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The British Empire Campaign against Leprosy.

IN our issue of October 20, p. 591, we published an article on the leprosy problem, describing the recent improvements in the treatment of the disease, and announcing the formation of the British Empire Leprosy Relief Association, with the direct object of applying the new knowledge to the difficult task of reducing, and eventually eradicating, leprosy from our possessions. A public appeal was made at the Mansion House on January 31 for 250,000*l.* for the campaign, and further information was then given regarding the proposed lines of work. Additional favourable reports of the new treatment have been received, among which is a trial in 4067 cases under American physicians at the Cullion Leper settlement of the Philippines, with great improvement in 74 per cent. of the cases treated for from six to nine months and no less than 93 per cent. after twelve to fifteen months' treatment, including a number in which all signs of the disease and its bacilli had disappeared, while in the Federated Malay States Dr. Travers has cleared up a sufficient number of lepers to furnish a complete staff for his institution.

There is no doubt, therefore, that a great advance has been made in dealing with this hitherto very intractable disease, and numerous cures, in the practical sense of removal of all symptoms and infectivity of the disease, with restoration to health and working powers, have been obtained. On the other hand, in some leper asylums, most of the inmates of which are advanced cases, the medical staffs are not convinced that any definite cures have been obtained, and they point to the impossibility of being certain that recurrence will not take place, as in tubercle. This is a scientific position with which even those who have reported good results are in agreement, although a few of the first-treated Calcutta cases have now remained well for six to eight years. The Medical Committee of the new Association, with Sir John Rose Bradford as chairman and members with long experience in the great leprous countries of Africa, India, and China, is, however, convinced that the time has come to carry out the unanimous recommendation of the Strasbourg International Congress of last July, that the best available treatment ought to be supplied to all lepers segregated for the benefit of others. Unfortunately, India and a number of African and other British colonies are too poor to do this without assistance: hence the appeal.

The Association will work so far as possible through existing agencies, and its activities will include the establishment of clinics at hospitals in endemic areas on the lines of Dr. E. Muir's clinic at the Calcutta School of Tropical Medicine, which is attracting large numbers of

early, and much more amenable, cases. The clearing up of the symptoms and infectivity of such cases will do more towards stamping out foci of infection in households before another generation has become infected than any segregation policy of advanced cases after they have infected others, and so will enable a more rapid reduction of the disease than has hitherto been possible. In many parts of the world such improved treatment has already produced the very practical result of inducing lepers to come for it early, instead of hiding their complaint as long as possible. Where the number of lepers is not too great to allow of the complete segregation of the infective cases, that method is advocated, combined with efficient treatment; the West Indies, and some other colonies, being very suitable for a demonstration of the possibility of practically stamping out leprosy within two or three decades with the aid of our present knowledge.

As the treatment of a large number of cases in the Philippines and in Calcutta has shown that considerable experience and minute attention to the details of the new methods are essential to full success, the Association also proposes to train leper staffs at such centres as Calcutta. With the same object, the best drugs, details regarding their administration, and abstracts of the latest literature, will be distributed, to enable trials and also research work to be co-ordinated throughout the Empire. One of the primary objects of the Association is to encourage research in the epidemiology of the disease, and to improve still further the treatment; for now that it has been demonstrated that a number of oils furnish soluble compounds of unsaturated fatty acids of great value in the treatment of leprosy, while chemists can synthesise a very great number of compounds of these substances, an enormous field of research has been opened up. This is already occupying investigators in at least three continents, and there is every reason to expect that research will in time lead to the discovery of still more rapidly curative products against leprosy, and, what is even more important, against the closely allied tuberculosis itself.

In adopting such a comprehensive programme the committees of the Association are fully alive to the difficulties of the task before them, as they estimate the minimum number of lepers in the British Empire at 300,000, while including early little-recognised cases it may be much higher. It is hoped, however, that their arduous and humanitarian Empire campaign will call forth as much sympathy and support in 1924 as was rightly accorded last year to our ally, Japan, on the destruction of her cities by earthquake. In 1889 the death of Father Damien from leprosy, after years of devoted work in the Hawaii leper settlement, thrilled the civilised world, and led to the formation of a committee in London under the chairmanship of King Edward VII. when Prince of Wales. This resulted in sending out the Indian Leprosy Commission and the multiplication of leper asylums under Indian and Colonial Governments and by the Mission to Lepers, which have done a great humanitarian work in relieving many helpless lepers, although until quite recently it was impossible to hold out to them any hope of recovery.

At length a new epoch has arrived, and, although we are still very far from possessing a certain cure for anything like all advanced cases, for the first time in the three-thousand-year-old struggle against the foulest of human diseases, it is practicable to attract the earlier and more curable cases, using that word in the practical sense of restoring them to health and usefulness, and thus to enhance greatly the prospects of at length reducing the incidence of the disease. It is safe to say, however, that, for want of funds, not 5 per cent. of the lepers in the British Empire are receiving the benefit of recent scientific advances, although our American cousins are already providing it for nearly all their known lepers in the United States, and in the Philippine and Hawaii possessions. It is hoped that the new Association will be provided with the means to remove this reproach to the fair name of Great Britain.

Michael Pupin.

From Immigrant to Inventor. By Prof. Michael Pupin. Pp. vii + 396 + 16 plates. (New York and London: Charles Scribner's Sons, 1923.) 18*s*.

THIS autobiography of Michael Pupin is of great human interest, and well deserves study by educationists. It gives one the impression of a boy of strong physique and sound common sense who made his way through the world with little fear of the future and with a profound reverence for the past. It will be read with special interest by those who knew Cambridge in 1884–85 and Berlin in 1885–86, when Hertz's discoveries first began to be discussed. It will also be of interest to those who know the Isle of Arran in the Firth of Clyde, as this island and its inhabitants made a great impression on one who as a boy had herded cattle at Idvor, a small village in Serbia. The main object of the book, as the author says in chapter xi., is to describe "the rise of idealism in American science," but from the point of view of dwellers on the east side of the Atlantic, this question is not of such interest as the story of his early life.

