SIR JAMES JEANS

PHYSICS AND PHILOSOPHY

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Dover Publications, Inc.
New York

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PREFACE

The aim of the present book is very simply stated; it is to discuss—and to some extent to explore—that borderland territory between physics and philosophy which used to seem so dull, but suddenly became so interesting and important through recent developments of theoretical physics.

The new interest extends far beyond the technical problems of physics and philosophy to questions which touch human life very closely, such as materialism and free-will. Thus I hope the book may interest many who are neither physicists nor philosophers by profession, and to this end I have made the discussion as simple as possible, avoiding technicalities when I could, and, when I could not, explaining them. I have also tried to arrange the book so that a reading of the first two chapters and the last shall give an intelligible view of the main argument and conclusions of the whole; many readers may prefer to read these three chapters first.

I need hardly add that my acquaintance with philosophy is simply that of an intruder, and nothing could be further from my intentions than to pose as an authority on questions of pure philosophy. If I had to choose a sub-title for my book, it might well be ‘The Reflections of a physicist on some of the problems of philosophy’.

I gratefully record my thanks to Sir Frederick Berryman for reading the whole of the proofs for me to Sir Arthur Eddington for reading part (although we did not always agree), and to both, as also to Professor J. B. S. Haldane, for various criticisms and suggestions. I also thank my wife for helping m with the typing of my manuscript.

J. H. JEAN

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July 8, 1942

This Dover edition, first published in 1981, is an unabridged republication of the work copublished in
1943 by Cambridge University Press and the Macmillan Company.

9780486119175

Library of Congress Catalog Card Number: 80-69674

Manufactured in the United States of America
Dover Publications, Inc., 31 East 2nd Street, Mineola, N.Y. 11501

CHAPTER I

WHAT ARE PHYSICS AND PHILOSOPHY?

Science usually advances by a succession of small steps, through a fog in which even the most keen-sighted explorer can seldom see more than a few paces ahead. Occasionally the fog lifts, an eminenc is gained, and a wider stretch of territory can be surveyed—sometimes with startling results. A whol science may then seem to undergo a kaleidoscopic rearrangement, fragments of knowledge being found to fit together in a hitherto unsuspected manner. Sometimes the shock of readjustment may spread to other sciences; sometimes it may divert the whole current of human thought.

Events of this last kind are rare, but instances come readily to mind. We are likely to think first of the results of replacing the geocentric astronomy of mediaeval times by the Copernican system —ma saw that his home was not the majestic fixed centre of the universe round which all else had to revolve, but one of many fragments of matter which were themselves revolving round a very ordinar one of the myriads of stars in the sky. Or we may think of the implications of the Darwinian biology- man saw that his body had not been specially designed for himself, the lord of creation, but was an adaptation and development of the bodies of animals which had preceded him on earth, and were in fact his own ancestry; all terrestrial creatures, even the meanest, proved to be his blood-relations, an if he had dominion over them it was only because he happened to have been born into the clever branch of the big family.

A third such rearrangement of ideas occurred when Newton’s system of mechanics and law of gravitation gained general acceptance—men saw that the heavenly bodies were no longer to be feare or even consulted as influences in human affairs; they were only chunks of inert matter moving as they were driven by universal laws. The Newtonian scheme of things seemed further to suggest—although it was never quite able to prove—that all bodies, even the smallest, were subject to the sam scheme of universal law, so that all change and motion were mechanical in their nature, the future following from the past with the inevitability of the motions of a machine. If this were so, man’s imagined freedom to choose between good and evil or select his own path through life was a pitiable illusion; the ball could only go where the player sent it.

A fourth such revolution has occurred in physics in recent years. Its consequences extend far beyond physics, and in particular they affect our general view of the world in which our lives are cas —in a word, they affect philosophy. The philosophy of any period is always largely interwoven with the science of the period, so that any fundamental change in science must produce reactions in philosophy. This is especially so in the present case, where the changes in physics itself are of a distinctly philosophical hue; a direct questioning of nature by experiment has shown the philosophica background hitherto assumed by physics to have been faulty. The necessary emendations have naturally affected the scientific basis of philosophy and, through it, our approach to the philosophical problems of everyday life. Are we, for instance, automata or are we free agents capable of influencin the course of events by our volitions? Is the world material or mental in its ultimate nature? Or is it both? If so, is matter or mind the more fundamental—is mind a creation of matter or matter a creatio of ~~mind? Is the world we perceive in space and time the world of ultimate reality, or is it only a~~ curtain veiling a deeper reality beyond?

The primary aim of the present book is to discuss the interrelation between physics and philosophy While the discussion is in general terms, it naturally has very special reference to the changes of recent years, and their bearing on philosophical questions such as those just mentioned. But as a preliminary let us consider the general questions: What is physics and what is philosophy?

WHAT IS PHYSICS?

Both physics and philosophy had their beginnings in those dim ages in which man was first differentiating himself from his brute ancestry, acquiring new emotional and mental characteristics which were henceforth to be his distinguishing marks. Foremost among these were an intellectual curiosity out of which philosophy has grown, and a practical curiosity which was ultimately to develop into science.

For primitive man, thrown into a world which he did not understand, soon found that his comfort, his well-being, and even his life were jeopardized by this want of understanding. Inanimate nature seemed helpful and friendly to him at times, but could become hostile when the life-giving sunshine and gentle rain gave place to the thunderbolt and whirlwind; these inspired in him the same feelings awe and fear as the wild beasts and human foes which threatened his life. His first reaction was to project his own human motives and passions on to the inanimate objects around him; he peopled his world with spirits and demons, with gods and goddesses great and small until, as Andrew Lang has said, ‘all nature was a congeries of animated personalities’. Such imaginings were not confined to cave-men and savages; even Thales of Miletus (640–546 B.C.), astronomer, geometer and philosopher, maintained that all things were ‘full of gods’.

Primitive man endowed these personalities with characteristics and qualities almost as definite as those of his real friends and foes. In so doing he was not altogether wrong, for they seemed to be creatures of habit; what they had done once they were likely to do again. Even the animals understan this; they avoid a place where they have suffered pain in the past, suspecting that what hurt them onc may hurt them again, and they return to a place where they have once found food, considering it a hopeful place in which to look for more. What were mere associations of ideas in the brains of animals readily became translated into natural laws in the minds of thinking men, and led to the discovery of the principle of the uniformity of nature—what has happened once will, in similar circumstances, happen again; the events of nature do not occur at random but after an unvarying pattern. Once this discovery had been made, physical science became possible. Its primary aim is to discover this pattern of events, in so far as it governs the happenings of the inanimate world.

Positivism

The primitive stage of human development which we have just depicted is that which Auguste Comt (1798–1857) described as the stage of *fetichism*, although we now usually call it *animism*. In this stag man believed he could modify the course of events by his own volition and to his own advantage, by influencing the gods and spirits with which he had filled his world—sometimes through a policy of appeasement, as by worship and sacrifice, and sometimes through prayers, spells and incantations.

