more than half a century later, no cure is available. Again, the attempt to create energy by the process known as "fusion" is still years away from practical implementation. The difficulty is partly theoretical and partly technical and no solution is yet in sight. Despite the abundance of such practical barriers, many scientists conjecture that fusion will be in common use by the end of the century. Some investigators believe that cancer and many other major diseases will be conquered in the foreseeable future. The prospect of success over a whole range of problems seems ever brighter. A large number of literate persons in the West are optimists in this sense; they think that a scientific-technological Shangri-La lies just around the corner.

So given that there are many scientific questions still unanswered, why is there such general confidence? The answer turns on what counts as the best method for comprehending and managing nature. This is a complicated matter that we shall explore in the remainder of the chapter. But one can say at least this much: It is now widely accepted that science has no competition in this respect. To feel the full force of this attitude one should compare and contrast scientific and pre-scientific approaches to understanding and grappling with the environment. This we can do with a brief glance at the past. We know from historical, geological, and paleographical data that life for human beings has always been perilous. Nature produces violent rainstorms, floods, fires, earthquakes, volcanic eruptions, droughts, illnesses, and death. Just think about infective diseases for a moment. The average length of life for humans in England in the sixteenth century was about half of what it is today in advanced industrial societies. Why was the pre-modern world such a hostile place? How did humans attempt to cope with its threats? What explanation for this state of affairs was given by pre-scientific thinkers?

A distinguished contemporary biologist, S. J. Singer, has given plausible answers to these queries. In *The Splendid Feast of Reason*, he writes:

> In the absence of any scientific understanding, the universal response of primitive people to their predicament was to mythologize this alien and material world, to animate it with mythical living and immortal beings who were more powerful than humans and who could control the awesome forces of nature, beings with whom humans could identify and to whom they could turn in supplication in times of need. We rationalists must admiringly acknowledge that, for their time, these mythologies constituted a remarkably sophisticated achievement, ranking in brilliance with any ever created in history. The invention and elaboration of mythologies of a natural world inhabited by superhumans and eventually human-like deities generated a more pliant and friendlier kind of external world in which to live. What had previously been an utterly forbidding and unapproachable external world became humanized, a mythical outgrowth of human life, which rendered that external world no longer foreign and autonomous but instead anthropocentric, focussed on humans. All of this extraordinary achievement must have required a prolonged period of pre-recorded history to construct, and it eventually took on an immense variety of highly imaginative forms in primitive societies (p. 14).

As Singer suggests, until the development of modern science human imagination was the method used for explaining and coping with the happenings that beset mankind. Imagination created a set of stories in which the fragile powers of mankind were in constant battle with the overwhelming power of nature. Natural forces were eventually personified into "gods" and the human struggle for existence was seen as having some success only if the gods could be appeased by sacrifices and propitiative gifts. Explanation was thus given an anthropomorphic twist. In the *Iliad* and the *Odyssey* of Homer, who is thought to have lived around 750 B.C.E., gods like Zeus and Poseidon are depicted as having human forms, even as having sexual relations with humans. Unlike humans they are described as being immortal and enormously powerful. When angered they generate electrical storms and plagues of insects that wipe out crops; hence the need to conciliate them. The *Bible* begins with the picture of a local deity similar to those found in Homer. In its first book, *Genesis*, some of whose parts were written about the same time as the *Iliad* and the *Odyssey*, Yahweh – the Hebrew God – talks to Noah as he loads animals onto the ark, and closes its door after Noah embarks. With the passage of time, this anthropomorphic form of religion gave way to a more abstract conception. In *Deuteronomy*, thought to be composed during the Josiah Reform of 610 B.C.E., that same deity has become an immaterial force, no longer visualized in human shape or form. Nevertheless, as a later document, *Job*, tells us, Yahweh still continues to intervene in the world, punishing those who violate his commandments and rewarding those who follow them.

This mythological-theological explanatory system began to break down with the advent of science. It is now widely believed in the West that scientific method is not only the most successful way of understanding and controlling nature, but that it is the *only* way. This is believed because nothing having its explanatory and practical success has occurred in the millions of years that humans have been on earth. It is also believed that this is just the beginning, that "we haven't seen anything yet."

SCIENCE AND TECHNOLOGY

As I mentioned it is important to distinguish science from technology. Science is concerned with understanding how things work. It is essentially a form of curiosity, though of course disciplined by the requirement that its investigative activities lead to knowledge and truth. Technology is different. It is designed to control nature, to make it subservient to human needs, wants, and desires. In everyday life, and especially in sophisticated industrial societies, these two disparate activities frequently overlap and may be difficult to distinguish. But they can and should be differentiated.

It is generally true, for example, that science in its purest forms may have little impact on the everyday activities of human beings. The discovery by Kepler that the planetary orbits are not circular, but elliptical, has little, if any, significance for those shopping in supermarkets. It does have relevance to certain sorts of technological activities, such as sending instrument bearing satellites to explore the atmospheres of Mars and Jupiter. Without an accurate knowledge of planetary orbits such vehicles could well miss their targets. Of course, some scientific findings do have everyday implications. As mentioned earlier, the discovery that the earth is a minor planet revolving around a relatively small luminous celestial body, and that the solar system itself is located in a miniscule corner of a large galaxy, has had momentous significance for some persons who accept the biblical account of the cosmos as literally true. Similar remarks can be made about the impact of Darwin's theories about the origin of the human species.

It is also true that technology in highly sophisticated forms can exist in societies where there is no science – or to be more exact, no science in the contemporary Western sense of that term. China is perhaps the most celebrated case. Until fairly recently China never developed science as we now know it; yet its technology was extensive and much advanced over anything in the Western world. Such things as the wheelbarrow, the cross-bow, the kite, iron casting, iron-chain suspension bridges, the axial rudder, the magnetic compass, porcelain, block printing, the screw, gunpowder, the force-pump for liquids, the square-pallet chain-pump, the edge-runner mill with water power, the rotary fan and rotary winnowing machine, piston-bellows, the wagon-mill, silk-handling machinery (i.e., a form of flyer for laying thread evenly on reels), and water-powered textile mills, were in common use many centuries before their counterparts in the West.

How the Chinese could achieve such a complex technology without a concomitant development in science has been a puzzle to historians. One suggestion is that according to their Yin and Yang doctrine the universe consists of a totality whose parts are indissolubly welded to one another and therefore cannot be disjoined without conceptual distortion. It is thus impossible, even in principle, to isolate individual events, processes, or objects for examination. In contrast, the Western conception is that the universe is composed of discrete and autonomous events that can be separated from one another and investigated individually. This outlook is called "Reductionism." It is one of the essential features of Western science. What this term means is that single items, such as particular solids, gases, or liquids, can be removed from their natural environments, brought into a laboratory, and then manipulated experimentally in order to discover their basic properties. It is to a great extent the reductionist approach of modern science that has led to its deep understanding of nature.

Reductionism is not the only feature that distinguishes modern science from earlier approaches. Its quantitative approach is another. The ancient Greeks and their seventeenth-century counterparts, such as Galileo and Newton, were driven by the desire to understand the world. In both eras science and philosophy were not sharply discriminated from one another. The kinds of questions that each attempted to answer were remarkably similar – "What is the ultimate nature of reality?"; "Is there a fundamental, underlying principle that can ultimately explain the seemingly endless complexity of nature?"; "Is the earth the center of the cosmos?"; "What is the relationship between the sun, the earth, the planets and the stars?"; "Is there meaning in the universe or is it indifferent to human interests and desires?"; "Is there a God who is the cause of all that exists, and if so, what is his function?"