The author is the professor of electro-mechanics at Columbia University, New York, and is well known to every telephone engineer in connexion with his work

on long-distance telephony, and to electricians for his experimental method of analysing alternating electric currents into their harmonics. In long-distance telephony it is essential that the wave form of the current through the telephone be at least roughly similar to the wave form of the current through the microphone, otherwise the noise it excites in the telephone will be unintelligible. The wave form of the current at the sending end of a long telephone circuit can be imagined as made up of its harmonics. As these have different frequencies, they travel with different speeds and their amplitudes diminish according to different laws. We therefore see that in a long telephone line considerable distortion will generally be produced in the wave shape of the current. When the line is long the sounds heard in the telephone have little resemblance to the speech into the receiver.

Heaviside first gave the true theory of the current transmission. He showed that if the product of the capacity and resistance per mile is numerically equal to the product of the inductance and leakage per mile, a complex wave is transmitted without distortion. He also pointed out that if the inductance per unit length in actual cables is increased their performance is greatly improved. The way, however, in which Heaviside presented the subject made it practically unintelligible to the telephone engineers at the end of last century; and as he did not go into details, much of his work was neglected.

In 1899 and 1900 Pupin published two very important papers in the Transactions of the American Institute of Electrical Engineers. He proved that a non-uniform cable with suitable inductance coils inserted at intervals would work practically as well as one of uniform high inductance per unit length; in other words, that it would work as well as a uniformly loaded cable provided that the wave-length of the electrical disturbance extended over about ten coils. In long-distance telephony "Pupin coils" are inserted at distances small in comparison with the wave-length of the average wave, and a very great improvement in the quality of the speech transmitted is the result. We find them, for example, in one of the Paris-London telephone cables. Indeed, they are used in practically every country in the world.

It is sometimes said that the use of the vacuum tube thermionic type of repeater will make all other methods obsolete. In our opinion, however, this is not the case. Repeaters can only be used when the line is very accurately balanced. A much higher grade of plant maintenance is necessary. The requisite continual testing and adjusting are much more expensive. It is probable that, in many cases, Pupin coils will be the more economical for many years to come. Civilised nations all over the world have reaped the benefit of this invention, as it has enormously diminished the cost of long-distance telephony.

Pupin's story is both interesting and instructive. He writes with an entire absence of self-consciousness, and, in the light of his later knowledge, draws important conclusions from his experiences of people in many countries. He was born at Idvor in Serbia some sixty-five years ago. Although from our point of view the Serbian peasantry were badly educated, for many of them could neither read nor write, yet they had retentive memories. Several of them knew most of the Bible by heart, and they all knew the vast store of the early traditions of their race, much of it in ballad form. They would not be prepared to admit that any one ignorant of their history and traditions and their local knowledge could be in any way superior to themselves. Pupin's father was a small farmer who was head man of the village, yet the author states that neither his father nor his mother could read or write. His father told him that thunder was the rumbling of Elijah's chariot as he drove across the heavens, and he was very angry with Pupin for telling him of Franklin's experiment.

When Pupin was a boy, Idvor belonged to the so-called military frontier of Austria. The Serbs enjoyed complete autonomy so long as they helped to repel Turkish raids. During the long winter evenings the inhabitants of Idvor would have meetings in one another's houses. The old men would tell vivid stories of their experiences in battle, and the old women would turn their spinning-wheels. There would be songs by the young women, and an old man would often recite the ballads of their race.

As a herd-boy Pupin located the position of the cattle at night, in the Serbian way, by sticking his knife into the ground and pressing his ear against the handle. At the early age of fifteen, he crossed the Atlantic in one of its most stormy moods in the crowded steerage of an immigrant ship. As he had not enough money to pay for a blanket and mattress, he would have died of cold had it not been for the warm smoke-stack. He landed in New York having no knowledge of English, and with only five cents in his pocket, which his appetite compelled him to spend immediately. He got employment as a farm hand, but drifted into casual employment, carrying coal into cellars and shovelling snow from side-walks. Later, he served as an assistant to an engineer in a biscuit factory, and when he was promoted to be a clerk, he felt "as people in England probably feel when a peerage is conferred on them." Luckily he came across an old employee engaged in the humblest work in the factory but yet an excellent classical scholar. From him he received a good foundation in

classics, which later on enabled him to secure entrance, with free tuition, to Columbia College, New York. His board and lodging were partially paid by sawing and splitting kindling wood for his landlady. Incidentally, this exercise greatly increased his physical strength and enabled him to gain several important athletic victories when at college. In 1883 he graduated at Columbia University and became a naturalised American.

Pupin's enthusiasm for science next led him to England, where he wanted to study under Clerk Maxwell. He had a letter of introduction to W. D. Niven, of Trinity College, Cambridge, who was the first to inform him that Clerk Maxwell had been dead for four years. Although he had no Tripos aspirations he went to Routh's mathematical classes, and found him a splendid drill-master. After eighteen months he went back to Idvor; in conversation with his mother, she told him that "Cambridge is a great temple consecrated to the *eternal truth*: it is filled with the icons of the great saints of science."

On his return to Cambridge he learned that J. J. Thomson was to succeed Lord Rayleigh as director of the Cavendish Laboratory. As he was ashamed to show his ignorance of experimental work to a professor of practically his own age, he determined to go to Germany. Before going to Berlin he stayed at Corrie in the island of Arran in the Firth of Clyde. He looked on enthusiastically at the Highland dancing in the hotel, and he tells us how he practised the steps of the Highland Fling in Glen Sannox. He lived for some weeks in a cottage on the slopes of Goat Fell, where he read Faraday's "Experimental Researches." Afterwards, when he mentions Faraday in this book, he generally refers to Corrie as well. He seems to have recognised that there was much in common between the Highland peasants of Arran and the Serbian peasantry of Idvor.