Comte says that in time this stage of animism gave place to a second stage of *metaphysics*, in whic the spirits and gods of the animistic stage become depersonified, and are replaced by vaguely conceived forces, activities or essences. In this stage the world is depicted as being controlled by ‘vit~~al forces’, ‘chemical activities’, a ‘principle of gravity’, and the like. These finally amalgam~~ate into a single activity which is usually referred to as ‘nature’, although we still occasionally personify it and spell it with a capital N. The sequence of events has now passed beyond human control.

Comte considers that this second or metaphysical stage must in due course give place to yet a third stage—the *positive* stage. The ‘forces’ which expelled the spirits and gods now suffer expulsion in their turn. Nothing is left in the world but happenings for which no explanation or interpretation is offered or even attempted, and science has now for its single aim the discovery of the laws to which these happenings conform—the pattern of events.

Thus to primitive man the sun was a life-giving god—to the Greeks the horse-drawn chariot of a god—while a later and less pagan age supposed that angels had been entrusted with the task of pushing along the sun, moon and planets, and of maintaining the motion of the celestial spheres to which the more distant stars were supposed to be affixed. This animistic stage ended when the god, h horses and his chariot, the angels and their celestial spheres, were eliminated by the progress of science. To be more explicit, it ended when Copernicus, in accordance with the earlier teaching of Pythagoras, Aristarchus and others, showed how the apparent motion of the sun, moon and stars acro the sky resulted from a daily rotation of the earth, while the motions of the planets through the stars could be explained by their revolutions round a fixed sun. Even when Kepler discovered the true shapes of these planetary orbits sixty years later, he still postulated a ‘power’ or influence to keep th planets moving; he thought they would all stop dead if a material emanation from the sun did not continually urge them on. The science of planetary movements had attained to its second stage.

Newton retained a ‘force’ of gravitation, but was fully conscious of the philosophical difficulties involved. When Leibniz attacked him for introducing occult qualities and miracles into his philosophy, he replied that ‘to understand the motions of the planets under the influence of gravity, without knowing the cause of gravity, is as good a progress in philosophy as to understand the frame of a clock, and the dependence of the wheels upon one another, without knowing the cause of the gravity of the weight which moves the machine, is in the philosophy of clockwork’. Astronomy was beginning to move into the third stage, to which it has only recently fully attained. The astronomer o to-day makes no claim to understand why the planets move as they do; he is content to know that the pattern of events can be described very neatly and concisely by picturing planetary motions as takin place in a curved space.

Comte believed that every science must inevitably go through these three stages in turn—this is hi famous ‘law of the three stages’. He further claimed that the abstract sciences could be arranged in a *hierarchy*, in the order

mathematics, astronomy, physics, chemistry, biology, sociology, in which each science is

(*a*) historically older,
(*b*) logically simpler,
(*c*) more widely applicable,

than any of the sciences which come after it on the list. Certain sciences which loom large in present-day knowledge, as for instance geology and psychology, are absent from the list and do not fit at all naturally into the hierarchy. If, however, we merge the minor sciences into the greater, the hierarchy assumes the simpler form and now possesses all the virtues claimed for it by its author.

Comte further claimed that each science in the hierarchy is independent of all that follow it, and also must reach the final or positive stage before them. Since mathematics must have been in the positive stage from its first beginnings, the claim for physics is that it depends only on mathematics, and must be the first experimental science to attain to the positive stage. We shall investigate these claims in due course, but first let us examine the true nature of physical knowledge.

Physical Knowledge

We each live our mental life in a prison-house from which there is no escape. It is our body; and its only communication with the outer world is through our sense-organs—eyes, ears, etc. These form windows through which we can look out on to the outer world and acquire knowledge of it. A man lacking all five senses could know nothing of this outer world, because he would have no means of contact with it; the whole content of his mind would be an expansion of what had been in it at birth.

The sense-organs of a normal man receive stimuli—rays of light, waves of sound, etc.—from the outer world, and these produce electric changes which are propagated over his nerves to his brain. Here they produce further changes, as the result of which—after a series of processes we do not in th least understand—his mind acquires *perceptions*—to use Hume's terminology—of the outer world. These give rise to *impressions* and *ideas* in turn, an impression denoting a sensation, emotion or feeling at the moment when a perception first makes its appearance in the mind, and an idea denotin what is left of an impression when its first vigour is spent, including for instance the memory of an impression or the repetition of it in a dream.

Thus the whole content of a man's mind can consist of three parts at most—a part that was in his mind at birth, a part that has entered through his sense-organs, and a part which has been developed out of these two parts by processes of reflection and ratiocination. Some have denied that the first pa exists at all, holding with Hobbes (1588–1679) that 'there is no conception in a man's mind which hath not at first been begotten upon the organs of sense'—*nihil est in intellectu quod non fuerit in sensu*. Others have thought with Leibniz (1646–1716) that this should be amended by the addition of the words *nisi intellectus ipse*—there is nothing in the understanding that has not come through the senses, except the understanding itself. We shall discuss these questions more fully as the need arise

Whenever a man increases the content of his mind he gains new knowledge, and this occurs each time a new relation is established between the worlds on the two sides of the sense-organs—the worl of ideas in an individual mind, and the world of objects existing outside individual minds which is common to us all.

The study of science provides us with such new knowledge. Physics gives us exact knowledge because it is based on exact measurements. A physicist may announce, for instance, that the density o gold is 19·32, by which he means that the ratio of the weight of any piece of gold to that of a volume of water of equal size is 19·32; or that the wave-length of the line Hα in the spectrum of atomic hydrogen is 0·000065628 centimetre, by which he means that the ratio of the length of a wave of Hα light to that of a centimetre is 0·000065628, a centimetre being defined as a certain fraction of the diameter of the earth, or of the length of a specified bar of platinum, or as a certain multiple of the wave-length of a line in the spectrum of cadmium.

These statements import real knowledge into our minds, since each identifies a specific number, th idea ~~of which is already in our minds, with the value of a ratio which has an existence in the world~~ outside; this idea of a ratio is again something with which our minds are familiar. Thus the statement tell us something new in a language we can understand.

Each ratio expresses a relation between two things neither of which we understand separately, such as gold and water. Our minds can never step out of their prison-houses to investigate the real nature o the things—gold, water, atomic hydrogen, centimetres or wave-lengths—which inhabit that mysterious world out beyond our sense-organs. We are acquainted with such things only through the messages we receive from them through the windows of our senses, and these tell us nothing as to the essential nature of their origins. But our minds can understand and know ratios—which are pure numbers—even of quantities which are themselves incomprehensible. We can, then, acquire real knowledge of the external world of physics, but this must always consist of ratios, or, in other words, of numbers.