Aristotle (384–322 B.C.E.), who is often described as the last great philosopher of the ancient world, inherited these and other questions from his predecessors. Like modern scientists he thought that human reason and, where possible, careful observation, should be brought to bear on these queries. He also believed that the task of science is to discover general laws. But he was also strikingly modern in thinking that the basic ingredients of the natural world are individual. So unlike the holistic conception of the Chinese, his *Weltanschauung* assumed that science can isolate individual objects and by applying general laws can then explain their behavior. Invoking these principles, Aristotle became the first serious experimental biologist of whom we have any accurate historical record. (Darwin called him the greatest biologist who ever lived.) His philosophical view of the universe as consisting of discrete objects was thus conditioned by his biological outlook, and this affected his conception of scientific explanation. He thought that the basic question any theory should answer is: "Given that every object, whether man-made or natural, has a unique constitution (or essence) what is its special purpose or function?" Take knives, for example. They can be made of different materials and can be used for different purposes: as ornaments, paperweights, and so on. But that is not what knives are designed to do. Their main function – their purpose – is to cut things. Thus, as Aristotle saw it, a scientific investigation should uncover the essential purpose that any entity belonging to the natural world is designed to serve. As he wrote: "If, therefore, artificial products are for the sake of an end, so clearly also are natural products. The relation of the later to the earlier terms of the series is the same in both" (*Physics*, Bk. II).

In effect, the idea that all objects, whether artificial or not, are to be characterized in terms of their essential natures eventually gave rise, in Aristotle's system, to the notion that all activity is motion directed toward a particular end. Heaviness is the essential nature of solid objects and that is why such objects fall to the earth (their predetermined end); and lightness is the intrinsic nature of gases, such as smoke and steam, and that is why they rise toward the sky. And, he tells us, it is "by nature and for an end that the swallow makes its nest and the spider its web."

> This is most obvious in the animals other than man: they make things neither by art nor after inquiry or deliberation. Wherefore people discuss whether it is by intelligence or by some other faculty that these creatures work – spiders, ants, and the like. By gradual advance in this direction we come to see clearly that in plants too that is produced which is conducive to the end – leaves, e.g. grow to provide shade for the fruit. If then it is both by nature and for an end that the swallow makes its nest and the spider its web, and plants grow leaves for the sake of the fruit and send their roots down (not up) for the sake of nourishment, it is plain that this kind of cause is operative in things which come to be and are by nature ...
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> If then, it is agreed that things are either the result of coincidence or for an end, and these cannot be the result of coincidence or

> spontaneity, it follows that they must be for an end; and that such things are all due to nature even the champions of the theory which is before us would agree. Therefore action for an end is present in things which come to be and are by nature ... In natural products the sequence is invariable, if there is no impediment.
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> *Physics*, Bk. II, Ch. 8

Thus, according to Aristotle, every living entity goes through a process of development from "potentiality" to "actuality," if it is not interrupted. Kittens develop into cats, puppies into dogs, human infants into adults, seeds into vines, and so forth. Each of the later items is more complex than its earlier forms. Though the concept of genetic structure was, of course, unknown to him, he brilliantly drew the conclusion that each of these more simple entities has an internal composition, its essential nature, that gradually unfolds until it arrives at maturity. The resulting product often differs radically from its progenitor. A fully formed oak tree diverges in shape, size and appearance from an acorn. In describing the process of change, he was in effect giving a wholesale explanation of the motion of natural objects, whether organic or inorganic, in biological terms. This is a very natural and intuitive way of looking at things. If someone asks, "Where are you going this morning?" it is sensible to respond by describing your purpose, e.g., "I am going downtown to buy some stamps." Your response answers the question "*Why* you are doing something." In contrast, modern science replaces Aristotle's question by asking "*How*" not "*Why*" something happens.

Aristotle's science was thus *teleological*, not quantitative. When you explain that you are going downtown to buy stamps your response does not mention the rate of speed at which you are moving. The answer to this question is quantitative and disregards purpose. Modern science looks at nature as a machine, operating according to mechanical principles, and not as an organism that acts purposively. It thus replaces the biological analogy by a mechanical picture of nature. This change in outlook begins with Galileo's experiments of dropping iron balls down an inclined channel and measuring their rate of acceleration. (Since he had no exact chronometer he very cleverly used his pulse as a metronome.)

Galileo's approach proved that, setting the resistance of air aside, the velocity at which bodies fall does not depend on their weight, contrary to what Aristotle believed. It was known in antiquity that objects pick up speed as they approach the ground, but it was not known what the relationship is between their speed, the distance traveled, and the time required for the fall. Galileo's experiments demonstrated that a body that falls for two seconds, travels four times as far a body that falls for one second; and a body falling for three seconds travels nine times as far as a body falling for only one second. On the basis of this observation, it is thus possible to formulate, in mathematical terms, a law that will allow one to predict the distance that every freely falling object will traverse in a specific quantity of time. The law of falling bodies ($S = \frac{1}{2}gt^2$) or Newton's inverse square law of gravitation are examples of the modern approach to this mathematization of nature. Change for modern science is thus not identical with development or growth. It is basically transfer of position at a law-like velocity. In contrast, it was Aristotle's non-quantitative account that influenced his successors for nearly two thousand years and in part explains why the development of modern science was delayed until the seventeenth century.

SCIENCE AND THE REAL WORLD

We have seen that reductionism and a quantitative approach to nature are both essential features of modern science. But there is yet a third – one that is so obvious as to escape general notice. This is the notion that there exists a real world, a domain that is independent of human conception, speculation or fantasy. When Schlick asserts that science can solve all problems, he is talking about real problems: fires, floods, and earthquakes that kill people and damage property. Ordinary persons take it for granted that animals, the oceans, the cities in which they live, and the ground on which they walk, are all real. Most scientists are also realists in this sense. What they do not take for granted is what the real world is like and how it works. To answer these questions requires investigation, that is, the discovery of evidence that rules out certain conjectures and makes others probable. Yet to explain what is meant by "the real world" is not easy. Scientists do not normally discuss the issue – this is what it means to say that they take an external reality for granted. Therefore, in order to grasp what is meant by this concept we shall have to look elsewhere than science. Probably the most simple accounts are to be found in philosophy, where two forms of realism, "metaphysical" and "epistemological realism" are distinguished from one another. They correspond, roughly, to the presupposition that there is a real world and that a reductive, quantitative investigation is required to discover its nature.

Metaphysical and epistemological realism

In deepening the theme of whether science can solve all problems, let's begin with a look at metaphysical realism. This doctrine entails that the sole satellite of the earth – the moon – at which I am now staring does not depend for its existence on my mind, any state of my mind, on the state of any other mind, or collection of minds, past, present, or future. Even if all psychological awareness, whether human or non-human, were to be obliterated, the moon would continue to exist – assuming, of course, that no non-mental process had also obliterated it. States of mind include thoughts, guesses, intentions, beliefs, doubts, and desires. One's idea that guests will soon be arriving for dinner is a mental state. Whether pains, itches, and depressions are also mental states is a much debated question I shall bypass here. The important point is that according to this view there are objects, events, and phenomena whose existence does not depend on any form of sentience or awareness.

Metaphysical realism is also what philosophers call a dualistic theory. This term means that the world is composed of *at least* two different kinds 'stuff', neither of which is reducible to the other or to anything else. Traditionally, they have been taken to be mind and matter. In this characterization of "metaphysical realism," the term "at least" is important. Metaphysical realism does not mean that the world must contain exactly two kinds of irreducible ingredients. Some philosophers – among them, John Searle, the current writer, and the late J. L. Austin – have argued that the world contains many kinds of irreducibly different things: mental events, such as thoughts; physical processes, such as iron rusting; material objects, such as rocks; abstract entities, such as numbers; substances, such as gold and water; games, such as chess and baseball; institutions, such as governments; and the creations of governments, such as money. What every form of metaphysical realism maintains is that some of these are mind-independent.

As this description indicates, metaphysical realism affirms that there are minds and various states of minds. The very definition of "real world" requires this additional commitment. For "real" here means "mind-independent." But to assert that there are minds is not to assert that there *must* be minds. The realist holds that the existence of minds is a contingent fact. It is easy to imagine a segment of the universe that lacks any form of sentience. Indeed, this appears to be a true description of much of the past history of the earth and, as far as we know, of Jupiter and Saturn today. Long before living entities appeared on earth it consisted of inorganic substances: water, mud, and various gases. Even to assert that there are minds does not entail a commitment to dualism. So-called "philosophical idealists" argue that everything that exists is mental. Hence for the idealist nothing is mind-independent. Metaphysical realism, nevertheless, includes as one of its defining features the condition that there are minds. This is essential because its thesis is that some things exist independently of minds – so some reference to minds is necessary even to formulate the realist position at all.