Pupin spent a happy time in Berlin under Helmholtz, Kirchhoff, and Koenig, and then returned to America to a post at Columbia College. During the War, he took a leading part in establishing the American National Research Council, which has done so much to stimulate enthusiasm for scientific research in the American colleges and universities. He gives credit also to Tyndall, who went to America fifty years ago and did invaluable work in starting the great movement for scientific research which has led to the establishment of large and flourishing research laboratories in almost every State of the Republic.

To men of science, engineers, and educationists this book will prove of interest. It will be particularly interesting to those who, like the writer, were fellow-students of the author at Cambridge.

ALEXANDER RUSSELL.

Industrial Medicine.

Industrial Hygiene and Medicine. By Dr. E. W. Hope, in collaboration with Dr. W. Hanna and Dr. C. O. Stallybrass. Pp. viii + 766. (London: Baillière, Tindall and Cox, 1923.) 21*s.* net.

THE authors of this work have covered in a single volume the whole field of industrial life from the medical point of view—its physiology, general and special pathology, therapeutics. They "hope that they have met the needs of the increasing body of persons, medical or other, interested in the subject of Industrial Hygiene."

It is of course inevitable that a work covering so wide a field should contain a large proportion of material acquired at second-hand; it would be unjust to expect it to conform to the standards imposed upon first-hand contributions to knowledge. The desiderata of a good text-book are clearness and accuracy of statement, with precise references to the original sources of information. The language of this book is clear, but the other desirable qualities are less conspicuous. The authors do not always indicate where they have obtained their information. At the conclusion of each chapter a detailed bibliography is indeed provided, but the method of compilation is open to criticism. On p. 44 bibliographical reference is made to a Report to the Industrial Fatigue Board on Standard Sickness Tables by Mr. E. A. Rusher, though no such report has ever been published. The substance of Mr. Rusher's researches was communicated by him to the Royal Statistical Society and printed in its Journal (Journal Roy. Stat. Soc., lxxxv, 1922, 27). Curiously enough the same mistake occurs in Collis and Greenwood's treatise published in 1921.

The accuracy of the information given is also not invariably above suspicion. Thus, in speaking of the sex incidence of tuberculosis, the authors say that "this excess of male mortality is almost entirely absent in rural districts, but is strongly marked in London and the County Boroughs." Reference to the annual reports of the Registrar-General shows that, although the excess of male mortality is much greater in urban than in rural districts, it is very large even in rural districts in later adult life, amounting to an excess of 36 per cent. at 40-45, 56 per cent. at 45-50, 42 per cent. at 50-55, and 83 per cent. at 55-60, in the year 1911. In the last pre-War year, 1913, the percentage excesses in these age groups were 36, 56, 64, and 92. In referring to the increase of the rate of tuberculosis upon women during the War, the authors say that "the rise was particularly marked in the large towns especially affected by the influx of women into the War industries,

but did not affect certain non-industrial towns at all." No authority is cited for this statement; if, as seems possible, it is based upon the work of Greenwood and Tebb, it should be remarked that these authors did not and could not use rates of mortality but proportional mortality figures; and they were unable to make any allowance for interlocal differences of age constitution.

The authors have also failed to refer to the fact that a disproportionately large share of the Wartime increase of mortality from tuberculosis was attributable to deaths in institutions which possibly, or even probably, were especially affected by food restrictions. This matter of institutional mortality has been particularly referred to in the reports of the Registrar-General (see, for example, the report for 1919, p. lxxvi) but was not mentioned in Collis and Greenwood's treatise. The authors assert that the view that small repeated infections in childhood set up an active immunity has been "mainly advocated by German and American authors." No reference is made to the teaching of Calmette.

As clear evidence of the importance of environment, rates of mortality before and after re-housing operations in Liverpool are quoted. No statement is made as to whether these rates are crude or age standardised, as to what was the number of persons exposed to risk, or as to the locus of original publication. In the short chapter on vital statistics of occupation, space is wasted on uninforming references to foreign statistical systems. It is idle to tell the student that "the registration of deaths is well carried out in Germany, Switzerland, and Holland"—it is well carried out in several other continental countries—and otiose to say that "it is highly desirable that some international uniformity should be attained." It is equally futile to say that "errors will be exaggerated if the available numbers on which the computation is based are insufficient." The student needs clearer guidance than this. The book contains other examples of stating the obvious and omitting what is less obvious but important. Thus no medical or other civilised reader needs to be told that "every convenience for the use of females must be partitioned off and be provided with a proper door." The male reader ought to be—but is not—told that unless in such conveniences a suitable receptacle for sanitary towels is provided, much unnecessary blocking of drains will occur.

Fault finding is an ungracious task, and it is pleasant to be able to say that the chapters on occupational affections of the skin and special senses, on miscellaneous occupations in relation to health (especially the section on the mercantile marine), and on industrial physiology, appear to the reviewer to be more carefully written than the other sections. The chapter on industrial physiology brings together results which have not yet figured in other text-books.

Many years ago Matthew Arnold commented unfavourably on the way in which the journeyman work of literature was done in Great Britain. Text-book writing is of this class, and Dr. Hope and his collaborators have not risen much above the low general level of merit. The student who desires to satisfy a board of examiners will certainly find this book a good investment; its perfunctory treatment of some great writers—illustrated on the very first page by a misprint in the title of Ramazzini's pioneer work—and avoidance of the hard task of expressing considered opinions on difficult or disputable propositions will detract from the enjoyment of a more serious reader. M. G.