The raw material of every science must always be an accumulation of facts; the values of ratios of which we have just been speaking constitute the raw material of physics. But, as Poincaré remarked, an accumulation of facts is no more a science than a heap of stones is a house. When we set to work t build our house—i.e. to create a science—we must first coordinate and synthesize the accumulated piles of facts. It is then usually found that a great number of separate facts can be summed up in a much smaller number of general laws. This indeed is the most fundamental and also the most general fact disclosed by the experimental study of science—the stones fit together and combine, out of their intrinsic nature, to make a house. In brief, nature is rational. The house, being a rational structure and not a shapeless pile of stones, will show certain marked features. These express the pattern of events for which we are searching.

In physics the separate stones are numbers—the ratios just described—and the features of the hous are relations between large groups of numbers. Clearly these relations will be most easily recorded and explained by embodying them in mathematical formulae, so that our scientific house will consist of a collection of mathematical formulae; in this way, and this alone, can we express the pattern of events. To take a simple illustration, the physicist finds that the spectrum of atomic hydrogen contain the line Hα which we have already mentioned, and also a very great number of other lines which are usually designated as Hβ, Hγ, Hδ, etc. The wave-lengths of these lines can be measured, and are foun to be related with one another in a very simple way which can be expressed by a quite simple mathematical formula. This is typical of the way in which the particular scientific house of physics is built up; a great number of separate facts of observation are all subsumed in a single mathematical formula, and our knowledge of the physical world is expressed by a number of such formulae.

Pictorial Representations

But now the complication intervenes that our minds do not take kindly to knowledge expressed in abstract mathematical form. Our mental faculties have come to us, through a long line of ancestry, from fishes and apes. At each stage the primary concern of our ancestors was not to understand the ultimate processes of physics, but to survive in the struggle for existence, to kill other animals witho themselves being killed. They did not do this by pondering over mathematical formulae, but by adapting themselves to the hard facts of nature and the concrete problems of everyday life. Those wh could not do this disappeared, while those who could survived, and have transmitted to us minds which are more suited to deal with concrete facts than with abstract concepts, with particulars rather than with universals; minds which are more at home in thinking of material objects, rest and motion, pushes, pulls and impacts, than in trying to digest symbols and formulae. The child who is beginning to l~~earn algebra never takes kindly to *x*, *y* and *z;* he is only satisfied when he is told that they are~~ numbers of apples or pears or something such.

In the same way, the physicists of a generation ago could not rest content with the *x*, *y* and *z* which were used to describe the pattern of events, but were for ever trying to interpret them in terms of something concrete. If, they thought, there is a pattern, there must be a loom for ever weaving it. The wanted to know what this loom was, how it worked, and why it worked thus rather than otherwise. Ar they assumed, or at least hoped, that it would prove possible to liken its ultimate constituents to such familiar mechanical objects as occur in looms, or perhaps to billiard-balls, jellies and spinning-tops, the workings of which they thought they understood. In time they hoped to devise a model which would reproduce all the phenomena of physics, and so make it possible to predict them all.

Such a model would, they thought, in some way correspond to the reality underlying the phenomena. No one seems to have considered the situation which would. arise if two different model were found, each being perfect in this respect.

Yet this situation is of some interest. If it arose, there would be no means of choosing between the two models, since each would be perfect in the only property by which it could be tested, namely the power of predicting phenomena. Neither model could, then, claim to represent reality, whence it follows that we must never associate any model with reality, since even if it accounted for all the phenomena, a second model might appear at any moment with exactly the same qualifications to represent reality.

To-day we not only have no perfect model, but we know that it is of no use to search for one—it could have no intelligible meaning for us. For we have found out that nature does not function in a way that can be made comprehensible to the human mind through models or pictures.

If we are to explain the workings of an organization or a machine in a comprehensible way, we mu speak to our listeners in a language they understand, and in terms of ideas with which they are famili —otherwise our explanation will mean nothing to them. It is no good telling a crowd of savages that the time-differential of the electric displacement is the rotation of the magnetic force multiplied by the velocity of light. In the same way, if an interpretation of the workings of nature is to mean anything to us, it must be in terms of ideas which are already in our minds—otherwise it will be incomprehensible to us, and cannot add to our knowledge. We have already seen what types of ideas can be in our minds—ideas which have been in our minds from birth, ideas which have entered our minds as perceptions, and ideas which have been developed out of these primitive ideas by processes of reflection and ratiocination.

Such ideas as originated in perceptions, and so entered our minds through one or more of the five senses, may be classified by the sense or senses through which they entered. Thus the content of a mind will consist of visual ideas, auditory ideas, tactile ideas, and so on, as well as more fundamenta ideas—such as those of number and quantity—which may be inborn or may have entered through several senses, and more complex ideas resulting from combinations and aggregations of simpler ideas, such as ideas of aesthetic beauty, moral perfection, maximum happiness, checkmate or free trade. It is useless to try to understand the workings of nature except in terms of ideas belonging to one or other of these classes.

For instance, the pitch, intensity and timbre of a musical sound are auditory ideas; we can explain the functioning of an orchestra in terms of them, but only to a person who is himself possessed of auditory ideas, and not to one who has been deaf all his life. Colour and illumination are visual ideas but we could not explain a landscape or a portrait in such terms to a blind man, because he would hav no visual ideas.

Clearly complex ideas of the kind exemplified above can give no help towards an understanding o the functioning of inanimate nature. The same is true of ideas which have entered through the senses of hearing, taste and smell—as for instance the memories of a symphony or of a good dinner. If for n other reason, none of these enter into direct relation with our perceptions of extension in space, whic is one of the most fundamental of the things to be explained. We are left only with fundamental idea such as number and quantity, and ideas which have entered our minds through the two senses of sigh and touch. Of these sight provides more vivid and also more important ideas than touch—we learn more about the world by looking at it than by touching it. Besides number and quantity, our visual ideas include size or extension in space, position in space, shape and movement. Tactile ideas comprise all of these, although in a less vivid form, as well as ideas which are wholly tactile, such as hardness, pressure, impact and force. For an explanation of nature to be intelligible it must depend only on such ideas as these.

Geometrical Explanations of Nature

Various attempts have been made to explain the workings of nature in terms of visual ideas alone, these depending mainly on the ideas of shape (geometrical figures) and motion. Three examples drawn from ancient, mediaeval and modern times respectively are:

(1) The Greek explanation that all motion tends to be circular because the circle is the perfect figu geometrically, an explanation which remained in vogue at least until the fifteenth century (p. 107, below), notwithstanding its being contrary to the facts.

(2) The system of Descartes, which tried to explain nature in terms of motion, vortices, etc. (p. 10 below). This also was contrary to the facts.

(3) Einstein’s relativity theory of gravitation, which is purely geometrical in form. This, so far as i known, is in complete agreement with the facts.

We shall discuss this last theory in some detail (p. 117, below). In brief, it tells us that a moving object or a ray of light moves along a geodesic, which means that it takes the shortest route from plac to place, or again, roughly speaking, that it goes as nearly in a straight line as circumstances permit. This geodesic is not in ordinary space, but in an ideal composite space of four dimensions, which results from blending space and time. This space is not only four-dimensional but is also curved; it is this curvature that prevents a geodesic being an ordinary straight line. Efforts have been made to explain the whole of electric and magnetic phenomena in a similar way, but so far without success.

