THE PHILOSOPHY OF PHYSICAL SCIENCE

by

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PREFACE

THIS book contains the substance of the course of lectures which I delivered as Tarner Lecturer of Trinity College Cambridge in the Easter Term 1938. The lectures have afforded me an opportunity of developing more fully than in my earlier books the principles of philosophic thought associated with the modern advances of physical science.

It is often said that there is no "philosophy of science", but only the philosophies of certain scientists. But in so far as we recognise an authoritative body of opinion which decides what is and what is not accepted as present-day physics, there is an ascertainable present-day philosophy of physical science. It is the philosophy to which those who follow the accepted practice of science stand committed by their *practice*. It is implicit in the methods by which they advance science, sometimes without fully understanding why they employ them, and in the procedure which they accept as giving assurance of truth, often without examining what kind of assurance it can give.

There should be no conflict between the claim that a philosophy is scientifically grounded and the claim that it is, so far as it goes, a true philosophy. But in a specialised work of this kind the primary object must be to ascertain and discuss the philosophy which, whether true or not, is the present philosophy of physical science in the sense stated above. Those of us who believe that science, notwithstanding continual failures and readjustments, is slowly drawing nearer to the truth, are content that philosophic truth should be reached by the same method of progressive advance.

In order to make sure of our scientific foundations it is found necessary to enter rather deeply into the principles of relativity theory and quantum theory. Since the intention is

to give, not merely an exposition, but a justification of the views to which they lead, some parts of the book introduce matters of considerable technical difficulty. Generally I have abstained from mathematical formulae; this, however, is not wholly out of consideration for the general reader, but because those whose minds are too much immersed in mathematical formulae are likely to miss what we are here seeking.

The discussion, although relating to the same subject matter, is mainly on different lines from that given eleven years ago in *The Nature of the Physical World*. The starting point in the present treatment is *knowledge*. The title of the earlier book might have been expanded into "the nature of the physical universe, with applications to the theory of physical knowledge"; the corresponding title of the present book would be "the nature of physical knowledge, with applications to the theory of the physical universe". The change of emphasis makes for a more logical sequence of ideas; but primarily it reflects a change which has occurred in physical science itself. It is significant of this change that the contrast between the scientific table and the familiar table, with which *The Nature of the Physical World* opens, had become a contrast between the scientific story and the familiar story of experience at the beginning of *New Pathways in Science*. The first was, I believe, the natural form of expression according to the scientific outlook of 1928; the second had become more natural six years later.

Neither the scientific advances of the last decade nor the years of reflection have altered the general trend of my philosophy. I say "my philosophy", not as claiming authorship of ideas which are widely diffused in modern thought, but because the ultimate selection and synthesis must be a personal responsibility. If it were necessary to give a short name to this philosophy, I should hesitate between "Selective subjectivism" and "Structuralism". The former name refers

to the aspect most prominent in the first eight chapters; the latter refers to a more mathematical conception which dominates the rest of the book. Both can now be carried much farther than in *The Nature of the Physical World*. The domain of subjectivity has been extended as a consequence of our better understanding of quantum mechanics; and the conception of structure has been made more precise by the connection now recognised between the foundations of physics and the mathematical Theory of Groups.

With this "philosophy of physical science" as a nucleus, I endeavour in the last two chapters to develop the outline of a general philosophical outlook which a scientist can accept without inconsistency. I am not among those who think that in the search for truth all aspects of human experience are to be ignored save those which are followed up in physical science. But I find no disharmony between a philosophy which embraces the wider significance of human experience and the specialised philosophy of physical science, even though the latter relates to a system of thought of recent growth whose stability is yet to be tested.

A. S. E.

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CHAPTER I

SCIENTIFIC EPISTEMOLOGY

I

BETWEEN physics and philosophy there lies a debatable territory which I shall call *scientific epistemology*. Epistemology is that branch of philosophy which treats of the nature of knowledge. It will not be denied that a significant part of the whole field of knowledge is that which has come to us by the methods of physical science. This part takes the form of a detailed description of a world—the so-called physical universe. I give the name "scientific epistemology" to the sub-branch of epistemology which deals with the nature of this part of our knowledge, and therefore indirectly with the nature and status of the physical universe to which it formally relates.

There are two matters of definition which it is desirable to make clear at the outset.

Some writers restrict the term "knowledge" to things of which we are quite certain; others recognise knowledge of varying degrees of uncertainty. This is one of the common ambiguities of speech as to which no one is entitled to dictate, and an author can only state which usage he has himself chosen to follow. If "to know" means "to be quite certain of", the term is of little use to those who wish to be undogmatic. I therefore prefer the broader meaning; and my own usage will recognise uncertain knowledge. Anything which would be knowledge if we were assured of its truth, is still counted as knowledge (uncertain or false knowledge) if we are not assured.