The Fauna and Flora of South Australia.

(1) *The Mammals of South Australia.* By Dr. F. Wood Jones. Part 1: Containing the Monotremes and the Carnivorous Marsupials (The Ornithodelphia and the didactylous Didelphia). Pp. 131. 4*s*.

(2) *The Fishes of South Australia.* By Edgar R. Waite. Pp. 243. 6*s*.

(Handbooks of the Flora and Fauna of South Australia, issued by the British Science Guild, South Australian Branch.) (Adelaide: R. E. E. Rogers, 1923.)

IT is not necessary to insist on the interest and extreme importance to the biologist of the fauna and flora of the Australian continent. It is perhaps well to reiterate the oft-repeated warning that this fauna and flora are in great danger of rapid extinction. For these two reasons the South Australian Branch of the British Science Guild is to be warmly commended for its enterprise in arranging for a series of handbooks descriptive of the animals and plants of South Australia. Realising the lack of inexpensive and authoritative works on the biology of Australia, which it rightly supposes is a severe handicap to the progress of science in that continent, and the need for a wider diffusion of accurate knowledge of this interesting and primitive biological community, the Guild has rallied to its aid the services of an enthusiastic body of South Australian biologists, who, between them, have planned this series of handbooks. The Government of South Australia has come to its assistance by undertaking the printing and publication. For this enlightened and broad-minded policy it deserves and will receive the thanks, not only of the public of Australia, but also of scientific men the world over.

(1) Dr. Wood Jones's account of the monotremes and carnivorous marsupials is a model of what a popular handbook should be. Excellently and clearly written,

illustrated by nearly one hundred beautifully clear line drawings—specially prepared for this work, we take it—by the author, and admirably reproduced, it is full of authoritative information on the structure, classification, and habits of these interesting mammals. It is prefaced by a brief account of those characters of the mammalia which are of importance in classification, a general definition of scientific terms, and explicit instructions for making records and measurements of specimens. The classification of the mammalia, definitions of the subclasses, and accounts of the families, genera, and species follow in turn, and concise keys to these are provided in every case, while the author does a great service by including the native and common names of all the mammals. His chapters on the distribution and past history of the Didelphia, the place of the Didelphia in the mammalian phylum, and the special problems of the mammalian fauna of Australia will be specially welcome as the considered opinion of an expert. We hope that Dr. Wood Jones's departure from Adelaide will not interfere with or even delay the publication of the second part of his handbook.

(2) Mr. Waite's handbook on the fishes is practically a reissue, in more popular form, of his admirable "Catalogue of the Fishes of South Australia," published in 1921, and as such, therefore, requires no special mention here except to say that its reissue in this form enhances its utility for the general public and provides a worthy companion to Dr. Wood Jones's handbook. The illustrations have been beautifully prepared and admirably reproduced.

The British Science Guild, the authors, and the Government of South Australia are to be congratulated on the inauguration of this excellent series of handbooks. It is to be hoped that nothing will interfere with the early completion of this valuable and greatly needed work.

A Tribute to Prof. Schreinemakers.

Recueil des travaux chimiques des Pays-Bas. Feestbundel aangeboden aan F. A. H. Schreinemakers ter herdenking van den dag, waarop hem voor 25 Jahren het Doctoraat honoris causa werd verleend (7 Juli, 1898–1923). Pp. 535-858+iv. (Leyde, Holland: A. W. Sijthoff, 1923.) 8*s*. 3*d*.

ON July 7, 1898, the degree of doctor *honoris causa* was conferred on Prof. F. A. H. Schreinemakers by the University of Leyden. In recognition of the splendid work carried out by Prof. Schreinemakers in the field of heterogeneous equilibria, wherein he has carried on and greatly developed and extended the work initiated by van't Hoff and Roozeboom, his former pupils and friends and other men of science presented him on July 7, 1923 (the twenty-fifth anniversary of his attaining the doctorate *honoris causa*) with a special commemorative volume containing a large number of scientific papers. This volume consists of Nos. 7 and 8 of volume 42 (or volume 4, 4th series) of the *Recueil des travaux chimiques des Pays-Bas*. The editor, Dr. W. P. Jorissen, is to be very warmly commended for having published this "Festschrift" as an integral and current part of a well-known scientific journal, and not as a separate, and to many scientific workers somewhat inaccessible, volume.

It is a significant token of the esteem in which Prof. Schreinemakers is held by his pupils and colleagues and by the scientific world in general, that the memorial volume contains 63 scientific papers and includes 324 pages of reading matter. Since these papers are published in the current volume of a scientific journal, it will be unnecessary to enumerate them in detail. Naturally a considerable number of them deal with investigations in the field of heterogeneous equilibria, whilst the majority of them have a more or less close relation to this subject. The range of topics dealt with is so great that it will be possible to refer only to a few.

Prof. Kamerlingh Onnes deals with the equilibrium between the liquid and gaseous phases of helium at low pressures, and shows that there exists a maximum in the heat of evaporation of the liquid. The velocity of saponification of fats by hot aqueous solutions in relation to the theory of adsorption at the interface liquid fat-aqueous solution is dealt with in an interesting manner by J. P. Treub. P. W. Bridgman communicates a paper on the compressibility of hydrogen gas at very high pressures, in which he shows that the molecules themselves suffer compression. The kinetic theory of the osmotic pressures of solutions of strong electrolytes is treated by P. Debye. W. Reinders and A. W. Vervloet deal with the equilibria between tungsten and its oxides in presence of steam and hydrogen. The measurement of the viscosity and surface tension of viscous liquids at high temperatures is dealt with by E. W. Washburn. There is an interesting paper by P. Ehrenfest on the equilibrium between volume phases and "two-dimensional" phases regarded as unimolecular adsorption layers. A. H. W. Aten deals with the electrolytic separation of metallic alloys. The concepts of acid and base are discussed from a very interesting and novel point of view by J. N. Brönsted. These examples will suffice to show the wide range of subjects dealt with by the contributors to this volume.