It is perhaps doubtful whether such a curved four-dimensional space ought to be described as a visual idea which is already in our minds. It may be only ordinary space generalized, but if so it is generalized out of all recognition. The highly trained mathematician can visualize it partially and vaguely, others not at all. Unless we are willing to concede that the plain man has the idea of such a space in his mind, we must say that no appreciable fraction of the world has been really ‘explained’ i terms of visual ideas.

Even if it had, such an explanation would hardly carry any conviction of finality or completeness t our modern minds. To the Greek mind the supposed fact that the stars or planets moved in perfect geometrical figures provided a completely satisfying explanation of their motion—the world was a perfection waiting only to be elucidated, and here was a bit of the elucidation. Our minds work differently. Optimism has given place to pessimism, at least to the extent that we no longer feel any confidence in an overruling tendency to perfection, and if we are told that a planet moves in a perfect circle, or in a still more perfect geodesic, we merely go on to inquire: Why? When Giotto drew his perfect circle, his pencil was not guided by any abstract compulsion to perfection—if it were, we should all be able to draw perfect circles—but by the skill of his muscles. We want to know what provides the corresponding guidance to the planets, and this requires that the purely visual ideas of geometrical form shall be supplemented by the addition of tactile ideas.

Mechanical Explanations of Nature

Explanations which introduce tactile ideas—forces, pressures and tensions—are of course dynamical or mechanical in their nature. It is not surprising that such explanations also should have been attempted from Greek times on, for, after all, our hairy ancestors had to think more about muscular force than about perfect circles or geodesics. Plato tells us that Anaxagoras claimed to be able to explain the workings of nature as a machine. In more recent times Newton, Huyghens and others thought that the only possible explanations of nature were mechanical. Thus in 1690 Huyghens wrote ‘In true philosophy, the causes of all natural phenomena are conceived in mechanical terms. We mus do this, in my opinion, or else give up all hope of ever understanding anything in physics.’

To-day the average man probably holds very similar opinions. An explanation in any other than mechanical terms would seem incomprehensible to him, as it did to Newton and Huyghens, through the necessary ideas—the language in which the explanation was conveyed—not being in his mind. When he wants to move an object, he pulls or pushes it through the activity of his muscles, and canno imagine that Nature does not effect her movements in a similar way.

Among attempted explanations in mechanical terms, the Newtonian system of mechanics stands first. This was supplemented in due course by various mechanical representations of the electromagnetic theories of Maxwell and Faraday (p. 120, below). All envisaged the world as a collection of particles moving under the pushes and pulls of other particles, these pushes and pulls being of the same general nature as those we exert with our muscles on the objects we touch.

We shall see later in the present book how these and other attempted mechanical explanations hav all failed. Indeed the progress of science has disclosed in detail the reasons why all failed, and all must fail. Two of the simpler of these reasons may be mentioned here.

The first is provided by the theory of relativity. The essence of a mechanical explanation is that each particle of a mechanism experiences a real and definite push or pull. This must be objective as regards both quantity and quality, so that its measure will always be the same, whatever means of measurement are employed to measure it—just as a real object must always weigh the same whether is weighed on a spring balance or on a weighing-beam. But the theory of relativity shows that if motions are attributed to forces, these forces will be differently estimated, as regards both quantity and quality, by observers who happen to be moving at different speeds, and furthermore that all their estimates have an equal claim to be considered right. Thus the supposed forces cannot have a real objective existence; they are seen to be mere mental constructs which we make for ourselves in our efforts to understand the workings of nature. A simple specific example of this general argument wil be found below (p. 121).

A second reason is provided by the theory of quanta. A mechanical explanation implies not only that the particles of the universe move in space and time, but also that their motion is governed by agencies which operate in space and time. But the quantum theory finds, as we shall see later, that th fundamental activities of nature cannot be represented as occurring in space and time; they cannot, then, be mechanical in the ordinary sense of the word.

In any case, no mechanical explanation could ever be satisfying and final; it could at best only postpone the demand for an explanation. For suppose—to imagine a simple although not very likely possibility—that it had been found that the pattern of events could be fully explained by assuming th matter consisted of hard spherical atoms, and that each of these behaved like a minute billiard-ball. A first this may look like a perfect mechanical explanation, but we soon find that it has only introduced us to a vicious circle; it first explains billiard-balls in terms of atoms, and then proceeds to explain atoms in terms of billiard-balls, so that we have not advanced a step towards a true understanding of the ultimate nature of either billiard-balls or atoms. All mechanical explanations are open to a simila criticism, since all are of the form '*A* is like *B*, and *B* is like *A*'. Nothing is gained by saying that the loom of nature works like our muscles if we cannot explain how our muscles work. We come, then, t the position that nothing but a mechanical explanation can be satisfying to our minds, and that such a explanation would be valueless if we attained it. We see that we can never understand the true nature of reality.

The Mathematical Description of Nature

In these and similar ways, the progress of science has itself shown that there can be no pictorial representation of the workings of nature of a kind which would be intelligible to our limited minds. The study of physics has driven us to the positivist conception of physics. We can never understand what events are, but must limit ourselves to describing the pattern of events in mathematical terms; n other aim is possible—at least until man becomes endowed with more senses than he at present possesses. Physicists who are trying to understand nature may work in many different fields and by many different methods; one may dig, one may sow, one may reap. But the final harvest will always be a sheaf of mathematical formulae. These will never describe nature itself, but only our observatio on nature. Our studies can never put us into contact with reality; we can never penetrate beyond the impressions that reality implants in our minds.

Although we can never devise a pictorial representation which shall be both true to nature and intelligible to our minds, we may still be able to make partial aspects of the truth comprehensible through pictorial representations or parables. As the whole truth does not admit of intelligible representation, every such pictorial representation or parable must fail somewhere. The physicist of the last generation was continually making pictorial representations and parables, and also making th mistake of treating the half-truths of pictorial representations and parables as literal truths. He did no see that all the concrete details of his picture—his luminiferous ether, his electric and magnetic forces, and possibly his atoms and electrons as well—were mere articles of clothing that he had himself draped over the mathematical symbols; they did not belong to the world of reality, but to the parables by which he had tried to make reality comprehensible. For instance, when observation was found to suggest that light was of the nature of waves, it became customary to describe it as undulations in a rigid homogeneous ether which filled the whole of space. The only ascertained fact i this description is contained in the one word 'undulations', and even this must be understood in the narrowest mathematical sense; all the rest is pictorial detail, introduced to help out the limitations of our minds. Kronecker is quoted as saying that in arithmetic God made the integers and man made the rest; in the same spirit we may perhaps say that in physics God made the mathematics and man made the rest.

To sum up, physics tries to discover the pattern of events which controls the phenomena we observe. But we can never know what this pattern means or how it originates; and even if some superior intelligence were to tell us, we should find the explanation unintelligible. Our studies can never put us into contact with reality, and its true meaning and nature must be for ever hidden from u

WHAT IS PHILOSOPHY?