However, it is not essential to metaphysical realism that it adopt any special view about the nature of mind. It has been asserted of the *human* mind, for instance, that it is a transcendental ego, a bundle of related perceptions, a complicated set of dispositions, a thinking substance, and so forth. Hence, one can be a metaphysical realist without coming to a decision about the nature of mentation. But every form of metaphysical realism presupposes the distinction between sentience, however it is ultimately analyzed, and events, objects, processes, and phenomena that do not depend for their existence on cognitive awareness in any of its various guises. Thus, the main distinction between metaphysical and epistemological realism is that the former generates conjectures about the nature of the real world whereas the latter attempts to determine whether those conjectures are true.

Metaphysical realism and monism

Epistemological realism is thus the investigative branch of realism; together they constitute explicit forms of the realism presupposed by modern science. There is, nonetheless, a difference between them. As we have seen, metaphysical realism is dualistic. But epistemological realism is not necessarily dualistic. Its investigative activities may eventually discover that all existents, including putative mental states, are really material. They may find the opposite to be true as well. The view is called "realist" in the sense that its inquiries begin with the assumption that mind and matter are fundamentally different. In practice, this assumption is the view that each human being participates in two irreducibly distinct realms, an inner, subjective, world of personal experience, and an external, publicly observable world. A contrast is thus drawn between a private, mental realm, to which only its proprietor has direct access, and an objective, material world that a reductive and quantitative approach can effectively explore.

In his *Biology & the Nature of Man*, the distinguished biologist W. H. Thorpe puts the contrast in this way:

> Let me say at the outset that, although I believe there to be an extremely close interrelation between mind and brain, I can only conclude that they are in some sense two things. All theories which imply that mind is merely a by-product of the activities of the brain, or that there is a complete parallelism over the whole range of man's mental experience between mental states and events and physico-chemical states and events in the brain I believe to be untenable. We know our own minds in a different way, at first hand, and better than we know anything else. I think the essential difference here is that between experience and observation ... There is no doubt that in the higher animals and in human beings, the brain is the main organ of correlation of the information flow received from all the various sense organs which are transmitting 'news' about the external world – including, of course, news from the body itself

> and from the sense organs which tell us about tensions in the muscles and the positions of the limbs and joints ...
>
> But even if we admit this much, this does not itself amount to saying that the brain is the sole organ of knowing since – returning to the kind of distinction I made just now – from the nature of the case, while it can cope with "knowing" it cannot cope with "experiencing." The kind of distinction between knowing and experiencing, coupled with the suggestion that the activity of the brain cannot provide a complete model of all mental states, events, and experiences, is likely to be highly repugnant to some people because of its dualistic implications. It implies two worlds, two systems, two events, where they would like, for plausible scientific reasons, to reduce everything to one only (pp. 21–24).

But as progress continues to be made in cognitive research, Thorpe's dualism may turn out to be an indefensible dichotomy. It may be that the mind is just an especially complex piece of matter, identical with the brain, and that thinking is simply a set of neurons firing at 40 Hertz. The question of whether the mental may ultimately turn out to be part of the objective material world is thus left open for future scientific exploration.

From a taxonomic point of view, the main alternative to metaphysical realism is thus not epistemological realism, but rather monism, that is, the idea that the world consists of only one kind of stuff. Monistic theories themselves divide into various categories: some maintain that the "stuff" is mental; others hold it to be "material." The philosophers, Bishop Berkeley, G. F. Hegel, and F. A. Bradley, were proponents of idealism; Thomas Hobbes and Karl Marx, of materialism. Russell once held that it was "neutral," that is, neither mental nor physical. He called this view "neutral monism." Most scientists are materialists. Some biologists, for instance, contend that human beings are nothing but complexes of matter; and that matter itself is simply a conglomerate of molecular, atomic and sub-atomic particles. But others – for example, the aforementioned W. H. Thorpe – defend a form of "vitalism," a dualistic view having a strong religious tint. The most common philosophical and psychological views today – behaviorism, eliminativism, and the identity theory – are all forms of materialism and thus are examples of monism according to this definition. All such theories are thus inconsistent with metaphysical realism, but not with epistemological realism, as described above.

Whether the private, human mental world will ultimately be found to be a form of materialism is still debated. But that there is at least an objective, non-mental realm is not a serious worry for modern science. For example, in collisions of electrons and positrons at the LEP accelerator at CERN (the European Organization for Nuclear Research), W and Z bosons were produced. These particles are too small to be seen even by electron microscopes, but their motions can be tracked by various types of instruments. That they are physical entities is thus beyond reasonable doubt, since predictions about their properties and behavior have been confirmed by such detectors. At the other end of the spectrum of size, astrophysical theory has identified a vast array of astral objects that existed long before there was any form of sentience in the universe. That the external world is wholly mental is thus rejected by modern science.

Metaphysical realism and the fundamental "stuff" of the world

Metaphysical realism has another facet, one with a long history that begins with the pre-Socratic Greek philosophers. This may be called the search for what is fundamental in nature. In a more sophisticated form than Greek thought could attain, modern science pursues a similar end. It wishes to discover the principles that govern nature from its tiniest ingredients to its most massive. Science begins with observations of and experiments on objects that one can see with the naked eye. The use of special instruments reveals these macroscopic objects to be composed of particles that cannot be seen with unaided vision. The aim of science is to explain how these miniscule objects become the building blocks of larger structures, including such massive objects as galaxies. The quest takes place at two intertwined levels of investigation. The first is highly theoretical; it concerns the discovery of principles or laws that tie diverse phenomena together. The other is descriptive; it attempts to account for the behavior of all the ingredients of nature, from the smallest to the largest.

Both levels of the quest are exemplified by the Law of Gravitation. It explains the behavior of smaller and larger entities and processes – for example, why an apple falls toward the ground, why the tides advance and recede in relation to a coastline, and why the moon does not drift away or plunge into the earth. It is an example of the kind of basic principle theorists seek. It explains in unexpected ways how diverse events, happenings, or structures in the real world are hooked together. It is the hope of modern science that if a single, synoptic principle, even more broadly encompassing than gravitation, could be found all the operations of nature could be explained. It could even answer the question whether the universe will eventually squeeze to a point or will go on expanding to infinity.

The earliest Greek philosophers, Thales, Anaximenes, and Heraclitus each attempted to discover such a fundamental principle. They found that what seemed to be a diverse and confusing set of events or happenings could be given a simple, single explanation. Thales, for example, noted that water, a liquid, hardens in severely cold weather, and becomes a vapor when heated. He also observed that if one digs deeply enough into the ground water bubbles up, and if one cuts persons or plants, the exposed surfaces are wet. His explanation of these diverse occurrences led him to the thesis that everything is composed of water. Using this explanatory principle, he thought he could account for the existence and behavior of all substances.

A later Greek philosopher, Democritus, argued that there were four elemental substances – earth, air, fire, and water – but even more importantly, that each of these was composed of even more fundamental entities that he called *atoms*. This view, arrived at without any observational backing, was given little credence for centuries until it was confirmed by two types of experimental evidence in the sixteenth century: first, by the detailed behavior of gases and, second, by the quantitative-weight relationships that accompanied a variety of chemical reactions. Two centuries later, John Dalton (1766–1824) explained the empirically derived laws of chemical combination by postulating the existence of atoms with unique sets of properties. His work generated numerous independent experimental verifications of the atomic hypothesis and today it is accepted by all scientists.

For about a century now it has been recognized that the atom also has a complex structure. What elementary particle physics has discovered in the past couple of decades is that the atom is composed of a bewildering array of smaller particles. Some congregate in small groups; others prefer to act singly. At present (2004), there are two main approaches dedicated to discovering a fundamental principle, comparable to the role played by DNA in biology, to explain the nature and behavior of these smaller particles. The earlier of these theories is called "The Standard Model." Its history can be traced to the work of Ernest Rutherford at the beginning of the twentieth century and even further back to the researches of John Dalton, the eighteenth-century English chemist. The other main contender for the grand master equation is String Theory. Both are too complicated to be described in any detail here but it is possible to depict some of their main features.

