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The New Physics.

SIR JOSEPH THOMSON is being entertained to dinner at Cambridge to-day on the attainment of his seventieth birthday. The event is one in which all who are concerned with scientific progress would desire to be associated in congratulatory expression, though only a limited number of friends are participating in the actual celebration. We are therefore devoting the main part of this week's issue of NATURE, as well as the whole of the special Supplement, to articles on the Cavendish Laboratory and its directors, with particular reference to Sir Joseph Thomson's work and influence. It would of course have been easy to obtain hundreds of appreciative messages for publication on this occasion, but in inviting such expressions of congratulation, we limited ourselves to some distinguished men of science abroad who have carried on research in the Cavendish Laboratory or have devoted themselves particularly to investigations along lines which started there. We are proud of the opportunity of publishing the tributes of affection and esteem received in response to our invitation, and we are sure that they represent the feelings of the whole scientific world.

When, in 1879, the late Sir William Crookes showed his beautiful experiments on the properties of what he called radiant matter, he could scarcely have foreseen the immense importance which such experiments were destined to assume before the close of the century. Nor could he then have suspected that the Cavendish Laboratory, inaugurated in 1874, would become the focus of the world's researches on pure electricity.

The influence of Cambridge upon electrical science since the foundation of the Cavendish Laboratory and the chair of experimental physics, has been unexampled and unrivalled. Glasgow through Kelvin, Leyden through Lorentz, Liverpool through Lodge, Manchester through Moseley, and Berlin through Helmholtz, Planck, and Einstein, have made great contributions to electrical fact and theory, but the galaxy of talent which has followed in the footsteps of Maxwell on the banks of the Cam must surely be generally acknowledged as the finest team yet engaged in the elucidation of a special branch of physics.

The importance of the work of Clerk Maxwell lay in the unification of two disciplines—those of light and of electricity respectively. It passed through several phases, in which the ultimate analysis of the phenomena then known was based upon more or less mechanical models with an underlying conception of essential continuity. Such continuity was a legacy of Faraday's recognition of the importance of the medium across which electric and magnetic forces are transmitted.

It lent a new significance to the conception of a luminiferous ether, and although the idea of a grainless continuum must always have presented certain philosophical difficulties, there is no doubt that it had a considerable heuristic value both in optics and in electromagnetism.

It does not detract from the great tradition of the Cavendish Laboratory that Sir J. J. Thomson's most noteworthy achievements have pointed in the opposite direction. His discovery of the electron in 1897 brought about a fundamental change in the ultimate conceptions of physical science. How radical was that change can only be realised by those whose electrical training took place in the 'eighties. Their preoccupation then was with the vectors and stresses in the electromagnetic field, with mechanical and hydrodynamical analogies, with sources and sinks, with the slip of lines of force on a conductor. Instead of all this, the new science of physics gives us electrons and positive nuclei, ionisation in gases, in liquids, and in solids, the emission of 'naked electricity' from hot wires, the collapse of electronic orbits, and the discrete structure of energy. Could a revolution be more complete; and the revolutionaries are the successors and disciples of the man who conceived the continuous electromagnetic ether and identified it with the all-pervading vehicle of light!

Nor can any one deny that this change of front has been exceptionally fruitful. The arch-revolutionary himself, who is now the revered Master of Trinity, devised the most powerful method of chemical analysis yet known, that positive-ray method which in the hands of Aston has brought about a new era in chemistry and shed a flood of light on the constitution of the atom and the true meaning of atomic weight. It has revealed the underlying unity of chemical substances, and has justified the bold guesses of Prout and Crookes, both of whom contended that all substances are derived from the same fundamental substance.

The Cavendish Laboratory, though one of the oldest of physical laboratories, is by no means the best equipped. Many of the new universities can boast of a better provision of expensive and up-to-date apparatus, and a few of them are far better designed. The more powerful electrical corporations, both in Europe and America, have magnificently equipped research laboratories. But tradition counts for much, even in pure science, and the habitual cultivation of science for its own sake imparts a breadth of outlook and of enterprise which is foreign to institutions working under a perpetual utilitarian effort.

We may confidently expect that Cambridge, under the guidance of Sir Ernest Rutherford, will regard the complete elucidation of atomic structure as its main function; and this elucidation may produce some very unexpected results. For no one can say that physical conceptions have settled down into a groove, as they seem to do after some revolutions. Quite the contrary. For the science is actually in a state of acute crisis. Never has its instrumental power been greater, but each new method of research seems to lead us to new and formidable problems. Einstein's conceptions of the universe as a four-dimensional manifold of space and time have gained ground rapidly, especially since the corroboration of his astronomical predictions by photographs taken during total solar eclipses. They have gained ground in spite of the greatest reluctance of the older physicists to give up their Newtonian principles. They have won the day in spite of several serious and fundamental modifications introduced by Einstein himself in his original arguments. These modifications have not cancelled his main thesis, and time is no longer independent of space, or space independent of time. Gravitation is a form of inertia, and produces a sort of kink in space impossible to conceive and impossible to formulate in terms of ordinary geometry. No wonder there are still some physicists of the old school who think that their cherished science has gone awry, and have given up all theorising in the expectation of better days.

