Explanations of SCIENCE

By Professor H. LEVY

A JUNGLE OF PHRASES.—Science has had to fight for its existence through a jungle of meaningless words and phrases, until it could evolve a language of description as clear, precise and exact as the experimental facts by whose accuracy it must stand or fall. For the kind of abstractions science finds essential to its investigations and its explanations are foreign to the thoughts, and would ring strange in the speech of the man in the street.

"Why did you fall?" someone asks. "Because I lost my balance," we answer easily, as if this so-called explanation were anything more than a repetition.

FICTITIOUS ANSWERS. — Apart from such fictitious answers, there are broadly three forms of explanation that when offered are acceptable as satisfactory replies—up to a point. There is the explanation that refers the event back to a previous physical occurrence. "Why did you fall off the bus?" it is asked, and the preceding event is mentioned in explanation: "Because it jerked as I stood on the step."

There is secondly the explanation that refers the event back to a more general class, or to a general "law." Thus, "Why is it dark so early?" is explained by the statement that it is winter, implying that the day in question is one of a class that possess this characteristic.

Thirdly there is the type of explanation that answers in terms of some simplified abstraction of the event. "If I move always in one direction round the Earth, why do I come back to the same place?" is answered by "Because the Earth is a sphere," the round form of the Earth being the only aspect of it that appears to be relevant to the question.

SATISFACTION. — Now it is not suggested that all forms of explanation can easily be embraced in these three simple forms, or that the three illustrations belong to quite distinct classes. What we have to notice, however, is that what is deemed a satisfactory explanation always contains one of two elements. Either it refers back to some earlier physical event or it refers back to a mathematical abstraction like a sphere, but an abstraction that has itself been derived from a physical object.

Thus in all cases there appears to be this essential feature of an explanation, that the terms in which it is couched must contain references to nothing except things that can themselves be directly approached experimentally, the properties of physical objects in fact.

MYSTERY IN SCIENCE. — Now this is all very important for a proper appreciation of modern tendencies in scientific development, especially for many of those features like Relativity and Quantum Theory that appear to the layman to savour so much of mystery that science seems to him to have departed finally from the realms of common sense.

Let us bear in mind the two forms of scientific explanation, the direct reference back to something physical, and the explanation in terms of something abstract, geometrical forms for example. One of the most extraordinary developments of mathematical science is the manner in which geometrical form has been exploited as a medium for scientific explanation.

It begins if you care with the representation of objects like the Earth, the planets, the sun, and the stars as spheres or points, and their route through the skies as curves of one type or another. To the points or to the spheres it attaches numbers to represent their massiveness, and lines radiating outwards from each towards every other such geometrical body to represent the forces that act on them; and it lays down a set of rules derived from experiment to settle the changes in speed that arise on these bodies when these forces are in operation.

Thus the whole problem of the interplay of planets for example, or indeed of the interplay of any system of interacting bodies, becomes reduced to a calculation of the rates at which their distances apart change. It is entirely a problem in *moving geometry*.

A WORLD OF SYMBOLS.—Now as long as the explanations are shown in this pictorial form, they are seen to be explanations of the type we have referred to, as harking back more or less directly to the physical facts. But mathematicians have pushed the form of explanation yet a stage further back. To each line they attach a letter, a symbol to represent its length or its direction, so that the rule or law is stated as a relation, or an equation as it is called in algebra, between these symbols.

Thus he has transferred the whole problem from the real world of space-time, of real planets and solid bodies with which he has started, to a symbolic world of algebraic letters on a piece of paper. So accustomed does he become to the handling of these letters that presently the marks on the paper acquire a much greater validity and reality to him than the real world to which they owe their origin.

THE SCIENTIFIC PEERAGE. — It is an extraordinary example of the powers and at the same time of the dangers of scientific abstraction. The method has been highly successful. It has shown that intricate systems of events can be analysed into a comparatively simple series of elementary "laws," and it has justified itself by innumerable predictions which have in due course been verified by subsequent experiment. But by its very success it has elevated the mathematician to the scientific peerage, and, being human, he has become not merely proud but arrogant.

Forgetting that he has been dealing with only one aspect, and that an abstraction of the physical world of which he is himself a part, he has asserted that our world is his, a world of symbols, of pointer-readings as Eddington calls them, and that its creation could have been the work only of a Pure Mathematician.

MATHEMATICAL EXAGGERATION.—It is, of course, as we see, a gross exaggeration of the legitimate claims of the mathematician. So intent has he, in fact, become on the handling of his symbols that the real world of the experimentalist, the real world of you and me, the world with which he started has slipped through his fingers and he is left gazing at his symbols as if they were the only reality.

