The Nature and Scope of Physical Science.

II.

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THE present position of physical science is that a large body of observations have been correlated by the two processes of abstraction and hypothesis. Abstraction has led us virtually to a contorted space-time, and hypothesis to a scheme of concepts unpicturable by the imagination. Both space-time and the scheme of concepts, however, by obeying prescribed rules, reproduce the data of observation, so that out of pure conceptions, having only a rational meaning, we can evolve, as it were, a very large part of the world of experience. This is the great achievement of modern physical science. The question that next arises is: What is the relation, in the category of reality, however we may define that word, of the world of experience to the connecting world of thought?

The question has been framed and answered by Sir Arthur Eddington and his answer is definite—the conceptual world is symbolic of the world of experience (" The Nature of the Physical World ", p. xv). But clearly that is not sufficient; otherwise science would be merely a form of art, and there would be no justification for laboriously expressing the obvious in terms of the incomprehensible when any poetaster could give an intelligible symbol of the world with infinitely greater facility. Apart from practical considerations, there are, so far as I can see, only two possibilities which can justify such a procedure: first, that the conceptual scheme is in some sense ' truer ' than the world of experience; second, that it reveals the existence of a connecting link between the diverse elements of experience. The fundamental characteristic of the views of science recently presented by Sir Arthur Eddington and Sir James Jeans is that the former alternative is adopted. I venture to suggest that this is a mistake: the conceptual world of physics is merely a means of making Nature intelligible to our minds and its laws are not to be interpreted as the truth about Nature.

It is impossible here to do more than indicate one argument supporting this statement. Since physical conceptions are always changing, any truth they represent must be exceedingly protean in form; on the other hand, the process of correlation of observations goes on continuously, and is, in fact, what directs the changes of conceptions. We cannot, therefore, regard the scheme of theoretical physics as telling us anything definitive about Nature, except that Nature appears to be intelligible.

An important example of the point at issue is found in the question of determinacy. It has recently been found advisable to suppose that there is a kind of indeterminacy in the behaviour of atoms, and this has been interpreted as a recognition of indeterminacy in Nature. Such an interpretation seems to subject us again to the error from which we have recently become emancipated. We have learned that abstractions (time, space, etc.) from phenomena are not to be foisted on atoms, and we immediately celebrate the discovery by foisting the characteristics of atoms on phenomena.

There is another example, however, which merits more detailed consideration, namely, the relation of science to measurement. Eddington (loc. cit., p. 275) and Jeans (" The Mysterious Universe ", pp. 140-141) identify the domain of science with the domain of the measurable, and their great authority has been widely invoked by non-scientific thinkers intent on ' putting science in its place '. It is usually a very simple matter to decide whether an experience is metrical or non-metrical in character, and a ready solution of many of the difficult questions raised by science is available if we can simply ignore everything that science has attempted to say of non-metrical experiences. Artists, theologians, metaphysicians, and moralists are thus enticed into what I believe to be a fool's paradise. Not only so, but this false escape from the challenge of science is necessarily accompanied by a real deprivation of its benefits. Art and religion have much to gain by a proper use of scientific principles, and the sharp restriction of the domain of science to the metrical elements of experience leaves them the poorer.

It is of course obvious that a large part of the data of science is non-metrical in character. The schoolboy's name for chemistry is ' stinks ', not ' balances ', and a very appropriate name it is. Biologists observe the flight of birds very closely, but they do not trouble to apply the Fitzgerald-Lorentz contraction, not because it is too small to be important but because it has no relation to the *kind* of observation they are interested in. It is clear, therefore, that much of the recording and augmentation of our experiences, which is essentially scientific, is not metrical. This in itself is sufficient to refute the doctrine in question: we need look no further in order to disillusion the non-scientific thinkers referred to above.

But this is not the whole of the matter. No doubt Jeans and Eddington would admit this readily enough, and still adhere to their opinions. For to them observations are just convenient tools for leading us to the truth underlying phenomena: it is that truth which they claim is metrical. Their doctrine applies not to the collecting of experiences but to their rational correlation, and they would say that when we come to analyse our experiences in order to discover the microscopic scheme of Nature, it is only the metrical elements that we can employ scientifically. I observe a cup, for example, and I notice that it is yellow in colour and hard to the touch. Those experiences I share with other normal people, and they are not primarily metrical. But when they are absorbed into the scientific scheme, it is only the metrical part of them which is used. The yellow colour, which I happen to dislike and of which someone else might be very fond, is represented only by a range of

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'wave-lengths', about which neither of us has any emotions at all. The hardness is represented by 'electro-magnetic forces' (or modifications of 'space-time') which are definable by means of equations. Through these metrical quantities, all that is scientifically tractable in the yellowness and hardness of the cup is expressed, and the other qualities of yellowness and hardness are left over as belonging, according to Eddington, to the extra-scientific domain of experience, or, according to Jeans, so far as I can gather, to the domain of illusions.