Such is physics, but it is less easy to say what philosophy is. While most philosophers seem to have had their private and differing views on the question, few have been willing to venture on a definitio Hobbes (1588–1679) defined it as ‘a knowledge of effects from their causes and of causes from their effects’—in other words the philosopher differs from the physicist only in that he tries to discover th pattern of events in the world at large, and not only in inanimate nature. Hegel (1770–1831) took a different view, defining philosophy as ‘die denkende Betrachtung der Gegenstände’, the investigatio of things by thought and contemplation, again suggesting a relation—although a different one—to science, which is the investigation of things by experiment and direct inquiry. While the workshop o the scientist is his laboratory, or perhaps the open field or the star-lit sky, that of the philosopher is h own brain.

In whatever ways we define science and philosophy, their territories are contiguous; wherever science leaves off—and in many places its boundary is ill-denned—there philosophy begins. Just as there are many departments of science, so there are many departments of philosophy. Contiguous to the department of physics on the scientific side of the boundary lies the department of metaphysics o the philosophical side—that department of philosophy which lies ‘beyond physics’. The boundary here is clearly defined, at least if we accept the positivist view of physics explained above. For then we must agree with Comte that the task of physics is to discover and formulate laws, while that of philosophy is to interpret and discuss. But the physicist can warn the philosopher in advance that no intelligible interpretation of the workings of nature is to be expected.

In view of this contiguity, it is not surprising that many philosophers have been physicists also. Indeed from the beginnings of recorded history down to the end of the seventeenth century—from th times of Thales, Epicurus, Heraclitus and Aristotle down to those of Descartes and Leibniz—the grea names in philosophy were often great names in science as well.

It is, however, hardly possible to understand the true relation between physics and philosophy unti we have glanced at some of the many forms which philosophy has assumed in the course of its long history. Without attempting anything like a sketch of the general history of philosophy (which would lie quite outside the scope of the present book), we may perhaps trace certain threads which run clearly through this history.

Ancient Philosophy

Ancient European philosophy was almost exclusively Greek, and to the Greeks philosophy was simpl what its name implies—the love of wisdom. Yet the Greek idea of wisdom was not quite the same as our own; their wisdom was based more on speculation, conjecture and contemplation, and less on fir knowledge or bedrock facts, which they had but little capacity for acquiring. In brief, it was less scientific than ours. Nevertheless it entered into some relation with science, for it comprised some real knowledge of mathematics, physics and astronomy, as well as a great mass of speculation as to cosmology, the fundamental structure of the world, and the principles governing the order of events.

But it was more especially concerned with ‘the conduct of life, public and private’, taking as its main topics for discussion such problems as the aim and meaning of life, the ethical principles of conduct, the most effective organization of human society, the best forms of government, education and ~~so forth; as well as more abstract, but not entirely irrelevant, questions such as the meaning~~ of justice, truth and beauty. In common language the philosopher was the man who could look beyond the narrow groove in which his daily work lay, and steer his way through life by availing himself of the accumulated wisdom of the race—a little knowledge mixed copiously with speculative conclusions drawn from this knowledge by contemplation, abstract reasoning and discussion.

Mediaeval Philosophy

Then came those darker ages in which the bright light of Greek culture suffered eclipse, and Europea philosophy with it. During this period Christianity appeared and conquered a large part of the earth, introducing a new moral code and reshaping men’s views as to the meaning and purpose of life. In sc doing, it took over a large part of what had hitherto been the province of philosophy, since it provide dogmatic and professedly infallible answers to problems that had so far been topics for philosophic debate; guides to human conduct were no longer to be sought through the study of philosophy or the exercise of reason, but in the precepts of religion.

If philosophy retained any existence during this period, it was mainly through the Church trying to graft the dogmas of religion on to the older doctrines of Greek philosophy. It was studied almost exclusively by ecclesiastics, usually monks, and its language was Latin—the language of the Church, but not of any living people. Greek philosophy had been primarily concerned with problems of citizenship, ethics, and the search for the good and the beautiful; mediaeval philosophy with the subtleties and casuistries of theological doctrine. Greek philosophy had tried to advance by the exercise of reason and by controlled speculation; mediaeval philosophy by the barren methods of the syllogism and of logic-chopping. Greek philosophy had ever aimed at progress to higher things; mediaeval philosophy tried to instil an unquestioning acceptance of established authority and resignation to an unchanging order; the watchword was no longer *excelsior* but *semper eadem.*

And if science retained any existence through this period, it was a science of a useless kind, which concerned itself with, as we now know, wholly unprofitable quests such as the search for the philosopher’s stone and the elixir of life, with alchemy and astrology, with magic and the black arts; its aims were wholly utilitarian and mostly unworthy.

The Philosophy of the Renaissance

In the middle years of the fifteenth century, glimmers of a new light were seen; a dawn began to break, and the darkness of these dismal ages gradually gave place to a brighter period of intellectual and spiritual activity. For the first century at least, the interest was preponderatingly humanistic, its inspiration being drawn from classical literature. But with the coming of the seventeenth century, a new scientific interest also began to emerge, of an intellectual rather than of a utilitarian type; the foundations of modern science were being laid.

It began with astronomy. The world of mediaeval cosmology had consisted of a central earth equipped with a hell beneath and a heaven above in which God sat for ever on a throne at the point vertically above Jerusalem; the sun, moon and the star-bespangled sphere of heaven, which angels continually pushed round the earth, figured as mere adjuncts designed to secure the greater comfort o the earth’s inhabitants. The writings of Copernicus, the speculations of Bruno and the observations o Galileo had shattered this old world beyond repair, and a new one was being built by the scientific astronomy of Galileo, of Kepler and, later, of Newton.

Physics soon experienced a similar change. The heathen gods and goddesses had long since passed into oblivion, so that nature could no longer be interpreted as the congeries of animated personalities who contended with one another and occasionally interfered capriciously in human affairs. Men now began to ask what it was, and how it functioned. In time it came to be interpreted as a vast machine—network of cogs, shafts and thrust-bars, each of which could only transmit the motion it received fron other parts of the mechanism and then wait for a new impulse to arrive.

This brought a beautiful simplicity into inanimate nature, but it also threatened to bring a most unwelcome simplicity into human life. For out of this view of nature there grew a philosophy of materialism, with Hobbes as its principal exponent and advocate. Its central doctrines were that the whole world could be constructed out of matter and motion; matter was the only reality; events of every kind were simply the motion of matter; man was only an animal with a material body, his thoughts and emotions alike resulting from mechanical motions of the atoms of this body.

If, then, the world of atoms worked with the inevitability of a machine, the whole race of men seemed to be reduced to cogs in the machine; they could not initiate but only transmit. Exhorting a man to be moral or useful was like exhorting a clock to keep good time; even if it had a mind, its hands would not move as its mind wished, but as the already fixed arrangement of its weight and pendulum directed. We could not choose our paths for ourselves; these were already chosen for us by the arrangement of the atoms in our bodies, and the imagined freedom of our wills was illusory.