The Standard Model reduces to a handful the number of basic particles that compose matter and gives an account of how they are related. It tells us what these particles can do and what they cannot, how they come together and how they fall apart, all at dimensions a billionth of a billionth of the human scale. The model does not stop at the subatomic. Its theories attempt to explain the origin of the universe and the symmetries that frame its design. According to this view, matter consists of two kinds of particles – quarks and leptons. The matter particles interact by means of force particles or bosons. Bosons form another complex collection, including W and Z (the weak force); photons (electromagnetism) and gluons (the strong force). Experiments using the DELPHI detector at CERN indicate – for reasons physicists do not understand – that the elementary particles divide into three sub-groups. Our world is mainly built up from particles in the first group: electrons and up and down quarks. Although the elementary particles are all pointlike objects, their masses differ greatly – although why this is so is also not known. The top quark, for instance, is as heavy as an atom of gold, whereas the neutrino weighs almost nothing.

It is now generally agreed that the Standard Model should be extended since it is believed that hiding behind the quarks and gluons lie new particles and new forces. What these will turn out to be is a matter of speculation as yet; it is hoped that when more powerful accelerators, such as the Large Hadron Collider, come on line the question will be answered.

The Standard Model has one major liability to overcome and one major mystery to solve. The liability is that it does not explain the nature of gravitation – that is, that no "graviton" has ever been found. According to Einstein's theory of general relativity, gravity is linked to the curvatures of space and time, and is so weak a force it does not fit the pattern of the other forces. That it has not been accommodated by the Standard Model is considered a serious liability and is thought to limit its ultimate explanatory power. The mystery is complex. It is the question: "Why do particles have mass?" According to present theory, the answer lies in a particle that has never been identified. It is called the "Higgs boson," and is named after the British physicist, Peter Higgs, who first proposed its existence. It may explain the lopsided masses of the photon and the W and Z weak force particles. If such a boson is found it would not be just another particle, but would represent a field that exists everywhere, permeating space, and touching everything.

String theory attempts to provide a different fundamental explanatory principle. It holds that instead of particles, matter is ultimately composed of tiny loops of strings that vibrate at different frequencies in a universe made of 10 or 11 spacetime dimensions, not just four. Different vibrations become a quark or a lepton or the gravitational force or the strong force – indeed any particle or force. String theory has been enlarged into "membrane" or "brane" theory. This theory claims our universe is just one of many three-dimensional branes inside a mega-universe having another dimension. Most of the fundamental strings are confined to our three-dimensional space because they are attached to the surface of our brane. The strings of gravity crowd around a foreign brane and only a few gravitons escape and this may explain why gravity is so weak. It is also possible that gravity is spread out over other larger dimensions and this "thinning out" may explain why it is a weak force. Membrane theory also attempts to explain how large dimensions account for the differences in the masses of particles. It is a consequence of the theory that an electron is light because it straddles two dimensions, so part of its mass is located elsewhere. As metaphysical-sounding as these conceptions are, physicists are already designing experiments to test them. Even if 10^{-33} centimeters is beyond the reach of any proposed accelerator, experimentalists may still see the effects of these deep-lying phenomena at scales that are available even now.

THE SKEPTICAL CHALLENGE

Despite the evidence that biology and physics have supplied to support the view that there is a real world "out there," some thinkers of a skeptical persuasion have challenged this assertion. Curiously enough, in mounting this challenge, they find science itself to be a form of skepticism. Historically, skepticism comes in two versions, both of which rest on an assumption that science itself accepts, namely that most of the information we supposedly have about an external reality rests on sense experience. The first version is the more radical; it states that the only *direct* information we have consists of subjective sensations, what W. H. Thorpe calls "experiencing," and that it is conceivable that nothing outside of these sensations exists. It is thus possible that we are deluded into thinking that there is an external reality. The second, more moderate version, states that the senses are notoriously unreliable, so that we can never be sure that any account about external reality, even a scientific one, is accurate.

Let us examine these two forms of skepticism, beginning with the contention that most of our knowledge of external reality comes from seeing, hearing, smelling (etc.) things. I know there is a rosebush in my front yard because I see it there. I know that cars exist because I can hear them going by, and if I glance out the window, I can see them. It is the visual and auditory senses that provide us with information about these things. The ordinary person and the scientist tend to trust the senses, and to assume that the information they generate is reliable. But the skeptic finds such acceptance too facile. Consider some simple counter-cases.

We use mirrors for all sorts of purposes: to shave, to examine one's skin, and to observe the positions of cars behind us. When one shaves, for example, one assumes that the image of one's face that appears in the mirror is accurate, and therefore that the process of shaving will be successful. Yet, if one thinks about mirrors a little more carefully, one realizes that every mirror image distorts one's perception of the world's features. If one holds up an English language book to a mirror, one cannot read it, because the print runs backward. Yet the print on the book does not. One looking in a mirror never sees one's own face directly, that is, in the way other persons do. What one sees is reversed and subtly altered. We can shave because we adjust our habits to this situation, but it is a mistake to think that one is seeing one's own face as others do.

There are many ordinary, daily-life situations like this. A straight stick put in water looks bent; yet we do not believe it has become bent just because it was immersed in water, which is an easily penetrable liquid. Railroad tracks seem to converge in the distance, and yet when we walk to the spot where they apparently merged we find them to be parallel. The wheels of automobiles seen on television seem to be going backward when the automobile is seen to be moving forward. Yet this is impossible. Such examples of distorted perception could be multiplied endlessly. Each of these sense phenomena is thus misleading in some way. If human beings were to accept the world as being exactly how it looks they would be deceived as to how things really are. They would think the stick in water really to be bent, the writing on pages really to be reversed, and the wheels really to be going backward.

These are visual anomalies, and they represent the sorts of ordinary occurrences that provide ammunition for the skeptic. Starting from these cases, the skeptic can show that, when scrutinized, our common-sense beliefs become increasingly vulnerable to doubt.

Consider the case of the stick that looks bent when immersed in water. How can one be sure that it does not become bent when put in water?

How can one be sure that it is straight when it is out of the water? Of course it looks straight, but it also looks bent. What justifies giving priority to some sense impressions over others?

A person of common sense might respond by saying that seeing is not a sufficient condition for knowledge. One needs to correct vision by some of the other senses. Thus one might claim that the stick in water is not really bent because one can feel it with his hands to be straight when it is in the water. Thus, one corrects aberrant visual sensations by tactile impressions. But the skeptic can easily meet this move. What, he might say, justifies accepting one mode of perception as more accurate than another? After all, there are common occurrences that cast doubt upon the reliability of touch. Suppose one were to cool one hand and warm the other, and then insert both into a bucket of water having a uniform thermometric reading. The water will feel warm to the cold hand, and cold to the warm hand. But by stipulation, the water has the same uniform temperature, and therefore cannot be both hot and cold at the same time. Does this imply that one is not sensing the water at all? It is an interesting possibility and some skeptics have argued that such an inference is correct. But whether it is or not, the experiment surely suggests that the tactile sense cannot be fully trusted either, and that in particular, there is no justification for giving it priority over vision.

These remarks merely scratch the surface. In his famous Dream Hypothesis, René Descartes (1596–1650) propounded an even deeper skeptical objection to the commonsense view. He pointed out that the sensations we experience when asleep are intrinsically indistinguishable from those we experience when awake, and accordingly it is not possible by means of the senses to know *at any given moment* whether we are awake or asleep. But if this is so, we can *never* be sure on the basis of sense experience that we are apprehending the real world. This is radical skepticism in a full-blown form. It supports the first form of skepticism that we could have a panoply of sense information to which nothing external corresponds.

Suppose in the light of such difficulties, it is proposed that no mode of sense perception is sufficient to guarantee that one has knowledge, and hence that one needs to correct the senses by some other mode of awareness, say by reason. Reason tells us, that despite appearances, it is illogical to believe that parallel steel tracks, without any apparent reason, suddenly converge or that water bends rigid objects, like sticks. So independently of what our senses say, we can count on reason as a corrective that will give us an accurate picture of the world's features.

