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The British Association.

THIS year's meeting of the British Association in Edinburgh will make, we believe, the beginning of a new epoch in the history of the Association. About a year ago it was pointed out in the *Times*, as well as in our own columns, that conditions are now different from what they were when the Association was founded in 1831, and that for such a body to develop it must adapt itself to the changed circumstances. The Council, in a spirit which should be characteristic of all scientific bodies, was not slow to recognise this need, and a meeting of representatives of all sections was summoned early in this year to consider what changes might appropriately be introduced now or contemplated in the near future. As a result, several departures from custom have been made, and will be followed at the Edinburgh meeting. The addresses of presidents of sections have hitherto been delivered usually on the day following the inaugural meeting, but this year they will be given at different times—those of Sections B, C, D, E, and I on Thursday; of Sections A, F, G, J, and K on Friday; and of Sections L and M on Monday. This will give members of the Association an opportunity of listening to several addresses if they wish. Some of the addresses will also be used to open discussions, this again being a new departure. Joint discussions between two or more sections are not a new feature, but particular prominence is given to them in this year's programme, and it is hoped that they will become increasingly important in future years.

Such changes as these may be said to mark the acceptance of the view that many members of the Association attend the annual meetings, not to listen to papers on their own subjects, but to become acquainted with the chief developments in other subjects. The Association has no *raison d'être* if it resolves itself into a series of meetings of specialised sections having no communication with each other. If that were its function, it could be satisfied by arranging for simultaneous annual meetings of the physical, chemical, geological, zoological, and other scientific societies at selected provincial centres. A far better purpose is served by regarding a meeting of the Association as an occasion for widening interest in scientific work generally, not only among those actively engaged in it, but also among the general public. Opportunity must, of course, be provided for workers in particular fields to exchange views with one another, but the main idea should be to deal with lines of advance in which large groups of members are interested, and these should be presented in such a way as to be intelligible to a general scientific assembly—as they are, for example, at a Friday evening discourse at the Royal Institution.

The number of sections is unimportant, provided only that separate rooms can be found for them and that they represent actual groups of workers in specific fields. There might, if necessary, be twenty sections, in each of which a dozen or more active investigators sat around a table and discussed their own special problems, but in addition there should be, on each day of the meeting, two or three joint conferences in which outstanding points of progressive scientific knowledge are displayed for the benefit of all members, so that biologists may learn what astronomers, physicists, and chemists are doing for the advancement of science, and in their turn enlighten workers in other domains of natural knowledge. The evening discourses do this to some extent, and the joint discussions also carry out the idea. What we suggest is that the Association should continue to develop these lines of wide appeal in order to extend the ground of common understanding.

So far we have referred only to the interests of the members themselves, but the Association has also a duty to the general community. It meets year by year in different parts of the kingdom in order to direct attention to scientific work and stimulate local effort and support. Only a relatively small proportion of the population of any centre will become members, but a large proportion can appreciate the spirit and service of science and understand the value of scientific knowledge and method in the conduct of provincial and national affairs. The Citizens' Lectures were instituted by the Association for this purpose, and it would be worth while to arrange for the delivery of a couple of these at, say, five o'clock in the afternoon, in addition to the usual evening lectures. Whatever is done to create interest and belief in scientific aims and work among the general public is to the benefit of science, and it is the privilege of the Association to fulfil this function.

An organisation which is approaching the centenary of its foundation cannot readily be modified to make it fit new conditions of vitality, yet the Association is re-shaping itself, and is thus making itself strong to survive for many years yet as the annual Parliament of science in these islands. The Edinburgh meeting promises to be a memorable event in a long and worthy record.

Science in the Middle Ages.

Mediaeval Contributions to Modern Civilisation: A Series of Lectures delivered at King's College, University of London. Edited by Prof. F. J. C. Hearnshaw. With a preface by Ernest Barker. Pp. 268. (London and Sydney: George G. Harrap and Co., Ltd., 1921.) 10*s*. 6*d*. net.

PROF. HEARNSHAW has produced a volume of a valuable type which is happily becoming more and more common. It is a composite book, written mainly by professors at King's College, where it was given as lectures last winter, and the various chapters hang more or less closely together as an account of the debt which the modern world owes to the Middle Ages. This is a conception of history which has gained ground in recent years, and is specially connected with the name of Benedetto Croce. We are coming to see that, as history is a living thing, and the present nothing but the realisation of the past, that part of the past deserves our most serious attention of which we can say with most assurance that it lives and moves in and around us to-day.

Prof. Hearnshaw has applied this conception to the work of the Middle Ages—*i.e.* to the millennium lying, broadly speaking, between the fifth and the fifteenth centuries of the Christian era. He has selected writers who deal with religion, philosophy, science, art, poetry, education, society, economics, and politics. The range is comprehensive. One feels that the choice of contributors might with advantage have been somewhat more comprehensive also. One would have welcomed Dr. A. J. Carlyle on the political theories and political activities of the Middle Ages, and no one would have spoken with more acceptance than Prof. W. V. Ker on the literary aspect of the period, though Sir Israel Gollancz has, of course, treated the English contribution with his usual mastery. The editor has, in fact, adhered a little too closely to the staff of his own college. But we are deeply grateful for what he has given us, and in particular for the two studies on the art and science of the Middle Ages by Dr. Percy Dearmer and Dr. Charles Singer. The latter is one of those happily added from outside to the King's College team, and his contribution specially concerns the readers of NATURE.

It is perhaps strange that the essay on "Science" in the medieval world—the department of human thought in which unquestionably the Middle Ages added least to modern civilisation—should stand out so prominently in this volume as a model of learning well arranged, judgment soundly exercised, and progress clearly exhibited. Yet this is so, and Dr. Singer's paper appears to us worthy of some slight enlargement and publication as a separate work.

He strikes the right keynote within the first four pages. "Medievalism," from the point of view of science, "was a slow process by which the human mind, without consciously increasing the stock of phenomenal knowledge, sank slowly into an increasing ineptitude." It reached a nadir about the tenth century, and after this may be discerned a slow ascent; but the date for the end of medieval and the birth of modern science is fixed by the point when men interested in phenomena, and especially physicists, began to look to the future rather than to the past. The essential bases of the new movement, which became definite towards the middle of the sixteenth century, are hope in mankind and the idea of progress. The medieval period is the thousand years which preceded this and followed the downfall of the Western Empire.

Dr. Singer maps out this millennium admirably in the chronological table which concludes the essay. There was first the "Dark Age" proper, extending from the fifth century to the end of the ninth, from Martianus Capella to Erigena. Then came the intermediate and transitional age of

Arab influence, from the beginning of the tenth to the latter part of the twelfth century; and three centuries of the Scholastics form the last division. The salient characteristics of each division and the leading figures are clearly brought out. Specially notable is the lively picture of the travelling scholar from the West who gets in touch with Arab learning through some Jewish interpreter in a back street of Toledo; and on the side of theory due emphasis is laid on the cardinal doctrine of medieval science, the correlation of the macrocosm and the microcosm, and the enforcement of this by Arabian astrology.

The whole essay is valuable and deserves careful study. The original scientific work of Albertus Magnus receives full credit, though Stadler's new text of one work, the "De Animalibus," was still inaccessible when the book was published. There is an excellent short summary of Roger Bacon's achievements, and Nicolas of Cusa (1401–64) is recorded as the first biological experimenter of modern times, Helmont's experiment on a growing plant, showing that it absorbs something of weight from the air, being due to him.

If we must record a difference from Dr. Singer, it is one of emphasis rather than one of opinion or of fact. He appears to us to exaggerate somewhat the breach with the classical past which the new thought at the end of the medieval period involves. The difference is due mainly to the fact that as a biologist he is struck more by the mass of new and accurate observation which the modern biologist introduced, and less by the continuity of abstract reasoning which mathematical and astronomical science inherited from the Greeks.

Plantation Rubber Research.

Plantation Rubber and the Testing of Rubber. By Dr. G. Stafford Whitby. (Monographs on Industrial Chemistry.) Pp. xvi+559+8 plates. (London: Longmans, Green, and Co., 1920.) 28*s.* net.

THE general editor of this well-known series refers in his introduction to the extraordinary development which the applications of chemistry have experienced during the last four or five decades. In the case of the rubber industry the development is even more recent. Practically the whole of the facts dealt with in Prof. Whitby's book have been discovered within the last fifteen years, and with few exceptions the application of a knowledge of the chemistry of rubber to the industry may also be said to date from the introduction of plantation rubber. Previous to 1905 publications dealing with rubber were few and far between. With one outstanding exception, namely, C. O. Weber's "Chemistry of India Rubber" (1902), there was no text-book dealing with the subject from a theoretical or scientific point of view. The student at that time could make himself familiar with practically all that was either known or surmised by a study of Weber's treatise, and although many of the ingenious suggestions put forward by Weber have had to be abandoned, the book is one that can still be read with profit.

With the inception and development of plantation rubber several chemists began to take an interest in the study of this material, and from time to time other text-books have appeared. Whereas Weber was able to cover the whole field, including manufacturing technique and chemical analysis, in three hundred pages, many later authors have restricted themselves to special branches of the subject. Prof. Whitby has done this, and although he has dealt neither with manufacturing technique nor with analysis, his book runs to some five hundred pages. The title, if cumbersome, is certainly descriptive of the contents, and the book falls naturally into two parts, the first dealing with the preparation and properties of plantation rubber and the second with the physical properties of vulcanised rubber and the interpretation of results obtained in terms of "quality." The first section presents an exact and up-to-date account of the facts and theories underlying the preparation of plantation rubber and a description of the technique as at present in vogue on the best plantations in the East. Such a task could be attempted only by one who has actually carried out experimental work on a plantation and controlled the preparation of rubber. Prof. Whitby had unique opportunities for observation and research, and he has made the most of them. Coming home after some years in the East, he has been able to follow up his plantation work with laboratory studies particularly directed to vulcanisation problems and their elucidation. Consequently the second part of the book presents as thorough and complete a review of the subject as the first.

In the early days of plantation rubber the planter naturally looked to the rubber manufacturer at home for information and advice as to the best form in which to market his product. But the majority of manufacturers did little beyond pointing out that "fine hard Para" was the best rubber, and should form the ideal of the planter's aims. The tedious and primitive process of the Amazon, however, was not suited to plantation requirements; so, having tested various coagulants and found acetic acid the most suitable, the planting industry eventually settled down to the production of rubber of two types: (1) washed coagulum, air-dried in the form commonly known as pale crêpe; and (2) surface-washed sheet rubber dried in a smoke-house, the so-called smoked sheet. Faced with these alternatives, the manufacturers were still unwilling or possibly unable to give the planter advice. Some could use only sheet, others only crêpe, yet from both varieties very good motor tyres were made and exhibited at the last rubber exhibition in 1914. Any lack of information or advice from the manufacturers was amply compensated for by the brokers and dealers. These gentlemen supplied abundant criticisms of surface defects and other minor details which have kept planters busy in their factories and the local chemists in their laboratories.

In spite, however, of the time thus occupied, a very considerable amount of scientific work dealing with vulcanisation and the chemical and physical properties of rubber has been accomplished. Prof. Whitby's book is a significant record of the research work carried out on behalf of the planting community. With one or two exceptions, our whole knowledge of the subjects treated rests on the results of such researches. The remainder of the book is concerned with the more purely physical researches on the properties of vulcanised rubber, for which we are indebted to the academic physicists. This is a novel feature, and comprises the first summary of the subject to be published.

The technical aspect of rubber vulcanisation is dealt with by the author in chap. 16. This is perhaps the one chapter in the book which might with advantage have been extended. It is true that our knowledge in this direction is very limited, for reasons already given, but the subject-matter does not include references to some of the more recently published work. It might with advantage have included an account of work on organic and inorganic "accelerators," or vulcanisation catalysts, and cognate subjects, with particular reference to the fast-curing types of plantation rubber in which the "natural accelerators" take the place of the synthetic products which would otherwise have been added by the manufacturer. In this chapter, and indeed throughout the book, the author has succeeded in preserving a detached and impartial attitude when commenting on published results. He has examined each thesis with care, and expressed his reasoned conclusions with moderation.

The book contains a mass of information—in fact, practically everything of importance that is known on the subject—and while it is put together systematically, it is no mere catalogue of facts and theories. One occasionally meets with an awkwardly worded sentence, but the meaning is usually clear. A few instances taken at random may be quoted. The word "breaking length" appears to be used in the sense of final length, whereas in other industries the expression has a totally different meaning. Hollow mixing rollers are usually provided with a single inlet or outlet, which serves for either steam or water; they are not provided internally with separate pipes for each. The "thickness" of a ring referred to on p. 288 is more correctly described as the width, for if the ring is considered as a short tube, the thickness would correspond to the thickness of the wall of the tube.

The author has dealt with a subject which is in a state of rapid development, and considerable skill must have been required to incorporate the new material appearing during compilation. This may account in part for the frequency of footnotes of considerable length, some of which might with advantage have been included in the text. We have noticed a few inaccuracies and misprints; for instance, "clippings," "modal," "centrifiguating," "Euphoria," and "laticometer." The book is provided throughout with copious references and an excellent bibliography which will be found of great value. H. P. S.

Aeronautics.

(1) *Aviation: Theoretico-Practical Text-book for Students.* By B. M. Carmina. Pp. ix + 172. (New York: The Macmillan Co.; London: Macmillan and Co., Ltd., 1919.) 11*s.* net.

(2) *The Theory and Practice of Aeroplane Design.* By S. T. G. Andrews and S. F. Benson. (The Directly-Useful Technical Series.) Pp. xii + 454. (London: Chapman and Hall, Ltd., 1920.) 15*s.* 6*d.* net.

(3) *Aeroplane Structures.* By A. J. S. Pippard and Capt. J. L. Pritchard. With an introduction by L. Bairstow. Pp. xiii + 359 + 21 plates. (London: Longmans, Green, and Co., 1919.) 21*s.* net.

(1) THERE is certainly room for a good elementary treatise on the aeroplane, written for young students who have only a moderate equipment of mathematical knowledge, and whose acquaintance with mechanics is limited to the fundamental principles and their immediate applications. Mr. Carmina had an obvious gap to fill, but one must unhesitatingly declare that he has failed to take advantage of the opportunity.

The programme the author sets himself is very suitable, there being chapters on the theory of flight, aeroplane construction, rigging, propellers and maintenance, while an appendix professes to deal with aerodynamical formulæ and calculations. The general descriptions are passable, and evidently the author has had practical experience, but the theoretical side of the book is lamentable, and renders the whole work quite unfit to be called a "text-book."

The account of stability makes one wonder whether there should not be some censorship over scientific publications. Thus the author decrees, without any reference to the shape of a body, that "in this state (viz. of neutral equilibrium) the center of gravity of the body is at its center." He declares the best form of equilibrium to be the neutral state. Apparently, stability is the next best thing. On propellers the author announces: "Propellers and mystery are synonymous. In our Year of Grace 1919, nobody knows exactly what a propeller is"; yet seventeen pages follow to elucidate this mystery. One is pleased to be able to say that the chapter on "flight hints" is quite interesting.

"Aerodynamical formulæ and calculations," in the form of an appendix, consists of a lecture delivered so far back as 1911. After the sort of sneers at mathematicians usual with a certain class of people who do not understand mathematics, the author gives some hopelessly inadequate formulæ which might have passed muster in the dark middle ages of aviation, but are certainly unfit as a statement of post-war knowledge. The climax of the book is reached, however, in the "definitions." Algebra is "defined," and a treatise on algebra follows which occupies four pages! The metric system is described as resting on a "natural and invariable standard," the metre being given as 30·37 in., and the litre as 1·0567 quarts. Momentum is defined as the "force of motion acquired by a moving body by reason of the continuance of its motion." Trigonometry is "defined," and then follows a treatise on trigonometry, complete with tables, in three pages! One can only regret that the author did not make sure about his mathematics and mechanics before he wrote the book.

(2) Messrs. Andrew and Benson's contribution to the "Directly-Useful" technical series of books issued by Messrs. Chapman and Hall deals with aeroplane design, largely from the aerodynamical point of view, but also from the structural. After two general chapters on the fundamental principles of aeroplane design and on the materials available for the purpose, the authors give a detailed account of the properties of aerofoils, with carefully compiled data in tabular and graphical form, of the kind made familiar by the publications of the aeronautics department of the National Physical Laboratory. This is followed by the theory of stresses and strains in struts and rods which is applied to wing-structures for monoplanes, biplanes, etc., in some detail, with a number of numerical illustrations. The aerodynamics of stream-line bodies and struts comes next, followed by chapters on the design of the fuselage and chassis, both aerodynamically and structurally. There is a good chapter on the design of airscrews, including a brief account of the stresses on an airscrew. As introductory to the design of control surfaces, the authors give the usual kind of treatment of the theory of stability, with an account of the different resistance derivatives and numerical applications to various kinds of machines. The chapter on performance includes the instruments used in machines, and this is followed by two interesting chapters on the general lay-out of machines and on the trend of aeroplane design.

The book is clear, accurate, and profusely illustrated by more than 300 excellent plates and diagrams. While not differing widely in matter and arrangement from other books already published, Messrs. Andrew and Benson's book, which is quite elementary in places, can be safely recommended as an easy and not too mathematical statement of our knowledge of the aeroplane in so far as this knowledge bears on the problem of design.

(3) Messrs. Pippard and Pritchard have produced a thoroughly trustworthy treatise, based to a large extent on their personal "experience during the war while engaged in the work of supervising experimental designs from the standpoint of structural strength." The book is not merely a statement of results; it contains a competent treatment of the subject from the theoretical point of view, and the student is not left wondering how results quoted are to be justified mathematically and mechanically, a fault that mars so many of the books on aeronautics.

After a statement of the nature of the problem dealt with in the book, the authors give a brief account of the mechanics of flight and then proceed to a description of the structure of an aeroplane in general and in detail. Chapters follow on the evolutions of an aeroplane in flight, with the consequent loads that the various parts have to carry during and immediately after such evolutions. The subject having been thus introduced, the authors then deal with the elementary theory of elasticity, framed structures from the graphical point of view, the calculation of centres of gravity and moments of inertia, leading up to a detailed treatment of the theory and calculation of bending moments, shear forces and stresses in beams under various conditions of loading and of support. The application to the aeroplane then follows, the forces on the main plane structure, the fuselage, and the control surfaces, in flight and on landing, being considered in turn. A chapter of particular interest is that on the partially disabled aeroplane. Questions of detail in design are dealt with next, followed by an account of the methods of testing.

From the mathematical and mechanical point of view the chapter on the "principle of least work" deserves special attention. The principle is a statement of the fact that for a structure in stable equilibrium the work function is a minimum, and the authors show how it can be used "to find the stresses in structures which are statically indeterminate—*i.e.* in structures with too many members."

There are three appendices. The first consists of tables of values of what are called Berry functions. As Prof. Bairstow puts it in his preface, "the most accurate method of calculation of spar stresses yet known is due to Mr. Arthur Berry, . . . and by the help of a number of tables which he compiled the work is not unduly laborious." The functions thus tabulated are:—

$$f(\theta)=6(2\theta \operatorname{cosec} 2\theta - 1)/(2\theta)^2, \quad \phi(\theta)=3(1-2\theta \cot 2\theta)/(2\theta)^2,$$
$$\psi(\theta)=3(\tan\theta-\theta)/\theta^3;$$
$$F(\theta)=6(1-2\theta \operatorname{cosech} 2\theta)/(2\theta)^2, \Phi(\theta)=3(2\theta \coth 2\theta - 1)/(2\theta)^2,$$
$$\Psi(\theta)=3(\theta-\tanh\theta)/\theta^3.$$

Values are also given for $\tanh\theta$. The second appendix reproduces the "materials specifications" issued by the Air Ministry from time to time, while appendix 3 gives the aerodynamical characteristics of various types of aerofoils.

The book is illustrated by twenty-one plates and 259 diagrams. It is an authoritative account of one of the most important aspects of aeroplane design, as well as of aeroplane theory, and will no doubt be the standard work on the subject in English for some considerable time.

S. BRODETSKY.

A Text-book on Oceanography.

A Text-book of Oceanography. By Dr. J. T. Jenkins. Pp. x+206. (London: Constable and Co., Ltd., 1921.) 15*s*.

"THE higher forms of schools, teachers in training, and students attending schools of Geography in the Universities" constitute the audience for whom this book is intended. It is a short summary of the more salient results of physical oceanography, and as such it is, on the whole, a well-balanced statement. It is based on the well-known "Handbuch der Ozeanographie" by Dr. Otto Krümmel. Dr. Jenkins follows the same line of treatment, and borrows from the matter of this authoritative work.

As Dr. Krümmel's book was published in 1907, the work before us neglects matters of much interest that have been investigated since that date. Thus there is comparatively little about hydrobiological phenomena, and the modern ionic theory of solution is not dealt with in spite of the great importance of recent work. The section on the composition of sea-water suffers by this omission. It is not quite accurate to say that "radio-activity is not observable in sea-water," and the young student may find some difficulty in the statement made that, "if the electric conductivity of pure water be taken as *nil*, then that of sea-water at 0° C. and of salinity 35 per mille will be 0·0293 ohms."

The section on the tides is badly done. There are several misprints in the expressions given for the tidal potential, and these may trouble inexperienced readers. Moreover, it is stated that "the numerous calculations necessary in the harmonic analysis can be performed by a machine—the tidal predictor." There are said to be four of these machines in existence, and that one of them belongs to the British Government. This does us too much credit: the British machine is privately owned, and there are really more than four in existence. As a matter of fact, the British tide-tables published by the Admiralty are also privately computed.

Is it correct to say that the form of waves is trochoidal? Cold surface water does not sink down at the Poles because of its greater density, but flows superficially and in a southerly direction for a considerable distance because of its low salinity before it sinks to the bottom. Recent work by the Scottish Fishery Board shows that the direction of flow of water in the north-west part of the North Sea may take the reverse direction to that represented on p. 182.

Apart from such mistakes, and in spite of a certain lack of appreciation on the part of the author of the spirit and method of modern marine research, the book is sure to be useful to just the kinds of students mentioned in the preface. But it is too small (and dear), and it is badly illustrated. The figures are all borrowed, and the sources of many of them are unacknowledged. From the point of view of the student the index is bad.

J. J.

Our Bookshelf.

