

SCIENCE AND HYPOTHESIS

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INTRODUCTION.

It is to be hoped that, as a consequence of the present active scrutiny of our educational aims and methods, and of the resulting encouragement of the study of modern languages, we shall not remain, as a nation, so much isolated from ideas and tendencies in continental thought and literature as we have been in the past. As things are, however, the translation of this book is doubtless required; at any rate, it brings vividly before us an instructive point of view. Though some of M. Poincaré's chapters have been collected from well-known treatises written several years ago, and indeed are sometimes in detail not quite up to date, besides occasionally suggesting the suspicion that his views may possibly have been modified in the interval, yet their publication in a compact form has excited a warm welcome in this country.

It must be confessed that the English language

hardly lends itself as a perfect medium for the rendering of the delicate shades of suggestion and allusion characteristic of M. Poincaré's play around his subject; notwithstanding the excellence of the translation, loss in this respect is inevitable.

There has been of late a growing trend of opinion, prompted in part by general philosophical views, in the direction that the theoretical constructions of physical science are largely factitious, that instead of presenting a valid image of the relations of things on which further progress can be based, they are still little better than a mirage. The best method of abating this scepticism is to become acquainted with the real scope and modes of application of conceptions which, in the popular language of superficial exposition—and even in the unguarded and playful paradox of their authors, intended only for the instructed eye—often look bizarre enough. But much advantage will accrue if men of science become their own epistemologists, and show to the world by critical exposition in non-technical terms of the results and methods of their constructive work, that more than mere instinct is involved in it: the community has indeed a right to expect as much as this.

It would be hard to find any one better qualified for this kind of exposition, either from the profundity of his own mathematical achievements, or from the extent and freshness of his interest in the theories of physical science, than the author of this book. If an appreciation might be ventured on as regards the later chapters, they are, perhaps, intended to present the stern logical analyst quizzing the cultivator of physical ideas as to what he is driving at, and whither he expects to go, rather than any responsible attempt towards a settled confession of faith. Thus, when M. Poincaré allows himself for a moment to indulge in a process of evaporation of the Principle of Energy, he is content to sum up: "Eh bien, quelles que soient les notions nouvelles que les expériences futures nous donneront sur le monde, nous sommes sûrs d'avance qu'il y aura quelque chose qui demeurera constant et que nous pourrions appeler *énergie*" (p. 166), and to leave the matter there for his readers to think it out. Though hardly necessary in the original French, it may not now be superfluous to point out that independent reflection and criticism on the part of the reader are tacitly implied here as elsewhere.

An interesting passage is the one devoted to

Maxwell's theory of the functions of the æther, and the comparison of the close-knit theories of the classical French mathematical physicists with the somewhat loosely-connected *corpus* of ideas by which Maxwell, the interpreter and successor of Faraday, has (posthumously) recast the whole face of physical science. How many times has that theory been re-written since Maxwell's day? and yet how little has it been altered in essence, except by further developments in the problem of moving bodies, from the form in which he left it! If, as M. Poincaré remarks, the French instinct for precision and lucid demonstration sometimes finds itself ill at ease with physical theories of the British school, he as readily admits (pp. 223, 224), and indeed fully appreciates, the advantages on the other side. Our own mental philosophers have been shocked at the point of view indicated by the proposition hazarded by Laplace, that a sufficiently developed intelligence, if it were made acquainted with the positions and motions of the atoms at any instant, could predict all future history: no amount of demur suffices sometimes to persuade them that this is not a conception universally entertained in physical science. It was not so even in Laplace's own day. From the point of view of the study of the evolution

of the sciences, there are few episodes more instructive than the collision between Laplace and Young with regard to the theory of capillarity. The precise and intricate mathematical analysis of Laplace, starting from fixed preconceptions regarding atomic forces which were to remain intact throughout the logical development of the argument, came into contrast with the tentative, mobile intuitions of Young; yet the latter was able to grasp, by sheer direct mental force, the fruitful though partial analogies of this recondite class of phenomena with more familiar operations of nature, and to form a direct picture of the way things interacted, such as could only have been illustrated, quite possibly damaged or obliterated, by premature effort to translate it into elaborate analytical formulas. The *apêrçus* of Young were apparently devoid of all cogency to Laplace; while Young expressed, doubtless in too extreme a way, his sense of the inanity of the array of mathematical logic of his rival. The subsequent history involved the Nemesis that the fabric of Laplace was taken down and reconstructed in the next generation by Poisson; while the modern cultivator of the subject turns, at any rate in England, to neither of those expositions for illumination, but rather finds in the partial

and succinct indications of Young the best starting-point for further effort.

It seems, however, hard to accept entirely the distinction suggested (p. 213) between the methods of cultivating theoretical physics in the two countries. To mention only two transcendent names which stand at the very front of two of the greatest developments of physical science of the last century, Carnot and Fresnel, their procedure was certainly not on the lines thus described. Possibly it is not devoid of significance that each of them attained his first effective recognition from the British school.