Yet on this imagined freedom man had built his social system and his ethical code; it alone gave a meaning to his ideas of right and wrong, of purpose and moral responsibility; it formed the cornerstone of the religions in which his nobler aspirations and emotions lay crystallized; on it he ha built his hopes of heaven and his fears of hell. Through the sufferings and trials of this world, he had consoled and sustained himself with the vision of the rich reward he would reap in a world to come, a reward which was to reimburse him a thousand times for the sacrifices and struggles he had so willingly made here—unless perchance, like Dante, he found his consolation in picturing the torment awaiting his enemies. But if human conduct was only a matter of the push and pull of atoms, all this became meaningless; it was in vain that he had starved his appetites, lacerated his body, and renounced all normal human pleasures; he was no more worthy of reward than the man who had wholeheartedly grasped at pleasure.

Never had a train of ideas seemed to touch human interests and everyday human life more closely; nothing could be of more tremendous import to the question of man’s significance in the general scheme of things, and we might have expected that it would produce a turmoil at least comparable with those produced by the scientific findings of Copernicus and Darwin. And there were some, it is true, who showed great interest in the new doctrine. Bentley, Master of Trinity College, Cambridge, wrote that ‘the taverns and coffee-houses, nay Westminster Hall and the very churches, are full of it’ and added that from his own observation ninety-nine per cent of English infidels were Hobbists.

Yet the average man, who was no infidel, gave no countenance to the new doctrine—partly perhap because he was not prepared to face its religious implications, but even more, we may conjecture, because it made no appeal to his common sense. He was perfectly clear in his mind that his will was free, no matter what abstruse arguments might be adduced to the contrary—was he not conscious of choosing freely at almost every moment of his life? Even though he might conceivably be mistaken i this, the world around him was so obviously a world of purposeful activity—men tried *and they succeeded*. The whole intricate fabric of civilized life was a standing record of achievement, not by atoms pushed and pulled by blind purposeless forces, but by resolute minds working to pre-selected ends.

Not only so, but the new doctrines of science merely restated, in rather more exact language, ideas which had long formed part of the common stock of philosophy and theology. We have already seen how Anaxagoras had explained the world as a machine in which every part moved only as directed by some other part. Seneca, again, had maintained that God ‘has determined all things by an inexorable law of destiny which He has decreed and Himself obeys’. Some fifteen hundred years later, the Archbishops, Bishops and clergy of the Anglican Church, assembled in Convocation in London in the year 1562, agreed on very similar ideas which they incorporated in their Articles of Religion, and ordered to be printed in every Book of Common Prayer. After another eighty years Descartes, who certainly tried hard not to say anything that was not entirely orthodox, wrote: ‘It is certain that God has foreordained all things’, and ‘The power of the will consists only in this, that we so act that we ar not conscious of being determined to a particular action by any external force.’

In other words, the great machine follows its foreordained course, and we small cogs are compelle unwittingly to acquiesce in its motion—which is just about what science was beginning to say on the subject.

RELIGION AND SCIENCE

Although the conclusions of science accorded well enough with theological dogma on the questions o free-will and predestination, they entered into no relation at all with the teachings of pastoral theology. The preacher did not tell his flock that God had foreordained all things, but exhorted them t try to accomplish things of their own volition, to strive after virtue and righteousness, and in brief to attempt precisely those things which their Articles of Religion pronounced to be impossible. He did not tell them they were unable to choose, but rather that an eternity of bliss or torment depended on the choice they made.

The plain man might be content to place himself and his thoughts unreservedly in the hands of his spiritual teachers, but others saw that there was a case for investigation. It seemed to be a case for philosophy to decide and yet, if philosophy was to sit in judgment, its verdict might well seem to be a foregone conclusion. It is said that a man’s philosophy is determined by his personality, or, in Fichte words: ‘Tell me of what sort a man is, and I will tell you what philosophy he will choose,’ and the history of human thought supplies many confirmations of the truth of this remark. As Prof. W. K. Wright has said: ‘No one in the seventeenth century but a lonely excommunicated Jew like Spinoza would have snatched at the mechanistic side of Descartes and Hobbes and given it a spiritual interpretation that could afford peace and serenity to his own tortured soul. Only enthusiastic lovers o the strenuous life like Leibniz and Fichte could have found ground for unqualified optimism in the prospect of an immortal life of unceasing activity. No one but a neurotic and selfish lover of success, with a distaste for having to work for it, such as Schopenhauer, would have seen in such a prospect th justification for a philosophy of unqualified pessimism and world renunciation. The philosophy of every great thinker is the most important part of his biography.’ To which we may surely add that the biography of every great thinker is the most important part of his philosophy.

Now most of the great thinkers of this period had rather similar biographies. They lived in a highly religious age in which serious men had been educated to be, and mostly were, devout Christians. Thu most of the philosophers of the period, while ostensibly searching objectively and impartially for truth, and following the path of reason wherever this might lead, were nevertheless convinced in thei own minds that their journeys could only end in a triumphant vindication of Christian doctrines, and laying of the doubts which had been raised by science. Also, whatever their personal convictions may have been, religious feeling was so strong, and religious authority so dominant, that every writer felt himself under pressure to arrive at conclusions which conformed with the teaching of the Church; he arrived at others at his peril, as Giordano Bruno and Galileo had discovered. Further, it was an age in which consistency did not rank very high among the virtues. This is not necessarily a condemnation; may be that we rate consistency too high to-day. Anyone whose mind is not completely petrified mus find his opinions continually changing under the pressure of new experience and further consideratio And if, even at the same instant, he sees two possible solutions to a problem, no matter how inconsistent these may be with one another, there can be no reason why he should not marshal the arguments for both; he will do this in a more valuable way than two men each of whom can only see one side to the question. However this may be, even the foremost thinkers of the age we are now considering seem to have felt no embarrassment in propounding entirely inconsistent doctrines; there was even a convenient doctrine of the *twofold truth*, which proclaimed a sort of relativity of truth—a conclusion might be true in philosophy but false in theology, or vice versa.

Considerations such as these must have influenced the courses which, consciously or unconsciousl the philosophers set themselves; indeed some openly admitted their ultimate aims. For instance, in h *Critique of Pure Reason*, Kant asserted that ‘The science of metaphysics has for the proper object of its inquiries only three grand ideas, GOD, FREEDOM [of the will] and IMMORTALITY, and it aims at showing that the second conception, conjoined with the first, must lead to the third as a necessary conclusion. All other subjects with which it occupies itself are merely means for the attainment and realization of these ideas.’

In the preface to the same book, Kant had explained that he had to abolish knowledge to make roo for belief. ‘I cannot even make the assumption—as the practical interests of morality require—of God, Freedom and Immortality, if I do not deprive speculative reason of its pretensions to transcendental insight.’

In such terms as these philosophy declared itself the handmaiden of theology.