Catalogue of the Fossil Bryozoa (Polyzoa) in the Department of Geology, British Museum (Natural History). The Cretaceous Bryozoa (Polyzoa). Vol. 3. *The Cribrimorphs.*—Part 1. By Dr. W. D. Lang. Pp. 12+cx+269+8 plates. (London: British Museum (Natural History), 1921.) 30*s.*

THOUGH the price must at present remain high, the issue of this volume is, we hope, a sign that research in our public scientific institutions will still find means of publication. Museums and geological surveys flourish largely by interchange of ideas, and the volumes issued by smaller countries—Finland is now a notable example, and Poland has come into the field—may react on those who would restrict the official output of Britain to works of economic value. Dr. Lang here presents us with careful descriptions of co-ordinated fossil species; but his biological introduction shows how he bears in mind their history as living things. He finds no obvious utility in the mode in which bryozoa have deposited calcium carbonate in a variety of artistic forms, and he regards such deposition, even in molluscs, as a mode of getting rid of material not required by the living tissue. He admits a protective result in many cases, but not a protective intensification through natural selection. In bryozoa the details of skeletal structure seem to him "due to the necessity of piling up superfluous calcium carbonate where it least interferes with the organism's bionomy." We are glad to note that this work is produced on good paper in harmony with its many predecessors.

G. A. J. C.

Critical Microscopy: How to Get the Best out of the Microscope. By Dr. A. C. Coles. Pp. viii+100+3 plates. (London: J. and A. Churchill, 1921.) 7*s.* 6*d.* net.

DR. COLES gives a clear account of various small alterations in his microscopical outfit which have enabled him to obtain better results, and he describes concisely the methods and adjustments necessary in order to obtain the highest resolving power. He has had particularly in mind the needs of protozoologists who have often to search for a minute organism present in small numbers. For conducting such a search the author strongly advises the use of a dry lens, such as the 8-mm. apochromatic, which can be employed on covered or uncovered preparations and with ordinary transmitted light, or with dark-ground illumination. He gives details of his method, first published in 1914, for detecting the presence of spirochætes, in uncovered preparations, with this low magnification. His account will be helpful to many workers who may not have realised how much can be done with a good 8-mm. objective. Useful hints are also given on sub-stage condensers, dark-ground illumination, and photomicrography. The author directs attention to the great importance of applying a correction for the thickness of the cover glass by means of a correction-collar on the objective, or, better, by alteration in the tube length. He quotes a number of useful explanations, by Mr. E. M. Nelson, of the optics of the microscope. A short explanatory note on "numerical aperture" and its significance might have been added.

Stanford University Publications, University Series: Mathematics and Astronomy. Vol. 1, No. 1: *Primitive Groups.* Part 1. By Prof. W. A. Manning. Pp. 108. (California: Stanford University, 1921.) 1.25 dollars.

THE first eighty pages of this book are devoted to an introduction to the theory of finite groups somewhat on the lines followed by many similar treatises. A special feature is the early stage at which group-characteristics are discussed, and nearly half of the introductory portion of the book is given up to an investigation of their properties and applications. The author makes no very marked distinction between permutation-groups, substitution-groups, and abstract groups, but passes easily from one to the other, as suits his purpose. His style is pleasant, but the proofs are a trifle condensed, as if he had felt acutely his limitations of space. The book will be more useful to the reader who has some slight acquaintance with the subject than to the beginner.

The properties of primitive groups occupy the last third of the treatise, which is far more specialised and contains more original matter. These pages will appeal to the intending researcher rather than to the mathematician requiring a knowledge of general outlines.

Print and arrangement are quite attractive. There is a good contents list, but the absence of an index is regrettable. If the remaining Stanford University publications all come up to the standard of this first number, they will indeed fulfil a useful purpose.

HAROLD HILTON.

Moby-Dick or the Whale. By H. Melville. With an introduction by Viola Meynell. (The World's Classics.) Pp. xii+675. (London: Humphrey Milford: Oxford University Press, 1920.) 2*s.* 6*d.* net.

THIS highly dramatic story, first published in 1851, though but little known to present-day readers, is a remarkable literary achievement, and deserving of attention on that score. In the course of its thrilling chapters is one entitled "Cetology," in which is given a whaler's descriptions of all the known species of Cetacea, their habits, distinctive features, and commercial value. The descriptions are embellished with many literary flourishes, but are nevertheless vivid and have a certain zoological value. "Moby-Dick" is a white sperm-whale that is madly pursued by one Ahab, who in the past has suffered loss by its jaws. More of the tale we must not tell: suffice it to say that "Midshipman Easy" and "The Cruise of the *Cachalot*" pale beside it.

Letters to the Editor.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

The Apparatus of Dr. Russ.

I HOPE Dr. Hartridge will pardon my suggestion that he is dismissing the possible effects of temperature too lightly.

In the Phil. Trans. Roy. Soc. of 1792, p. 86, Mr. Bennett described apparatus of great sensibility, in which a piece of dragon-fly wing or thistledown carried on a light arm suspended by a spider line in a closed case responded with amazing sensibility to the heat from a person at a distance in virtue of convection currents set up by the warmer side of the case. It is not surprising that suggestions of animal magnetism should have been made, *e.g.* that the right hand should act oppositely to the left, but the author of the paper ignored these, and was content with explanations based upon known laws of physics.

A little later (1798) Cavendish in his famous paper on the mean density of the earth showed how potent minute differences of temperature were to disturb even the 2-in. balls of lead that he suspended from the ends of his lever.

In 1862 Joule described in the Proc. Lit. and Phil. Soc. Manchester, p. 73, a convection thermometer in which a glass tube 2 ft. long and 4 in. in diameter was divided longitudinally into two portions by a diametrical partition extending to within about 1 in. of the top and bottom. "In the top space a bit of magnetised sewing-needle, furnished with a glass index, is suspended by a single filament of silk." The draught up on the warmer side and down on the cooler side caused the needle to be deflected, acting on the glass index as a wind-vane. This was found to be a superlatively delicate radiation thermometer.

In 1890, in conjunction with the late Dr. Watson and Mr. Briscoe, I showed to the Physical Society (*Phil. Mag.*, 1891, p. 59) an experiment which increased the delicacy of the Joule thermometer very greatly by replacing the straw and silk by a mirror and counterweight hung by a quartz fibre, but we found that by no system of screening, even in a cellar, could we maintain such quiet in the air as to allow the mirror to remain anywhere near the neutral position or to remain at rest. One side or the other was the hotter, and this was always changing. If we had never succeeded in obtaining a real state of rest the delicacy would have been useless. We, however, hit upon a plan which did keep the two sides strictly alike in temperature. We surrounded the tube by an exterior glass tube kept turning on its axis rapidly by clockwork all day. As the exterior glass was opaque to "dark heat" and no light was allowed to fall on the tube, the inner tube could not have one side hotter than the other, and then the mirror came to its neutral position and was very fairly steady there, so that heat developed electrically on one side of the partition in warming the air gave rise to deflections which could be measured with some certainty.

In all the delicate work that I have done with quartz-fibre suspensions the strictest attention to freedom from disturbance by air movement was essential to success. Only by such special care can air movements of so small an amount as 1 in. in a fortnight or so be avoided, and if not avoided a stable zero on which everything must depend is impossible.

In no ordinary large apparatus of the physical laboratory is the air ever quiet, and in the closed box of Dr. Russ is it safe to suppose that there are not convection currents abundantly able to cause deflection of anything suspended by a single silk fibre?

C. V. BOYS.

The Designation of the Radium Equivalent.

IN all problems that are primarily concerned with strictly radio-active phenomena the quantity λN, denoting the number of atoms transformed in a unit of time, plays a very important part. In such problems comparable amounts of different radio-elements are such as correspond to the same value of λN. There is need for a name to denote the amount of any radio-element, irrespective of family, that is thus comparable to one gram of radium. If, tentatively, we use the letter r to denote this desired name, then an r of any material may be defined as that amount of the material that will produce transformed atoms at the same rate as transformed atoms are produced by one gram of radium. The quantity r plays in radio-activity a part that is analogous to that played by the gram-molecule in physical chemistry, and the advantages to be secured by naming it are quite similar to those that were secured by the introduction of the term "gram-molecule."

As the curie is an r of radium emanation, the adoption of a new name to denote the quantity r will give two names for the same quantity of radium emanation. The majority of those with whom the subject has been discussed regarded this as undesirable. They consider it better to redefine the curie so as to cover the entire field.

I shall be glad if you will publish this letter so that a further expression of opinion may be obtained. A more detailed presentation of the subject will shortly appear in the Journal of the Washington Academy of Sciences. N. ERNEST DORSEY.

Bureau of Standards, July 30.

Pisidium clessini in British Lochs.

DR. ANNANDALE (NATURE, August 18, p. 778) assumes from Mr. B. B. Woodward's letter that this species is a deep-water form, but this is not so. *P. clessini* is abundant in some of the Welsh and Kerry tarns, where Mr. Charles Oldham and I have collected it in from 1 to 4 ft. of water. It is a form which I have had under observation for some years past—indeed, since I first collected it on Brandon Mountain in Co. Kerry in 1910.

Not being able to identify it with any described species of Pisidium, I have several times been on the point of figuring it as new. At the last moment, however, I have always been checked by the fact that I was not satisfied that it was a good species. This view, I may say, is shared by my colleagues, Mr. Charles Oldham and Mr. R. A. Phillips. We are not satisfied that *P. clessini* is anything but a cold-water (depauperate) form of the widespread *P. casertanum.* This latter occurs abundantly also in many mountain tarns, but is always—in our experience—conspicuous by its absence in those in which *P. clessini* occurs.

Superficially, *P. clessini* is very distinct, and Dr. Odhner is satisfied that its anatomical characters render it necessary that we should regard it as a species; yet he has not been able to assure me that these characters are not the result of starvation acting over a prolonged period on a number of generations. For my own part I shall not be satisfied in its standing as a species until I can find it living in association with *P. casertanum.* In Cwm Clyd on Y Garn, in North Wales, I have taken *P. casertanum* within a few yards of *P. clessini,* but the former was in a shallow swamp which warmed up in the summer, while the latter was living in the very cold water of Llyn Clyd. A. W. STELFOX.

National Museum, Dublin.

Scientific Publication.

THERE is at present much discussion of the difficulties of scientific publishing, and such discussion with resultant action is necessary, for there are few, if any, signs of reduction in printing costs, and the output of manuscript is steadily increasing. Societies issuing journals cannot meet their expenses unless the present high subscriptions are maintained, or in many cases increased, and most of us can with difficulty withstand the present drain upon our resources, and certainly cannot afford another penny in this direction. There would seem to be three alternatives before us. One is to ask each author to pay for or subsidise the publication of his own paper. This in many cases is financially impossible, and in any event introduces a whole series of new and very difficult problems, which renders it an extremely undesirable solution. The second is to reorganise our scientific societies and publishing boards with a lumping together of transactions, journals, annals, etc., and a consequent cheapening of direction and production. This is, to my way of thinking, the obvious solution, but few seem to agree thereon. The third method is to make a radical change in the format of our scientific journals, with or without an alteration in the existing structural relations of the learned societies. This is the substance of the present letter.

Perhaps there are two main reasons why people write scientific papers: first, that the authors really believe that their work will help forward the progress of science; and, secondly, that, having spent one or more years investigating a problem, they naturally wish to justify their time to themselves and their colleagues, to keep their names before the scientific public, and to give a basis for promotion in the scientific hierarchy. The memoirs are very stereotyped, being written in moderate detail with selected, and occasionally digested, original matter, and rounded off with a little summary; and so the very necessary, and more ignoble, aim is achieved. But is this time-honoured method of scientific publication really the best way to advance science? Moreover, in these stringent post-war days can we really afford, both financially and scientifically, to continue unaltered in our pre-war habits? Can we expect to publish our papers of pre-war length in pre-war style, or must we recognise that times have changed and modify our scientific ways and our journals accordingly?

What, after all, is the fate of a technical research paper in, let us say, botanical science? So many papers are published that it is a sheer impossibility to read more than a tithe. Moreover, the various aspects of botany are so specialised that the memoirs from one branch are not very intelligible to workers in other branches, or at the best do not arouse any great enthusiasm. In consequence, when a journal is published, many botanists just glance through the contents (who has not done this?), and if nothing catches their eye the journal is returned to the shelf; others read the summaries and are content; whilst a few, a very few, read carefully through the entire journal, or, more usually, through some particular memoir. Again, a morphologist reading, shall we say, a physiological paper is often lost in the data and formulæ, and longs for a clear-cut statement of what it is all about; and a physiologist reading the same memoir sighs sceptically over the abbreviated tables and graphs, and wishes to see more of the original figures and experimental details. The position is, in fact, that for the great majority of us all that is really necessary or useful is a very full summary or a *précis* of the paper—unless we happen to be one of the dozen or so investigators of like or cognate problems, when what we really need is a much more detailed presentation of the original matter. The present method, trying to please everybody, satisfies no one.

Now what I would say is this. Let us face reality, and let us quite frankly recognise—as sooner or later we shall be compelled to recognise—the financial limitations of our pockets and the space limitations of our periodicals. If we are to cater for the specialist, let us do it properly and write up our investigations in great detail with full original data, both negative and positive. Then very few researches can be published, for a journal could contain only one or two; and we should depend for our general literature, as of course we do now, on abstracting journals. If we are single-minded, and consider only the progress of knowledge, there is much to be said for this plan, for most of us admit that two-thirds of the scientific papers published are merely records of time spent, and have no permanent, and little (if any) temporary, value in the advancement of learning.

The alternative plan, and perhaps the more feasible, is to retain the scientific journals for the general scientific public and delete the long and very technical portions of the memoirs. The journals would then contain a number of very full summaries, the real essence of the studies, with the minimum of original data necessary for their comprehension. This would mean that the essential results of investigations could be produced much more rapidly, and this, with the volume of manuscript awaiting publication, would be advantageous; and, secondly, that the results would become much more widely known, being more readable. Further, in the majority of cases, owing to the elimination of expensive tables and plates (in any case most plates are, except in very special cases, a sheer anachronism and luxury in these days), the costs of production would be reduced by more than one-half, and this—there is no use blinking the fact—is for most of us a very material consideration indeed.

With regard to the full results of the investigations for specialist purposes, I would suggest that these be written up in the greatest detail, incorporating the essential working notes, so that anyone repeating the work could find in the memoir every required datum. These memoirs, together with the original drawings and photographs, type-slides, and specimens, would then be filed for reference in a kind of Somerset House for scientific records. This might be a central institution, as the British Museum, or preferably a decentralised scheme would be adopted, and botanical memoirs filed at Kew, zoological ones at the Natural History Museum, chemical ones at the Institute of Chemistry, and so forth. Very important papers much in demand might be mimeographed, or duplicated by photography or some other cheap process, and copies purchased at cost price by the principal research laboratories, or in special cases the originals could be sent to responsible investigators. These and many other elaborations could be adumbrated.

The above is the merest suggestion of what I cannot help thinking is a feasible scheme that would go far towards solving many of our chief difficulties. It is perhaps somewhat revolutionary, but, whether we like it or not, even the scientific times move forward, and we can no longer maintain—most of us cannot afford to maintain—our pre-war usages. One would like opinions on this matter, for action of some kind will need to be taken in the not distant future.

WILLIAM B. BRIERLEY.

Rothamsted Experimental Station, Harpenden, August 29.

Whispering-Gallery Phenomena at St. Paul's Cathedral.

THE very curious and interesting acoustical effects observed in the Whispering Gallery under the dome of St. Paul's Cathedral have, as is well known, been explained by the late Lord Rayleigh as due to the curvilinear propagation of sound, the waves which proceed from a source placed close to the wall of the gallery clinging to its surface and creeping tangentially along it. This view was developed mathematically by Lord Rayleigh ("Scientific Papers," vol. 5, p. 617), the theoretical conclusions arrived at being (*a*) that the sound-waves travel in a comparatively narrow belt skirting the wall, the thickness of this belt decreasing with the wave-length of the sound; (*b*) that in this belt the intensity is a maximum near the wall and decreases rapidly and continuously as we proceed radially away from it; and (*c*) that the intensity does not fluctuate markedly as we proceed circumferentially parallel to the wall.

We were much interested in the subject, and by the courtesy of the authorities of the cathedral have been enabled to carry out an extended series of observations in the gallery with the view of making a precise test of Lord Rayleigh's theory. Our experiments show conclusively that while the indication of theory as expressed in (*a*) is substantially accurate, neither of the conclusions (*b*) and (*c*) is in accordance with actual facts. Using a steady source of sound placed close to the wall at one point, we found that elsewhere the intensity of the sound showed pronounced oscillations in proceeding inwards radially from the wall, the ear of the observer passing several times through alternate zones of great intensity and of comparative silence. In the latter some of the overtones of the source could be heard clearly, while the fundamental was practically inaudible. These alternations of intensity could be demonstrated in the gallery, using a fairly high-pitched source and a sensitive flame as indicator. The distance between the successive zones of silence was about the same as the half-wave-length of the source. There were also distinct periodic fluctuations of intensity in proceeding circumferentially—that is, parallel to the wall. The latter were not equally distinct in all parts of the gallery, being most marked at the other end of the diameter containing the source.

The circumferential fluctuations of intensity might be interpreted as being, at least in part, due to the stationary interferences of waves which meet after passing in opposite directions round the gallery. But the radial fluctuations are less easily explained, and must be regarded as fundamental in any satisfactory theory of the Whispering Gallery. We find that effects similar to those we observed at St. Paul's may be demonstrated in the laboratory with any large circular reflecting surface, using a bird-call with a sensitive flame as sound-detector.

The experiments thus show that, while the explanation put forward by Lord Rayleigh is at least on the right lines, it is far from being a completely satisfactory theory of the Whispering Gallery. We propose at an early opportunity to go more fully elsewhere into the question of the revision necessary in the theory.

C. V. RAMAN.
G. A. SUTHERLAND.

22 Oxford Road, Putney, S.W.15, August 26.

Ceratium furca and Pedalion mirum.

IN describing the specific characteristics of *Ceratium furca*, one of the Peridiniæ or Dinoflagellates, Saville Kent in his "Manual of the Infusoria" gives the habitat as salt-water, and he appends a note to the effect that, "although usually regarded as entirely marine, M. Werneck has reported the occurrence of an apparently identical species in fresh-water in the vicinity of Salzburg."

It may be of interest to students of the Protozoa to state that on August 19 and 27 I discovered this species in two separate bodies of fresh-water in this district. It may be the case that other workers have found the form at other points in Great Britain, and that, by reason of my not having access to the scattered literature on Protozoa, I am only reporting an already well-established fact; but it will be most interesting to know whether *Ceratium furca* has been found elsewhere in this country, and I shall be glad to have the views of those who have given attention to this matter.

Kent gives the entire length of *C. furca* as 1/120th of an inch, say 212 microns. I find that very few of my specimens are so small as this, and I have measured several up to 256 microns, which is 21 per cent. larger than the recorded length.

The remarkable and interesting Rotifer, *Pedalion mirum*, discovered by Dr. Hudson in 1871 is described in Hudson and Gosse's classical work, "The Rotifera," as being very rare, and up to the date of the publication of that work, twelve years later, it had been recorded only from three places. Others have doubtless since been added, but Pedalion may probably still be regarded as a rare species. I have found it in both the waters in which *Ceratium furca* occurred, and in the first gathering on August 19 it was fairly numerous. A list of the known habitats of this Rotifer would be most interesting.

ALFRED E. HARRIS.

44 Partridge Road, Roath, Cardiff, August 29.

Illumination of Plankton.

IN avoiding compressed-air illness by the excellent method which we owe to Dr. J. S. Haldane, divers ascending from deep water often have to spend periods of half an hour or so in idleness suspended on a rope in mid-water 20–30 ft. below the surface. The blank tedium of such occasions can be relieved by watching the ebb and flow of plankton past the face-glass of the helmet and musing on the remarkable variation in its apparent quality and quantity from day to day.

As the diver looks upwards and inwards towards the black, shadowy keel of the salvage vessel he sees the individuals of the plankton standing out vividly by a sort of dark-ground illumination. Turning his head outwards and looking into unrelieved water space, again using a simile from microscopy, the field is overflooded with light, contrast is absent, and the teeming multitudes blend into granular haziness. In August, after our salvage ship has been moored for an hour or two in the open sea, mackerel find her out, and daily a compact shoal of them congregates some 20–40 ft. below, remaining in position until she gets under way and quits the spot.

A diver hanging in the shoal has a clear space some 6 ft. wide around him; beyond this the water is crammed with mackerel, the outline of the shoal corresponding roughly with that of the ship above. One sees that the fish are feeding on plankton, not by steadily pumping the water through their gill-filters, but snatching gulps from different directions, turning their eyes about and making little jumps here and there. Evidently the depth they maintain, slightly different from day to day, is that at which their food is drifting; but what is the mysterious attraction that keeps roving fish fixed beneath a stationary ship for hours together?

A paper by Bullen in the Journal of the Marine Biological Association for June, 1912, produces evidence (from examination of stomach contents and aquarium observations) that mackerel when feeding on plankton exercise selective powers, picking out certain forms, such as Copepods, and rejecting others, presumably by visual means. After observing the shoals on many occasions while hanging suspended in their midst, I feel sure that it is the assistance given by the black background of the ship to visual selection that links the fish to her.

Most objects floating in the open seas, jellyfish, sharks, driftwood, or derelicts, when carefully approached, are found to be accompanied by fish satellites. The attractive force is not necessarily the same in every case, but where (as in the case of the mackerel under the salvage ship) the stomach contents turn out to be selected plankton it is probably a matter of illumination.

It is likely that each member of a shoal is benefited by the background afforded by the bodies of its immediate neighbours, and, if so, a factor in the shoaling habit comes to light. Going deeper, a use suggests itself for the lateral light-producing organs of some bathypelagic fishes which are so placed that they can scarcely assist the fishes' own vision.

G. C. C. DAMANT.

H.M. Salvage Vessel *Racer*, Lough Swilly.

Co-operative Indexing of Periodical Literature.