We offer Prof. Schreinemakers our very warm congratulations on the high and well-deserved honour which has been paid to him, and we wish him many years of health and happiness.

Our Bookshelf.

Alloys Resistant to Corrosion: a General Discussion held jointly by the Faraday Society and the Sheffield section of the Institute of Metals, April, 1923. Pp. 153-230. (London: The Faraday Society, 1923.) 5*s.* 6*d.* net.

THE demands of various industries for metals presenting a higher resistance to corrosion than the steels and non-ferrous alloys in general use have led to the introduction of a number of new alloys within a few years, and this collection of papers communicated to the Faraday Society gives interesting information as to the character and composition of those that have proved of value. The importance of the two metals nickel and chromium in this branch of metallurgy is very striking. One or the other is present in nearly all the alloys mentioned as being highly resistant to corrosion, whilst alloys containing high percentages of both metals, such as nichrome, are amongst the most resistant of all, not only at ordinary temperatures, but also in contact with oxidising gases at high temperatures. The so-called stainless steels contain chromium as the alloying element, whilst the further addition of nickel has resulted in the production of new steels of high quality, at present too costly for most commercial purposes. The ternary system iron-nickel-chromium is surveyed in one of the papers in this volume, and it would seem that a wide range of useful compositions is to be found within the limits of that system, although there has been little methodical investigation of the alloys as a whole. Monel metal is an example of the non-ferrous alloys that may be used where there is likelihood of corrosion, and it may be noticed on reading these papers that attempts have been made, with some success, to increase the resistance of the ordinary nickel silver by adding small quantities of tin. The theory of corrosion is in a backward condition, and the new alloys have been arrived at by a process of trial and error, theory giving at present little guidance. A paper on the corrosion of metals under comparatively dry conditions, by Mr. U. R. Evans, is the most scientific of those contributed to the discussion, the remainder being essentially records of observations, and including valuable results of workshop experience.

Les nouvelles conceptions de la matière et de l'atome. Par Prof. A. Berthoud. (Encyclopédie Scientifique: Bibliothèque d'histoire et de philosophie des sciences.) Pp. v+314. (Paris: Gaston Doin, 1923.) 13·20 francs; paper, 12 francs.

THIS book should form an excellent introduction to the modern theory of the structure of the atom, and can be confidently recommended for this purpose. The development of atomic theory is traced from its origin in chemical theories up to the point at which the various unsuccessful atomic models, with electrons in coplanar rings, became current, shortly after Bohr's successful model of the hydrogen atom. This is an early stage at which to stop in view of the date of publication. The author does not include the more recent developments in the detailed electronic structure, which have carried atomic theory successfully a long stage further. But the book is not the less valuable. The reader will naturally not turn to such a book for the very latest developments. The whole subject matter is chosen with judgment, and the various lines of investigation—electromagnetic theory, relativity, radio-activity, isotopes, X-rays, α-particles, and atomic numbers—which have led up to modern views are shown in their proper perspective. The book ends with a good survey of recent structural speculations on the chemical side, and keeps in view throughout the essential unity of chemistry and physics.

Chambers's Encyclopædia: a Dictionary of Universal Knowledge. New edition. Edited by Dr. David Patrick and William Geddie. Vol. 3: Catarrh to Diophantus. Pp. iv+836. (London and Edinburgh: W. and R. Chambers, Ltd.; Philadelphia: J. B. Lippincott Co., 1923.) 20*s.* net.

THE general usefulness of this work of reference is fully maintained in the third volume. Numerous short articles, instead of long sub-divided articles, make it an encyclopædia to which reference is quick and easy. The searcher can find the facts he wants with a minimum expenditure of time and trouble. Many of the old articles have been retained in a revised form, but a number of new ones have been added and others rewritten. There are new coloured maps of China, Czechoslovakia, and Denmark, and a number of useful woodcuts and diagrams. The advantage of having a complete but concise encyclopædia in one alphabet should make this work most useful to student, worker, and teacher. The paper is thin but opaque, and the type is large enough for easy reading.

Life of the Wayside and Woodland: When, Where, and What to Observe and Collect. (The Wayside and Woodland Series.) By T. A. Coward. Pp. viii+216 +111 plates. (London and New York: F. Warne and Co. Ltd., 1923.) 10*s.* 6*d.* net.

THE sub-title of this book indicates accurately its scope. The round of the year is divided into six bi-monthly periods, January and February—November and December; and in each such period paragraphs are allotted to the mammals, birds, reptiles, and other animals, both vertebrate and invertebrate, and also to the plants, both flowering and otherwise, that are then likely to come under observation. The illustrations, whether coloured or black-and-white, are excellent, being the work of some of the most expert nature-photographers. As a practical popular guide to the plant and animal life of the countryside, the book can be highly commended.

Van Nostrand's Chemical Annual: a Hand-Book of Useful Data for Analytical, Manufacturing, and Investigating Chemists, Chemical Engineers, and Students. Edited by Prof. John C. Olsen. Fifth issue, 1922, thoroughly revised and enlarged. Pp. xxii+900. (London, Bombay and Sydney: Constable and Co., Ltd., 1923.) n.p.

THESE tables contain much useful data, some of which are not to be found in chemical reference books of the same size. Some of the technical data refer to American practice, but for this reason will also be useful to British readers who consult American literature.

Letters to the Editor.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, nor to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

A Comparison of Whitehead's and Einstein's Formulæ.