PREDICTION IMPOSSIBLE. — It is worth while however pursuing further the more modern trend of this mathematical pursuit of the truth about the universe, for we can see in it the historical development of mathematical abstraction. The mathematician formulates rules of action as they have shown themselves in the past, and to show what they will imply in the future if these laws still continue to apply. No such prediction, therefore, has any validity until it has actually been verified, that is, until it has itself become a thing of the past. *There is no valid prediction in science.*

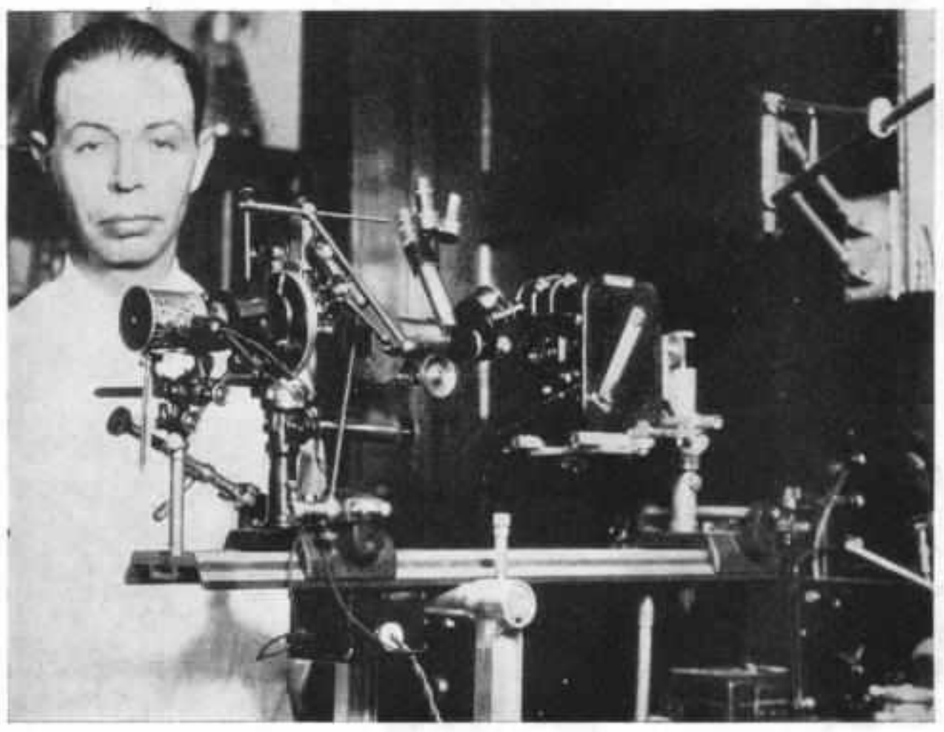
A PICTURE OF NOTHING.—Now we have to recognise two fields in which such forms of prediction become particularly precarious; they are those that refer to the exceedingly large and remote, both in space and in time, and those that refer to the exceedingly small, for in both these ranges the power of verifying any predictions that are made on the basis of accepted laws is seriously restricted. For after all our physical powers of observation are limited in both directions. That is one of the facts we have to take into account when framing and applying these physical laws.

The size of the abstraction, for example, to which we attach the name electron is so small that it is well beyond our physical range of vision with the most powerful microscope, even were it of such a nature as to make its position or speed as a separate entity definite and precise. It seems to follow that an attempt to seek an explanation of the behaviour of electrons in the mass in terms of abstractions of individual electrons—pictorial abstractions—when the real individual has never been seen is likely to be doomed to failure from the start. Unlike the sphere as an abstraction of the Earth, it will represent an approximate picture of nothing experienced.

SCIENTIFIC LIMIT.—What kind of explanation in these circumstances can the scientist give? He has first the experimental facts, and these require an explanation, but in terms of what? There are no other similar and simpler experiences to which they can be referred, and he can form no simple picture to serve as a geometrical basis.

In the face of this impasse he has done a rather peculiar thing. It will be remembered that on previous matters he has started with the object, imagined a geometrical picture and represented it in terms of algebraic symbols. Baulked in this case of these earlier steps he has simply switched them out and turned directly to the mathematical symbols in the endeavour to find formulæ that will give him the right answer in making a prediction. He has relinquished the hope of interpreting his formulæ at any stage earlier than at the final prediction. It is the limit of scientific abstraction.

Many writers have seen in this a deep-seated mystery at the foundations of science, but if we look at the matter from the general standpoint we have adopted there is no mystery. Physical science has exposed very clearly the limits of our powers of perception as we look down the scale of size. By that same action it has set a limit to a sensible orthodox demand for explanation of physical behaviour of the type science provides. It has exposed a very definite and precise limitation to the meaning of explanation.



THE WORLD'S MOST POWERFUL MICROSCOPE

Dr. R. R. Rife, of San Diego, standing beside the microscope he has just invented, which is said to be the most powerful in the world, making visible to the eyes of man bacteria never seen before