I AM much interested in the leading article in NATURE of June 9 entitled "Co-operative Indexing of Periodical Literature," because the H. W. Wilson Company is doing on a commercial basis what the publications you mention are doing on what you call a "co-operative basis." This leads to an inquiry as to when the publication of an index or abstract is "co-operative." Perhaps co-operation meant originally the donation of indexing work on the part of individuals or libraries. However, it appears that of the co-operative publications mentioned none of the editorial work is donated. The "Engineering Index" is now published by one of the great engineering societies, and its deficit paid by that society. The deficit of the "Index Medicus" is met by the Carnegie Institution of Washington. The deficit of the "Index to Legal Periodicals," published by the H. W. Wilson Company, is made good out of the treasury of the Association of Law Libraries, and the deficit of the "Agricultural Index" is made good out of the treasury of the H. W. Wilson Company. In the case of all these publications subscriptions are solicited, and the income is used to pay for editorial work and expenses so far as it will go, the deficits being met as stated. Is the publication of an index less "co-operative" if the deficit is met by an individual or a corporation than if it is met by an association or a foundation? In other words, should not a corporation engaged in an educational work be recognised as "co-operating" with men of science and scholars in the diffusion of knowledge?

Librarians say that indexes are more used in libraries than abstracts and digests. This, of course, does not imply that abstracts and digests are not useful to scientific and professional people, but since the chief support for abstracts, indexes, and digests comes from libraries, should not the advice of librarians be considered? A mere examination of the physical condition of various indexes and abstracts in libraries might be a fair indication of their comparative usefulness, and prove to be a revelation to those who are paying some of the deficits.

At one time the subject of agriculture was considered by the Committee on the International Catalogue of Scientific Literature, and it was expected that a volume covering this subject would some time be published. The publishing of our "Agricultural Index" gives opportunity to compare the value of a dictionary-catalogue published on the "cumulative plan" monthly, annually, and triennially with a classified catalogue published only (and tardily) as an annual. Would it not be interesting to make inquiries among those who use such reference tools most in order to determine what method is most efficient? If it should be found that indexing and cataloguing publications produced by private corporations actually serve a useful purpose, and perhaps relieve "co-operative" organisations of some share of the deficit, should not these publications receive, if not commendation, at least a nod of recognition?

I have wondered why men of science, when planning catalogues or classifications, do not consult those who make that work a profession. When people build houses it is generally thought best to consult an architect.

It may be worth while to note that of the four examples of indexes that you mention, three are now compiled on the alphabetic or dictionary plan. The "Engineering Index," published since 1884, changed from the classified to the dictionary form on the annuals with the year 1919. The "Index Medicus" has just recently changed from the classified to the alphabetic form. We believe the changes were made at the request of librarians who, through their experience, found the dictionary plan the more serviceable.

It is to be hoped that in the conference proposed by NATURE, to which representatives of all branches of knowledge are to be invited, librarians and all those who make printed indexes will be included.

H. W. WILSON,
President.

The H. W. Wilson Company, Publishers of Indexes and Reference Works, 958–964 University Avenue, New York City, August 6.

A CO-OPERATIVE index is one published by, or on behalf of, a professional body with the view of securing an adequate standard of efficiency. These indexes are generally based, in part at any rate, upon voluntary labour. Mr. Wilson is in error in supposing that the main support for abstracts and digests comes from the libraries. It is derived from the subscriptions of members of the professional bodies. Librarians are not qualified to advise on the matter.

Indexing suffers chiefly from the lack of co-ordination and the insufficient supply of trained workers. It is to secure a proper co-ordination of effort that a conference has been proposed in these columns. The conference should undoubtedly include representatives of the libraries and of the commercial indexes.

THE WRITER OF THE ARTICLE.

The British Association at Edinburgh.

THE prospects of a first-rate meeting in Edinburgh are now assured. The journal, which extends to more than forty pages, shows that all the sections will have a full programme—in fact, the difficulty in several cases has been to fit the communications into the time available. The number of members already enrolled indicates that the total entry will exceed 2000, so that from a numerical, as well as from other points of view, the Edinburgh meeting is certain of success. The proof copy of the list of members shows that British science is to be strongly represented at the meeting. In the list are the names of many well-known men of science, including about one hundred fellows of the Royal Society. Three past-presidents of the Association will attend the meeting—Sir James Dewar, Sir Oliver Lodge, and Sir Edward Sharpey Schafer—in addition to Prof. Herdman, who resigns the office of president to Sir Edward Thorpe.

A goodly number of overseas and foreign men of science have signified their intention of being present at the meeting. Physics, mathematics, and chemistry are represented by Prof. Svante Arrhenius (Stockholm), Prof. H. E. Fierz (Zürich), Prof. F. M. Jaeger and Prof. Kapteyn (Gröningen), Dr. Irving Langmuir (New York), Prof. J. C. McLennan (Toronto), Dr. Hans Petterssen (Gothenberg), Prof. Volterra (Rome), and Prof. R. W. Wood (Johns Hopkins University). Geology and zoology have also a goodly representation of men of science from overseas. In the former section are Prof. Collet (Geneva), Prof. R. A. Daly (Harvard), Baron de Geer (Stockholm), and Prof. Kolderup (Bergen), while in the section of zoology are Prof. J. F. van Bemmelen and Prof. J. W. van Wijhe (Gröningen), Prof. Hérouard (Paris), and Prof. Vernon Kellogg (Washington). Other foreign representatives are Dr. Krogh (Copenhagen), in the section of physiology, Dr. Langfeld (Harvard), in the section of psychology, and Dr. J. P. Lotsy (Holland), in the section of botany. Most of these are to take part in the proceedings of the sections, either by presenting some communication on their recent work, or by joining in the discussions which have been arranged.

There will be a daily weather report for Edinburgh. The Meteorological Office, Air Ministry, has arranged that during the week over which the meetings of the British Association extend—September 7–14—a demonstration will be given daily of the methods employed in preparing the British daily weather map and in forecasting the weather in different districts of the country during the ensuing twenty-four hours. For this purpose a temporary branch of the Meteorological Office, Edinburgh, is being opened in the natural philosophy department of the university, in which building the meetings of Section A (Mathematics and Physics) are being held. This temporary office is being supplied with wireless apparatus capable of receiving all the different European synoptic messages. In addition, arrangements are being made for the receipt of weather messages from various centres by telegraph and telephone, including messages from ships in the Atlantic, and some of the information which is ordinarily collected by the Air Ministry for the purposes of aviation.

Most of the meteorological data thus collected will be represented on a large blackboard map which has been erected in the entrance hall of the natural philosophy department, where it can be seen by those attending the meetings. Some information chiefly referring to local or Scottish weather conditions will also be shown. The area over which the map extends is from Spitsbergen, in the north, to Africa, in the south, and from Warsaw to the Azores, and it is expected that the representation on it of the morning's weather throughout this area will be complete by 10 a.m.

A local daily weather report, embodying the more important data on the map, will be issued by 11 a.m., and a limited number of copies will be ready for issue soon after that hour. The report will include a "general inference" from the ascertained pressure distribution, as well as a special forecast for the Edinburgh district.

The demonstration will show what information can be obtained by the use of a suitable wireless receiving instrument, and how that information may be utilised; and it will illustrate the methods by which Scotland generally, and Edinburgh in particular, could be served in the matter of prompt and accurate information with regard to the weather of the day and its probable changes in the ensuing twenty-four hours.

J. H. ASHWORTH.

Some Aspects and Problems of Post-war Science, Pure and Applied.*

By SIR T. EDWARD THORPE, C.B., D.Sc., Sc.D., LL.D., F.R.S., HON. F.R.S.EDIN., *President*.

THE British Association for the Advancement of Science owes its origin, and, in great measure, its specific aims and functions, to the public spirit and zeal for the interests of science of Scotsmen. Its virtual founder was Sir David Brewster; its scope and character were defined by Principal Forbes. In constitution it differed from the migratory scientific associations existing on the Continent, which mainly served to promote the social intercourse of their members by annual

* Presidential address delivered at the Edinburgh meeting of the British Association on September 7.

gatherings, in that it was to be a permanent organisation, with a settled establishment and headquarters, which should have not merely its yearly reunions, but which, "by methods and by influence peculiarly its own, should continue to operate during the intervals of these public assemblies, and should aspire to give an impulse to every part of the scientific system; to mature scientific enterprise; and to direct the labours requisite for discovery."

Although, for reasons of policy, it was decided that its first meeting of September 27, 1831, should be held at York, as the most central city for the three kingdoms, and its second and third meetings at the ancient Universities of Oxford and Cambridge respectively, it was inevitable that the Association should seize the earliest opportunity to visit the Metropolis of Scotland, where, as an historical fact, it may be said to have had its origin.

The meeting in this city of September 8, 1834, was noteworthy for many reasons. It afforded the first direct proof that the Association was fulfilling its purpose. This was shown by the popular appreciation which attended its activities, by the range and character of its reports on the state and progress of science, by the interest and value of its sectional proceedings, and by the mode in which its funds were employed. In felicitous terms the president of the preceding year, the Rev. Prof. Sedgwick, congratulated the gathering "on the increased strength in which they had assembled, in a place endeared to the feelings of every lover of science by so many delightful and elevating recollections, especially by the recollection of the great men whom it had fostered, or to whom it had given birth." In a few brief sentences Prof. Sedgwick indicated the great power which this Association is able to apply towards the advancement of science by combination and united action, and he supported his argument by pointing to the results which it had already achieved during the three short years of its existence. Prof. Sedgwick's words are no less true to-day. His contention that one of the most important functions of this philosophical union is to further what he termed the "commerce of ideas" by joint discussions on subjects of kindred interest, has been endorsed by the recent action of the Council in bringing the various sections into still closer touch with each other with a view to the discussion of common problems of general interest. This slight reorganisation of the work of the sections, which is in entire accord with the spirit and aims of the Association, as defined by its progenitors and formulated in its constitution, will take effect during the present meeting. Strictly speaking, such joint sectional discussions are not unknown in our history, and their utility and influence have been freely recognised. But hitherto the occasions have been more or less informal. They are now, it is hoped, to be part of the regular official procedure of the meetings, to which it is anticipated they will afford additional interest and value.

Another noteworthy change in our procedure is the introduction of discussions on the addresses of the presidents of sections. Hitherto these addresses have been formally read and never discussed. To the extent that they have been brief chronicles of the progress of the special departments of science with which the section is concerned they have given but little opportunity for discussion. With the greatly increased facilities which now exist for every worker to keep himself informed of the development of the branch of knowledge in which he is more particularly interested, such *résumés* have in great measure lost their true purpose, and there has, consequently, been a growing tendency of late years for such presidential addresses to deal with contemporary topics of general interest and of fundamental importance, affording ample opportunity for a free exchange of opinion. The experiment will certainly conduce to the interest of the proceedings of the sections, and will contribute to the permanent value of their work. We see in these several changes the development of ideas connected with the working of the Association which may be said to have had their birth at its first meeting in Edinburgh, eighty-seven years ago.

Sixteen years later—that is, on July 21, 1850—Edinburgh again extended her hospitality to the British Association, which then honoured itself by electing the learned principal of the united colleges of St. Salvator and St. Leonard, St. Andrews, to the presidential chair—at once a tribute to Sir David Brewster's eminence as a natural philosopher, and a grateful recognition of his services to this body in suggesting and promoting its formation.

On the occasion of his inaugural address, after a brief account of recent progress in science, made with the lucidity of expression which characterised all the literary efforts of the learned biographer of Newton and versatile editor of the *Edinburgh Encyclopaedia*, the *Edinburgh Magazine*, and the *Edinburgh Journal of Science*, the president dwelt upon the beneficent influence of the Association in securing a more general attention to the objects of science, and in effecting a removal of disadvantages of a public kind that impeded its progress. It was due largely to the action of the Association, assisted by the writings and personal exertions of its members, that the Government was induced to extend a direct national encouragement to science and to aid in its organisation.

Brewster had a lofty ideal of the place of science in the intellectual life of a community, and of the just position of the man of science in the social scale. In well-weighed words, the outcome of matured experience and of an intimate knowledge of the working of European institutions created for the advancement of science and the diffusion of knowledge, he pleaded for the establishment of a national institution in Britain possessing a class

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of resident members who should devote themselves wholly to science—with a place and station in society the most respectable and independent—"free alike," as Playfair put it, "from the embarrassments of poverty or the temptations of wealth." Such men, "ordained by the State to the undivided functions of science," would, he contended, do more and better work than those who snatch an hour or two from their daily toil or nightly rest.

This ideal of "combining what is insulated, and uniting in one great institution the living talent which is in active but undirected and unbefriended exercise around us," was not attained during Brewster's time, nor, notwithstanding the reiteration of incontrovertible argument during the past seventy years, has it been reached in our own.

I have been led to dwell on Sir David Brewster's association with this question of the relations of the State towards research for several reasons. Although he was not the first to raise it—for Davy more than a century ago made it the theme of presidential addresses, and brought his social influence to bear in the attempt to enlist the practical sympathy of the Government—no one more consistently urged its national importance or supported his case with a more powerful advocacy than the principal of the University of Edinburgh. It is only seemly, therefore, that on this particular occasion, and in this city of his adoption, where he spent so much of his intellectual energy, I should specially allude to it. Moreover, we can never forget what this Association owes to his large and fruitful mind. Every man is a debtor to his profession, from which he gains countenance and profit. That Brewster was an ornament to his is acknowledged by every lover of learning. That he endeavoured to be a help to it was gratefully recognised during his lifetime. After his death it was said of him that the improved position of men of science in our time is chiefly due to his exertions and his example.

I am naturally led to connect the meeting of 1850 with a still more memorable gathering of this Association in this city. In August, 1871—just more than half a century ago—the British Association again assembled in Edinburgh under the presidency of Lord Kelvin—then Sir William Thomson. It was an historic occasion by reason of the address which inaugurated its proceedings. Lord Kelvin, with characteristic force and insistence, still further elaborated the theme which had been so signal a feature of Sir David Brewster's address twenty-one years previously: "Whether we look to the honour of England," he said, "as a nation which ought always to be the foremost in promoting physical science, or to those vast economical advantages which must accrue from such establishments, we cannot but feel that experimental research ought to be made with us an object of national concern, and not left, as hitherto, exclusively to the private enterprise of self-sacrificing amateurs, and the necessarily inconsecutive action of our present Governmental Departments and of casual committees."

Lord Kelvin, as might have been anticipated, pleaded more especially for the institution of physical observatories and laboratories for experimental research, to be conducted by qualified persons, whose duties should be not teaching, but experimenting. Such institutions as then existed, he pointed out, afforded only a very partial and inadequate solution of a national need. They were, for the most part, "absolutely destitute of means, material, or *personnel* for advancing science, except at the expense of volunteers, or of securing that volunteers should be found to continue such little work as could then be carried on."

There were, however, even then, signs that the bread cast upon the waters was slowly returning after many days. The establishment of the Cavendish Laboratory at Cambridge, by the munificence of its then chancellor, was a notable achievement. Whilst in its constitution as part of a university discipline it did not wholly realise the ideal of the two presidents, under its successive directors, Prof. Clerk Maxwell, the late Lord Rayleigh, and Sir J. J. Thomson, it has exerted a profound influence upon the development of experimental physics, and has inspired the foundation of many similar educational institutions in this country. Experimental physics has thus received an enormous impetus during the last fifty years, and although in matters of science there is but little folding of the hands to sleep, "the divine discontent" of its followers has little cause for disquietude as regards the position of physics in this country.

In the establishment of the National Physical Laboratory we have an approach to the ideal which my predecessors had so earnestly advocated. Other presidents, among whom I would specially name the late Sir Douglas Galton, have contributed to this consummation. The result is a remarkable testimony to the value of organised and continuous effort on the part of the British Association in forming public opinion and in influencing Departmental action. It would, however, be ungrateful not to recall the action of the late Lord Salisbury—himself a follower of science and in full sympathy with its objects—in taking the first practical steps towards the creation of this magnificent national institution. I may be allowed, perhaps, to refer to this matter, as I have personal knowledge of the circumstances, being one of the few survivors of the Committee which Lord Salisbury caused to be formed, under the chairmanship of the late Lord Rayleigh, to inquire and report upon the expediency of establishing an institution in Great Britain upon the model of certain State-aided institutions already existing on the Continent, for the determination of physical constants of importance in the arts, for investigations in physical problems bearing upon industry, for the standardisation and verification of physical instruments, and for the general purposes of metrology. I do not profess to give the exact terms of the reference to the Committee, but in substance these were recognised to be the general aims of the contemplated institute. The evidence we received from many men of science, from Departmental officers, and from representatives of engineering and other industrial establishments was absolutely unanimous as to the great public utility of the projected laboratory. It need scarcely be said that the opportunity called forth all the energy and power of advocacy of Lord Kelvin, and I well remember with what strength of conviction he impressed his views upon the Committee. That the National Physical Laboratory has, under the ability, organising power, and business capacity of its first director, Sir Richard Glazebrook, abundantly justified its creation is recognised on all hands. Its services during the four years of war alone are sufficient proof of its national value. It has grown to be a large and rapidly increasing establishment, occupying itself with an extraordinary range of subjects, with a numerous and well-qualified staff, engaged in determinative and research work on practically every branch of pure and applied physics. The range of its activities has been further increased by the establishment since the war of co-ordinating research boards for physics, chemistry, engineering, and radio-research. Government Departments have learned to appreciate its services. The photometry division, for example, has been busy on experiments on navigation lamps for the Board of Trade, on miners' lamps for the Home Office, and on motor-car head-lamps for the Ministry of Transport, and on the lighting of the National Gallery and the Houses of Parliament. Important work has been done on the forms of ships, on the steering and manœuvring of ships, on the effect of waves on ship resistance, on the interaction between passing ships, on seaplane floats, and on the hulls of flying-boats.

It is also actively engaged in the study of problems connected with aviation, and has a well-ordered department for aerodynamical research.

It can already point to a long and valuable series of published researches, which are acknowledged to be among the most important contributions to pure and applied physics which this country has made during recent years.

I may be pardoned, I hope, for another personal reference if I recall that it was at the Edinburgh meeting, under Lord Kelvin's presidency, fifty years ago, that I first became a member of this Association, and had the honour of serving it as one of the secretaries of its chemical section. Fifty years is a considerable span in the life of an individual, but it is a relatively short period in the history of science. Nevertheless, those fifty years are richer in scientific achievement and in the importance and magnitude of the utilitarian applications of practically every branch of science than any preceding similar interval. The most cursory comparison of the state of science, as revealed in his comprehensive address, with the present condition of those departments on which he chiefly dwelt, will suffice to show that the development has been such that even Lord Kelvin's penetrative genius, vivid imagination, and sanguine temperament could hardly have anticipated. No previous half-century in the history of science has witnessed such momentous and far-reaching achievements. In pure chemistry it has seen the discovery of argon by Rayleigh, of radium by Mme. Curie, of helium as a terrestrial element by Ramsay, of neon, xenon, and krypton by Ramsay and Travers, the production of helium from radium by Ramsay and Soddy, and the isolation of fluorine by Moissan. These are undoubtedly great discoveries, but their value is enormously enhanced by the theoretical and practical consequences which flow from them.

In applied chemistry it has witnessed the general application of the Gilchrist-Thomas process of iron-purification, the production of calcium cyanamide by the process of Frank and Caro, Sabatier's process of hydrogenation, a widespread application of liquefied gases, and Haber's work on ammonia synthesis—all manufacturing processes which have practically revolutionised the industries with which they are concerned.

In pure physics it has seen the rise of the electron theory, by Lorentz; Hertz's discovery of electro-magnetic waves; the investigation of cathode rays by Lenard, and the elucidation of crystal structure by Bragg.

It has seen, moreover, the invention of the telephone, the establishment of incandescent lighting, the electric transmission of force, the invention of the cinematograph, of wireless telegraphy, the application of the Röntgen rays, and the photographic reproduction of colour.

In physical chemistry it has witnessed the creation of stereochemistry by Van t'Hoff and Le Bel, Gibbs's work on the phase rule, Van t'Hoff's theory of solutions, Arrhenius's theory of ionic dissociation, and Nernst's theory of the galvanic cell.

Such a list is far from complete, and might be greatly extended; but it will at least serve to indicate the measure of progress which the world owes to the development and application during the last fifty years of the two sciences—physics and chemistry—to which Lord Kelvin specially referred.

The more rapid dissemination of information concerning the results of recent or contemporary investigation, which Lord Kelvin so strongly urged as "an object to which the powerful action of the British Association would be thoroughly appropriate," has been happily accomplished. The timely aid of the Association in contributing to the initial expense of preparing and publishing monthly abstracts of foreign chemical literature by the Chemical Society is gratefully remembered by British chemists. The example has been followed by the greater number of our scientific and technical societies, and the results of contemporary inquiry in every important branch of pure and applied science are now quickly brought to the knowledge of all interested workers. In fact, as regards the particular branch of science with which I am more directly concerned, the arrangements for the preparation and dissemination of abstracts of contemporary foreign chemical literature are proving to be a veritable embarrassment of riches, and there is much need for co-operation among the various distributing societies. This need is especially urgent at the present time owing to the greatly increased cost of paper, printing, binding, and indeed of every item connected with publication, which expense, of course, ultimately falls upon the various societies and their members. The problem, which has already received some attention from those entrusted with the management of the societies referred to, is not without its difficulties, but these are not insoluble. There is little doubt that a resolute and unanimous effort to find a solution would meet with success.

The present high cost of book production, which in the case of specialised books is about three times what it was in 1914, is exercising a most prejudicial effect upon the spread of scientific knowledge. Books on science are not generally among the "best sellers." They appeal to a comparatively limited and not particularly wealthy public, largely composed of the professional classes who have suffered in no small measure from the economic effects of the war The present high price of this class of literature is to the public detriment. Eventually it is no less to the detriment of the printing and publishing trades. Publishers are well aware of this fact, and attempts are being made by discussions between employers and the executives of the Typographical Association and other societies of compositors to reach an equitable solution, and it is greatly to be hoped that it will be speedily found.

All thinking men are agreed that science is at the basis of national progress. Science can develop only by research. Research is the mother of discovery, and discovery of invention. The industrial position of a nation, its manufactures and commerce, and ultimately its wealth, depend upon invention. Its welfare and stability largely rest upon the equitable distribution of its wealth. All this seems so obvious, and has been so frequently and so convincingly stated, that it is superfluous to dwell upon it in a scientific gathering to-day.

A late distinguished Admiral, you may remember, insisted on the value of reiteration. On this particular question it was never more needed than now. The crisis through which we have recently passed requires it in the interests of national welfare. Of all post-war problems to engage our serious attention, none is more important in regard to our position and continued existence than the nation's attitude towards science and scientific research, and there is no more opportune time than the present in which to seek to enforce the teaching of one of the most pregnant lessons of our late experience.