In Whitehead's theory of gravitation, as in Einstein's, the tracks of particles in a gravitational field are determined by the condition that a certain integral taken along the track is stationary. The integrand is denoted by dJ in Whitehead's theory and ds in Einstein's. Light-tracks are further conditioned by dJ or ds, respectively, being zero. Since both theories are known to give the observed results for the perihelion of Mercury and the deflexion of light, dJ cannot be widely different from ds in the field of a single particle (the sun); but I do not think it has hitherto been noticed that dJ is *exactly* equal to ds.

For a particle at rest at the origin the most familiar form of ds is that given by Schwarzschild,

$$ds^2 = -(1-2m/r)^{-1}dr^2 - r^2d\theta^2 - r^2\sin^2\theta d\phi^2 + (1-2m/r)dt_1^2, \quad . \quad (1)$$

where Schwarzschild's co-ordinate is denoted by t_1 to distinguish it from Whitehead's "time." If in (1) we introduce a new co-ordinate t, given by

$$t = t_1 - 2m\log(r-m), \quad . \quad . \quad . \quad (2)$$

the expression reduces to

$$ds^2 = (-dr^2 - r^2d\theta^2 - r^2\sin^2\theta d\phi^2 + dt^2) - (2m/r)(dt-dr)^2. \quad . \quad (3)$$

By setting $ds = o$ in (3) it is found that for the co-ordinates (r, t) the outward velocity of light in a radial direction is unity; the inward velocity depends on r.

Corresponding to the element $(dr, d\theta, d\phi, dt)$ there is a "causally correlated" element of the world-line of the attracting particle—*i.e.* disturbances propagated with unit velocity from the two ends of the latter element reach respectively the two ends of the former. The components of the causally correlated element are easily seen to be $(o, o, o, dt-dr)$. Whitehead denotes the *Euclidean* lengths of the two elements by $d\mathrm{G_M}$ and $d\mathrm{G}_m$, and the potential (propagated with unit velocity in Euclidean space) due to a simple source m on the latter element by ψ_m. Accordingly (3) can be written

$$ds^2 = d\mathrm{G_M}^2 - 2\psi_m d\mathrm{G}_m^2,$$

which is precisely Whitehead's expression for dJ^2 ("Principle of Relativity," p. 81, (13)).

Since then $dJ = ds$ the tracks of planets and of light are the same in Whitehead's theory as in Einstein's. Divergences can only arise in problems involving the exact metrical interpretation of the symbols—*e.g.* the shift of spectral lines. In Einstein's theory the time as measured by a clock is ds, and neither dt_1 nor dt have any fundamental metrical equivalent; in Whitehead's theory dt is pre-eminently the "time," but I must leave to adherents of his theory the elucidation of what this implies. It may be remarked that Schwarzschild's t_1 corresponds to a synchronisation of time, at different parts of the solar system, by the condition that the outward velocity of light is equal to the inward velocity; Whitehead's t corresponds to a synchronisation by the condition that the outward (but not the inward) velocity is constant throughout the system. The formulæ for dJ and ds no longer agree perfectly if more than one attracting particle is considered, because Whitehead calculates the resulting field by simple superposition, whereas Einstein's formulæ are non-linear.

A. S. Eddington.

Observatory, Cambridge,
January 20.

The Mass-spectrum of Indium.

Since the last report on the results of the mass-spectrograph (Nature, September 22) the work with that instrument has been very disappointing. Owing partly to the capricious behaviour of the apparatus for producing accelerated anode rays, with consequent difficulties in obtaining intense beams, and partly, no doubt, to the unfavourable properties of the elements remaining to be analysed, the only success worth recording is in the case of the element indium (At. No. 49, At. Wt. 114·8).

The mass rays of indium were obtained from an anode containing the fluoride which had been prepared from a sample of the metal kindly supplied to me by Prof. Richards of Harvard. The mass-spectrum of the element shows one line only at 115. This measured against I^{127} and Cs^{133} shows no deviation from the whole number rule. Its intensity was not sufficient to rule out the possibility of a small percentage of a second isotope, but in the absence of any evidence on this point indium is best regarded as a simple element of mass number 115 as predicted by Russell (Nature, October 20, p. 588).

F. W. Aston.

Cavendish Laboratory,
Cambridge, January 23.

The Continuous Spectrum of Hydrogen.

In the last few months we have been engaged in observations of electron discharges in hydrogen which appear to supplement those described by Prof. Harvey B. Lemon in Nature of January 26. The region investigated by us is that of lower values of voltage, discharge current and gas pressure, our upper limits being 60 volts, 10 milliamperes, and 0·8 mm. of mercury respectively. Our source of electrons consisted of a filament either of tungsten or of baryta-coated platinum about 2 cm. from a flat circular nickel anode of 2·5 cm. diameter provided with a central rectangular slit, the whole being suitably enclosed in an evacuated transparent quartz tube.

Over the whole of this range except at the lowest pressures there are two well-marked stable types of luminous discharge. The low voltage type sets in at a voltage which increases with increasing pressure and varies between about 20 to 35 volts and is accompanied by a very sharp and extensive increase in the discharge current passing through the tube. The luminosity present in this discharge consists of a bell-shaped blue glow of great intensity with an extremely sharp boundary and is located on the side of the anode towards the cathode. We have not been able to ascertain with certainty that there is any luminosity in any other part of the discharge at this stage. Most of the energy of this radiation consists of the continuous spectrum extending into the extreme ultra-violet as described by Lemon, but the Balmer lines and some secondary spectrum lines are also discernible. We have evidence that as the temperature of the filaments is increased and the gas pressure is reduced, the striking voltage for this discharge tends to a limit which is very close to the ionisation potential of hydrogen (15·9 volts, $H_2 \rightarrow H + H_+ + e$).