Yet reason has its own difficulties. It suffers from various liabilities: forgetting, jumping to unwarranted conclusions, miscalculations, misunderstandings, and misinterpretations. Almost everybody has forgotten or misremembered something important. One remembers having met a friend at the airport in Rome; yet that person has never been in Rome. One has added a column of figures incorrectly, getting the wrong sum. So why should one trust reason if its conclusions sometimes run counter to sense perception?

As these various examples show, the skeptical attitude cannot merely be dismissed. If it is ultimately mistaken, one will have to show why. That will require some hard thinking in order to arrive at a clear and defensible explanation of the apparently simple claim that the stick is really straight. In effect, a person who attempts to meet this challenge will need to develop a compelling theory that justifies the common sense and scientific beliefs that our senses are reliable. It would be viciously circular to appeal to science to decide this question since science assumes the reliability of sense experience, and that is just the point at issue. But that science does depend on data acquired through the senses is beyond question. And it is this fact that is the basis for the surprising claim made by some philosophers that science is a form of skepticism – moderate skepticism, to be sure, but skepticism nonetheless.

Apart from these considerations, there are other arguments in support of the notion that science is a form of skepticism. These call into account our mundane conception of the world, one that is based on sense experience. Our daily experience is of a *macroscopic* world, one whose components we can see, touch, hear, and feel. That world is composed of inanimate objects, like rocks and mountains, and of animate beings like insects, animals, and human beings. We can all see the sun, the moon, and feel ourselves standing on solid ground. As Ptolemy indicated, observation makes it plain that the earth does not move and that the sun revolves around it from East to West. Since time immemorial this has been the accepted picture of the cosmos. Yet science tells us that it is entirely wrong. The earth is in fact rotating and moving through space, and the sun does not revolve around it. It follows that if science is right the information generated by the senses is erroneous.

Consider a second case. The ordinary person tends to think of water as a liquid that is useful for various purposes: for drinking, washing, and mixing with other substances. Common sense also distinguishes between water, ice, and steam. Neither of the latter is a liquid, for example. What science tells us about water, ice, and steam differs from this conception. It claims that water, ice, and steam are basically identical because all are composed of H_2O. On this view, water is a collection of hydrogen and oxygen molecules – things we cannot see with the naked eye. Water is thus not to be identified with its observable properties, but with entities that are of microscopic size. In liquidity and transparency, we see the manifestations of these invisible ingredients, but the essential nature of water is hidden from the ordinary perceiver. Once again, our senses have misled us.

Now a third example. Common sense believes that many objects are perfectly solid. The table I am writing on is a case in point. But according to scientific theory, the table is mostly empty space and is not really solid. Its perceptible solidity is thus misleading as to its real nature. The truth of the matter is that the table is a cluster of invisible electrical particles occupying mostly empty space.

The conclusion to be drawn from these instances (and one could add an extensive list of others) is that we have good reasons for believing that everyday observation misrepresents the nature of reality. In undermining common sense, in favor of a highly complex, very counter-intuitive picture of an underlying reality, science supports skeptical doubts about the apparent knowledge the senses give us. It demonstrates that they do not provide an accurate account of how things are. But if science itself relies on observation, then are we justified in thinking its picture of the world is any more accurate than the ordinary man's? And if there is doubt about this, then are we justified in thinking that science can solve all problems?

THE SCIENTIFIC RESPONSE

Despite the seeming strength of the preceding skeptical arguments, they can be neutralized in various ways. If such counter-arguments are cogent – and the present writer thinks they are – one can support the scientific presupposition that there is an external world, and the concomitant belief that science can eventually come to discover what it is like and how it operates. Here are two arguments in support of science:

First, it is true that most, though not all, scientific knowledge of an external reality is based on observation. In the case of human beings it is the brain that processes such information. But observations depend for their existence on entities, such as the body and some of its organs, that are mind-independent. Even Thorpe, a dualist, agrees with this point. Here, we recall, is what he said in the passage I quoted earlier:

> There is no doubt that in the higher animals and in human beings, the brain is the main organ of correlation of the information flow received from all the various sense organs which are transmitting "news" about the external world – including, of course, news from the body itself and from the sense organs which tell us about tensions in the muscles and the positions of the limbs and joints.

In this citation, Thorpe is stressing that the human body, including its muscles, limbs and joints, is part of the external world and is not a mental entity. The essential point he is making is that subjective mental experience depends on bodily features and that these themselves are mind-independent. So here we have an argument that sentience depends for its existence on that which is non-sentient. Accordingly, science is justified in rejecting the skeptical contention that because mental experience is private we have no reason to believe in an external material reality.

There is a second source of support for science's view of reality that is strictly biological and is derived from the theory of evolution. It begins by contrasting unaided human vision with the extensions that telescopes and microscopes provide.

Prior to the development of such instruments most of the information about the world that human beings acquired was by means of a visual system that includes the eye, rods and cones, the retina, the optic nerve, and the brain. This system arose from and was refined by evolutionary development and natural selection. If we return to Aristotle for a moment and ask what is the purpose or point of this system, the answer, later given by Darwin, is that it makes survival possible. It enables humans to see and find sources of food and shelter, avoid predators and other hostile forces, and select mates for propagating the species. The fundamental thrust of evolutionary theory is thus to demonstrate that natural selection has allowed all species of animals, including human beings, to survive because they perceive a real world, not a supposititious, fanciful reality, but the real thing itself. Stalking and capturing a real rabbit will keep a hawk and its young fed rather than remaining hungry. What animals perceive of the world is limited by the range of their visual capacities. Accordingly, there are aspects of the real world that cannot be seen by the unaided animal eye, no matter how keen. As S. J. Singer writes:

> Things are seen with the unaided eye only if they emit or reflect radiation within a very narrow range of the electromagnetic spectrum (which we call light) and only if they are suitably contrasted with their background ... Humans do not see X-rays, ultraviolet or infrared radiation, microwaves or radio frequencies (that is, well over 99 percent of the electromagnetic spectrum) and were therefore entirely unaware of the existence of such phenomena as recently as 150 years ago. Likewise, our perception of distance is limited by the stereoscopic analysis provided by our two eyes and brain so that, for example, we cannot discriminate astral distances; to us, all the visible stars appear to be located on a single canopy in the night sky, much as we see them projected on the roof of a planetarium. We cannot distinguish with the unaided eye between a distant galaxy containing billions of stars and a nearby single star in our own galaxy, since both appear to us as single points of light.

> These limits on our perception are further examples of the functional economy of evolution. Natural selection is parsimonious. It selects only for qualities that are important for survival. Our ancestors did not need to recognize objects at very long distances in order to capture prey or to avoid predators, and in view of the curvature of the Earth's surface, our ability to perceive long distances horizontally was in any event proscribed. In a similar vein, we did not need to, and therefore did not, see objects that are less than about 0.1 mm in size. The entire world of microorganisms was therefore invisible to us and remained unknown until microscopes were invented (pp. 144–145).

But what might be called the "middle sized furniture" of the world can be apprehended by the visual systems of most animals. Singer's point that natural selection is parsimonious and selects only for qualities that are conducive to survival is powerful. It means that evolutionary theory does more than take it for granted that there is a real world. It explains why there *must* be such a world given the millions of years that so many species have persevered. The existence of an external world is thus *proved* not by *observation* as the skeptical challenge assumes, but by the persistence of uncountable species of living beings.

SELF-CORRECTION, SCIENTIFIC TRUTH, AND SCIENTIFIC KNOWLEDGE

So far we have identified three essential characteristics of science: its reductive and quantitative investigative approaches to the world, its presupposition that there is an objective, mind-independent world whose operations are not obvious, and that the scientific task is to find out how they work. Let us now mention a fourth: science's quest for knowledge and truth.