It is, unfortunately, only too true that the industrial world has in the past underrated the value of research. One indication that the nation is at length aroused to its importance is to be seen in the establishment of the Department of Scientific and Industrial Research, with its many subordinate associations. The outbreak of the Great War, and much in its subsequent history, revealed, as we all know, many national shortcomings, due to our indifference to, and actual neglect of, many things which are at the root of our prosperity and security. During the war, and at its close, various attempts, more or less unconnected, were made to find a remedy. Of the several committees and boards which were set up, those which still exist have now been co-ordinated and brought under the control of a central organisation—the Department of Scientific and Industrial Research. Research has now become a national and State-aided object. For the first time in our history its pursuit with us has been organised by Government action. As thus organised it seeks to fulfil the aspirations to which I have referred, whilst meeting many of the objections which have been urged against the endowment of research. It must be recognised that modern ideas of democracy are adverse to the creation of places to which definite work is not assigned and from which definite results do not emanate. This objection, which strikes at the root of the establishment of such an institution as Sir David Brewster contemplated, is, to a large extent, obviated by the scheme of the Department of Scientific and Industrial Research. It does not prescribe or fetter research, but, whilst aiding by personal payments the individual worker, leaves him free to pursue his inquiry as he thinks best. Grants are made, on the recommendation of an Advisory Council of experts, to research workers in educational institutions and elsewhere, in order to promote research of high character on fundamental problems of pure science or in suitable cases on problems of applied science. Of the boards and committees and similar organisations established prior to or during the war, or subsequent to it, with one or two exceptions, all are now directly under the Department. They deal with a wide range of subjects, such as the Building Research Board, established early in 1920 to organise and supervise investigations on building materials and construction, to study structural failures, and to fix standards for structural materials. The Food Investigation Board deals with the preservation by cold of food, and with the engineering problems of cold storage, with the chemistry of putrefaction, and the agents which induce it, with the bionomics of moulds, and the chemistry of edible oils and fats. The Fuel Research Board is concerned with the immediate importance of fuel economy and with investigations of the questions of oil-fuel for the Navy and Mercantile Marine, the survey of the national coal resources, domestic heating, air pollution, pulverised fuel, utilisation of peat, the search for possible substitutes for natural fuel oil, and for practicable sources of power alcohol.

The Geological Survey Board has taken over the Geological Survey of Great Britain and the control of the Museum of Practical Geology. The maintenance of the National Physical Laboratory, originally controlled by a general board and an executive committee appointed by the president and council of the Royal Society, is now transferred to the Department of Scientific and Industrial Research. A Mines Research Committee and a Mine Rescue Apparatus Committee are attached to the Department. The former is concerned with such questions as the determination of the geothermic gradient, the influence of temperature of intake and return air on strata, the effect of seasonal changes on strata temperature of intakes, the cooling effect due to the evolution of fire-damp, heat production from the oxidation of timber, etc. The Department is also directing inquiries on the preservation and restoration of antique objects deposited in the British Museum. It is concerned with the gauging of rivers and tidal currents, with special reference to a hydrographical survey of Great Britain in relation to the national resources of water-power. In accordance with the Government policy, four co-ordinating boards have been established to organise scientific work in connection with the fighting forces, so as to avoid unnecessary overlapping and to provide a single direction and financial control. The four boards deal, respectively, with chemical and physical problems, problems of radio-research, and engineering. These boards have attached to them various committees dealing with special inquiries, some of which will be carried out at the National Physical Laboratory. The Government have also authorised the establishment of a Forest Products Research Board.

The Department is further empowered to assist learned or scientific societies and institutions in carrying out investigations. Some of these were initiated prior to the war, and were likely to be abandoned owing to lack of funds. Whenever the investigation has a direct bearing upon a particular industry that had not hitherto been able to establish a research association, it has been a condition of a grant that the institution directing the research should obtain contributions towards the cost on a *l.* for *l.* basis, either directly through its corporate funds, or by special subscriptions from interested firms. On the formation of the appropriate association the research is, under suitable safeguards, transferred to it for continuance. The formation of a number of research associations has thus been stimulated, dealing, for example, with scientific instruments, non-ferrous metals, glass, silk, refractories, electrical and allied industries, pottery, etc.

Grants are made to research associations formed voluntarily by manufacturers for the purposes of research, from a fund of a million sterling, placed at the disposal of the Research Department for this purpose. Such associations, to be eligible for the grant, must submit articles of association for the approval of the Department and the Board of Trade. If these are approved, licences are issued by the Board of Trade recognising the associations as limited liability companies working without profits. Subscriptions paid to an association by contributing firms are recognised by the Board of Inland Revenue as business costs of the firms, and are not subject to income or excess profits taxes. The income of the association is similarly free of income tax. Grants are ordinarily made to these associations on the basis of 1*l.* for every 1*l.* raised by the association between limits depending upon the particular industry concerned. In the case of two research associations grants are made at a higher rate than *l.* for *l.*, as these industries are regarded as having a special claim to State assistance on account of their "pivotal" character. The results of research are the sole property of the association making them, subject to certain rights of veto possessed by the Department for the purposes of ensuring that they are not communicated to foreign countries, except with the consent of the Department, and that they may be made available to other interested industries and to the Government itself on suitable terms.

These arrangements have been found to be generally satisfactory, and at the present time twenty-four of such research associations have been formed to whom licences have been issued by the Board of Trade. Others are in process of formation, and may be expected to be at work at an early date. These research associations are concerned with nearly all our leading industries. The official addresses of most of them are in London; others have their headquarters in Manchester, Leeds, Sheffield, Birmingham, Northampton, Coventry, Glasgow, and Belfast.

The Department has further established a Records Bureau, which is responsible for receiving, abstracting, filing and collating communications from research workers, boards, institutions, or associations related to, or supervised by, the Department. This information is regarded as confidential, and will not be communicated except in writing, and after consultation with the research worker or organisation from which it has been received. Also such non-confidential information as comes into the possession of the Department which is of evident or probable value to those working in touch with the Department is collected and filed in the bureau and made generally available.

It is also a function of the bureau to effect economy in preventing repetition and overlapping of investigations and in ensuring that the fullest possible use is made of the results of research. Thus the programmes of research associations are compared in order to ensure that researches are not unwittingly duplicated by different research associations. Sometimes two or more research associations may be interested in one problem from different points of view, and when this occurs it may be possible for the bureau to arrange a concerted attack upon the common problem, each research association undertaking that phase of the work in which it is specially interested and sharing in the general results.

As researches carried out under the Department frequently produce results for which it is possible to take out patents, careful consideration has been given to the problems of policy arising on this subject, and other Government Departments also interested have been freely consulted. As the result, an Inter-Departmental Committee has been established with the following terms of reference:—

(1) To consider the methods of dealing with inventions made by workers aided or maintained from public funds, whether such workers be engaged (*a*) as research workers, or (*b*) in some other technical capacity, so as to give a fair reward to the inventor and thus encourage further effort, to secure the utilisation in industry of suitable inventions and to protect the national interest; and

(2) To outline a course of procedure in respect of inventions arising out of State-aided or supported work which shall further these aims and be suitable for adoption by all Government Departments concerned.

About forty patents have been taken out by the Department jointly with the inventors and other interested bodies, but of these nine have afterwards been abandoned. At least five patents have been developed to such a stage as to be ready for immediate industrial application.

It will be obvious from this short summary of the activities of the Department of Scientific and Industrial Research, based upon information kindly supplied to me by Sir Francis Ogilvie, that this great scheme of State-aided research has been conceived and is administered on broad and liberal lines. A considerable number of valuable reports from its various boards and committees have already been published, and others are in the press, but it is, of course, much too soon to appreciate the full effects of their operations; but it can scarcely be doubted that they are bound to exercise a profound influence upon industries which ultimately depend upon discovery and invention. The establishment of the Department marks an epoch in our history. No such comprehensive organisation for the application of science to national needs has ever been created by any other State. We may say we owe it directly to the Great War. Even from the evil of that great catastrophe there is some soul of goodness would we observingly distil it out.

I turn now to a question of scientific interest which is attracting general attention at the present time. It is directly connected with Lord Kelvin's address fifty years ago.

The molecular theory of matter—a theory which in its crudest form has descended to us from the earliest times, and which has been elaborated by various speculative thinkers through the intervening ages, scarcely rested upon an experimental basis until within the memory of men still living. When Lord Kelvin spoke in 1871, the best-established development of the molecular hypothesis was exhibited in the kinetic theory of gases as worked out by Joule, Clausius, and Clerk Maxwell. As he then said, no such comprehensive molecular theory had ever been even imagined before the nineteenth century; but, with the eye of faith, he clearly perceived that, definite and complete in its area as it was, it was "but a well-drawn part of a great chart, in which all physical science will be represented with every property of matter shown in dynamical relation to the whole. The prospect we now have of an early completion of this chart is based on the assumption of atoms; but there can be no permanent satisfaction to the mind in explaining heat, light, elasticity, diffusion, electricity and magnetism, in gases, liquids, and solids, and describing precisely the relations of these different states of matter to one another by statistics of great numbers of atoms when the properties of the atom itself are simply assumed. When the theory, of which we have the first instalment in Clausius's and Maxwell's work, is complete, we are but brought face to face with a superlatively grand question: What is the inner mechanism of the atom?"

If the properties and affections of matter are dependent upon the inner mechanism of the atom, an atomic theory, to be valid, must comprehend and explain them all. There cannot be one kind of atom for the physicist and another for the chemist. The nature of chemical affinity and of valency, the modes of their action, the difference in characteristics of the chemical elements, even their number, internal constitution, periodic position, and possible isotopic rearrangements must be accounted for and explained by it. Fifty years ago chemists, for the most part, rested in the comfortable belief of the existence of atoms in the restricted sense in which Dalton, as a legacy from Newton, had imagined them. Lord Kelvin, unlike the chemists, had never been in the habit of "evading questions as to the hardness or indivisibility of atoms by virtually assuming them to be infinitely small and infinitely numerous." Nor, on the other hand, did he realise, with Boscovich, the atom "as a mystic point endowed with inertia and the attribute of attracting or repelling other such centres." Science advances not so much by fundamental alterations in its beliefs as by additions to them. Dalton would equally have regarded the atom "as a piece of matter of measurable dimensions, with shape, motion, and laws of action, intelligible subjects of scientific investigation."

In spite of the fact that the atomic theory, as formulated by Dalton, has been generally accepted for nearly a century, it is only within the last few years that physicists have arrived at a conception of the structure of the atom sufficiently precise to be of service to chemists in connection with the relation between the properties of elements of different kinds, and in throwing light on the mechanism of chemical combination.

This further investigation of the "superlatively grand question—the inner mechanism of the atom"—has profoundly modified the basic conceptions of chemistry. It has led to a great extension of our views concerning the real nature of the chemical elements. The discovery of the electron, the production of helium in the radioactive disintegration of atoms, the recognition of the existence of isotopes, the possibility that all elementary atoms are composed either of helium atoms or of atoms of hydrogen and helium, and that these atoms, in their turn, are built up of two constituents, one of which is the electron, a particle of negative electricity the mass of which is only 1/1800 of that of an atom of hydrogen, and the other a particle of positive electricity the mass of which is practically identical with that of the same atom—the outcome, in short, of the collective work of Soddy, Rutherford, J. J. Thomson, Collie, Moseley, and others—are pregnant facts which have completely altered the fundamental aspects of the science. Chemical philosophy has, in fact, now definitely entered on a new phase.

Looking back over the past, some indications of the coming change might have been perceived wholly unconnected, of course, with the recent experimental work which has served to ratify it. In a short paper entitled, "Speculative Ideas respecting the Constitution of Matter," originally published in 1863, Graham conceived that the various kinds of matter, now recognised as different elementary substances, may possess one and the same ultimate or atomic molecule existing in different conditions of movement. This idea, in its essence, may be said to be as old as the time of Leucippus. To Graham as to Leucippus, "the action of the atom as one substance taking various forms by combinations unlimited, was enough to account for all the phenomena of the world. By separation and union with constant motion all things could be done." But Graham developed the conception by independent thought, and in the light of experimentally ascertained knowledge which the world owes to his labours. He might have been cognisant of the speculations of the Greeks, but there is no evidence that he was knowingly influenced by them. In his paper, Graham uses the terms "atom" and "molecule," if not exactly in the same sense that modern teaching demands, yet in a sense very different from that hitherto required by the limitations of contemporary chemical doctrine. He conceives of a lower order of atoms than the chemical atom of Dalton, and founds on his conception an explanation of chemical combination based upon a fixed combining measure, which he terms the *metron*, its relative weight being one for hydrogen, sixteen for oxygen, and so on with the other so-called "elements." Graham, in fact, like Davy before him, never committed himself to a belief in the indivisibility of the Daltonian atom. The original atom may, he thought, be far down.

The idea of a primordial ylé, or of the essential unity of matter, has persisted throughout the ages, and, in spite of much experimental work, some of it of the highest order, which was thought to have demolished it, it has survived, revivified and supported by analogies and arguments drawn from every field of natural inquiry. This idea, of course, was at the basis of the hypothesis of Prout, which, even as modified by Dumas, was held to be refuted by the monumental work of Stas. But, as pointed out by Marignac and Dumas, anyone who will impartially look at the facts can scarcely escape the feeling that there must be some reason for the frequent recurrence of atomic weights differing by so little from the numbers required by the law which the work of Stas was supposed to disprove. The more exact study within recent years of the methods of determining atomic weights and the great improvement in experimental appliances and technique, combined with a more rigorous standard of accuracy demanded by a general recognition of the far-reaching importance of an exact knowledge of these physical constants, have resulted in intensifying the belief that some natural law must be at the basis of the fact that so many of the most carefully determined atomic weights on the oxygen standard are whole numbers. Nevertheless, there were well-authenticated exceptions which seemed to invalidate its universality. The proved fact that a so-called element may be a mixture of isotopes—substances of the same chemical attributes, but of varying atomic weight—has thrown new light on the question. It is now recognised that the fractional values independently established in the case of any one element by the most accurate experimental work of various investigators are, in effect, "statistical quantities" dependent upon a mixture of isotopes. This result, indeed, is a necessary corollary of modern conceptions of the inner mechanism of the atom. The theory that all elementary atoms are composed of helium atoms, or of helium and hydrogen atoms, may be regarded as an extension of Prout's hypothesis, with, however, this important distinction, that whereas Prout's hypothesis was at best a surmise, with little, and that little only weak, experimental evidence to support it, the new theory is directly deduced from well-established facts. The hydrogen isotope, H_3, first detected by Sir J. J. Thomson, of which the existence has been confirmed by Aston, would seem to be an integral part of atomic structure. Rutherford, by the disruption of oxygen and nitrogen, has also isolated a substance of mass 3 which enters into the structure of atomic nuclei, but which he regards as an isotope of helium, which itself is built up of four hydrogen nuclei, together with two cementing electrons. The atomic nuclei of elements of even atomic number would appear to be composed of helium nuclei only, or of helium nuclei with cementing electrons; whereas those of elements of odd atomic number are made up of helium and hydrogen nuclei together with cementing electrons. In the case of the lighter elements of the latter class, the number of hydrogen nuclei associated with the helium nuclei is invariably three, except in that of nitrogen, where it is two. The frequent occurrence of this group of three hydrogen nuclei indicates that it is structurally an isotope of hydrogen with an atomic weight of three and a nuclear charge of one. It is surmised that it is identical with the hypothetical "nebulium" from which our "elements" are held by astro-physicists to be originally produced in the stars through hydrogen and helium.

These results are of extraordinary interest as bearing on the question of the essential unity of matter and the mode of genesis of the elements. Members of the British Association may recall the suggestive address on this subject of the late Sir William Crookes, delivered to the Chemical Section at the Birmingham meeting of 1886, in which he questioned whether there is absolute uniformity in the mass of the atoms of a chemical element, as postulated by Dalton. He thought, with Marignac and Schutzenberger, who had previously raised the same doubt, that it was not improbable that what we term an atomic weight merely represents a mean value around which the actual weights of the atoms vary within narrow limits, or, in other words, that the mean mass is "a statistical constant of great stability." No valid experimental evidence in support of this surmise was or could be offered at the time it was uttered. Maxwell pointed out that the phenomena of gaseous diffusion, as then ascertained, would seem to negative the supposition. If hydrogen, for example, were composed of atoms of varying mass, it should be possible to separate the lighter from the heavier atoms by diffusion through a porous septum. "As no chemist," said Maxwell, "has yet obtained specimens of hydrogen differing in this way from other specimens, we conclude that all the molecules of hydrogen are of sensibly the same mass, and not merely that their mean mass is a statistical constant of great stability." [1] But against this it may be doubted whether any chemist had ever made experiments sufficiently precise to solve this point.

The work of Sir Norman Lockyer on the spectroscopic evidence for the dissociation of "elementary" matter at transcendental temperatures, and the possible synthetic intro-stellar production of elements, through the helium of which he originally detected the existence, will also find its due place in the history of this new philosophy.

Sir J. J. Thomson was the first to afford direct evidence that the atoms of an element, if not exactly of the same mass, were at least approximately so, by his method of analysis of positive rays. By an extension of this method Dr. F. W. Aston has succeeded in showing that a number of elements are in reality mixtures of isotopes. It has been proved, for example, that neon, which has a mean atomic weight of about 20.2, consists of two isotopes having the atomic weights respectively of 20 and 22, mixed in the proportion of 90 per cent. of the former with 10 per cent. of the latter. By fractional diffusion through a porous septum an apparent difference of density of 0·7 per cent. between the lightest and heaviest fractions was obtained. The kind of experiment which Maxwell imagined proved the invariability of the hydrogen atom has sufficed to show the converse in the case of neon.

The element chlorine has had its atomic weight repeatedly determined, and, for special reasons, with the highest attainable accuracy. On the oxygen standard it is 35·46, and this value is accurate to the second decimal place. All attempts to prove that it is a whole number—35 or 36—have failed. When, however, the gas is analysed by the same method as that used in the case of neon it is found to consist of at least two isotopes of relative mass 35 and 37. There is no evidence whatever of an individual substance having the atomic weight 35·46. Hence chlorine is to be regarded as a complex element consisting of two principal isotopes of atomic weights 35 and 37 present in such proportion as to afford the mean mass 35·46. The atomic weight of chlorine has been so frequently determined by various observers and by various methods with practically identical results that it seems difficult to believe that it consists of isotopes present in definite and invariable proportion. Dr. Aston meets this objection by pointing out that all the accurate determinations have been made with chlorine derived originally from the same source, the sea, which has been perfectly mixed for æons. If samples of the element could be obtained from some other original source, it is possible that other values of atomic weight would be obtained, exactly as in the case of lead, in which the existence of isotopes in the metal found in various radioactive minerals was first conclusively established.

Argon, which has an atomic weight of 39·88, was found to consist mainly of an isotope having an atomic weight of 40, associated to the extent of about 3 per cent. with an isotope of atomic weight 36. Krypton and xenon are far more complex. The former would appear to consist of six isotopes, 78, 80, 82, 83, 84, 86; the latter of five isotopes, 129, 131, 132, 134, 136.

Fluorine is a simple element of atomic weight 19. Bromine consists of equal quantities of two isotopes, 79 and 81. Iodine, on the contrary, would appear to be a simple element of atomic weight 127. The case of tellurium is of special interest in view of its periodic relation to iodine, but the results of its examination up to the present are indefinite.

Boron and silicon are complex elements, each consisting of two isotopes, 10 and 11, and 28 and 29, respectively.

Sulphur, phosphorus, and arsenic are apparently simple elements. Their accepted atomic weights are practically integers.

All this work is so recent that there has been

[1] Clerk Maxwell, art. "Atom," *Ency. Brit.*, 9th ed.

little opportunity, as yet, of extending it to any considerable number of the metallic elements. These, as will be obvious from the nature of the methods employed, present special difficulties. It is, however, highly probable that mercury is a mixed element consisting of many isotopes. These have been partially separated by Brönsted and Hevesy by fractional distillation at very low pressures, and have been shown to vary very slightly in density. Lithium is found to consist of two isotopes, 6 and 7. Sodium is simple, potassium and rubidium are complex, each of the two latter elements consisting, apparently, of two isotopes. The accepted atomic weight of cæsium, 132·81, would indicate complexity, but the mass spectrum shows only one line at 133. Should this be confirmed, cæsium would afford an excellent test case. The accepted value for the atomic weight is sufficiently far removed from a whole number to render further investigation desirable.

This imperfect summary of Dr. Aston's work is mainly based upon the account he recently gave to the Chemical Society. At the close of his lecture he pointed out the significance of the results in relation to the periodic law. It is clear that the order of the chemical or "mean" atomic weights in the periodic table has no practical significance; anomalous cases, such as argon and potassium, are simply due to the relative proportions of their heavier and lighter isotopes. This does not necessarily invalidate or even weaken the periodic law, which still remains the expression of a great natural truth. That the expression as Mendeléeff left it is imperfect has long been recognised. The new light we have now gained has gone far to clear up much that was anomalous, especially Moseley's discovery that the real sequence is the atomic number, not the atomic weight. This is one more illustration of the fact that science advances by additions to its beliefs rather than by fundamental or revolutionary changes in them.

The bearing of the electronic theory of matter, too, on Prout's discarded hypothesis that the atoms of all elements were themselves built up of a primordial atom—his *protyle*, which he regarded as probably identical with hydrogen—is too obvious to need pointing out. In a sense, Prout's hypothesis may be said to be now re-established, but with this essential modification—the primordial atoms he imagined are complex and are of two kinds—atoms of positive and negative electricity—respectively known as protons and electrons. These, in Dr. Aston's words, are the standard bricks that Nature employs in her operations of element building.