The current carried by the discharge described

above usually decreases with increasing voltage; at the same time the luminous bell becomes larger and ultimately splits off from the anode into one or more striæ. On increasing the voltage further, there is another sudden increase in the discharge current, and the luminosity shifts to the cathode, round which it forms a very fuzzy halo. The spectrum of this consists mainly of Balmer's series down to ι, but the secondary spectrum is also well marked. At the higher voltages (50-60) there is no trace of the continuous spectrum in this glow. That present in the spectrograms of this discharge at the lower voltages may be due to stray light from other parts of the discharge. This type of discharge is stable and characterised by a falling current with rising voltage.

Provided the cathode is sufficiently hot there is a third type of stable discharge at the lowest pressures (0·05-0·1 mm.) on a range of voltage higher than either of the preceding. This is characterised by a glow filling the whole volume of the bulb, and its spectrum consists of a large number of lines with the continuous spectrum almost absent.

We have also made a few experiments with a gauze at the same potential as the anode plate a few millimetres in front of the hot cathode. With this arrangement, provided the pressure is not too low, a feebly luminous discharge sets in at 23 volts. This is very close to the potential attributed by Horton and Davies (*Phil. Mag.* November 1923, vol. 46, p. 895) to the ionisation of molecular hydrogen ($H_2 \rightarrow H_2^+ + e$).

We hope to publish a more complete account of these experiments elsewhere.

O. W. RICHARDSON.
T. TANAKA.

King's College, London.
January 29.

Problems of Hydrone and Water.

CLERK MAXWELL used to say that it was a sign of progress when we began to overhaul the foundations of our science and return to the very beginnings. Prof. Armstrong is calling upon us to do this in electricity. All I want to suggest to him at present is that he is rather over-emphasising the rôle of electrolysis and conduction generally, and not recognising the full value of electric *displacement*, so much emphasised by Faraday and Maxwell. Conduction necessarily involves some dissipation of energy, something analogous to friction; it does not store energy, and it gives no recoil. A pure dielectric dissipates no energy, and it recoils perfectly. A dielectric slab brought near a charged body becomes polarised, positive on one face, negative on the other: there has been a displacement of electricity through it, but not by conduction. It may even be worth while to ask Prof. Armstrong to refer back to an ancient paper of mine in the *Phil. Mag.* for November 1876, in which I design models to illustrate Maxwell's theory. This paper, I was delighted to find, pleased Clerk Maxwell sufficiently to induce him to write me a most interesting letter about it—humorously suggesting, I recollect, lubrication with Canada balsam as suitable for § 10 of that paper,—a letter which, to my long-standing regret, has suffered from "moving accidents" and got itself lost. If the elastically supported buttons or beads on the cord of that model slip on the cord, there is conduction; but if they grip it tight, they represent a dielectric.

As to the meaning of electric charge, it was one of the complaints of the late Prof. Cornu that after a perusal of Maxwell he rose quite uncertain as to what an electric charge was. Since his day we had hoped that the discovery of the electron supplemented in a useful manner the necessarily vaguer views of old time; but far be it from me to say that we have nothing still to learn about the frictional machine. To separate the charges—to increase their distance apart—we do require something more than displacement; we require a transfer, and that does involve either conduction or convection, or both. It is familiar knowledge that the rubber must be connected to the ground if a charge is to be continuously and freely drawn from the prime conductor. The machine generates a current. But surely neither impurities nor aquosity need be pressed into the service in this case! If Prof. Armstrong can show experimentally that nothing else will serve, and that the inefficiency of a "dry" machine can be remedied by no other conductor than water, then that would be a fact worthy of consideration. But I am quite sure that a dry electroscope will behave as usual.

For contact E.M.F. generally, even as powerfully displayed in the frictional machine, I am all for the chemical strain (not chemical action or combination) theory; and Armstrong's residual chemical affinity is one mode of expressing that, and is useful in cohesion too; though, there, magnetic as well as electric attraction has to be taken into account.

OLIVER LODGE.

January 26.

Earthworms and the Cluster Fly.

IN his little book on earthworms and their allies (1912), Beddard expresses the opinion that the northern regions of America possess no indigenous earthworms. This refers to large areas in Canada and the Northern United States. In the mountainous district of Colorado, and the adjacent upland plains, it appears that earthworms were formerly absent. Old settlers assure us that when they first came there were none. This seemed almost incredible, but in recent years Prof. Frank Smith of the University of Illinois has collected earthworms in Colorado, and found only the widespread presumably introduced types. There are indeed a few small native oligochætes in the mountains, but these (Enchytræids) are not pertinent to the present discussion. Beddard infers that the earthworms came from the south, but the Lumbricidæ are evidently of long standing in the Palæarctic region, and as one species (*Eisenia nordenskioldi*) extends to the Anadyr region in the extreme north-east of Siberia, it is surprising that we find no endemic genera or species in the far north of America. In the more southern parts of North America, apparently including all of the Eastern United States, there is a rather scanty indigenous fauna of Lumbricidæ. These American species are so closely allied to those of the Palæarctic region as to leave no doubt that they are derived from a common source, and we may reasonably assume that their ancestors came by way of Eastern Asia. Thus the present distribution corresponds in a general way with that of certain groups of plants and other organisms which have evidently died out in a large part of North America.

The cluster fly, *Pollenia rudis*, is a native of the Palæarctic region, where it is parasitic on the native earthworms, as Keilin has shown. This fly was introduced many years ago into the United States, and has become abundant in Colorado since the European types of earthworms were brought in with plants. The combination, brought about unwittingly through human agency, has resulted in a veritable plague of flies at Longmont, Colorado. Mrs. M. G. Wadsworth, sending flies for examination, reports that for at least eight years past houses in her vicinity

have been invaded by these flies in prodigious numbers every winter. It is not worth while to transcribe her very detailed account, as it agrees with others previously published, but she gives a vivid description of the persistence of the infestation, from October to about the middle of March, and the extreme difficulty of dealing with it.