Even though science is a form of curiosity, such wonderment is not idle; it is tempered by the requirement that its investigative activities lead to an accurate picture of things. This aim distinguishes it from many other disciplines, such as pure mathematics. A mathematician may construct a conceptual scheme of great elegance that has no application to reality. Yet that it does not may not affect its mathematical significance. But science is different. If a scientific idea does not fit the facts it will eventually be discarded despite its ingenuity. A famous case of this sort is the theory advanced by Claudius Ptolemaeus (fl. C.E. 127–145) to the effect that the earth is the center of the universe and does not move. Ptolemy argued that since all bodies fall to the center of the universe, the Earth must be fixed at its center, otherwise falling objects would not be seen to drop toward the center of the Earth. Furthermore, if the Earth rotated every twenty-four hours, a body thrown vertically upward should not fall back to the same place, as it was seen to do. Ptolemy also pointed out that no countervailing data had ever been observed. As a result of his arguments, the geocentric system became the accepted truth in Western Christendom until it was superseded in the sixteenth century by the heliocentric system of Copernicus. The Copernican view that the planets have circular orbits was in turn replaced by Kepler's discovery that the orbits are elliptical. A new explanation of why bodies fall to the ground was given still later by Newton's theory of universal gravitation. Yet as elegant and powerful as it is, the Newtonian system is now known to be a special case of a more general form of astrophysics that was developed by Einstein at the beginning of the last century, and it is this outlook, supplemented by quantum theory, that is currently accepted by most scientists.

There are many such developments in the history of science. The replacement of phlogiston theory by Lavoisier's discovery that oxygen is the causal factor in combustion is another example of scientific advance. Despite frequent misfires, science has a notable record for correcting its earlier errors. Most intelligent persons are impressed by this record, and it is widely believed today that science will continue to make steady progress toward a true view of things. The notion of self-correction is obvious and needs no further explanation here; but the concepts of truth and knowledge are less so. Even at first glance it is clear that they differ. The claim that there is life on Mars may well be true even if nobody knows that it is. But what, then, is the difference between these notions?

Scientific truth

Let us begin with the concept of truth. The most famous definition derives from Aristotle: "To say of what is that it is not, or of what is not that it is, is false, while to say of what is that it is, or of what is not that it is not, is true" (*Metaphysics*, Bk. 4, Ch. 7). It will be noticed that this formula distinguishes between two different categories of items, between *saying* and *what is*. According to this conception, truth is a relation that holds between a particular speech act and what that speech act is about. Philosophers call this a "semantic" relation. In modern philosophy there are many different accounts of the appropriate candidates for each category. For *saying* the main choices are *propositions*, *sentences*, *affirmations*, *beliefs*, *assertions*, *utterances*, *claims*, and *statements*. These are all different and each has its proponents. For *what is* the candidates include *the world*, *facts*, *reality*, *what is the case*, *situations*, *the way the world is*, *states of affairs*, and *state descriptions*. Again, each is different and each has its adherents. But despite such disagreements there is a consensus that truth is a relationship that holds between a specimen of language (or its analogues) and some feature or features of the world.

To illustrate: Suppose my wife and I have decided to go on a picnic and as we leave the house I say to her, "It is raining." I have made an assertion about the weather. If rain is then falling it is that fact that makes my utterance, "It is raining," true. If it is not raining that is also a fact; and it is that state of affairs that makes my assertion false. This is what Aristotle's formulation entails. It is called the "correspondence theory," because it holds that when there is a correspondence between an assertion, belief, or statement and the way the world is, we have truth. If that correspondence does not obtain we have falsity.

This concept of truth is relevant in the following way to our discussion of the main features of science. As emphasized earlier, metaphysical realism presupposes that the real world exhibits both sentience and non-sentience. The concept of truth satisfies this complex condition. It presupposes that the real world contains sentient beings capable of thought and speech, as well as non-sentient features about which such beings can and do make assertions or claims. Among such non-sentient features are facts. Truth, in contrast, depends on sentience. If there were no creatures capable of belief or statement-making, truth would not exist. Nor would science exist. But facts would. The fact that it is now raining has nothing to do with anyone's beliefs, doubts, thoughts, or any other psychological factors. As far as we know, the capacity for truth (or its antonym, falsity) is a distinctly human feature. To attempt to arrive at a true account of nature is a further distinctive feature of science. It is not, to be sure, the *only* aim of science. Knowledge is another. It is generally important and almost always relevant to ask: "But how can we *know* that any scientific claim *is* true?" The answer resides in epistemological realism, the investigative arm of metaphysical realism. It attempts to explain the nature and extent of the evidence that must be adduced in support of any truth claim if we are to know that the claim is true. Thus, together with truth, the quest for knowledge is a fourth distinctive feature of science. We have just discussed one of the two partners of this complex criterion; now let us look at the other. We shall find that what counts as evidence, and in particular that what counts as sufficient evidence for knowledge, is a complex matter.

Scientific knowledge

An investigation into the nature of knowledge ideally would begin with the study of the differing uses of the word "knowledge," found in everyday speech. These would include such expressions as "know him," "know that," "know how," "know why," "know whether," and so forth. But in general the philosophical and scientific traditions have focused on the kind of knowledge expressed when it is said that someone knows that such and such is the case. This sort of knowledge, called *propositional knowledge*, can be expressed in the formula, *A knows that p*, where A is a sentient being and p is a proposition, statement, assertion, etc. An example: "I know that our neighbor has a dog." It is this use of the term that we shall examine in what follows.

There is a direct connection between knowledge and truth, since it is universally agreed that A cannot know that p if p is false. If I assert that the moon is only 100 miles from the Earth that remark cannot be a piece of knowledge because it is false. Furthermore, A can be said to know that p only if A has evidence that supports the truth of p. Once again, there is a connection between knowledge and truth, via the evidential relationship. If the evidence is weak or if there is no evidence the claim to know lacks adequate support, and in such a case one cannot know that p. It is the requirement that there be evidence that rules out lucky guesses or superstition as cases of knowledge.

This brings us to two conceptions of propositional knowledge: "the Platonic" and "the Scientific." These overlap to some extent but they are basically opposed as we shall see. They coincide in agreeing that one cannot know that p if p is false. But they diverge over the issue of whether knowledge entails certainty. The Platonist says it does and the scientist says the opposite. Here is how the Platonist argues his case. He begins with an observation about the nature of possibility. His position is that if it is possible to be mistaken about p, then one cannot know that p. Thus, if it is possible that it will rain tomorrow or possible that it will not rain tomorrow, one cannot know today which it will do. Hence, if one knows that p, it is not possible to be mistaken about p. But if one can't be mistaken, then one is certain. And if this is so, then if one knows that p one knows that p with certainty. It is this conclusion that science rejects.

The notion of possibility also plays an important role in the scientific conception of knowledge. The scientist agrees that the existence of possibility is inconsistent with *certitude*. But he rejects the inference that it is incompatible with *knowledge*. Here is how he defends this position.

Let us agree, he will say, that all scientific explanations are generalizations based on past observation. Consider the discovery that water at sea level boils at 100 degrees Celsius. This finding was arrived at by means of observations conducted over a vast period of time. Would any scientist, therefore, be committed to the thesis that it is *absolutely certain* that water in the future will continue to boil at that temperature? The answer is "no." It is "no" because past experience is not an infallible guide to the future.

Nor can he say with certainty that water has always boiled at 100°C. It is thus *possible* that next week water will begin to boil at a different temperature. But in acknowledging this point, the scientist does not agree that knowledge – as distinct from certainty – is not attainable in such a circumstance. In fact he asserts the opposite. Knowledge, from a scientific perspective, is a matter of the strength of the evidence in support of a particular assertion. When the evidence is very strong, as it is in this case, one has knowledge about a particular feature of the world.

In distinguishing knowledge from certainty, science is in effect rejecting the Platonic conception of knowledge. This is not a verbal disagreement, but a substantive one. It is connected with the difference between a logico-mathematical and an empirical outlook. The Platonic outlook depicts knowledge as if it were identical with the kind of certitude found in logic and mathematics. But from a scientific standpoint this outlook is unrealistic and impracticable. It fails to understand that logic and mathematics have no factual content. Their theorems are tautologies and thus never get beyond the linguistic level to the world of fact. Knowledge about the world is not merely linguistic: it ultimately derives from observation, that is, from the kind of data that the senses provide. That is the only kind of knowledge that provides substantive information about matters of fact. But no observational data are sufficiently strong to entail certainty. The argument for this point is convoluted. It rests on yet another dichotomy: that between analytic and synthetic knowledge. Let us therefore take an additional, somewhat lengthy step and explore this contrast. We shall find in it justification for the scientific position that knowledge is to be distinguished from certainty.