This idea, as Eddington clearly points out, requires that science is a closed, self-contained system, including all that is metrical in our experiences. But it is difficult to see how the existence of this closed system can be established. Even in the metrical part of our experiences there are phenomena which lie outside it. Take motion, for example. The system includes the motion of a comet, but it does not include the motion of a fly. We need consider none of the non-metrical aspects of the fly, but only its motion as a piece of matter. The matter is made up of protons and electrons, formed into atoms indistinguishable from those of the comet, and its motion can be described completely in terms of space and time. Nevertheless, the motion of the fly is essentially of a different character from that of the comet; it cannot be included within the closed system of metrical physics. Although itself metrical, we can make nothing intelligible out of it unless we associate it with something non-metrical, which we call 'life'; and if anyone thinks that motions associated with life are so entirely incalculable as to be outside science, he should reflect for a moment on the significance of a fly-paper.

The fact is that science is fitted to deal with all experiences which are common to all normal people. Such of these experiences as are metrical in character are largely—but, as we have just seen, not entirely—susceptible to correlation by the present scheme of physics. The others appear to be amenable only to conceptions which are individually different but ultimately of the same character. For these experiences also we employ abstractions and hypotheses. The abstraction of space-time is irrelevant, so we leave it in the phenomena and instead take out such concepts as life, mind, will. These are just as truly abstractions as are space and time; the 'I' of psychology is as valid a scientific idea as the 'i' of mathematics, and has perhaps still more right to be called an imaginary quantity, for it can at least be imagined. Similarly, we employ hypotheses. The hypotheses of protons and electrons are irrelevant, so we conjure up such ideas as organic evolution and subconsciousness. We observe and we correlate by the same methods as those employed in physics, and to a certain extent we can predict events. In every respect our treatment of these experiences has the same character as that of the metrical experiences. It appears to be an arbitrary and extremely inconvenient use of language to call the one treatment scientific and the other not.

Eddington gives an admirable example (loc. cit., pp. 251-252) of the supposed limitation of science to measurement. He describes an imaginary examination question in which an elephant is assumed to slide down a grassy hillside and it is required to find the time of descent. He points out that in solving the problem we do not consider the elephant but merely its mass, namely, 2 tons. Similarly, the hillside is represented by a slope of 60° and a coefficient of friction. Thus the poetry fades out of the problem and only 'pointer-readings' are left.

Now the whole secret of the matter is in the object of the inquiry, which is mentioned as a sort of after-thought: "The question presumably was to find the time of descent of the elephant". Naturally, since the time of descent is essentially a metrical quality, we should expect the relevant parts of the data to be metrical in character. But suppose the further question is put: "To find the damage done to the elephant". "Two tons" is of no use now; the living, struggling, trumpeting animal must be reckoned with. We can do without a knowledge of the slope of the hill, and the coefficient of friction 'leaves us cold'. As before, the poetry fades out of the problem, and it takes the metrical elements with it; but there is still something left, and that something is scientific in character. It involves such things as abrasions and broken limbs; it is approachable with chloroform and X-rays; the problem requires a knowledge of the anatomical structure and physiological processes of elephants—that is, scientific knowledge; and the answer can be stated in scientific terms conveying the same meaning to all normal people.

The division of common experience into metrical and non-metrical parts, of which only the former can be dealt with scientifically, therefore appears too simple. The whole of common experience is open to scientific treatment; part of that which is metrical is included in the physical scheme, and the remainder, together with the non-metrical elements, must be placed in a different scientific category—or perhaps more than one such category. Even this does not exhaust the potentialities of science, for it has an influence outside its own proper sphere, namely, among those experiences which are peculiar to the individual. Such experiences are not in themselves subject to scientific treatment, but, by virtue of a parallelism which exists between them and experiences which are so subject, they cannot be considered as if they were altogether independent of science; or, rather, if we do so consider them, we are closing our minds to much relevant information. It is common knowledge that a man's temper, which is outside the scope of science, shows a close relation with the condition of his digestion, which is very largely, at least, susceptible to scientific treatment.

This point, though sufficiently obvious, is widely overlooked. It is frequently supposed that by defining the field of science we define its influence. The former problem is difficult enough, but not insuperable: the latter is not likely to be solved in our day.

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