Another powerful German challenge to accepted views came from Max Planck, whose conception of 'quanta' of energy has been more readily accepted than relativity, solely because we happen to live in an era which looks for discontinuous structure everywhere. If the value of a physical hypothesis is to be measured by the extent of the field covered by it and by its success in connecting phenomena previously isolated, then the quantum hypothesis must be accorded a very high rank indeed. For it provides a link between such hitherto unrelated things as specific heat, atomic volume, photoelectricity, series spectra, and the decay of radioactive substances. Even if it were not true, it would deserve to be so, and it might be adjudged *ben trovato* on account of its quickening effect upon research. Much remains to be done, however, before the new views have been linked up with the old. A multitude of questions remain to be solved. If all energy is transferred in discrete quanta, what is the nature of such a quantum? What is its form or structure while it is on its way from one material system to another? Is it a wave-train? And if so, what is it that undulates?

The physical theories prevalent in 1870 would have unhesitatingly ascribed the undulation to a fixed ether resembling in many respects a stiff jelly, but otherwise permeable to ordinary matter. Twenty years afterwards, an incompressible continuum having many analogies to water would have occurred to most physicists when asked to provide (as the late Lord Salisbury asked them in his presidential address to the British Association at Oxford in 1894) a nominative case to the verb ' to undulate.' Einstein's ' gesture of despair ' in renouncing all hope of ever discovering a phenomenon which would exhibit the ether drift demanded by many ingenious experimental arrangements led to a widespread abandonment of all ether hypotheses, on the plea that a substance the existence of which could not be proved might as well not exist at all.

The generalised theory of relativity more recently formulated by Einstein does, in effect, re-introduce the ether as the bearer of gravitational and electromagnetic energies, but it is an ether which remains inaccessible to any analysis based upon the classical mechanics. The same defect—if it is a defect—attaches to Niels Bohr's beautiful model of the hydrogen atom consisting of a positive nucleus with its valency electron in one of several possible orbits. The change from one orbit to the next is attended by the emission or absorption of one energy quantum, the value of which is in exact proportion to the frequency of the radiation. This model has been completely successful in explaining the spacing of the spectrum lines of hydrogen, but no one can say why the model should be so constituted. Attempts have been made, notably by Schrödinger, to formulate a new system of mechanics, provisionally called ' undulatory mechanics,' which shall be founded upon atomic phenomena rather than upon those large-scale observations which since Galileo have provided the foundation for mechanical hypotheses.

All this, however, is yet in embryo. Practical physicists concern themselves less with theoretical foundations than with the applications of a ready-made hypothesis which appears to provide a valuable guidance through unexplored mazes; and so they try the new weapons furnished by the quantum theory on all sorts of things, the excitation of line and band spectra, catalysis, photochemistry, X-rays, heat radiation, absorption spectra, and countless other matters. Some of them even attempt to count the quanta emitted by a feeble radiator by allowing them to impinge upon a fine metallic point and observing the photoelectric flash produced. Such experiments, first initiated by Geiger, will no doubt be followed up soon. The human eye, gazing upon a sixth-magnitude star, receives several hundred quanta per second. It is just possible that its insensibility to anything below that brightness is the result of a long evolutionary adaptation. For the utility of vision must depend upon the constancy of the visual impression of a point fixed in space, and an eye provided with a much greater sensitiveness would defeat the object of vision by revealing discontinuities in the light itself, due entirely to its discontinuous structure.

There is little doubt that practice will rush ahead of theory. The conception of a magneton or elementary magnetic moment, first advanced by Weiss and Langevin, has been elaborated by Bohr on the basis of his hydrogen model, and may yet do for magnetism what the electron has done for electricity. But experimentalists appear to be content with the slenderest guidance by hypothesis. They are tackling the constitution of crystals, the refraction and dispersion of Röntgen rays, and the artificial disintegration of the atomic nucleus without pausing to ask themselves for a clear conception of what they are doing or whither their results will lead. If we may follow Jeans in his graphic exposition of conditions in the distant bowels of space, we may rest assured that the most astounding discoveries made in our laboratories will fall short of those hidden in the interiors of distant stars and nebulæ, where unknown elements heavier than uranium are generated from unknown power sources, where substances have densities amounting to tons per cubic inch, where matter dies in a burst of radiant energy, and is born again by a process as mysterious as time itself.

The younger generation of physicists may well be envied. So far from being confined in their discoveries to the ' third decimal place,' they have before them an untilled field in which the transition from the apparently unknowable to the knowable, and from the knowable to the known, is not only rapid, but is also undergoing a constant acceleration.

A Half-way House of Science.

Tierpsychologie: vom Standpunkte des Biologen. Von Prof. Dr. Friedrich Hempelmann. Pp. viii+676. (Leipzig: Akademische Verlagsgesellschaft m.b.H., 1926.) 36 gold marks.

THE rival camps of mechanists and vitalists have been struck, the contending parties have advanced to meet one another, holding out the ' right hand of fellowship,' and are jointly engaged in constructing a half-way house, a shelter for those who wander on the path between biology and physiology. Here, in this shelter, the teaching of the school of animal psychology and its new technique can be imbibed. Its fundamental study has commanded attention, since interest in the phenomena of living matter was first aroused, but its establishment as a science is of recent date, and is at present much handicapped by the incompleteness of the physiological record of structure and function. The *Sturm und Drang*