The true value of any theory consists in its comprehensiveness and sufficiency. As applied to chemistry, this theory of "the inner mechanism of the atom" must explain all its phenomena. We owe to Sir J. J. Thomson its extension to the explanation of the periodic law, the atomic number of an element, and of that varying power of chemical combination in an element we term valency. This explanation I give substantially in his own words. The number of electrons in an atom of the different elements has now been determined, and has been found to be equal to the atomic number of the element, that is to the position which the element occupies in the series when the elements are arranged in the order of their atomic weights. We know now the nature and quantity of the materials of which the atoms are made up. The properties of the atom will depend not only upon these factors, but also upon the way in which the electrons are arranged in the atom. This arrangement will depend on the forces between the electrons themselves and also on those between the electrons and the positive charges or protons. One arrangement which naturally suggested itself is that the positive charges should be at the centre with the negative electrons around it on the surface of a sphere. Mathematical investigation shows that this is a possible arrangement if the electrons on the sphere are not too crowded. The mutual repulsion of the electrons resents overcrowding, and Sir J. J. Thomson has shown that when there are more than a certain number of electrons on the sphere, the attraction of a positive charge, limited as in the case of the atom in magnitude to the sum of the charges on the electrons, is not able to keep the electrons in stable equilibrium on the sphere, the layer of electrons explodes, and a new arrangement is formed. The number of electrons which can be accommodated on the outer layer will depend upon the law of force between the positive charge and the electrons. Sir J. J. Thomson has shown that this number will be eight with a law of force of a simple type.

To show the bearing of this result as affording an explanation of the periodic law, let us, to begin with, take the case of the atom of lithium, which is supposed to have one electron in the outer layer. As each element has one more free electron in its atom than its predecessor, glucinum, the element next in succession to lithium, will have two electrons in the outer layer of its atom, boron will have three, carbon four, nitrogen five, oxygen six, fluorine seven, and neon eight. As there cannot be more than eight electrons in the outer layer, the additional electron in the atom of the next element, sodium, cannot find room in the same layer as the other electrons, but will go outside, and thus the atom of sodium, like that of lithium, will have one electron in its outer layer. The additional electron, in the atom of the next element, magnesium, will join this, and the atom of magnesium, like that of glucinum, will have two electrons in the outer layer. Again, aluminium, like boron, will have three; silicon, like carbon, four; phosphorus, like nitrogen, five; sulphur, like oxygen, six; chlorine, like fluorine, seven; and argon, like neon, eight. The sequence will then begin again. Thus the number of electrons, one, two, three, up to eight, in the outer layer of the atom, will recur periodically as we proceed from one element to another in the order of their atomic weights, so that any property of an element which depends on the number of electrons in the outer layer of its atom will also recur periodically, which is precisely that remarkable property of the elements which is expressed by the periodic law of Mendeléeff, or the law of octaves of Newlands.

The valency of the elements, like their periodicity, is a consequence of the principle that equilibrium becomes unstable when there are more than eight electrons in the outer layer of the atom. For on this view the chemical combination between two atoms, A and B, consists in the electrons of A getting linked up with those of B. Consider an atom like that of neon, which has already eight electrons in its outer layer; it cannot find room for any more, so that no atoms can be linked to it, and thus it cannot form any compounds. Now take an atom of fluorine, which has seven electrons in its outer layer; it can find room for one, but only one, electron, so that it can unite with one, but not with more than one, atom of an element like hydrogen, which has one electron in the outer layer. Fluorine, accordingly, is monovalent. The oxygen atom has six electrons; it has, therefore, room for two more, and so can link up with two atoms of hydrogen: hence oxygen is divalent. Similarly nitrogen, which has five electrons and three vacant places, will be trivalent, and so on. On this view an element should have two valencies, the sum of the two being equal to eight. Thus, to take oxygen as an example, it has only two vacant places, and so can find room only for the electrons of two atoms; it has, however, six electrons available for filling up the vacant places in other atoms, and as there is only one vacancy to be filled in a fluorine atom the electrons in an oxygen atom could fill up the vacancies in six fluorine atoms, and thereby attach these atoms to it. A fluoride of oxygen of this composition remains to be discovered, but its analogue, SF_6, first made known by Moissan, is a compound of this type. The existence of two valencies for an element is in accordance with views put forward some time ago by Abegg and Bödlander. Prof. Lewis and Dr. Irving Langmuir have developed, with great ingenuity and success, the consequences which follow from the hypothesis that an octet of electrons surrounds the atoms in chemical compounds.

The term "atomic weight" has thus acquired for the chemist an altogether new and much wider significance. It has long been recognised that it has a far deeper import than as a constant useful in chemical arithmetic. For the ordinary purposes of quantitative analysis, of technology, and of trade, these constants may be said to be now known with sufficient accuracy; but, in view of their bearing on the great problem of the essential nature of matter and on the "superlatively grand question, What is the inner mechanism of the atom?" they become of supreme importance. Their determination and study must now be approached from entirely new points of view and by the conjoint action of chemists and physicists. The existence of isotopes has enormously widened the horizon. At first sight it would appear that we should require to know as many atomic weights as there are isotopes, and the chemist may well be appalled at such a prospect. All sorts of difficulties start up to affright him, such as the present impossibility of isolating isotopes in a state of individuality, their possible instability, and the inability of his quantitative methods to establish accurately the relatively small differences to be anticipated. All this would seem to make for complexity. On the other hand, it may eventually tend towards simplification. If, with the aid of the physicist, we can unravel the nature and configuration of the atom of any particular element, and determine the number and relative arrangement of the constituent protons and electrons, it may be possible to arrive at the atomic weight by simple calculation, on the assumption that the integer rule is mathematically valid. This, however, is almost certainly not the case, owing to the influence of "packing." The little differences, in fact, may make all the difference. The case is analogous to that of the so-called gaseous laws in which the departures from their mathematical expression have been the means of elucidating the physical constitution of the gases and of throwing light upon such variations in their behaviour as have been observed to occur. There would appear, therefore, ample scope for the chemist in determining with the highest attainable accuracy the departures from the whole-number rule, since it is evident that much depends upon their exact extent.

These considerations have already engaged the attention of chemists. For some years past a small International Committee, originally appointed in 1903, has made and published an annual report in which they have noted such determinations of atomic weight as have been made during the year preceding each report, and they have from time to time made suggestions for the amendment of the tables of atomic weights, published in text-books and chemical journals, and in use in chemical laboratories. In view of recent developments, the time has now arrived when the work of this International Committee must be reorganised and its aims and functions extended. The mode in which this should be done has been discussed at the meeting in Brussels, in June last, of the International Union of Chemistry Pure and Applied, and has resulted in strengthening the constitution of the Committee and in a wide extension of its scope.

The crisis through which we have recently passed has had a profound effect upon the world. The spectacle of the most cultured and most highly developed peoples on this earth, armed with every offensive appliance which science and the inventive skill and ingenuity of men could suggest, in the throes of a death struggle must have made the angels weep. That dreadful harvest of death is past, but the aftermath remains. Some of it is evil, and the evil will persist for, it may be, generations. There is, however, an element of good in it, and the good, we trust, will develop and increase with increase of years. The whole complexion of the world—material, social, economic, political, moral, spiritual—has been changed, in certain aspects immediately for the worse, in others prospectively for the better. It behoves us, then, as a nation to pay heed to the lessons of the war.

The theme is far too complicated to be treated adequately within the limits of such an address as this; but there are some aspects of it germane to the objects of this Association, and I venture, therefore, in the time that remains to me, to bring them to your notice.

The Great War differed from all previous internecine struggles in the extent to which organised science was invoked and systematically applied in its prosecution. In its later phases, indeed, success became largely a question as to which of the great contending parties could most rapidly and most effectively bring its resources to their aid. The chief protagonists had been in the forefront of scientific progress for centuries, and had an accumulated experience of the manifold applications of science in practically every department of human activity that could have any possible relation to the conduct of war. The military class in every country is probably the most conservative of all the professions and the slowest to depart from tradition; but when nations are at grips, and they realise that their very existence is threatened, every agency that may tend to cripple the adversary is apt to be resorted to—no matter how far it departs from the customs and conventions of war. This is more certain to be the case if the struggle is protracted. We have witnessed this fact in the course of the late war. Those who, realising that in the present imperfect stage of civilisation wars are inevitable, yet strove to minimise their horrors and formulated the Hague Convention of 1899, were well aware how these horrors might be enormously intensified by the applications of scientific knowledge, and especially of chemistry. Nothing shocked the conscience of the civilised world more than Germany's cynical disregard of the undertaking into which she had entered with other nations in regard, for instance, to the use of lethal gas in warfare. The nation that treacherously violated the treaty of Belgium and even applauded the action, might be expected to have no scruples in repudiating her obligations under the Hague Convention. April 25, 1915, which saw the clouds of the asphyxiating chlorine slowly wafted from the German trenches towards the lines of the Allies, witnessed one of the most bestial episodes in the history of the Great War. The world stood aghast at such a spectacle of barbarism. German *kultur* apparently had absolutely no ethical value. Poisoned weapons are employed by savages, and noxious gas had been used in Eastern warfare in early times, but its use was hitherto unknown among European nations. How it originated among the Germans—whether by the direct unprompted action of the Higher Command, or, as is more probable, at the instance of persons connected with the great manufacturing concerns in Rhineland, has, so far as I know, not transpired. It was not so used in the earlier stages of the war, even when it had become a war of position. It is notorious that the great chemical manufacturing establishments of Germany had been, for years previously, sedulously linked up in the service of the war which Germany was deliberately planning—probably, in the first instance, mainly for the supply of munitions and medicaments. We may suppose that it was the tenacity of our troops, and the failure of repeated attempts to dislodge them by direct attack, that led to the employment of such foul methods. Be this as it may, these methods became part of the settled practice of our enemies, and during the three succeeding years—that is, from April, 1915, to September, 1918—no fewer than eighteen different forms of poison—gases, liquids, and solids—were employed by the Germans. On the principle of Vespasian's law, reprisals became inevitable, and for the greater part of three years we had the sorry spectacle of the leading nations of the world flinging at one another the most deadly products that chemical knowledge could suggest and technical skill contrive. Warfare, it would seem, has now definitely entered upon a new phase. The horrors which the Hague Convention saw were imminent, and from which they strove to protect humanity, are now, apparently, by the example and initiative of Germany, to become part of the established procedure of war. Civilisation protests against a step so retrograde. Surely comity among nations should be adequate to arrest it. If the League of Nations is vested with any real power it should be possible for it to devise the means and to ensure their successful application. The failure of the Hague Convention is no sufficient reason for despair. The moral sense of the civilised world is not so dulled but that, if roused, it can make its influence prevail. And steps should be taken without delay to make that influence supreme, and all the more so that there are agencies at work which would seek to perpetuate such methods as a recognised procedure of war. The case for what is called chemical warfare has not wanted for advocates. It is argued that poison gas is far less fatal and far less cruel than any other instrument of war. It has been stated that "amongst the 'mustard gas' casualties the deaths were less than 2 per cent., and when death did not ensue complete recovery generally ultimately resulted. . . . Other materials of chemical warfare in use at the armistice do not kill at all; they produce casualties which, after six weeks in hospital, are discharged practically without permanent hurt." It has been argued that, as a method of conducting war, poison-gas is more humane than preventive medicine. Preventive medicine has increased the unit dimension of an army, free from epidemic and communicable disease, from 100,000 men to a million. "Preventive medicine has made it possible to maintain 20,000,000 men under arms and abnormally free from disease, and so provided greater scope for the killing activities of the other military weapons. . . . Whilst the surprise effects of chemical warfare aroused anger as being contrary to military tradition, they were minute compared with those of preventive medicine. The former slew its thousands, whilst the latter slew its millions and is still reaping the harvest." This argument carries no conviction. Poison gas is not merely contrary to European military tradition; it is repugnant to the right feeling of civilised humanity. It in no wise displaces or supplants existing instruments of war, but creates a new kind of weapon, of limitless power and deadliness. "Mustard gas" may be a comparatively innocuous product as lethal substances go. It certainly was not intended to be such by our enemies. Nor, presumably, were the Allies any more considerate when they retaliated with it. Its effects, indeed, were sufficiently terrible to destroy the German *moral.* The knowledge that the Allies were preparing to employ it to an almost boundless extent was one of the factors that determined our enemies to sue for the armistice. But if poisonous chemicals are henceforth to be regarded as a regular means of offence in warfare, is it at all likely that their use will be confined to "mustard gas," or, indeed, to any other of the various substances which were employed up to the date of the armistice? To one who, after the peace, inquired in Germany concerning the German methods of making "mustard gas," the reply was: "Why are you worrying about this when you know perfectly well that this is not the gas we shall use in the next war?"

I hold no brief for preventive medicine, which is well able to fight its own case. I would only say that it is the legitimate business of preventive medicine to preserve by all known means the health of any body of men, however large or small, committed to its care. It is not to its discredit if, by knowledge and skill, the numbers so maintained run into millions instead of being limited to thousands. On the other hand, "an educated public opinion" will refuse to give credit to any body of men of science who employ their talents in devising means to develop and perpetuate a mode of warfare which is abhorrent to the higher instincts of humanity.

This Association, I trust, will set its face against the continued degradation of science in thus augmenting the horrors of war. It could have no loftier task than to use its great influence in arresting a course which is the very negation of civilisation.

The British Association at Edinburgh.

ABSTRACTS OF PRESIDENTIAL ADDRESSES.

THE presidential addresses delivered at a meeting of the British Association are now published in volume form, thus providing a convenient annual record of authoritative thought and opinion upon a wide range of scientific subjects. The title of the volume just issued is "The Advancement of Science, 1921"; the publisher is Mr. John Murray, and the price 6*s*., or to members attending the Edinburgh meeting 4*s*. 6*d*. The address of the president of the Association, Sir Edward Thorpe, is also on sale separately, price 1*s*. Following our usual custom, we print this address in full in the present issue, and we hope, in succeeding issues, to publish the parts of addresses of presidents of sections of interest to scientific readers generally. The subjects dealt with in these addresses are described in the subjoined abstracts.

PROBLEMS OF PHYSICS.

In Section A (Mathematics and Physics) Prof. O. W. Richardson will review in his address the present state of a number of leading problems now engaging the attention of physicists. After a brief reference to relativity, the far-reaching importance of the discoveries relating to the nature of the nuclei of atoms being made at Cambridge by Sir Ernest Rutherford will first be emphasised. The conditions which govern the emission of electrons by matter will then be considered broadly. This involves a review of the present state of our knowledge of thermionic emission and of photoelectric action. These two groups of phenomena are shown to be very closely, perhaps inseparably, connected. Nevertheless, the claim that thermionic emission is merely a manifestation of the photoelectric activity of a body under its own thermal radiation will not withstand a critical examination. The same is true of the wider claim which has been put forward that all chemical action is a similar and immediate effect of radiant activity. There is not, in either case, enough radiation to produce the observed results. The controversy which has lasted more than a century as to the origin of contact potential differences will be referred to, and it will be shown that the new phenomena supply the material required to settle this dispute. All three groups of phenomena are, in fact, closely related, and have undergone similar vicissitudes. In conclusion, attention will be directed to the rapid unification of light and X-ray phenomena as the result of recent investigations.

CHEMISTRY AND LIFE.

Four years of warfare having given the public some insight into the relation between chemistry and industry, with perhaps undue stress on utilitarian aspects of the science, it appears desirable to emphasise also the fundamental part played by chemical principles in the commonplace operations of daily life. This is done by Dr. M. O. Forster in his presidential address to Section B (Chemistry), entitled "The Laboratory of the Living Organism."

Illustrations are drawn from the marvellously interwoven stages of digestion and assimilation, from the purely chemical potentiality distinguishing animals from plants, and from the chemistry of the nucleic acids, the constitution and degradation of which have now been clarified by researches extending over the past fifty years. The present state of knowledge embracing chlorophyll and hæmoglobin is discussed, and is followed by a survey of the anthocyans, the pigments of blossoms and fruits. Attention is directed also to the diverse activities of micro-organisms and the need for systematic inquiry into the capabilities of those humble practitioners of the chemical art.

It is claimed that, by simple readjustments, the general scheme of secondary education could be made to include the principles of chemistry, physics, mechanics, and biology in quantity sufficient to render all intelligent citizens able to recognise, at least superficially, the miraculous transformations in which they take part, and which surround them on every side. Such a result would not only add enormously to the æsthetic value of life, but would provide the sympathetic and intellectual background for those who will, in the near future as history counts time, be called upon to surmount the real danger with which civilisation is threatened, namely, the continued failure of governments and people to realise that the worst enemy of man is Nature ignored or misunderstood, whilst his best friend is Nature studied and controlled.

EXPERIMENTAL GEOLOGY.

Dr. J. S. Flett's presidential address to Section C (Geology) deals with the subject of experimental geology. Of recent years a great and increasing amount of research has been done in determining the behaviour of molten silicates and other minerals when they are cooled and allowed to crystallise. By means of the electric furnace such experiments are now comparatively easy, and the electric pyrometer ensures accurate measurement of temperature. Many rock-forming minerals can thus be studied as regards their genesis and the conditions under which they are stable. Quartz, felspar, diopside, enstatite olivine, nepheline, wollastonite, tridymite, and many other components of igneous rocks can be produced in the laboratory. The action of gases can also be determined in apparatus specially designed to resist great pressure at high temperatures. Microscopic examination of the products has reached a stage of minute accuracy which greatly facilitates the interpretation of the results. We might almost regard this as a "new" petrology, but it is really a development of a method of inquiry which was initiated by Sir James Hall in the early years of the nineteenth century. Hall made experiments to prove that by slow cooling a molten basalt would consolidate, not as a glass, but as a crystalline rock. Afterwards he made a laborious investigation into the behaviour of chalk and limestone when heated in closed vessels, and succeeded in obtaining a crystalline marble. His results have been much discussed, and of recent years his experiments have been repeated with all the refinements of the modern laboratory. Hall's position as the founder of experimental geology has been vindicated, and his work remains a classic in this department.

HEREDITY, ENVIRONMENT, AND EVOLUTION.

Prof. E. S. Goodrich points out in his address to Section D (Zoology) that it is nearly one hundred years since Charles Darwin began his scientific studies in the University of Edinburgh. Certain problems relating to Darwin's doctrine of evolution still remain unsolved, and it is useful from time to time to re-examine the very foundations on which our theories are laid.

In trying to answer the question why some characters are inherited and others not, inheritance is defined as the reappearance in the offspring of a character possessed by the ancestor. Its constant reappearance is shown to be due neither to its age nor to its importance, but to the presence of both the germinal factors of inheritance and the environmental conditions or stimuli which cooperated in its formation in the parent. Characters are all of the nature of responses to stimuli which mould the course of metabolism. The factors alone are transmitted from parent to offspring in the germ-cells. The characters are produced anew at every generation. We should carefully distinguish between transmission and inheritance, and it is clear that whereas factors may be transmitted, characters as such never are.

There is no difference in kind or value between characters, and if some are inherited regularly and others not, the distinction lies in the constancy of the factors and conditions which give rise to them. There is only one kind of character, but there are two kinds of variation—modification due to change in the effective environmental stimuli, and mutation due to change in the complex of germinal factors. These variations must not be confused, as is so often done, with the characters that result from them.

The perpetual growth reproduction and transmission of the factors of inheritance (continuity of the germ-plasm) are but one aspect of the continuity of the metabolic processes at the basis of all the manifestations of life. Just as the various steps in the metabolic process are dependent on those which preceded them, so when an organism becomes differentiated into parts these react on each other and act as internal environmental stimuli, calling forth further responses which may modify the first. From chains of interdependent responses arise the power of individual adaptation and self-regulation. Whereas the lower organisms develop to a great extent in response to external stimuli over which they have no control, the higher gradually substitute internal for external stimuli, thus acquiring considerable independence. Inheritance is made secure by ensuring that the necessary conditions are always present. The answer to the original question now appears to be that only those characters can be regularly inherited which depend for their appearance on conditions always fulfilled in the normal environment, external or internal.

Prof. Goodrich goes on to deal with the nature of the factors themselves, their relation to metabolism, and their possible alteration by the environment. How new factors are acquired is the fundamental problem of biology. Prof. M. F. Guyer's experiments are described. His remarkable results seem to show that an anti-body may be made to act on the germinal factors corresponding to its antigen, and that heritable mutations may thus be produced experimentally. A Lamarckian interpretation of these results is rejected.

In answer to the question, "What share has the mind taken in evolution?" it is pointed out that to the continuous physico-chemical metabolic process, describable in scientific language as a consistent series of events in an outside world, there corresponds a continuous series of mental events describable in psychical terms. The one is not a product of the other, nor does it control or interfere with the other; but confusion may arise because in a description of behaviour the gaps in our very incomplete knowledge of one series are usually filled in from the other. It is further pointed out that instinctive behaviour is carried out by a mechanism developed under the influence of stimuli, chiefly internal, which are constantly present in the normal environmental conditions, while intelligent behaviour depends on responses called forth by stimuli which may or may not be present. Hence the former is, but the latter may or may not be, inherited.

Finally, it is urged that these questions of factors and environment, heredity and evolution, are not of mere academic interest, but are of great importance for the progress of civilisation. Could we acquire the power to control and alter at will the factors of inheritance in domesticated animals and plants, and even in man himself, such vast results might be achieved that the past triumphs of the science would fade into insignificance.

APPLIED GEOGRAPHY.

Dr. D. G. Hogarth takes "Applied Geography" as the subject of his address to Section E (Geography). By this term is meant a loan asked of, or offered by, geography for the purpose of another science. It may be applied by students and teachers of the borrowing science, or by those of the lender; but if the latter devote themselves to such application they are for the time being seconded from their own sciences to the service of the others. Many geographers, especially in America, disagree with this view, holding such applications to be functions, even the main functions, of geography itself. If, however, the study of the "human response to land-forms" is the science of geography, that science is still in its earliest infancy! Geography has properly to consider man only from the point of view of his distribution over physical space; and study of the physical environment should precede the study of man in it. The prior importance of physical geography is not recognised in official curricula.

Geographical science is first and last the science of distribution. It includes the investigation, study of causation, survey, and diagrammatic delineation of all the superficial features of the earth. Of these, causation will be the last study to be exhausted. To the understanding of it many other sciences have to give help to geography, even as they ask her in turn to help them about the distribution of their own material. But it is, and will, remain a true function of geography. At the same time delimitation of geography from the sciences aiding it or aided by it is not easy, and has been obscured by progressive changes in the popular use of the word "geography," and by the continual parturition of specialisms by the latter, which come in time to be accepted as new sciences, but often remain for a while imperfectly detached from the mother. Such has been geodesy.

To teach geography, therefore, only in its application to history is not to teach geography as a science, and to do so discourages the study of the thing to be applied. This lessens the value of the application as much as it does the standard of geography proper. The Ministry of Education, the great scientific societies, and the universities must see to it that the study of the mother science is better encouraged, if many other sciences and much education are not to suffer.