In brief, philosophy awakened from its long mediaeval slumber to find itself confronted, among many others, with a special task. Just as the task of mediaeval philosophy had been to remove all ground for conflict between philosophy and religion, so that of the newly awakened renaissance philosophy was to avoid conflict between science and religion.

Descartes

The foremost philosopher of this period was Descartes (1596–1650). Undeterred by his having writte the sentences quoted above (p. 22), he wished above all things to maintain the freedom of the human will against the scientific considerations which seemed to be abolishing it. Apparently the crux of the whole matter, as he saw it, was the supposition that the brain consisted of ordinary matter; discredit this, and science would become harmless.

When he had written as a physiologist, he had speculated that the brain contained a fluid which he called *animal spirits*. This was neither mind nor matter, but formed a sort of intermediary between th two; mind could act on it to the extent of changing the direction, but not the amount, of its motion— for Descartes believed that the amount of motion of a material system must remain constant (p. 111) This fluid could in turn act on matter. To this Leibniz subsequently raised the objection that not only the total amount of motion must remain constant, but also the amount in each separate direction in space, and that any change in the directions of motion of the animal spirits would obviously change the amounts of motion in these separate directions.

When, however, Descartes wrote as a philosopher and Christian apologist, he maintained that minc was of a completely different nature from matter, and could have no contact with it. The two had entir~~ely different functions to perform—mind to think and matter to occupy space—and they we~~re so completely divorced that neither could affect the other to the slightest degree. In this way the will wa set free, but only at the cost of creating a new problem which was to dominate philosophy for generations—if my will has no contact of any sort with the matter of my body, how can it compel thi body to turn to the right or to the left as it pleases?

Descartes left this problem unsolved, but we find certain of his followers—Malebranche, Geulincx Mersenne and others, now known as the Occasionalists—solving it to their own satisfaction by supposing that the volitions of our minds are only the ‘occasional’ causes of the movements of our bodies, the real, ultimate, or ‘efficient’ cause being God. Mind and matter never interact directly, but rather run on parallel never-intersecting tracks. The good God has so arranged things that the activiti of mind and matter correspond exactly to one another, and keep in such perfect step that each seems t influence the other without actually doing so. In the same way—they might have said, had they know of such things—the makers of a cinematograph film arrange that the voices and action shall correspond and synchronize through the whole length of the film; we see a soldier move smartly at th word of command, and his movement seems to be a direct consequence of the command, but actually it is the result of a pre-arranged. correspondence.

Leibniz

Leibniz (1646–1716) went further in the same direction, describing Descartes’ doctrine of the distinctness of mind and matter as ‘the ante-room of truth, but only the ante-room’.

Giordano Bruno had already supposed the world to consist of a number of ultimate indivisible unit which he called ‘monads’; these were at the same time spiritual and material in their nature. Every human being and every living thing was such a monad. The monads were all distinct and different, an could not be resolved into anything simpler.

Leibniz also supposed the world to consist of a great number of simple units, which he too described as monads—whether he borrowed the name from Bruno is not known. These monads, he says, are the true atoms of the universe, the ultimate constituents of everything, and they possess neither shape nor size nor divisibility. Now, as Plato had argued in the *Phaedo*, dissolution and decay appertain only to complex, and above all to divisible, structures. Thus their very simplicity shields th monads from dissolution and decay, so that they are necessarily eternal and immortal. Each man’s soul is a single monad, and his body a collection of monads of various kinds. All substances are of th nature of force[2], and consist of individual centres of force, which must thus be monads, and ‘in imitation of the notion which we have of souls’ must contain something of the nature of feeling and appetite. These monads, then, are more or less spiritual in their nature. The lowest monads of all, Leibniz writes, resemble animals in a swoon, higher monads have clearer perceptions and are endow with memory, while God is the highest monad of all. Since all monads are spiritual in their nature, matter can have no real existence, and must come from seeing monads in a confused way.

The monads have no windows on to the outer world through which anything could come in or go out, so that each lives its utterly secluded life, uninfluenced by its fellow-monads. Its changes are determined only by its own internal state; it can come into existence only through a creative act of God, and can go out of existence only through annihilation by God. Yet God, the supreme monad, keeps all the other monads in step on a series of parallel tracks.

Leibniz calls this the *System of pre-established Harmony*. ‘Under this system’, he wrote, ‘bodies a as though there were no souls, and souls act as though there were no bodies, and both act as though each influenced the other.'

Leibniz explained this further by comparing the soul and body (or mind and matter as we should now say) to two clocks which always show the same time, a comparison which the Occasionalists hac used before him. There are, he says, three ways in which two clocks can be made always to show the same time. One—and here he refers to the experiments of Huyghens—is by putting them in close physical contact, so that each clock transmits its vibrations to the other, and the two clocks advance i unison; this is the solution of ordinary philosophy, but must, Leibniz thinks, be rejected because we cannot imagine anything being transmitted between mind and matter. The second way is to have a clockmaker continually putting the clocks in agreement; this also Leibniz rejects because it requires the incessant intervention of a *deus ex machina* 'for a natural and ordinary thing'. The third and only other way, says Leibniz, is to construct the two clocks so perfectly at the outset that they will agree through all time.

This last is the way of the system of pre-established Harmony. In the beginning God created mind and matter in such a way that each can follow its own laws, and yet the two move in the same perfect agreement as would prevail 'if God were for ever putting in his hand to set them right'.

To use Leibniz' own illustration, we, with our puny abilities, can make an alarm clock and set it to sound an alarm at any hour we require. Obviously, then, so great a craftsman as God could make Caesar's body and pre-arrange its atoms so that it should go to the Senate House at such or such an hour on the Ides of March, should utter such and such words, and so on. The same great Craftsman could also create the soul of Caesar in such a way that it should experience certain emotions in a pre-arranged order and at pre-arranged moments of time, and could, if He so wished, plan that these should exactly correspond to, and synchronize with, Caesar's bodily movements. According to Leibniz, He had so wished.

The wheel had now come round full circle. In his eagerness to establish the freedom of the will, Descartes had divided the universe into two ingredients, mind and matter, which could not interact; this raised the problem of how mind and matter could keep in step without interacting. Leibniz, tryin to explain this, had to suppose that neither had more freedom than a machine which, having once bee set in motion, was compelled to execute a predestined series of mechanical movements. In this way, every mind became an automaton, which is precisely the conclusion that Descartes had been trying to escape, and one that Leibniz would presumably have liked to avoid if he could.

Kant

So the question stood when Kant brought his mind to it. He saw that the circle of arguments of Descartes and Leibniz could lead nowhere except to the very conclusion that both were, like himself, eager to avoid. He was as much concerned as his predecessors to establish the freedom of the will, bu he had a clearer conception of the difficulties in the way. 'As the complete and unbroken connection of phenomena is an unalterable law of nature,' he wrote, 'freedom is impossible—on the supposition that phenomena are absolutely real. Hence those philosophers who adhere to the common opinion on this subject can never succeed in reconciling the ideas of nature and freedom.'