It may, in fact, be maintained that the part played by mechanical and such-like theories—*analogies if you will*—is an essential one. The reader of this book will appreciate that the human mind has need of many instruments of comparison and discovery besides the unrelenting logic of the infinitesimal calculus. The dynamical basis which underlies the objects of our most frequent experience has now been systematised into a great calculus of exact thought, and traces of new real relationships may come out more vividly when considered in terms of our familiar acquaintance with dynamical systems than when formulated under the paler shadow of more analytical abstrac-

tions. It is even possible for a constructive physicist to conduct his mental operations entirely by dynamical images, though Helmholtz, as well as our author, seems to class a predilection in this direction as a British trait. A time arrives when, as in other subjects, ideas have crystallised out into distinctness; their exact verification and development then becomes a problem in mathematical physics. But whether the mechanical analogies still survive, or new terms are now introduced devoid of all naive mechanical bias, it matters essentially little. The precise determination of the relations of things in the rational scheme of nature in which we find ourselves is the fundamental task, and for its fulfilment in any direction advantage has to be taken of our knowledge, even when only partial, of new aspects and types of relationship which may have become familiar perhaps in quite different fields. Nor can it be forgotten that the most fruitful and fundamental conceptions of abstract pure mathematics itself have often been suggested from these mechanical ideas of flux and force, where the play of intuition is our most powerful guide. The study of the historical evolution of physical theories is essential to the complete understanding of their import. It is in

the mental workshop of a Fresnel, a Kelvin, or a Helmholtz, that profound ideas of the deep things of Nature are struck out and assume form; when pondered over and paraphrased by philosophers we see them react on the conduct of life: it is the business of criticism to polish them gradually to the common measure of human understanding. Oppressed though we are with the necessity of being specialists, if we are to know anything thoroughly in these days of accumulated details, we may at any rate profitably study the historical evolution of knowledge over a field wider than our own.

The aspect of the subject which has here been dwelt on is that scientific progress, considered historically, is not a strictly logical process, and does not proceed by syllogisms. New ideas emerge dimly into intuition, come into consciousness from nobody knows where, and become the material on which the mind operates, forging them gradually into consistent doctrine, which can be welded on to existing domains of knowledge. But this process is never complete: a crude connection can always be pointed to by a logician as an indication of the imperfection of human constructions.

If intuition plays a part which is so important,

it is surely necessary that we should possess a firm grasp of its limitations. In M. Poincaré's earlier chapters the reader can gain very pleasantly a vivid idea of the various and highly complicated ways of docketing our perceptions of the relations of external things, all equally valid, that were open to the human race to develop. Strange to say, they never tried any of them; and, satisfied with the very remarkable practical fitness of the scheme of geometry and dynamics that came naturally to hand, did not consciously trouble themselves about the possible existence of others until recently. Still more recently has it been found that the good Bishop Berkeley's logical jibes against the Newtonian ideas of fluxions and limiting ratios cannot be adequately appeased in the rigorous mathematical conscience, until our apparent continuities are resolved mentally into discrete aggregates which we only partially apprehend. The irresistible impulse to atomize everything thus proves to be not merely a disease of the physicist; a deeper origin, in the nature of knowledge itself, is suggested.

Everywhere want of absolute, exact adaptation can be detected, if pains are taken, between the various constructions that result from our mental activity and the impressions which give rise to

them. The bluntness of our unaided sensual perceptions, which are the source in part of the intuitions of the race, is well brought out in this connection by M. Poincaré. Is there real contradiction? Harmony usually proves to be recovered by shifting our attitude to the phenomena. All experience leads us to interpret the totality of things as a consistent cosmos—undergoing evolution, the naturalists will say—in the large-scale workings of which we are interested spectators and explorers, while of the inner relations and ramifications we only apprehend dim glimpses. When our formulation of experience is imperfect or even paradoxical, we learn to attribute the fault to our point of view, and to expect that future adaptation will put it right. But Truth resides in a deep well, and we shall never get to the bottom. Only, while deriving enjoyment and insight from M. Poincaré's Socratic exposition of the limitations of the human outlook on the universe, let us beware of counting limitation as imperfection, and drifting into an inadequate conception of the wonderful fabric of human knowledge.

J. LARMOR.

AUTHOR'S PREFACE.

To the superficial observer scientific truth is unassailable, the logic of science is infallible; and if scientific men sometimes make mistakes, it is because they have not understood the rules of the game. Mathematical truths are derived from a few self-evident propositions, by a chain of flawless reasonings; they are imposed not only on us, but on Nature itself. By them the Creator is fettered, as it were, and His choice is limited to a relatively small number of solutions. A few experiments, therefore, will be sufficient to enable us to determine what choice He has made. From each experiment a number of consequences will follow by a series of mathematical deductions, and in this way each of them will reveal to us a corner of the universe. This, to the minds of most people, and to students who are getting their first ideas of physics, is the origin of certainty in science. This is what they take to be the rôle of