It will not be necessary for us to formulate a general definition of knowledge. Our procedure will be to specify

a particular collection of more or less widely accepted knowledge, and then to make an epistemological study of its nature. Especially, though not exclusively, we have to consider the knowledge acquired by the methods of physical science. For brevity I will call this *physical knowledge*. In principle we might identify physical knowledge with the contents of certain encyclopaedic works, such as the *Handbuch der Physik*, which between them cover the various branches of physical science. But there are obvious objections to a slavish acceptance of a particular authority; and I will therefore define physical knowledge to be that which a right-thinking person* would to-day accept as justified by physical science.

It should not be overlooked that physical knowledge includes a vast amount of miscellaneous information which would be out of place in scientific text-books. For example, the result of a measurement of weight is physical knowledge, whether it is made for the purpose of deciding a scientific issue or for deciding the amount of a tradesman's bill. The condition is that it shall be passed as scientifically correct (by the right-thinking person), not that it shall be scientifically important. It should also be noticed that the term is intended to refer to physical science as it stands to-day. We are not going to occupy ourselves with speculations as to possible future developments. We are to take stock of the results which the methods of physical science have yielded up to now, and see what kind of knowledge we have been acquiring.

I have said that I do not regard the term "knowledge" as implying assurance of truth. But in considering a particular body of knowledge, it may be assumed that an effort has been made to admit to that body only the more trustworthy knowledge; so that usually a reasonable degree of certainty

* "Right-thinking person" is, of course, a modest way of referring to oneself.

or probability is attributable to the knowledge which we shall have occasion to discuss. But the assessment of certainty of knowledge is to be regarded as separate from the study of the nature of knowledge.

The other matter of definition is the term "physical universe". Physical knowledge (as accepted and formulated to-day) has the form of a description of a world. We *define* the physical universe to be the world so described. Effectively therefore the physical universe is defined as the theme of a specified body of knowledge, just as Mr Pickwick might be defined as the hero of a specified novel.

A great advantage of this definition is that it does not prejudge the question whether the physical universe—or Mr Pickwick—really exists. That is left open for discussion if we can agree on a definition of "really exists", which for most persons is a parrot-phrase whose meaning they have not troubled to consider. The few who have attempted to give it a definite meaning do not always agree on the meaning. By defining the physical universe and the physical objects which constitute it as the theme of a specified body of knowledge, and not as things possessing a property of existence elusive of definition, we free the foundations of physics from suspicion of metaphysical contamination.

This type of definition is characteristic of the epistemological approach, which takes knowledge as the starting point rather than an existent entity of which we have somehow to obtain knowledge. But in defining scientifically a term already in common use, we must be careful to avoid abuse of language. To justify the above definition of the physical universe, we ought to show that it is not in conflict with what the ordinary man (in which term I do not include philosophers) understands by the physical universe. This justification is deferred to p. 159.

II

The nature of physical knowledge and of the world which it professes to describe has long been a battleground for rival schools of philosophers. But physicists can scarcely be denied a hearing on a subject which concerns them so intimately. A student of physical science should be in a position to throw some light on the nature of the knowledge obtainable by the methods which he practises. Recently a number of books have been written by authors whose qualifications are purely scientific, in which scientific epistemology is developed and used as an approach to the wider problems of philosophy. I do not think that this "intrusion" into philosophy is a matter for surprise or caustic comment.

One often finds an impression that it is an innovation for scientists to indulge in philosophy; but this is incorrect. I have noticed that some of the recent books are plentifully sprinkled with quotations from scientists of the nineteenth century which, whether they fortify the argument or not, prove at any rate that our predecessors shared the common foible of holding strong philosophic views—and expressing them. Some were out of their depth, then as now. But some were profound thinkers—Clifford, Karl Pearson, Poincaré, and others—whose writings have an honoured place in the development of scientific philosophy.

It is, however, important to recognise that about twenty-five years ago the invasion of philosophy by physics assumed a different character. Up till then traffic with philosophy had been a luxury for those scientists whose disposition happened to turn that way. I can find no indication that the scientific researches of Pearson and Poincaré were in any way inspired or guided by their particular philosophical outlook. They had no opportunity to put their philosophy into practice. Conversely, their philosophical conclusions were

the outcome of general scientific training, and were not to any extent dependent on familiarity with recondite investigations and theories. To advance science and to philosophise on science were essentially distinct activities. In the new movement scientific epistemology is much more intimately associated with science. For developing the modern theories of matter and radiation a definite epistemological outlook has become a necessity; and it is the direct source of the most far-reaching scientific advances.

We have discovered that *it is actually an aid in the search for knowledge to understand the nature of the knowledge which we seek.*

By making practical application of our epistemological conclusions we subject them to the same kind of observational control as physical hypotheses. If our epistemology is at fault, it will lead to an *impasse* in the scientific developments proceeding from it; that warns us that our philosophical insight has not been deep enough, and we must cast about to find what has been overlooked. In this way scientific advances which result from epistemological insight have in turn educated our epistemological insight. Between science and scientific epistemology there has been a give and take by which both have greatly benefited.