LABOUR, CAPITAL, AND WAGES.

The conclusions put before Section F (Economic Science and Statistics) by the president, Mr. W. L. Hichens, in his address, are as follows:—There is no simple and straightforward system applicable to the division of the proceeds of industry between labour and capital. Both are essential to industry, and, therefore, to each other; hence the deeper interests of both lie in co-operation, and the task before the leaders of labour and of capital consists in promoting the interests of both, not in selfishly pursuing the advantage of the one at the expense of the other. Both must recognise the need of contenting the other, for if capital is not satisfied its springs will dry up and the industrial body will wither away, whilst if labour is discontented and the members of the industrial body war against each other, the end is death. The real solution of the problem is a moral one, and can be achieved only if justice and virtue govern the lives of the members of the community, for all human organisations must reflect the character of those who work them. Arbitration offers no immediate solution of the difficulty, for to be effective it must be voluntarily accepted by the majority on both sides, and the principles by which arbitrators are to be guided must first be clearly expressed and accepted; but it is the goal at which civilisation must aim, and as a step in this direction public inquiries into all disputes between labour and capital should be encouraged after all attempts at mutual agreement have failed. A clearer understanding of economic truths in the industrial world is essential if disputes are to be avoided. It must be recognised that the wealth available for wages depends on the total production of the country, and that whilst, if production increases, wages will go up, if it falls wages must come down. So long as the present industrial system continues, the wages system must prevail, and profit-sharing is no substitute for it.

The fundamental wage, or the wage of unskilled labour, should be a living wage—that is, a wage suitable to the development of the physical, moral, and intellectual attributes of the citizens of a free country; but it must be recognised that the degree to which this ideal can be attained must depend on the skill and endeavour of the people, and due regard must be had to the progress, maintenance, and well-being of the industries of the country. It is idle to hope that the living wage can be based permanently on any given standard of civilisation; it is bound to fluctuate at different periods, and will depend largely on whether the industries of a country are progressive, stagnant, or retrogressive.

WATER-POWER DEVELOPMENT.

Prof. A. H. Gibson's address to Section G (Engineering) is devoted to a consideration of inland water-power and tidal-power development, with special reference to the possibilities in the United Kingdom and in the British Empire. The importance of water-power development, in view of the necessity for the conservation of solid and liquid fuels, needs no emphasis, and the extent to which such development has been taking place during recent years may be gauged by the fact that two-thirds of the water-power now being utilised throughout the world has been harnessed during the past decade. The proportion of the available water-power which is utilised throughout the British Empire is only slightly above 1 per cent. as compared with, approximately, 24 per cent. for the continent of Europe and for the U.S.A. The scope for further development in this field is obvious, and it should form a fruitful field of activity for British engineering for many years to come.

On the mechanical and electrical sides of water-power engineering the development has been rapid, and the modern turbine differs essentially from the types in common use a few years ago. Much investigation work in this direction is now in progress, and promises to give important results. Research in many other directions is also urgently required, and the importance is urged of instituting, on an adequate scale, a hydraulic laboratory at some institution of university standard for the special study of the many special problems now awaiting solution, a number of which are indicated in the address. The subject of tidal power is also considered briefly, with special reference to the problems still to be solved before any large scheme can be undertaken with confidence.

THE RÔLE OF PHYSIOLOGY.

The relation of physiology to national life, to science generally, and to medicine in particular, is the theme of the address delivered by Sir Walter M. Fletcher to Section I (Physiology). Physiology, as we know it to-day, became established as a progressive branch of science when it was divorced from the study of anatomy just fifty years ago, when William Sharpey became professor of anatomy and physiology at University College, London, and to Sharpey and his personal influence the development of all the chief British, Canadian, and American schools of physiology can be traced. But until 1914 physiology had developed as one of the primary departments of knowledge chiefly in the older universities, where it was out of touch with the great centres of population and, in consequence, with medical needs. While this detachment allowed of a fuller and freer development of the subject, the urgent needs of humanity were not brought clearly before physiologists. The problems presented by the war served to remedy, in great measure, this defect. Changes in blood pressure and quality, the chemical mechanisms of the body, studies in heat loss and production in relation to climate, clothing, and diet, are some of the many "human" problems which had to be solved; the stresses and accidents of warfare provided an infinitely varied series of experiments on the human body. It also had a wholesome effect from its tendency to break down the barriers that had grown up between physiology and the practical needs of medicine.

The progress of physiology during the past half-century can be regarded alternatively as an analysis of the varied though inseparable functions of the parts of the body or as a synthesis leading towards the unification of the functions of all the parts in a single functional organism. The analysis has led to a growth of specialism within the mother-science, but there is a growing tendency to regard the whole organism as a physiological unit in relation to which alone the functions of the organs and their cellular subdivisions can find due expression.

At the present time there appears to be a danger that physiology will be confined to the medical schools, a fate which will limit its outlook by depriving it of co-operation with kindred sciences and tend to keep from it many promising recruits who are not contemplating medical studies. The primary task of physiology is to enlarge the vision of man and enrich his knowledge of truth; to find power to diminish pain and restore health is a secondary task which must not be allowed to obscure the primary and greater aim.

Mind and Consciousness.

In Section J (Psychology) Prof. Lloyd Morgan deals with the status of mind and consciousness in what he speaks of as emergent evolution—the word "emergent" being here used in the sense suggested by G. H. Lewes in distinction from "resultant." In line with Prof. Alexander's treatment in "Space, Time, and Deity," ascending stages in evolution of (1) the physical, (2) the chemical, (3) the vital, and (4) the conscious are emphasised. In each a new "quality" is found and must loyally be accepted as given. But the physical and the conscious are regarded as heterogeneous in that the latter is felt or enjoyed. If we may infer that life process, as such, is accompanied by enjoyment, its affective integration may primarily be that to which the ill-chosen adjective "unconscious" should be applied. It is urged that since this word is "served with a negative prefix," it is imperative in some way to define the conscious. Differentiating criteria are suggested in the presence of some measure of (*a*) revival, (*b*) expectancy, and (*c*) objective reference. That which is unconscious is characterised by the absence of these criteria. The distinction between subliminal and supraliminal is, on this view, different from that between unconscious and conscious. There is much supraliminal enjoyment which is unconscious if these criteria of consciousness be accepted. It is keenly enjoyed, but without felt "againness" in revival or "comingness" in expectancy. In the development of consciousness two levels are recognised: (1) the unreflective stage of naive perceptual cognition, and (2) the reflective stage of judgment where "values"—truth, beauty, and ethical goodness—are emergent. A distinction is drawn between scientific interpretation and metaphysical explanation. At any given level science interprets the emergent characters found therein as dependent on, but more than, those which obtain at lower levels; metaphysics interprets the lower in terms of that which is reached at a higher stage, and ultimately the highest. Each may be valid in its appropriate universe of discourse. They should be regarded as complementary and not antagonistic.

Plant Evolution.

The subject of Dr. D. H. Scott's address to Section K (Botany) will be "The Present Position of the Theory of Descent in Relation to the Early History of Plants." The first part of the address is concerned with general questions, and especially emphasises our present ignorance of the methods of evolution. The advent of genetics marked the end of the Darwinian period. The absence of satisfactory evidence of variation is pointed out, and attention is directed to the new theory of the origin of species by crossing. The prevalent attitude towards the doctrine of natural selection is briefly criticised. The essential service rendered to biology by genetics, in ensuring that organisms should be thought of as races rather than as isolated individuals, is recognised. The question of the conception of a "species" is touched on in passing.

The second and larger portion of the address is occupied with questions relating to the early history of plant evolution. Such inquiries, though necessarily speculative and, from a post-Darwinian point of view, more difficult than ever, are not regarded as hopeless. The transmigration from sea to land is discussed in the light of our newly acquired knowledge of an early Devonian land flora. The affinities of the Rhynie plants and their allies in relation to Pteridophyta, Bryophyta, and Thallophyta are considered, and the bearing of the new data on the homologies of the sporangium is indicated. The question of the existence of ferns in the older Devonian flora is discussed. The independence and antiquity of the seed-plant phylum are maintained, and in connection with this subject a brief sketch is given of our present knowledge of the Pteridosperms and of their relation to other Spermophytes. In conclusion, the current monophyletic and polyphyletic hypotheses of the origin of vascular plants are contrasted.

Education in Music.

Sir Henry Hadow urges in his address to Section L (Education) that music should be recognised in our formal education of school and college, and that it should be given a place in the curriculum and full recognition in the examination system. He suggests that music for the whole school should consist of little more than class singing and an occasional concert or lecture, and that those who have the taste and aptitude for pursuing its serious study should do so in substitution for some other subject. The study of a great composer might be made of as much educational value as that of a great poet. On the other side, the qualities of abstract thinking and of mental construction implied in the study of musical form are closely analogous to those of our natural sciences, and might well be made of the same educational value. It should be quite possible to draw up a syllabus for music which would fit into the existing schemes of school and college work, and would not encourage faddists, or excuse idlers, or produce that lamentable class of people, not yet quite extinct, who talk emotionally about music without any understanding. There should also be a great improvement in the place of music in our libraries. Every public library in the country, and, if possible, every school and university library, should contain a musical department which includes not only the standard classical compositions, but also the first-rate books on musical æsthetics and criticism. Moreover, our attitude towards music needs to be simplified. We want really to pool our knowledge, to concentrate our interests, and to develop a sense of comradeship and co-operation, and this can be done only if we are all made free of the company—if our musical education is such that we can meet each other as frankly and openly in this field as educated men are accustomed to do in the discussion of science or poetry.

AGRICULTURAL ECONOMICS.

The address of Mr. C. S. Orwin to Section M (Agriculture) deals with the importance of the study of agricultural economics. It points out the overriding influence of the economic factor in all matters affecting the management and development of land. Soil, climate, and other factors have their importance, but the farmer can grow anything if there is a market for it, and his main consideration must be in all cases, not what will the land grow, but what can he sell at a profit to himself. Examples are given to illustrate the relatively small importance of soils and climate in crop production and the dominating influence of the market in combination with transport facilities.

Attention is also directed to the need for economic study in the organisation of farm management so as to prevent the wasteful application of one or more of the factors of production: land, capital, and labour. Thus a small farm may be made highly productive by a prodigal use of manual labour, but the same amount of labour applied to a larger area of land in conjunction with a bigger capital outlay on machinery equipment will increase the output per man employed, and it is suggested that production can be directed scientifically and to the general advantage only by a study of the three factors so as to use them in proper relation to each other.

The address aims at directing attention to the fact that the scientific research work in agriculture, which was first inaugurated publicly about twenty-five years ago, has taken no account of the need for the study of agricultural economics, and that agricultural research can never bear its proper fruit until investigations conducted along the lines of natural science are balanced by research work on an equal scale in agricultural economics.

SCIENCE AND CITIZENSHIP.

Sir Richard Gregory's "Message of Science," delivered to the Conference of Delegates of Corresponding Societies, is a plea for closer association between scientific workers and the rest of the community, as a means of promoting social well-being.

Civilised man has proved himself unworthy of the gifts which science has placed at his disposal, with the result that squalid surroundings and squandered life are the characteristics of modern Western civilisation instead of social conditions and ethical ideals superior to those of any other epoch. Responsibility for this does not lie with scientific discoverers, but with statesmen and democracy. Like the gifts of God, those of science can be made either a blessing or a curse, to glorify the human race or to destroy it; and upon civilised man rests the decision as to the course to follow. With science as an ally, and the citadels of ignorance and self as the objective, he can transform the earth; but if he neglects the guidance which knowledge can give, and prefers to accept the phrases of rhetoricians, this world will become a place of dust and ashes.

Unsatisfactory social conditions are not a necessary consequence of the advance of science, but of incapacity to use it rightly. Whatever may be said of captains of industry and princes of commerce, men of science cannot be accused of amassing riches at the expense of labour, or of having neglected to put into force the laws of healthy social life. Power—financial and political—has been in the hands of people who know nothing of science, not even that of man himself, and it is they who should be arraigned at the bar of public justice for their failure to use for the welfare of all the scientific knowledge offered to all. Science should dissociate itself entirely from those who have thus abused its favours, and not permit the public to believe it is the emblem of all that is gross and material and destructive in modern civilisation. It is the pituitary body of the social organism, and without it there can be no healthy growth, mentally or physically.

The Conference of Delegates provides an appropriate platform for this message of exhortation. There are now 130 Corresponding Societies of the Association, with a total membership of about 52,000, and their representatives should every year go back, not only strong with zeal for new knowledge, but also as ministers filled with the sense of duty to inspire others to trust in it.

The Present Position of the Wave Theory of Light.[1]

By DR. R. A. HOUSTOUN.

II.

WE come now to the fundamental difficulties. They have been stated very clearly by Dr. G. W. C. Kaye in his book on X-rays, and we shall borrow his method of presenting them:—

(1) When X-rays encounter a gas, only an exceedingly small fraction of its molecules becomes ionised.

(2) The extent of this ionisation is unaffected by temperature.

(3) When X-rays encounter a metal, the corpuscles ejected have a velocity which

(*a*) does not depend on the intensity of the X-rays, and so is independent of the distance of the metal from the X-ray bulb;

(*b*) increases continuously with the hardness, *i.e.* frequency, of the X-rays;

[1] Continued from p. 15.

(*c*) does not depend on the nature of the metal; and

(*d*) is equal to the velocity of the cathode rays in the X-ray bulb.

The last fact is a very striking one. To quote from the Robert Boyle lecture recently delivered by Sir William Bragg at Oxford (NATURE, May 19, p. 374):

It is not known how the energy of the electron in the X-ray bulb is transferred by a wave motion to an electron in the photographic plate, or in any other substance on which the X-ray falls. It is as if one dropped a plank into the sea from a height of 100 ft., and found that the spreading ripple was able, after travelling 1000 miles and becoming infinitesimal in comparison with its original amount, to act upon a wooden ship in such a way that a plank of that ship flew out of its place to a height of 100 ft. How does the energy get from the one place to the other?

According to the discussion of these difficulties usually given, the X-rays should spread equally in all directions according to the wave theory. Consequently the few molecules which, according to (1), become ionised should be in some exceptional condition, *i.e.* have a high kinetic energy. But this energy cannot be ordinary heat energy, since according to (2) ionisation does not vary with temperature. It must be some store of internal energy of a radio-active nature, not readily unlocked by outside agencies. The X-ray thus acts as a trigger to start an explosion, of which the corpuscle is the outward and visible sign.

Why should the speed of the corpuscles depend on the wave-length of the X-ray, if the latter merely exerts a trigger action, and why is it independent of the distance of the X-ray bulb? Why is it independent of the nature of the metal? The difficulty of answering these questions in a satisfactory manner has led many to believe that the energy of the X-ray does not spread equally in all directions, but travels in a straight line, and is handed over completely to one corpuscle. Thus we had Bragg's corpuscular or neutral-pair theory of the X-ray and Einstein's quantum theory.

The case for a localised energy theory or entity theory, as it is called, for there are different names, appears at first sight to be strengthened by the numerical values of the quantities involved. The velocity of the cathode-ray particle, the X-ray it produces, and the velocity of the secondary corpuscle are connected by the equation

$$\tfrac{1}{2}mv^2 = h\nu,$$

where m is the mass of the cathode-ray particle or secondary corpuscle, v its velocity, h Planck's constant, and ν the frequency of the X-ray. Not only is there agreement between the value of h determined from this equation and the value derived from experiments on black body radiation, but there is extremely good agreement. In an article in the *Journal de Physique* for August, 1920, by M. de Broglie, who has himself added very considerably to our knowledge of both emission and absorption X-ray spectra, there is a description of the methods and a collection of results, from which it is evident that the differences are less than 1 per cent.

References have been made to Newton's emission theory. It is difficult for students to study this theory, as the "Opticks" has not been printed in English since 1730. A reprint is long overdue; the book is really accessible only in the German, in Ostwald's "Klassiker." There are quite erroneous ideas prevalent about the utility of Newton's emission theory for present-day purposes. Newton himself was not enthusiastic about it, and was cautious about using it. In the first sentence of the "Opticks" Newton says: "My design in this book is not to explain the Properties of Light by Hypotheses, but to propose them and prove them by reason and experiment," and he is very careful in pursuance of this design to make his statements as free from hypotheses as possible. Again and again he uses the word "ray" when it is obvious the thought in his mind is "stream of particles constituting the ray." But he eventually committed himself quite definitely. Light consisted of streams of particles, the violet rays being the smallest particles and the red rays the largest: the glass of the prism attracted the particles in the ray incident on it, and this attraction caused the deviation of the ray: the smaller particles were attracted more strongly than the larger particles, and consequently suffered a greater deviation: hence the formation of the spectrum. In order to explain interference Newton found it necessary to assume that the particles underwent periodic changes of state. These changes he referred to as "fits of easy reflection," because at the changes the particles were reflected more easily; the fits occurred at equal intervals along the path of the ray, and the length of these intervals varied with the colour; for the "rays which paint the colour in the confine of yellow and orange" the interval of the fits was 1/89,000 part of an inch, *i.e.* $2{\cdot}8 \times 10^{-5}$ cm.

But, though Newton adopted the emission theory, he had misgivings on the subject. This is especially evident from a query, No. 13, which he appends to the end of his "Opticks" as a problem suitable for future investigation. This query begins, "Do not several sorts of rays make vibrations of several bignesses, which according to their bignesses excite sensations of several Colours, much after the manner that the vibrations of the Air, according to their several bignesses, excite sensations of several sounds?" Then he suggests that the violet rays make the shorter vibrations, and the red ones the longer vibrations.

Newton's theory is, of course, so hopelessly inadequate for the explanation of interference, diffraction, changes of phase and amplitude, resolving power, etc., that no one has ever seriously thought of applying it to these fields of work. It even gives a wrong value for the pressure of light, a subject in which one would expect it to be at an advantage. The wave theory, on the other hand, holds an extremely strong position in these fields, a position much stronger than is imagined, for few workers at present experiment on such things as, say, phase difference produced by total reflection, or conical refraction, and consequently there are not many people aware of the extremely high degree of agreement attained. It has not been quite so successful in dealing with the emission and absorption of light; this, however, cannot be ascribed so much to a defect of the theory as to our ignorance of the structure of matter.

Newton's theory being out of the question, and there being no definite alternative offered, we must attempt to explain the phenomena of X-ray energetics on the wave theory. This is not so difficult as is supposed, for in previous discussions important facts have usually been left out.

In the first place the wave theory does not limit us to the harmonic-wave trains of the elementary text-books. It certainly permits of the passage of energy in pulses which widen out very little as they travel. In some signalling experiments a beam of light has been used which was 2 in. wide at one end and 5 ft. wide at the other at a distance of five miles. There would be no difficulty in supposing this repeated on an atomic scale, if we could only imagine a mechanism for getting the beam started. Perhaps electrons vibrating with suitable phase differences on a space lattice might do. In any case it is a matter of arranging the interfering sources suitably; a hint to the properties of the Fourier integral is here enough. White light on the modern view consists of pulses, and we can easily make calculations on the interference, diffraction, and dispersion of such pulses. For example, a single pulse is changed by its passage through a dense flint plate of 1 cm. thickness into a group of about 500 visible waves.

Also it is not necessary that the pulse should be as narrow as the electron in order that all the energy in it should be absorbed by the electron. The analogy of a large metal plate coated with soot is very misleading in this respect. Lord Rayleigh has shown (*Phil. Mag.*, August, 1918), or at least made it plausible, that an electron captures all the energy passing through an area comparable with λ^2/π, where λ is the wave-length.

There is difficulty on the wave theory about starting the energy off along one line, since it would require elaborate and improbable conditions in the source. So it seems preferable to fall back on the other explanation, namely, that of "trigger action."

The spherical wave, uniform throughout its front and diverging from a single point source, is a mathematical fiction, used only in the interests of simplicity. What we have in reality is always a superposition of wavelets from a number of electrons, say n, included within a small region and vibrating simultaneously. These wavelets interfere. If their amplitudes were all the same and equal to a, the resultant intensity would vary from $(na)^2$ to 0, according to the degree of reinforcement present, the lower values being more probable and the average being na^2. There are thus singular points in the wave-front. The ionisation cannot depend on the intensity of the resultant wave, because this brings us up against the difficulty numbered 3 (*a*) above. As a result of the interference, though, changes of phase and different rates of change of intensity will be produced, and it is natural to suppose that some complicated combination of these produces the critical conditions; by an accurately timed series of impulses the electron is thrown out of its orbit, and an atomic explosion follows. Thus the objections above headed (1) and (2) are met.

The strongest argument in favour of the "trigger action" theory is undoubtedly the numerical value of Planck's constant itself. There has been comparatively little attention given to the meaning of the quantum itself, or to the connection between the atomicity of energy, or rather action it signifies, and the atomicity of electricity already established. The tendency has been rather to take the quantum for granted and to quanticise everything. There has also been a widespread assumption that the quantum is inexplicable in terms of the concepts already existing.

Suppose, however, that we take a sphere of positive electricity of uniform density ρ and radius a, and assume that inside the sphere there is one electron which oscillates about its centre through the positive electricity. Let ν be the frequency of the oscillations, and suppose the radius of the sphere just large enough to neutralise the electron. Then

$$\nu = \sqrt{\left(\frac{\rho e}{3\pi m}\right)} \text{ and } e = \frac{4}{3}\pi a^3 \rho.$$

Now suppose that the electron starts from rest on the surface of the sphere and falls towards the centre. Let v be the velocity acquired by the time it reaches the centre. Then $v = 2\pi a\nu$. On eliminating ρ and a these three relations give

$$v = \left(\frac{2\pi e^2}{m}\right)^{\frac{1}{3}} \nu^{\frac{1}{3}}.$$

If an electron has one quantum kinetic energy, its velocity is given by

$$v = \left(\frac{2h}{m}\right)^{\frac{1}{2}} \nu^{\frac{1}{2}}.$$

The difference between the two formulæ for v amounts to the sixth root of ν, an amount which would scarcely matter if only the visible spectrum were in question, but is much too great when we take the X-ray region also into consideration. But there is a surprising numerical agreement. If we fix our attention on two wave-lengths, (i) that of sodium in the visible spectrum, and (ii) the wave-length 10^{-8} cm. in the X-ray region, we find that the two expressions for v give in the case of (i) $9{\cdot}29 \times 10^7$ cm./sec. and $8{\cdot}64 \times 10^7$ cm./sec., and in the case of (ii) $1{\cdot}68 \times 10^9$ cm./sec. and $6{\cdot}64 \times 10^9$ cm./sec., the second value in each case being given by the quantum formula. Thus there is fair agreement for sodium, but the new formula gives only one-quarter of the correct value in the X-ray region.