The analytic/synthetic distinction

The analytic/synthetic distinction is the basis of what is perhaps the most widely accepted theory of knowledge today. It is a theory that has a long history and some version of it has been defended by most major philosophers since the time of Descartes.

According to this theory all knowledge claims are expressible as propositions that fall into two categories that are *exclusive* and *exhaustive.* To say that the categories are exclusive means that no proposition can be a member of both, and to say they are exhaustive means that they include all instances of knowledge claims. We thus have a synoptic theory covering all possible cases. One of the complications in describing the theory is exactly how these contrasting categories are to be defined or characterized.

Historically, there have been many different names and conceptions associated with each side of the distinction, but let us confine ourselves to three of the most important: Leibniz (1646–1714) distinguished between necessary and contingent propositions; Kant (1724–1804) discriminated between analytic and synthetic judgments; and both Kant and Hume (1711–1776) distinguished a priori from a posteriori propositions. In a longer essay, each of these pairs would have to be distinguished from one another. For instance, to say that a proposition is necessary is not identical with saying that it is analytic. To say the former is to say that the proposition holds (is true) in all possible worlds; to say the latter is to say that the predicate term is part of the meaning of the subject term and in that sense gives us a (partial) analysis of the meaning of the subject term. Some philosophers have maintained that "Every event has a cause," is necessary because it holds in all possible worlds, but that it is not analytic because "being caused" is not part of the meaning of "event." Some propositions, however, are both analytic and necessary. "All husbands are married" is necessary because it is true in all possible worlds, and it is analytic because "being married" is part of the meaning of "being a husband." Similar differences hold between the other notions.

For our purposes here, the important idea is that historically all of the propositions belonging to the analytic (necessary, a priori) side of the distinction have been thought to possess an important epistemological characteristic that marks them off from those belonging to the synthetic (contingent, a posteriori) side of the distinction. The characteristic is that they can be determined to be true without any reference to experience. The operative point can be brought out by considering how we come to establish the truth of the following propositions:

(a) All husbands are married.
(b) All present-day laptop computers weigh less than 20 pounds.

It is clear at some relevant time in the past we could only have determined whether (b) is true by an appeal to experience, that is, by investigating the weights of laptop computers, or by checking the production records of manufacturers, say. The idea is that in order to determine the truth of (b) some research would be requisite. It is not enough merely to have understood the proposition. This is what it means to say that (b) is *a posteriori*; namely, that its truth can be ascertained only *after* some resort to experience. This proposition also has the feature that it might have been false: one can imagine that a certain firm made some heavy, experimental laptops it did not sell to the public. So to say that (b) might have been false is equivalent to saying that it is not a necessary truth, since there are imaginable circumstances in which it might not have been true. But now let us contrast (b) with (a). We can tell without any research that (a) is true. We know this *prior* to any sort of investigation of the facts of the matter. The kind of knowledge we have in this case is thus said to be *a priori*. All we have to do is to understand the proposition and we can *see* that it is true. Moreover, it is not merely true; it is necessarily true. For it is impossible to imagine or describe any circumstances in which, as those terms are customarily used, someone could be a husband without being married. So (a) is both a priori and necessary.

Now Hume and many subsequent philosophers saw this exclusive–exhaustive division, however it was expressed, as having important implications for the theory of knowledge. They contended that propositions belonging to the category of the synthetic, contingent, a posteriori side of this opposition are never certain, and they bolstered this inference with the argument that all such propositions can be determined to be true only on the basis of past experience; and since past experience, being only a sample of all experience, might turn out in the light of future happenings to be unreliable, such propositions could never be certain. At most they could be known to be true only with some degree of probability. In contrast, a priori, analytic, or necessary propositions can be certain. To say that they are certain entails that they hold in all possible circumstances, so that no future experience can run counter to them; and this in turn entails that one asserting them cannot be mistaken. But such certitude produces no information about the world; it is a product of the special, usually definitional, relationships holding between the terms in a proposition. From the truth of the sentence, "All giants are tall," it does not follow that there are giants. Or as Wittgenstein wittily remarked: "I know, for example, nothing about the weather, when I know that it rains or does not rain" (*TLP*, 4.461). Such propositions thus provide information about conceptual relationships, not about matters of fact. Accordingly, this analysis issued in the following conclusion about knowledge, namely that insofar as propositions are descriptive of the world they can never be certain; and insofar as they are certain they are devoid of information about the world. The contention that science can have knowledge that is less than certain is supported by such an analysis. Science is content to rest its case on probability. The highest degrees of probability obtainable about the world are cases of knowledge for science. As Bertrand Russell once wrote:

> What shall we regard as having the greatest likelihood of being true, and what as proper to be rejected if it conflicts with other evidence? It seems to me that science has a much greater likelihood of being true in the main than any philosophy hitherto advanced ... Therefore, we shall be wise to build our philosophy upon science, because the risk of error in philosophy is pretty sure to be greater than in science.

In using such terms as "likelihood," and "the risk of error," to characterize the scientific endeavor, Russell is implying that certainty is not to be expected as the outcome of its investigative pursuits. Instead, it is knowledge and truth. That this is so is bolstered by the line of reasoning we have just advanced. We thus have arrived at a fourth criterion – the quest for knowledge and truth – that defines modern science.

There are doubtless other criteria that distinguish modern science from other intellectual activities but the four we have cited are sufficient to explain why many people accept Schlick's dictum that in principle science can answer all questions. Moreover, when we add the success of technology to the preceding account one can even more fully appreciate why such optimism is widespread. Let us, therefore, complete our case for the overweening confidence in science by a glance at how technology has altered nature for the benefit of the human race. Before beginning such an account, we concede, of course, that technology has had, still has, and always will have a dark side. But we shall ignore that fuliginous aspect here. Our aim, instead, is to present the strongest case for the proposition that science in principle can solve all problems. So let us reinforce this endeavor by appealing to the aid that the troops of technology can supply. The case can be made in two sentences: "Would you rather have lived four hundred years ago before science and technology altered the world or today?" The answer for most persons, as we shall now indicate by a brief, fictional narrative, is obvious.

THE POWER OF TECHNOLOGY

It is almost impossible to overestimate the effect of technology on daily living. Its use today is widespread and deeply ingrained. Technological devices are so familiar as to be virtually invisible – that is, until something goes wrong. A washing machine or a television set that stops working is tantamount to a crisis. Then we take notice. Of course, when a new technology is introduced it tends to make a splash. Consider the impact that the first movies made on Western culture. But as time passes the new is taken for granted and is absorbed into the routine of everyday practice. The effect of technology is thus subtle; it is quickly internalized and its profound effects pass undetected. Most of us wear wristwatches. In the middle ages there were no watches. Human behavior was mostly regulated by the ringing of church bells. The intervals at which these were sounded depended on gross observations – the season, the position of the sun or moon, and so on. Today, in contrast, most of us maintain rigid schedules, frequently checking our watches or clocks in order to keep appointments. We rush from one thing to another as if we were automata governed by control towers. Meetings, lectures, classes, and games are fixed to take place within minutes. Yet most of us are unaware of how the precise measurement of time has affected our lives. The pace of the contemporary world is hectic when compared with how persons have conducted themselves through most of recorded history.