In the view of scientists at least, this observational control gives to modern scientific epistemology a security which philosophy has not usually been able to attain. It introduces also the same kind of progressive development which is characteristic of science, but not hitherto of philosophy. We are not making a series of shots at ultimate truth, which may hit or miss. What we claim for the present system of scientific philosophy is that it is an advance on that which went before, and that it is a foundation for the advances which will come after it.

In science the observational test is valuable, not only for controlling physical hypotheses (for which it is indeed the

only possible guarantee), but also for detecting fallacies of argument and unwarranted assumptions. It is the latter kind of control that an observational test applies to scientific epistemology. This may seem superfluous to those who never reason incorrectly. But perhaps even the most confident philosopher will admit that there are some of his opponents to whom such control would be salutary. I have little doubt that every one of the philosophical conclusions in this book has been anticipated by one of the schools of philosophy—and emphatically condemned by another. But to those who recognise them as familiar truisms or as long-condemned fallacies, I would point out that they are now put forward with altogether new sanctions which ought to be reckoned with.

Theoretical physicists, through the inescapable demands of their own subject, have been forced to become epistemologists, just as pure mathematicians have been forced to become logicians. The invasion of the epistemological branch of philosophy by physics is exactly parallel to the invasion of the logical branch of philosophy by mathematics. Pure mathematicians, having learnt by experience that the obvious is difficult to prove—and not always true—found it necessary to delve into the foundations of their own processes of reasoning; in so doing they developed a powerful technique which has been welcomed for the advancement of logic generally. A similar pressure of necessity has caused physicists to enter into epistemology, rather against their will. Most of us, as plain men of science, begin with an aversion to the philosophic type of inquiry into the nature of things. Whether we are persuaded that the nature of physical objects is obvious to commonsense, or whether we are persuaded that it is inscrutable beyond human understanding, we are inclined to dismiss the inquiry as unpractical and futile. But modern physics has not been able to maintain this aloofness. There can be little doubt that its advances, though applying

primarily to the restricted field of scientific epistemology, have a wider bearing, and offer an effective contribution to the philosophical outlook as a whole.

Formally we may still recognise a distinction between science, as treating the *content* of knowledge, and scientific epistemology, as treating the *nature* of knowledge of the physical universe. But it is no longer a practical partition; and to conform to the present situation scientific epistemology should be included in science. We do not dispute that it must also be included in philosophy. It is a field in which philosophy and physics overlap.

III

So long as a scientific writer on philosophy confines himself to scientific epistemology, he is not outside the borders of his own subject. But most authors have felt that they could usefully advance farther and consider the general philosophical bearing of the new conceptions. This venturesomeness has been strongly criticised; but it seems to me that the critics have failed to grasp the situation.

It is recorded that Archbishop Davidson, in conversation with Einstein, asked him what effect he thought the theory of relativity would have on religion. Einstein answered: "None. Relativity is a purely scientific theory, and has nothing to do with religion." In those days one had to become expert in dodging persons who were persuaded that the fourth dimension was the door to spiritualism, and the hasty evasion is not surprising. But those who quote and applaud the remark as though it were one of Einstein's most memorable utterances overlook a glaring fallacy in it. Natural selection is a purely scientific theory. If in the early days of Darwinism the then Archbishop had asked what effect the theory of natural selection would have on religion, ought the answer to have been "None. The Darwinian

theory is a purely scientific theory, and has nothing to do with religion"?

The compartments into which human thought is divided are not so water-tight that fundamental progress in one is a matter of indifference to the rest. The great change in theoretical physics which began in the early years of the present century is a purely scientific development; but it must affect the general current of human thought, as at earlier times the Copernican and the Newtonian systems have done. This alone would seem to justify the scientific authors in taking a broad view of their task. It seems to me unreasonable to maintain that the working out of these wider implications of the new conception of the physical universe should be left entirely to those who do not understand it.

Not so very long ago the subject now called physics was known as "natural philosophy". The physicist is by origin a philosopher who has specialised in a particular direction. But he is not the only victim of specialisation. By the breaking away of physics the main body of philosophy suffered an amputation. In practice, if not in theory, academic philosophy has also become specialised, and is no longer coextensive with the system of thought and knowledge by which we orient ourselves towards our moral and material environment. To a man's philosophy in the broadest sense—to his *religio vitae*—natural philosophy, under the name of science, has continued to be a powerful, perhaps even a predominant, contributor. It would be difficult to point to any development in academic philosophy which has had so great an influence on man's outlook as the growth of the scientific theory of evolution. In the last twenty years it has been the turn of physics to reassert itself as natural philosophy; and I believe that the new contribution of physical science, if fully grasped, is not less significant than the doctrine of evolution.

We may define rather more closely the status of a scientist