By 'the common opinion' Kant meant what would now be described as Naive Realism, or Commor sense Realism. This rejects all metaphysical subtleties, and maintains that the phenomena we observe correspond fairly closely to the realities of the world outside us; when we think we see a brick at som point of space, there really is something 'there', which is much like what we imagine a brick to be.

Thus the world is just about what it seems to be, consisting simply of the particles and objects which are ~~found, by observation and experiment, to obey a causal law. If, says Kant, this is all there is~~ to th world, then obviously the will cannot be free.

On the other hand, many philosophers have found it difficult to accept the hypothesis that an objec is just about what it appears to be, and so is like the mental picture it produces in our minds. For an object and a mental picture are of entirely different natures—a brick and the mental picture of a bric can at best no more resemble one another than an orchestra and a symphony. In any case, there is no compelling reason why phenomena—the mental visions that a mind constructs out of electric current in a brain—should resemble the objects that produced these currents in the first instance. If I touch a live wire, I may see stars, but the stars I see will not in the least resemble the dynamo which produce the current in the wire I touched. In this instance, the current produces a vision in my mind which differs utterly from the object which created the current. May it not be the same with all the phenomena of nature?

When we perceive an object, we perceive at most a few of its qualities. Having perceived these fev qualities, we frequently jump to the conclusion that the object belongs to some familiar class of obje possessing these qualities. We see a kittenish patch of colour behaving in a kittenish way, and conclude that we are seeing a kitten. But our identification may be wrong; the little creature may be a skunk. Again, when a tiny meteor smaller than a pea is falling through the air, it will send the same electric currents to our brains as will a giant star millions of times larger than the sun and millions of times more distant. Primitive man jumped to the conclusion that the tiny meteor was really a star, an we still describe it as a shooting-star. This and innumerable other instances show that two objects ma differ widely in their intrinsic natures and yet produce similar, and even identical, phenomena. And a the two objects of such a pair cannot both be like their mental images, there is no longer any sufficier reason for thinking that either of them must be.

Thus we can no longer hold that objects in general are pretty much like their mental images. The images need not resemble the objects in which they originate, and our perception of the outer world may consist only of *representations* which are constructed by our minds out of the activities flowing into our brains, and bear little or no resemblance to the realities outside. They may be like the code signals which the signalman sends over the wires to say what kind of train is coming next; these bear no resemblance to the train. Or, as Boltzmann suggests, they may be merely symbols which are relate to the objects as letters are to sounds, or as notes are to musical tones.

Kant, holding that phenomena are only representations, argues that they must originate in something other than phenomena, so that even though the phenomena may be bound to other phenomena by causal laws, their origins need not be. If we limit our attention to the phenomena, our observations suggest that causality governs everything, but if we could make contact with the reality underlying the phenomena we might see that this is not so.

A few pages later, he explains that his remarks were not intended to prove the *actual existence of freedom*, or even to demonstrate the possibilities of freedom; ‘that nature and freedom are at least *no opposed*—this was the only thing in our power to prove, and the question which it was our task to solve’.

Still, it seems difficult to accept this as providing even a *possible* solution to the problem of huma free-will. The average man is not interested in the origins underlying phenomena; the freedom of which he wants to assure himself, and instinctively believes himself to possess, is a freedom to control, or at least to influence, the phenomena, or, according to Kant, the representations. Imagine two men who are similar down to the last atoms of their bodies, placed in environments which again are ~~similar down to the last atoms. If free-will is to be explained in the way Kant suggests, we can~~ imagine one exercising his freedom and deciding on a saintly life, while the other may decide at the same moment that he is more hedonistically inclined. Up to the moment of making these choices, the phenomena have been the same for both, so that if causality prevails in the world of phenomena, as Kant supposes, the subsequent phenomena must also be the same for both; the two men must mutter the same prayers and drink similar drinks—with similar results. So far as the phenomena go, their tw lives will be identical, and to their acquaintances will be indistinguishable. It follows that the men ca have no moral responsibility for their actions—only at most for their intentions and desires. Clearly this is not what the plain man means by freedom of the will, and neither is it what Kant wanted to establish. But the question is no longer of more than academic interest, since, as we shall soon see, science now finds that even the phenomena are not governed by causal laws.

On other questions besides that of human free-will at which we have just glanced it was obvious that the methods of science could lead only to the conclusions of science; if philosophy was to reach other conclusions she must employ other methods. Furthermore, if she wished her conclusions to tak precedence over those of science, she must be able to claim that her methods were in some way more trustworthy than the methods of science. This led to a critical examination of the methods by which scientific knowledge was obtained, and to an intensive study of certain problems of what is now calle epistemology—the science of knowledge. This will form the subject of our next chapter.

CHAPTER II

HOW DO WE KNOW?

(DESCARTES TO KANT; EDDINGTON)

THE SOURCES OF KNOWLEDGE

We have already noticed how knowledge is gained by establishing relations between an inner process of understanding in our private minds and the facts of that public outer world which is common to us all. As Plato pointed out, the use of a common language is based on the supposition that such relation can be established by all of us.

In the period we have been considering, science claimed only one source of knowledge of the facts and objects of the outer world, namely the impressions they make on the mind through the medium o the senses. Yet the untrustworthiness of the senses had been one of the commonplaces of philosophy from Greek times on, and if the same facts and objects of the outer world made different impressions on different minds, where did science stand? If we trusted to individual sense-impressions, we could never get beyond the position described by Protagoras (*c*. 481–411 B.C.): ‘What seems to me is so to me, what seems to you is so to you’; each individual would become his own final arbiter of truth, and there could be no body of objective knowledge. Six centuries before Christ, in the earliest days of Greek philosophy, Thales of Miletus had urged the importance of gaining a substratum of facts, independent of the judgment of individuals, on which a body of objective knowledge could be built.

These difficulties are non-existent to the modern physicist, who can trust his instruments to give absolutely objective and unbiased information, but they loomed large when there were no instrument beyond the unaided human senses. To avoid them, Plato argued in the *Theaetetus* (*c*. 368 B.C.), we must distinguish between what the mind perceives through the senses and what it apprehends of itsel by thinking. Such concepts as number and quantity, sameness and difference, likeness and unlikeness good and bad, right and wrong do not enter our minds through our senses, but reside permanently in our minds. And as concepts such as these provide the formal element in all true knowledge, it follow that this does not come from our sensations, but rather from the judgments our minds pass on our sensations.

Plato elaborated this into an argument that the human mind is equipped from birth with a set of *forms* or *ideas* which exist in it independently of the objects of the outer world. These latter serve as sort of raw material for the impress of the forms, so that each object becomes a sort of meeting-place for a number of forms. A red square brick, for instance, is a lump of this raw material stamped with the impresses of the forms of redness, squareness and brickiness. When we declare that a particular object is a red square brick, we mean that in our judgment this particular piece of matter fits into thes three forms. We may of course be mistaken; seen in a different light, the object may appear of some colour other than red, measured against a set-square it may prove to be far from square, and hit with