The agreement, such as it is, cannot be a chance one. It means that if we construct a model atom in the simplest manner possible, so as to respond to frequency ν, then the maximum internal energy of the system is of the order of the quantum corresponding to that frequency, and it inspires the hope that some day we may obtain a model which will give an exact agreement. In other words, this calculation gives us good reason for believing that when more is known about the constitution of matter it will be found that a frequency ν is specially qualified for unlocking the quantity of energy $h\nu$.

The difficulty labelled 3 (*c*) above requires that there should be electrons with a wide range of periods in all metals.

It should be remembered that the phenomena of X-rays themselves, the verification of the theory of scattering, the theory of the crystal lattice, etc., have given us a wide extension of the field of usefulness of the wave theory. It is, of course, nowadays extremely difficult to keep abreast of all the work that is being done even in one field; consequently, different workers attach different values to the facts, and there are many opinions on the points discussed here. But as yet there is no reason for physicists to make any essential change in their attitude towards the wave theory, and in any case it does not conduce to clear thinking to use two mutually contradictory metaphors at the same time.

It is a curious fact that if Euclid does not deserve so much credit for his postulate of parallels as was formerly supposed, he may, on the other hand, lay claim to foreshadowing one feature of some modern views on light. For, according to his "Optics" (*circa* 280 B.C.), he thinks that there are gaps between the rays, that they are localised like the spread-out fingers of a hand; when the observer fails to perceive a small object like a needle lying directly in front of his nose, it is because the needle has got into one of the gaps between the rays.

Classical and Modern Education.[1]

By W. BATESON, F.R.S.

FOLLOWING that general misgiving as to our national system of education which, long felt by thoughtful men, found loud and continual expression during the war, Mr. Asquith, then Prime Minister, appointed (1916) Committees to consider the position of natural science and of modern languages respectively. After these Committees had reported, a third Committee was set up (1919) to investigate the position of classics in our educational system. The Report of this Committee, recently issued, is a comprehensive document, full of interesting materials, readable and scholarly, as from the character of the Committee might be expected. The history of classical teaching in the several parts of the United Kingdom, its rise and recent decline, are set out in detail, with an abundance of information never before collected. As to the main inference, no mistake is possible. The classical element in British education is disappearing, and will probably soon be gone altogether.

> In the Public Schools few boys are learning Greek, and even Latin, though still generally taught in middle and lower forms, tends more and more to be dropped higher up. None of the new Provided Schools has yet been able to develop a classical tradition and few of them teach Greek. . . . The danger with which we are faced is not that too many pupils will learn Latin and Greek, but that the greater part of the educated men and women of the nation will necessarily grow up in ignorance of the foundations on which European society is built.

The course of events has been exactly that which the defenders of compulsory classics at Oxford and Cambridge foresaw as the consequence of any weakening of front. Classics were maintained in education solely by the authority of the two old universities. Fearing the financial consequences of competition, they reduced the minimum demanded until it became ridiculous, the inevitable result being that Greek had to be dropped, with Latin soon to follow. The reformers were, of course, mostly persons who set no great store by classical education, but they were aided by many representatives of the humanities, who believed, or were persuaded, that the inherent value of classical training was so obvious that it would hold its own without protection. They forgot that, on their abdication, the decision would pass into the control of those who knew the classics only as a symbol of exclusion, with the Board of Education naturally well disposed towards any movement which could be represented as popular.

Probably emanating from that group of the reformers, there are passages in the Report which maintain an undertone of hope. Wonders have been achieved by a few resolute and devoted scholars in some of the most modern universities. This is "of good augury," and "with the enthusiasm born of free choice of subject" there may yet be a revival. Numerous recommendations on points of detail are suggested to this end. The regulations, especially those relating to "Advanced Courses" in secondary schools, and the examination schedules should not be weighted unduly against the classics. In every large district there should be at least one school where Greek teaching can be had and provision is made for boys and girls with literary tastes, and generally the Committee pleads that in every branch of educational administration classical education should be respected as a thing of great worth.

The value of the classics has never been better

1 "Classics and Education." Report of the Committee appointed by the Prime Minister to inquire into the Position of Classics in the Educational System of the United Kingdom. Pp. 308. (London: H.M. Stationery Office.) 2*s*. net.

set forth. This part of the Report is admirable good sense, and approaches to eloquence as nearly as a Report to a Prime Minister can do. In the classics a man "obtains access to literature, both in prose and poetry, which in the judgment of many is absolutely the noblest in the world; but if that claim be not admitted, it is at least unique, inimitable, and irreplaceable. We have here a spiritual value not easily reckoned. . . ." Not merely are the works of antiquity "classic in the sense that they belong to the highest class of human achievement," but they have the peculiar merit of introducing the student to a world which is not our own, though presenting problems closely akin to ours, thus promoting a certain power of understanding and of judgment in fundamentals. The student has "attained this access to beauty and this power of understanding by means of a peculiar course of training which requires the exercise of many different powers of the mind, and forms a remarkable combination of memory-training, imagination, æsthetic appreciation, and scientific method. For better or worse, the study of the classics is quite a different thing from the learning of languages pure and simple." Even the merely verbal exercises start the "invaluable habit of thinking out the real meaning of words and phrases before attempting to translate them." The exposure of the inadequacy of translations is especially convincing. "Few people would seriously maintain that we can get 'all we want' out of an English translation of Victor Hugo or Goethe, or a French translation of Shakespeare or Burke."

The attitude of the Committee towards grammar is symptomatic of a welcome change. Hitherto the classical teacher has refused to put grammar anywhere but first. He would surrender nothing. By this pedantry thousands have been repelled. No one doubts that grammatical exercises are a fine educational instrument, but in comparison with the rest that classical education can do, grammar is such a small, poor thing. Had the scholastic world repented of this error when the warning came, the classics might have survived as the staple of at least a complete education. The remarks of the present Committee on methods of teaching are all that could be wished. It is advised that "great stress should be laid on the subject-matter and the historical background of the texts read, though not to the prejudice of exact training in the language." We may be thankful for this concession to common sense.

Probably it comes too late. Time was when modern languages, and especially science, were admitted grudgingly, and could be treated with scant respect. There is a sadly humbled tone now, and the classical apologist comes delicately before his judges. All he begs for is an equal chance; for instance, that in the "first examination" the requirements in other subjects should not be so exacting as to discourage the candidates from offering at least Latin as well as one modern foreign language, and that natural science should not be made compulsory.

It is true that the classics offer an access to beauty and give a power of understanding which nothing supplies so readily and so well, but the members of the Committee are sanguine men if they expect their recommendations to be adopted. The mind of the country is set on other things. "The civilisation of the modern Western world is grounded upon the ancient civilisation of the Mediterranean coast," as they rightly say in their exordium. The understanding of those who know nothing of these origins is hopelessly imperfect and starved. To this theme the Committee often recurs. The members have had the good fortune to meet with much evidence indicating a growing appreciation of the value of the classics, which is epitomised in striking passages of the Report. Mr. Mansbridge is quoted to the effect that a widespread demand for classical teaching may be expected amongst working people, who are greatly interested in the civilisation of Greece, "in spite," as he adds, "of deep-rooted prejudice against a nation which had such a sharp division of the classes"—a naive and significant illustration of the instructive value of classical experience. The social reformer may learn something by contemplating the peculiar and, as he holds, reprehensible system of Athens, a spectacle from which he naturally shrinks, as the feminist might from inspecting the dreadful example of the termite queens, or the hen hornbill plastered into the nest by her husband.

The Committee is under the impression that the scientific world especially concurs in its opinion. It is very doubtful whether the representatives of labour or of science who testified before them are truly representative of the mass with whom authority now rests. As the Committee remarks in another place, discussing the policy of the local education authorities, "it is unlikely that any body of ratepayers would consent to special financial provision for the encouragement of classics." It is: most unlikely. Let them raise the question in any place of common resort, or even, say, at a laboratory tea, and they will carry away no illusions about growing appreciation of the classics. They will find themselves in a world which cares not a jot that "all our modern forms of poetry, history, and philosophy" originated with the Greeks, and has only a scant curiosity as to whether Western civilisation is grounded on that of the Mediterranean or of some other coast. So complete is the break already that the younger students scarcely know that classical education can be seriously defended, and regard any tenderness for it as mere perversity and affectation. We are probably witnessing that rare and portentous event, a break in the continuity of civilisation. In the Press, in the arts, and, most singular of all, in learning of various kinds, the same phenomenon appears. The modern room of a picture gallery tells the same story as the pages of a scientific periodical. The new generation means to go a lot more easily than the last. Precision of language and finish are out of fashion and superfluous; as they would say, they have no use for them. A narrower range suffices. Any deep background of knowledge is only a source of perplexity. Richness and abundance are uncongenial to modern pragmatism. A simpler diet, consisting largely of ready-prepared and familiar substitutes, such as home provides, is preferable. All this is very curious and most interesting to observe. The world may become more contented, but it is likely to be duller, and that simultaneously with these changes a revival of interest in the classics can occur seems highly improbable.

The Report betrays a consciousness that the subject dealt with is one wider than the nominal problem of classical education, and the members of the Committee know that they are in reality pronouncing on a great social question. They are haunted by timidity and obsessed with the democratic nostrum of equal rights and opportunities; but, though fighting for their lives, they dare not make a firm stand. They should have declared boldly that learning, classical and natural, though comprising many parts, is one indivisible whole. Never was it so urgently necessary that the unity of the intellectual world should be maintained and strengthened. The natural and permanent division of society is between them and the rest. Instead of seeing in science a competitor, the classical advocates should have welcomed natural knowledge as an indispensable and essential part of complete education. Spontaneous curiosity is, as they truly say, the only safe foundation for the continuous life of any study; but curiosity is a function of active minds, which alone are entitled to the privilege of direction. Freedom of choice is a counsel of perfection; a mere vanity unless the choosers have themselves wisdom, and the knowledge by which choice must be guided. In default, the decision must be made by informed authority, and must be enforced by compulsion.

If the continuity of civilisation is to be preserved, there can be no question of abandoning the classics, but in the name of truth and advancement no less must science be presented to all who pretend to complete education. They must acquire a "widespread knowledge, however elementary, of the ancient world," and an equally widespread knowledge of the elements of natural truth. The rudiments of classics, of natural science, and of a modern language can be easily mastered by any boy of ability before he is seventeen. The feebler will no doubt drop behind. They will find their place below.

Notes.

A COMMITTEE has been appointed by the Home Secretary to re-examine, more particularly in the light of the further information which has become available since the inquiries of the Departmental Committees appointed in 1911, the question of the danger from the use of lead paints to workers in the painting trades, and the comparative efficiency and cost, and the effect on the health of the workers, of paints containing lead and leadless paints respectively; and to advise whether any modifications of the conclusions and recommendations of those Committees have become necessary. The members of the Committee are:—Sir Henry Norman, Bart. (chairman), Mr. G. Bellhouse, Dr. O. J. Kauffmann, Dr. T. M. Legge, Mr. A. E. Munby, Dr. A. Scott, and Mr. H. O. Weller. The secretary is Mr. C. W. Price, of the Home Office, Whitehall, S.W.1, to whom any communications should be addressed.

THE Air Ministry has accepted the offer of Sir Ernest Shackleton to carry out meteorological investigations and to gather topographical information during the forthcoming expedition in the *Quest*, and is affording all necessary assistance to the expedition in order that as complete information as possible may be collected. The expedition has been furnished with instruments and equipment necessary for carrying out meteorological observations, and the *Quest* has been constituted an official reporting ship of the Meteorological Office. The vessel has also been supplied with photographic apparatus and with kites similar to those employed in the investigation of the upper air over the Atlantic during the voyage of the s.s. *Montcalm* before the Transatlantic flight of the R34 in 1919. It is further proposed to take records of the temperature and pressure of the upper air by using a seaplane which is to accompany the expedition.

NEWS from the Mount Everest Expedition in Col. Howard Bury's dispatch to the *Times* is dated from Kharta, August 4. The northern and north-western sides of the mountain appeared to offer no practicable means of ascent, and the southern side is flanked by great precipices. In the hope of finding a way on the eastern side the expedition moved its base from Tingri to Kharta. The route was by Netsogu, Rebu, across the Doyala River to Chongpu, where a region of luxuriant vegetation was reached. The new camp appears to be in the Arun Valley and is placed on an old river terrace with fine views up and down the valley. Its altitude is about 12,300 ft. A mile below the camp begin the deep gorges of the Arun. Mr. Mallory and Mr. Bullock rejoined the expedition *en route*, bad weather having compelled them to give up their plan of trying to reach Kharta by the high pass north of Mount Everest. On August 2 they began the exploration of the eastern approaches of the mountain. The weather in August was bad, but better conditions were expected in September. Yet, in spite of these difficulties, more than 9000 miles of new country have now been mapped.

THE report of the Science Museum at South Kensington for 1920, which has recently been published, records the re-opening of a portion of the galleries which had been closed to the public for four years in consequence of their being occupied for the purposes of the war. But although this has rendered it possible to re-arrange some of the collections of scientific instruments and apparatus, the museum as a whole is very seriously handicapped by the inadequacy of its accommodation, which is but a third of what a committee reported in 1911 to be immediately necessary for the adequate display of the collections. A considerable number of collections have consequently been withdrawn from the exhibition galleries and placed in store, where they can be seen by visitors who express a desire to consult them. In all sections very considerable additions have been made, including a Newcomen pumping engine of 1791, a group of two hundred models of historical warships, a number of aeronautical engines, also a gravity torsion balance of the pattern designed by the late Baron R. Eötvös and the microscope by Powell and Lealand which gained the premium offered by the Royal Society in 1843. The number of visitors showed a considerable increase, but until the new museum buildings are made available the museum will become increasingly inconvenient for visitors on account of the extreme congestion of the exhibition galleries. Additions to the collections are constantly being made by gifts and loans of objects of historical or technical importance, but their instructional value is greatly diminished by the impossibility of displaying them adequately under existing conditions.

THE crafts of spinning and weaving have long been practised in the Sudan. Fragments of fine linen found by Dr. Reisner at Kerma have been dated about 2000 B.C., and he thinks that they were certainly woven in the country, though possibly by some Egyptian workmen attached to the household of one of the great noblemen who administered the country. But the manufacture of fine linen has disappeared; the modern craft is carried on in a very simple way, and the craftsman is not held in honour. A useful account of spinning and weaving at the present day is supplied in vol. 4, No. 1, April, 1921, of *Sudan Notes and Records* by Mrs. I. W. Crowfoot, who gives a full account of the appliances used, and compares them with those described by Mr. H. Ling Roth in his valuable "Studies in Primitive Looms" (Journal of the Royal Anthropological Institute, vol. 47, 1917). The trade of thread- and cloth-making has been for some time moribund in the Sudan, and Mrs. Crowfoot pleads for its encouragement as a trade for boys and as a homecraft for girls, particularly in view of the high prices and low quality of the machine-made textiles, which alone at present supply the needs of the people of the Sudan.

SMUGGLING of drugs, such as morphia, cocaine, raw opium, and Chandu, or opium prepared for smoking, is strictly forbidden in the Federated Malay States, but, as might have been expected, the prohibition has led to the use of many ingenious devices by the Chinese and Malays to evade the revenue authorities. A full list of these, with sketches, is given by Mr. W. G. Stirling in the Journal of the Straits Branch, Royal Asiatic Society, April, 1921. Clothes and walking-sticks, soles of shoes, dried walnuts, dead ducks, the dovetailing of a cabinet, a stack of saucers, a sitting hen on her eggs, a pail of rice—all have been used in some clever way for the storage of contraband Chandu.

THE influence of alcoholic grandparents upon the behaviour of white rats is the subject of an interesting paper by Messrs. E. C. Macdowell and E. M. Vicari (*Journ. Exper. Zoology*, vol. 33, No. 1, 1921, p. 209). A series of rats was alcoholised, and the grandchildren were subjected to a series of tests on finding their way in a circular maze provided with doorways, blind alleys, mirrors, etc. From the point of view of learning their way to the centre and going there for food, the test rats were found to be less successful than the controls. If this be true, a modification of the genetic basis of inheritance has been demonstrated.

THE REV. F. C. R. JOURDAIN, leader of the Oxford University Expedition to Spitsbergen, tells a woeful tale in the *Times* of August 25 of the depredations of egg-collectors among the nesting-birds of Spitsbergen. The introduction of oil-engines into sealing sloops has enabled them to work practically the whole of the west and north coasts of Spitsbergen with little danger of their being trapped by drift-ice. They have thus been able systematically to clear the nests of the large colonies of eider-ducks breeding there. One boat was met which had 15,000 eggs of the eider-duck on board! Examination of the colonies showed that the vast majority of the nests contained one or, at most, two eggs. With the brent goose the state of things was even worse. The large colonies which were known to nest on some of the eider holms as lately as 1908 have disappeared entirely, and the survivors scattered to nest in isolated pairs on the mainland, there to fall victims to the Arctic fox. Colonies of eider-ducks on the more inaccessible parts of Spitsbergen provided a welcome contrast. Here the nests contained an average of six eggs each, the largest number in a single nest being thirteen, and the busy scene of life on an untouched eider colony provided a glimpse of the Spitsbergen of the past, before the coming of the oil-engine and the coal prospector. The article is illustrated by admirable photographs of nesting birds obtained by the party.

THE American marsupial Cænolestes has always been something of a puzzle to students of mammalia, being variously regarded as a diprotodont, as a special type of subordinal rank the diprotodont characters of which are convergent, and as an aberrant polyprotodont. In view of such divergent views on its affinities, a more detailed study of its characters was desirable, and Mr. W. H. Osgood has supplied this need (Field Museum of Natural History, Zoological Series, vol. 14, No. 1). He regards Cænolestes as a surviving member of an ancient group, retaining many primitive features and exhibiting no marked degree of specialisation. It bears no special affinity to the American Didelphyiidæ, but shows many resemblances to the Australian peramelids, though it has advanced beyond them to greater morphological similarity with the specialised diprotodonts. Its ancestor was probably a northern form which had already separated from the generalised polyprotodont stock, possibly extended all over Holarctica, and may, therefore, have given rise to the Australian diprotodonts. Mr. Osgood is therefore led to support the Holarctic origin of the mammalia so powerfully advocated by Matthew in 1915. He concludes that Cænolestes must be classified as a diprotodont marsupial belonging to a special subfamily of its own in the family Palæothentidæ, the approximate position assigned to it by Osborn in 1910, but suggests that, in view of its resemblances to the peramelids, it may be necessary later to remove the latter from the polyprotodonts and to unite them with Cænolestes in a special group of equal value with the Australian Diprotodontia and the remaining Polyprotodontia. Mr. Osgood's conclusions are supported by Prof. C. J. Herrick from a study of the brain of Cænolestes. His results, published as an appendix to Mr. Osgood's work, show that the brain of Cænolestes resembles most closely those of Perameles and Notoryctes, and is more simply organised than that of any Australian diprotodont.

THE Note of the Financial Adviser to the Egyptian Government on the Budget of 1921–22 (Cairo, May, 1921) is of interest for the stress which it lays on the importance of scientific research in Egypt. A country of a restricted habitable area and with a population ten times as large as it would naturally support needs all the assistance that scientific knowledge and technical skill can give. The importance of conducting research in various fields is so great, and its omission will be so dearly paid for, that nothing should be allowed to hamper its steady prosecution. The spheres in which such investigations are already proceeding are principally the study of the Nile and the rainfall which feeds it; the improvement of the cotton plant; the prevention of disease among the population, and the application of the knowledge which has been gained of bilharzia and ankylostoma to the improvement of village life; the study of the fish-life in the lakes, waterways, and territorial waters of the country as bearing on an important food-supply which could be largely developed; and the exploration of the desert regions for further deposits of petroleum, since Egypt is otherwise dependent upon imported fuel. Registration of title to land has become an urgent need, not only to facilitate transactions in landed property, but also to enable re-assessments of land tax to be made rapidly, and to provide the means of quickly and accurately collecting crop statistics, which are of the greatest importance, not only to the agriculturist, but also to the irrigation engineer who has to distribute the water, and to the Government in the interest of public economy and of public finance. There is probably no country where properly directed scientific research gives so prompt and abundant a return for expenditure made upon it as Egypt.

THE Nile Commission during its sittings in Cairo last year received a memorandum from a committee of Egyptian engineers which dealt with various matters relating to the irrigation projects under consideration by the Commission. The committee has now published an English translation of a communication which it has forwarded to Adly Yeghen Pasha, the Egyptian Prime Minister, in which it criticises some of the conclusions of the Commission. The principal contentions would appear to be that the additional water required for Egypt can be stored by a heightened Aswan Dam; that Egypt has a claim to all the water she requires or may require before the Sudan can use the supply which flows through it; and that irrigation works in Egypt itself are more important than the proposals for utilising the Nile supply as a whole. The outlook seems to be rather too narrow a one, for the subject needs to be examined in all its bearings, agricultural as well as irrigational, while the ever-increasing demand for water necessitates accurate hydrographical studies of the whole basin. We understand that the Egyptian Government has appointed a Special Committee to study the whole question in all its bearings, and to recommend how the various interests can best be served. Mr. C. E. Dupuis, formerly Inspector-General of Sudan Irrigation and Water Adviser to the Egyptian Ministry of Public Works, will be the chairman, and will be assisted by scientific and technical members. This Committee will doubtless examine carefully and critically the proposals which the committee of Egyptian engineers is supporting.

MR. ALEX. B. MACDOWELL has examined the records of temperature at Greenwich with regard to the incidence of very warm and very cold months in the seven years of sun-spot maxima, 1848–1917, and the same number of years of sun-spot minima, 1843–1913. Taking a very warm month as one with mean temperature more than 3° above average and a very cold month as one more than 3° below, he finds thirteen very warm months and twenty very cold ones (thirty-three together) in the years of maxima of sun-spots as compared with four very warm and nine very cold (thirteen together) in the years of minima. In sending us a communication on this subject Mr. MacDowell asks:—"How is it that both very warm and very cold months turn up so much more frequently when the sun is disturbed than when it is quiet?"