Examples, making the same point, can be multiplied indefinitely. But there is also another way of illustrating the profound influence of technology. Consider the following fable, for example. It begins in fifth-century B.C.E. Athens. Its protagonist is a young Greek named Georgios. As the narrative opens he is listening to one of the most famous political speeches ever given: the Funeral Oration of Pericles. Georgios never hears the whole speech. He suddenly falls into a trance, and is transported, unconscious, via a magic carpet to sixteenth-century England. En route he somehow learns English, while not forgetting his life in Greece. When he awakens he is again listening to a speech. The orator is Henry VIII, King of England. The year is 1533. Henry is announcing to a crowd assembled at his court in Windsor that Pope Clement VII has refused his request to divorce his wife, Catherine of Aragon. Henry is also explaining why he wishes to divorce Catherine and to marry a twenty-year-old beauty, Anne Boleyn. He points out that after many years of marriage Catherine has been unable to provide a male heir to the throne. Their only child, Mary (born in 1516) is female. The crowd murmurs its approval, since they wish a male to carry on the royal line.

After the speech, Georgios (now called George) goes to London and finds lodgings there. He is struck by the similarities between the Greece he knew and sixteenth-century England. Though Athens was a democracy and England is a monarchy, there is otherwise very little difference between the two cultures. Travel in Periclean Athens was by ship, horse, horse-drawn carriage, or on foot, and two thousand years later he finds that this is still how the English get from one place to another. Athens, at night, was gloomy, and London is not much better. (Frying-pan shaped lamps, using fat derived from animal intestines, were not be used in London for another century, and then they were a failure.)

He remembers only too well the plague that decimated Athens, and now here in London he notes that smallpox, typhus, typhoid, and dysentery are commonplace. In the more than two thousand years that have passed, the system for disposing of human waste has not really improved. An open cesspool is used by the richer Londoners; the poor urinate and defecate wherever there is a sheltered spot. No streets are paved. Homes are hovels, made of clapboard, and are the sites of filth, squalor, and disease. Most people live with their animals – swine, chickens, dogs, cats, horses and donkeys. The dwelling places of the poor are overcrowded – ten to a room is common. Rooms are generally without furniture, even without beds. Refuse is thrown into the street, where it festers. George is told by neighbors that only about one child in four born in London survives infancy. In the midst of death people seek every possible means of assuaging the futility of existence. The consumption of alcohol is prodigious and much of the population is in a state of irremediable inebriation. Crime is rampant; burning, looting, rape, prostitution, and civil unrest are endemic. London is in most respects like the Athens he knew. He feels quite at home here.

But suddenly George falls into a coma. Deeply asleep, he is transferred, again by magic carpet, to New York City. Now the year is 2004. When he awakens he is in a place called an airport. As he looks around, he sees a group of people who are standing in front of what seems to him to be a painting of a man. As he moves forward to join them, he realizes that they are listening to a speech. He sees the lips of the figure move and he can hear his voice clearly. The man in the painting thus seems alive. He has never seen a painting in which a figure moves and makes sounds that one can hear. He is told that the orator is the leader of the American people, and that he is called The President of the United States. Someone adds that the President is speaking to a group called "The Congress." He is puzzled because he is also informed that though he and the other auditors listening to the man in the picture are in New York, that same man is at that very moment speaking in Washington. Yet George is somehow hearing and seeing the President. It is just as if he were in Washington. Yet he is not. He could not have heard or seen Pericles or Henry if he were not in their immediate presence. Someone tells him this is possible because he is watching television. He has no idea what this is.

Things quickly become more confusing. As he glances around the room, he sees large glass windows and through them objects that are totally unfamiliar. They gleam in bright lights. He asks what they are and is informed they are airplanes. Asking about these he is told that they carry people from one place to another while flying through the sky. He wonders if they are a special species of bird and is told "no;" that they are machines, made by man. He has no conception of what a machine is. And how can things that fly through the air be made by human beings? It is incredible and unbelievable. Perplexed, he decides to leave the airport. As he walks through doors that open magically as he approaches, he becomes increasingly bewildered by what seems to him a fantasy world. He sees people rapidly conveyed away by horseless carriages that someone calls "taxis." He cannot understand how these strange objects move without being pulled by an animal. As he stands amazed, he hears someone holding an object and talking into it. The person is clearly carrying on a conversation with someone who is not present. George wonders how this is possible. He is witnessing a conversation by means of a cellphone.

As he walks around the city, he becomes aware that it does not look like either Athens or London. There are innumerable high buildings – so high he has to crane his neck to see their tops. The streets are paved and smooth. There are sidewalks for pedestrians. The people look clean and well-fed. He sees human beings of all races, black, brown, and white. There is a babble of languages, one of which is a dialect of English. People say "erl," but don't mean a nobleman as they did in England. Here they mean "oil." But he can still understand most of what they say.

For George, New York is wholly different from Tudor London or Periclean Athens. He has entered a domain of which he cannot make sense. Without knowing what has produced this world, he is witnessing the effects of modern technology. In less than five centuries, it has revolutionized human existence. It has altered the quality of human life in ways that are entirely unprecedented. George will eventually discover that technology has not allowed human beings completely to defeat their ancient adversary, nature. He will learn that there are still hurricanes, floods, droughts, and a variety of diseases and illnesses. But he will also learn that technology has done much to level the playing field. When he discovers that he will live much longer now, that his life will be easier, that he will be healthier and have options for travel and enjoyment he could never have imagined in his earlier incarnations, he will be glad to be living in the twenty-first century. It is like the difference between being rich or poor. It is not a difficult choice at all.

THE PRICE OF SUCCESS

Much of the success of modern science can be accounted for in terms of its technological applications and its reductive and quantitative approaches to nature. But there is almost always a price to be paid for success. For modern science it is that the qualitative aspects of human experience cannot be accommodated by a quantitative approach. Yet these are some of the most important features for living creatures: the taste of an apple, the appreciation of a sunset, the beauty of a great painting or a musical composition, the pleasures of friendship, of love, of accomplishment, and so forth. None of these is quantifiable in the way that the motion of inanimate bodies is. There is thus a domain of (especially) human existence that is non-factual and hence seemingly not accessible to scientific analysis. Its natural turf is generally called "the humanities," that group of disciplines that include the arts, literature, music, history, cultural anthropology, and philosophy. When Schlick asserts that "Since science in principle can say all that can be said there is no unanswerable question left," he is possibly mistaken. Perhaps in the humanities there are unanswerable questions. Schlick's is a controversial statement, and some thinkers have rejected it. One of the greatest philosophers of the past century, Ludwig Wittgenstein, said: "We feel that if all possible scientific questions be answered, the problems of life have not been touched at all." But Wittgenstein then added: "Of course, there is then no question left, and just this is the answer." Perhaps Schlick meant that the humanities do not "say" anything. If their functions are not those of describing or discovering facts, but in dealing with "the problems of life," or with values, then he may be right after all in claiming that it is only science that can access the natural world. And if this is what he meant then it would seem that he and Wittgenstein are in agreement.

But I do not think they are. I think that Schlick's remark has to be understood in a different way from Wittgenstein's. Wittgenstein is saying that what he is calling "the problems of life," and which he associates with ethics, aesthetics and more generally with values, are not solvable by scientific means. My view is that Schlick would agree with Wittgenstein on this point. He would agree, that is, that there are human problems which are not open to scientific resolution; but then he would add that this is not what he was referring to with his aphorism. What he meant is that if a problem is factual in nature then in principle it is capable of scientific solution. In my opinion this is a much more interesting challenge than Wittgenstein's. It is generally agreed that science does not and even in principle cannot deal with moral and aesthetic dilemmas. Science is a fact-finding activity and most moral and aesthetic problems cannot be resolved by an appeal to the facts.

Hume was among the first of the post-Cartesian philosophers to make the distinction. He said from an "is" one cannot derive an "ought." What he meant is simple and compelling. From the fact that humans drink alcohol in various forms nothing follows about what they ought or ought not do, that is, whether it is right or wrong to drink alcohol. Whether people actually drink alcohol or in what quantities they drink it is a scientific, factual question. Whether they should or should not drink alcohol and in what quantities is a question of a different order. The two should not be conflated. Most, though not all, philosophers agree with Hume. I think that Schlick was well aware of the distinction and, accordingly, that his aphorism was limited to questions of fact. So that is the challenge: Are there any questions of fact that science – even in principle – cannot solve? I assert that there are, and the rest of the book will be devoted to proving that this is so. Let us turn to the first of these problems now – "Is There Life After Death?" With respect to this issue science will draw a blank – and so will everybody else.