CLIMATOLOGY in California is dealt with in the U.S. *Monthly Weather Review* for April, 1921, by Mr. A. H. Palmer, Meteorologist to the Weather Bureau at San Francisco. Eleven regular first-class stations are maintained in the State, and there are also about three hundred climatological sub-stations, at most of which the observers are voluntary. Special attention is paid to precipitation data, this being the most important element of climate in California. Various educational and research institutions also maintain climatological stations. The University of California has four precipitation and two evaporation stations. Certain stations are maintained primarily for agriculture; nearly all the large citrus-growing regions have climatological stations, and the instruments are usually situated in or near the fruit groves.

Climatology has contributed largely to the successful introduction of the date-palm, for this tree requires tropical or semi-tropical weather conditions and very little water; the palms will flourish in what appears to be a sandy desert provided the temperature conditions are favourable. About two hundred and fifty Southern Pacific railway station agents also keep temperature and precipitation records. The author mentions that a San Francisco instrument manufacturer has sold more than a thousand rain-gauges, and rainfall records are readily maintained.

TECHNOLOGIC Paper No. 192 of the Bureau of Standards, Washington, consists of an account by Dr. G. K. Burgess, of the Bureau, of the tests of six hollow cylindrical steel castings manufactured by the centrifugal process. The castings were 6 ft. long and of diameters up to 18 in., with holes of various diameters through them; they were made with the mould revolving about the axis at a speed not specified. Samples of the metal taken from different parts of the complete castings were tested for hardness, tensile strength, soundness, structure, and density, both in the condition as cast and after heat treatment of various kinds. It was found that there was a slight segregation of carbon, phosphorus, sulphur, nickel, and copper in the radial direction, but none of manganese and silicon. Small blow-holes were evident in the inner 1/16 in. of the castings. After heat treatment several of the castings showed mechanical strength equal to forged materials of the same composition, and satisfied the ordnance requirements for gun forgings. Microscopic examination showed no hard spots, flaws, or other defects outside the layer 1/16 in. thick at the inner surface, and the process appears to be one of great promise.

MESSRS. DUCKWORTH AND Co. include in their autumn list of forthcoming books "The Wheat Plant: A Monograph," by Prof. J. Percival. Part 1 will deal with the botany of the plant and its various parts, and part 2 with the methods of cultivation of the different varieties, with chapters also on hybridisation, breed, and yield. Another work promised by the same publishers is "The Great White South: Being an Account of Experiences with Captain Scott's South Pole Expedition, and of the Nature Life of the Antarctic," by H. G. Ponting, with an introduction by Lady Scott.

THE Cambridge University Press is bringing out in the autumn for Major Leonard Darwin a small work entitled "Organic Evolution: Outstanding Difficulties and Possible Explanations," being a collection of brief notes on biological matters arising from "The Origin of Species."

Our Astronomical Column.

THE AUGUST METEORIC DISPLAY.—Another proof of the unusually abundant display of August meteors belonging to the Perseid shower is provided by observations made by Mr. P. Meesters at Halfweg (near Amsterdam–Haarlem), Holland, with an outlook from north-west by north to east.

On August 11, watching from 9.15 until 11.15 A.M.T., Mr. Meesters counted twenty-eight meteors, viz. 2, 3, 4, 2, 1, 5, 7, 4, during each quarter of an hour. On August 11, watching from 9.15 until 10.15 A.M.T., thirty-nine meteors were seen, viz. 6, 17, 9, 7. At 9.29 A.M.T., in two seconds, four meteors were seen equal to Venus or Jupiter. Clouds came over the sky at 10.15 A.M.T. From 11.30 until 1.45 A.M.T. Mr. Meesters counted 286 meteors, viz. 60, 68, 54, 50, 54, in each quarter of an hour. On August 12, watching from 9.15 until 10.15 A.M.T., he counted 4, 7, 6, 1 objects in each quarter of an hour; clouds coming over the sky prevented further observations. On August 13, from 1.45 until 2 A.M.T., three Perseids were seen between drifting clouds. Several of the Perseids were equal to, or brighter than, stars of the first magnitude. The maximum display was thus in the latter part of the night of August 11.

THE BRIGHT OBJECT NEAR THE SUN.—Two observations of this object were made in England on August 7, some hours before that at Mount Hamilton. The first (communicated by Col. Markwick) was made by Lieut. F. C. Nelson Day and others at Ferndown, Dorset, about 7h. G.M.T. Its magnitude was estimated as *minus* 2 and its distance from the sun as 4°.

Mr. S. Fellows observed it at Wolverhampton with binoculars shortly after sunset (*Eng. Mech.*, August 19). He noted it as reddish, elongated towards the sun, from which it was distant 6°. The estimates of distance are probably too rough to use for the deduction of motion. It may be noted that a comet with retrograde motion near the plane of the ecliptic and small perihelion distance approaching the sun from behind might remain in close proximity to it the whole time that it was bright.

Astr. Nach. No. 5116 contains full particulars of the luminous bands seen at the Königstuhl and Sonneberg Observatories on August 8d. 12h. G.M.T. It appears probable that they were auroral, especially as Prof. M. Wolf noted a similar appearance on August 5, 11h. 15m. to 11h. 36m. G.M.T. It was "a long, very bright cloud west of the Pleiades, brightest near δ Arietis . . . it faded rapidly, only a trace visible at 11h. 36m."

MINOR PLANETS.—The planet (7) Iris is in opposition this month, and as its magnitude is 7·2 it is within reach of binoculars. The following ephemeris for Greenwich midnight is by M. Michkovitch (Marseilles Circ. No. 512), with corrections of +0·4m., +4′, deduced from an Algiers observation on August 16:—

	R.A. h. m.	N. Decl. ° ′	log r	log Δ
Sept. 9	23 29·3	8 44	0·295	9·993
14	23 25·1	8 23		
19	23 20·7	7 57	0·290	9·981
24	23 16·5	7 26		
29	23 12·7	6 52	0·286	9·982

Perihelion passage will be early in 1922.

Astr. Nach. No. 5116 contains the names assigned by Prof. M. Wolf to seventeen planets discovered by him in recent years. Planets 834 and 907 are named respectively Burnhamia and Barnardiana after the two famous American astronomers.

Species in Foraminifera.

ATTENTION should have been directed sooner than now to an interesting paper by Messrs. E. Heron-Allen and E. Earland on the species of *Verneuilina polystropha* and some other Foraminifera (Proc. Roy. Irish Academy, vol. 35, Section B, No. 8, pp. 153–77, 3 pls.). It is in part a contribution to the study of variation in the Foraminifera, and in part an account of certain experiments, which, to say the least, are very suggestive to those interested in the problem of species. Variation in Foraminifera may affect the size of the primordial chamber, the plan or arrangement of the chambers, and the external form. The authors also discuss the occurrence of gigantism and nanism, the predominance of the chitinous membrane over the calcareous shell, and the changes involved in a free or adherent mode of life within the same species. The facts seem to the authors to prove the futility of all classifications of Foraminifera based on the external shell, but the difficulty is to find any other basis.

The normal *Verneuilina polystropha* is a remarkably constant form, singularly free from the variations and monstrosities which occur in normal circumstances among other Foraminifera. It shows dimorphism, represented by a long form which is megalospheric and by a short form which is always microspheric. The megalospheric primordial chamber is sometimes divided into two chambers by an internal chitinous septum. Dwarf or pigmy forms also occur which cannot be confused with young specimens.

Experiments go to show that there is in *V. polystropha* a marked tendency to select and incorporate heavy minerals among the normal siliceous sand grains. A number of the specimens utilised gem-splinters "of a size and shape utterly disproportionate to the size of the tests, thus producing a variety which presents a striking contrast to the normal type." The observation would have had greater value if the number of specimens that "selected" *large and heavy* gem-splinters had been given, so that it might be compared with the number that had simply incorporated gem-sand and with the number of those that kept to ordinary sand. Fifty per cent. of ordinary sand was supplied along with the gem-sand. Another observation records the occurrence of monsters in considerable proportion in a tank with sea-water rendered hypertonic by doubling the normal lime-content.

The paper points to the idea that in a natural system of Foraminifera the processes of construction and habits of growth and reproduction must count as of more value than the material employed in the construction of the test. We hope that the authors will make their proof of the "selection" of shell-material more convincing. It is a very important point.

Biological Statistics.

IN the first article in the current issue of *Biometrika* (vol. 13, parts 2 and 3, July, 1921, Cambridge University Press, 25*s*.) Prof. Karl Pearson and Miss A. G. Davin give us a study of the sesamoids of the knee-joint in man. The best-known works on the subject are those of Gruber and Pfitzner, but, as a whole, the records of these bones are scanty and unsatisfactory, so that an up-to-date attempt to deal with the subject, using the evidence obtained from skiagrams, is welcome. It has been stated fairly freely in the past that sesamoids are manufactured from cartilage by intensive stress, but the authors point out, and adduce evidence in support of the view, that it is more probable that they are vestiges of some structure of earlier form. The available measurements show that there are orthosesamoidal (true bone sesamoid) lateral fabellæ in about 7 per cent. of the knee-joints of man, and few, and possibly no, cases of orthosesamoidal mesial fabellæ. Part of the paper is devoted to an interesting historical note on the subject, including a discussion of the "sesame," from which the name "sesamoid" is derived; it is written in a way that is a pleasant reminder of the spirited manner of some historical studies published by one of the authors a good many years ago.

Miss Tildesley contributes a paper on the Burmese skull, which is a valuable continuation of the large amount of useful measurement and investigation that has already been done at University College, London. The present work is based on 142 skulls procured by the late Col. P. H. Caster from the neighbourhood of Moulmein, and the material is divided according to sex and also into three groups according to race—or supposed race. Miss Tildesley gives a large number of measurements for each skull, and in comparing her results with such measurements as she could find of Chinese, Hindu, etc., skulls, she gives a coefficient, suggested by Pearson, which may be helpful in measuring race-likeness. Whatever view may be taken by craniologists with regard to this index, they will at any rate be grateful for the material collected and published, and approve the way in which Miss Tildesley displays her facts and puts all her cards on the table, so that others have the opportunity of drawing their own conclusions. We may particularly commend as an aid to comparison the loose contours on thin paper. The article contains a useful table for calculating the occipital index, and gives evidence of the agreement of measurements obtained directly from the skulls with those obtained from contours.

"Student" continues his studies of probable errors commenced in earlier issues, and gives, on the basis of extensive sampling, an experimental determination of the probable error of Dr. Spearman's correlation coefficients obtained by replacing actual measurements by ranks. This experimental method seems to us the sound way of getting down to the real distribution of deviations; it affords the right kind of check on any theoretical statistical investigation. The issue also contains a further mathematical article by Prof. Tchouproff, of Petrograd, on "The Mathematical Expectation of the Moments of Frequency Distributions," and one confesses to a feeling of wonder that work of this kind can be produced from Petrograd at the moment. There are also three short notes by Prof. Pearson and a review by Miss Elderton of an American study of women delinquents.

It will be seen that the issue contains papers that should interest different classes of scientific readers, and it may be added that the journal, which is produced by the Cambridge University Press, is well up to the standard which we have grown to expect of that press.

University and Educational Intelligence.

CAMBRIDGE.—Applications for the George Henry Lewes studentship in physiology, shortly to be vacant, should be sent with a brief statement of the candidate's qualifications, the subject of his proposed research, and the name of a referee, to Prof. Langley, the Physiology School, by October 1. The studentship is of the annual value of about 245*l*., tenable for one to three years at the discretion of the trustees.

MR. G. S. MOCKLER has been appointed lecturer in geology in the University of Durham.

PROF. G. W. O. HOWE, of the City and Guilds (Engineering) College, has been appointed superintendent of the electrical department of the National Physical Laboratory.

THE degree of Doctor of Law has been conferred on Sir William J. Pope by McGill University on the occasion of the annual meeting of the Society of Chemical Industry held in Montreal.

MR. P. VAN DER BIJL, formerly of the Natal Herbarium, has been appointed professor of phytopathology and mycology in the University of Stellenbosch, Union of South Africa.

MR. J. BARR, head of the textile analysis department of the City of Bradford Conditioning House, has been appointed manager of the new yarn-testing bureau at University College, Nottingham.

A COMPETITION for vacancies in the grade of chemists, Class II., in the department of the Government Chemist will shortly be held. In this connection a leaflet of regulations governing the appointments has just been issued. It is obtainable until September 15 from the Government Chemist, Clement's Inn Passage, W.C.2.

A SYLLABUS of the courses which will be available at the Sir John Cass Technical Institute, Jewry Street, London, E.C., during the session 1921–22 has been issued. Systematic courses in experimental science preparing students for the science examinations of London University and the Institutes of Physics and Chemistry will be given, but the trend of instruction generally is in the direction of technology, particularly of the chemical, metallurgical, and electrical industries. Full facilities are provided in all departments for research work. Higher technological instruction is provided for by special courses on the fermentation industries, glass technology, colloids, metallography and pyrometry, heat treatment and the mechanical testing of metals, and petroleum technology. The latter constitutes a new development which has been helped forward largely by the generosity of the leading oil companies; a two years' course has been arranged which is designed to meet the needs of those associated with practical and scientific control in the petroleum industry.

THE issues of the *British Medical Journal* of September 3 and the *Lancet* of August 27 constitute the educational and student's numbers which our two contemporaries publish annually at this time. In both will be found full and up-to-date information of the facilities for medical training in the British Isles, as well as the regulations for the various diplomas and degrees which can be obtained. Useful articles are also included which deal with public health and medical services, and with the medical services in the Army, Navy, Air Force, and in the Colonies. Some interesting figures are given in the *British Medical Journal*, showing the annual entry of first-year students in the British Isles during the past twenty years. Before the war the average number was 1400, while during the war it increased to 1900. In May, 1916, the total number of students in training was 6103; two years later it was 7630, and in January, 1910, the numbers rose to 9490. Under the influence of demobilisation in 1919, 3420 new students were registered; and although in 1920 the number had dropped to 2531, there appears to be grave apprehension that the demand for medical men in the near future will be much below the numbers already in training.

Calendar of Scientific Pioneers.

September 8, 1894. Hermann Ludwig Ferdinand von Helmholtz died.—The son of a Potsdam professor of literature, Helmholtz served as a surgeon in the Prussian Army, was a professor of physiology at Königsberg, Bonn, and Heidelberg, in 1871 became professor of physics at Berlin, and in 1887 was made director of the Physikalisch-Technischen u. Reichsanstalt at Charlottenburg. Accounted one of the world's greatest men of science, he was one of the first to grasp and advocate the principle of the conservation of energy, invented the ophthalmoscope, contributed specially to physiological optics and acoustics, discovered the fundamental properties of vortex motion in fluids, and made advances in many branches of mathematical physics.

September 9, 1841. Augustin Pyramus de Candolle died.—Born in Geneva in 1778, de Candolle first lectured on botany at the Collège de France in 1804. A great advocate of the natural system of classification, his "Flore Française" appeared in 1805. From 1806 to 1812 he investigated the botany and agriculture of France and Italy for Napoleon.

September 9, 1896. Luigi Palmieri died.—The successor of Melloni as director of the observatory on Vesuvius, Palmieri for many years held chairs in the University of Naples, and was known for his study of atmospheric electricity and seismology.

September 11, 1768. Joseph Nicolas Delisle died.—An ardent astronomer, Delisle from 1726 to 1747 was attached to the newly founded Imperial Academy of Sciences at St. Petersburg, where Euler and Daniel Bernoulli were his colleagues. After his return to France he became Geographical Astronomer to the French Navy.

September 11, 1913. Sir Walter Noel Hartley died.—From 1879 to 1911 Hartley was professor of chemistry at the Royal College of Science, Dublin. He was among the pioneers in the application of spectroscopic methods to the study of the elements, and was the first to prove the presence of gallium in the sun. He also made researches in the Bessemer process of making steel.

September 12, 1888. Richard Anthony Proctor died.—A prolific writer and a gifted lecturer, Proctor not only did much to popularise astronomy, but also made researches on the rotation period of Mars and on other subjects. The periodical *Knowledge* was founded by him in 1881.

September 13, 1877. Johann Jakob Nöggerath died.—On the founding of the Bonn University in 1818, Nöggerath was appointed to the chair of mineralogy. Among his work was an extensive study of the minerals and geology of Rhenish Westphalia.

September 14, 1712. Giovanni Domenico Cassini died.—The founder of the famous family of astronomers, Cassini was invited to France in 1669, and from 1671 until the Revolution the Paris Observatory was the home of himself or one of his descendants. Between 1665 and 1675 Cassini determined the period of rotation of Jupiter and Mars, discovered four satellites of Saturn and observed the double ring of that planet, and made the first successful estimate of the sun's distance. He afterwards determined the period of rotation of the sun and the oblateness of Jupiter, and made a chart of the moon.

September 14, 1879. Bernhard von Cotta died.—The friend of Lyell, von Buch, and Humboldt, Cotta from 1842 to 1874 was a professor at the Mining Academy at Freiburg, Saxony. One of the first to apply the microscope to the study of fossil plants, he travelled extensively, wrote on the geology of the Alps and on mountains, and did much to popularise the study of geology. E. C. S.

Societies and Academies.

CAPE TOWN.

Royal Society of South Africa, August 17.—Dr. J. D. F. Gilchrist, president, in the chair.—L. **Péringuey**: Note on the occurrence of native-made bronze and brass objects in South Africa.—H. G. **Denham**: Note on the sub-salts of bismuth.

HOBART.

Royal Society of Tasmania, June.—Mr. L. Rodway, vice-president, in the chair.—W. L. **May**: New species of fossil Mollusca. A number of specimens collected by Atkinson from the fossil cliffs at Wynyard.—H. H. **Scott** and C. **Lord**: Studies in Tasmanian mammals, *Zaglossus Harrissoni*, sp.nov. A new species of giant anteater, estimated to be some 660 mm. in length, and more robust in proportion than the largest Tasmanian Tachyglossus of to-day. The type-locality is the Pleistocene deposits of King Island, Bass Straits.

July.—Mr. L. Rodway, vice-president, in the chair.—E. **Ashby**: Description of new species of Loricella.—A. N. **Lewis**: The Glacial remains in the National Park of Tasmania.—G. H. **Hardy**: Australian Bombyliidæ (Diptera).

Books Received.

Jahrbuch des Norwegischen Meteorologischen Instituts für 1920. Pp. xiv+174. (Kristiania.)

The Alo Man: Stories from the Congo. By Mara L. Pratt-Chadwick and L. Lamprey. (Children of the World.) Pp. 170. (London and Sydney: G. G. Harrap and Co., Ltd.) 3*s*. 6*d*. net.

Studies in Deficiency Disease. By Dr. Robert McCarrison. (Oxford Medical Publications.) Pp. xvi+270. (London: H. Frowde and Hodder and Stoughton.) 30*s*. net.

Das Klima Thrakiens als Grundlage der Wirtschaft. By Prof. Erich Obst. (Osteuropa Instituts in Breslau: Vorträge und Aufsätze. iv Abt., Geographie und Landeskunde, Heft i.) Pp. 61. (Leipzig and Berlin: B. G. Teubner.) 2*s*. 6*d*.

What is Science? By Dr. Norman Campbell. Pp. ix+186. (London: Methuen and Co., Ltd.) 5*s*. net.

Turbines. By A. E. Tompkins. Third edition, entirely revised. Pp. viii+180. (London: S.P.C.K.; New York: The Macmillan Co.) 8*s*. net.

British Insect Life: A Popular Introduction to Entomology. By E. Step. Pp. 264+32 plates. (London: T. Werner Laurie, Ltd.) 10*s*. 6*d*. net.

The Trend of the Race: A Study of Present Tendencies in the Biological Development of Civilized Mankind. By Prof. S. J. Holmes. Pp. v+396. (New York: Harcourt, Brace and Co.) 4 dollars net.

The Land and its Problems. By C. Turnor. (A New Series on Economics.) Pp. 254. (London: Methuen and Co., Ltd.) 7*s*. 6*d*. net.

Animal Life of the British Isles: A Pocket Guide to the Mammals, Reptiles, and Batrachians of Wayside and Woodland. By E. Step. (The Wayside and Woodland Series.) Pp. vii+184+111 plates. (London and New York: F. Warne and Co., Ltd.) 10*s*. 6*d*. net.

Origin and Evolution of the Human Race. By Dr. A. Churchward. Pp. xv+511+78 plates. (London: G. Allen and Unwin, Ltd.) 45*s*. net.

Ministry of Munitions and Department of Scientific and Industrial Research. Technical Records of Explosives Supply, 1915–1918, No. 2. Manufacture of Trinitrotoluene (TNT) and its Intermediate Products. Pp. viii+116. (London: H.M. Stationery Office.) 17*s*. 6*d*. net.

The Book of Nature Stories. By H. W. Seers. (Reprint of "Nature Stories to Tell to Children.") Pp. 256. (London and Sydney: G. G. Harrap and Co., Ltd.) 5*s*. net.

God's Country: The Trail to Happiness. By J. O. Curwood. Pp. 167. (London: Duckworth and Co.) 6*s*. net.

Mining Physics and Chemistry. By J. W. Whitaker. Pp. xii+268. (London: E. Arnold and Co.) 9*s*. net.

The Mechanism of Life in Relation to Modern Physical Theory. By Prof. J. Johnstone. Pp. xii+248. (London: E. Arnold and Co.) 15*s*. net.

Chemical Disinfection and Sterilization. By Dr. S. Rideal and Dr. E. K. Rideal. Pp. vii+313. (London: E. Arnold and Co.) 21*s*. net.

A Manual of Pharmacology. By Prof. W. E. Dixon. Fifth edition, completely revised. Pp. xii+468. (London: E. Arnold and Co.) 18*s*. net.

Western Australia: Geological Survey. Bulletin No. 78. The Mining Geology of Kookynie, Niagara, and Tampa, North Coolgardie Goldfield. By J. T. Jutson. With Petrology, by R. A. Farquharson. Pp. 98+5 plates. (Perth, W.A.)

A Critical Revision of the Genus Eucalyptus. By J. H. Maiden. Vol. 5, part 7. (Part 47 of the complete work.) Pp. iv+187–223+4 plates. (Sydney: W. A. Gullick.) 3*s*. 6*d*.

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