We wonder what can now be found to attack the flies. Lutz remarks that the species is even more susceptible to fungus (Empusa) attack than the house fly, but our dry climate is unfavourable to the fungus. There may be another chapter of this drama to be written in the future. The hymenopterous *Nasonia brevicarnis* of Ashmead, known to be parasitic on domestic Muscidæ, has been found in some numbers in Boulder, Colorado. T. D. A. COCKERELL.

University of Colorado.

Cretaceous Beds in North China.

DURING recent years the work of the Geological Survey in North China has been steadily filling the gaps in our records between the Jurassic and Pleistocene deposits, but until now no rocks of Cretaceous age have been recognised in the area. The absence of post-Jurassic marine sediments is correctly interpreted as indicating that there was no extensive submergence after that date, but it might be anticipated that the Cretaceous should be represented by locally developed continental deposits.

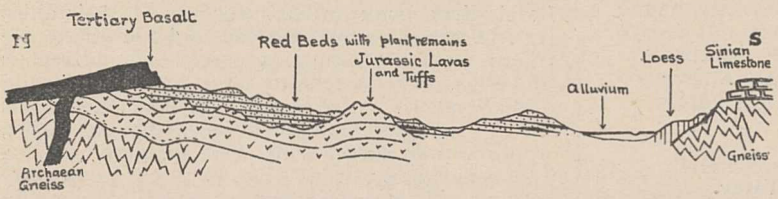

FIG. 1.—Structure of section projected on a north-south line 10 miles west of Kalgan.

The discoveries of Berkey, Granger, and Morris of the American Museum's third Asiatic expedition to Mongolia in 1922–3 showed that the surface of the land mass to the north underwent a periodic gentle warping throughout later Mesozoic and Tertiary times. The area of downwarp, however, was continually shifting its position, thus leading to a migration of the basins of deposition. In consequence, though no one locality yielded more than a few of the representatives of all the formations recognised, somewhere or other the party found horizons referable to practically every post-Jurassic period with the exception of the Miocene. In particular, the Iren Dabasu sandstone and shale and the other members of the Shama continental series are regarded as Cretaceous. It might, therefore, be not unreasonable to hope that deposits of similar age would be found at some point nearer the coast along the northern border of China proper, occupying the lacuna between the Jurassic eruptives and the Tertiary basalts.

During June 1923 the present writer had an opportunity of visiting the Kalgan area 170 miles north-west of Peking, where the ancient camel route passing through the Great Wall crosses the frontier from China up on to the Mongolian plains by the passes of Wanchuan and Hanoorpa. Since the general features of the district are already known through the descriptions of von Richthofen, Pumpelly, etc., and the more detailed work of Andersson, this brief preliminary account refers only to the beds which appear to be of Cretaceous age. The relations existing between other formations can be readily appreciated from the generalised N.-S. cross-section projected on a line 10 miles west of Kalgan (Fig. 1).

The oldest rock exposed is Archæan gneiss of a type indistinguishable from similar phases of the Taishan complex. Though followed unconformably in the south by the pre-Cambrian Palæozoic (for which the Geological Survey has recently adopted the term Sinian System in the revised sense proposed by Grabau), subsequent folding and erosion bring the gneiss into direct contact with overlying Mesozoic, Tertiary, and Pleistocene formations further north.

To the north-east, a basal conglomerate mainly derived from the gneiss is followed by the lower members of a thick series of trachyte and allied porphyritic lavas and ashes. They have been provisionally dated as Jurassic, on the ground of lithological similarity to the porphyries cropping out in the Western Hills of Peking. Here similar lavas intrude the Mentoukou coal series of lower Jurassic age, and are overlain by the Tiaochishan conglomerate (with derived lava pebbles), which carries plant fossils. Bearing in mind the suspicion that has recently fallen on Jurassic plant fossils as horizon determinants in certain areas, especially in view of the apparent persistence of certain types previously regarded as diagnostic of fairly definite periodic divisions, the question may be raised as to whether there is justification for strictly limiting the Tiaochishan formation to Jurassic. The Geological Survey of India has recently had to re-date as Cretaceous beds formerly placed at the top of the Jurassic on palæobotanical evidence, and the discoveries in Mongolia call for a similar careful revision of the upper Jurassic shales on the Russian border. There is, however, no reason to doubt the Jurassic age of the lavas and intercalated sediments and tuffs.

Near Kalgan the lavas are overlaid by a thick series of red and white cross-bedded sediments, the contact of which with the igneous rock below points to a fairly mature topography, implying an interval of erosion. The unconsolidated condition of the red beds allows them often to yield to dynamic stresses by readjustment without showing the effects of fracture observable in the rigid lava below; but after due allowance has been made for this, the jointing and warping of the porphyries still seem sufficient to indicate that both crustal movement and erosion intervened before the depositing of the sediments above. These latter are of every degree of coarseness from fine silt to conglomerates with 4-inch boulders, and are almost entirely derived from the porphyries. The only faunal remains collected were some pieces of reptile bones (probably too much worn to be determinative) and a fragment of turtle plate found in 1922 when crossing the Wanchuan pass with Dr. Grabau and Prof. F. K. Morris. At a lower horizon, however, thin coal seams with plant fossils occur in two localities. One of these was first recorded by Dr. J. G. Andersson, Adviser to the Bureau of Mines, but yielded only Podozamites and other forms sufficiently indeterminate to warrant their provisional correlation with the Jurassic beds further south. Specimens collected by the writer seem now to point to a Cretaceous age for these plant beds.

Pending specific determination, it is unwise to be too definite, especially with the limited means of library and museum facilities available for comparison. But the specimens found include some closely resembling *Onychiopsis mantelli*, Brogniart (Seward, "Fossil Plants," vol. ii. p. 375), and *Sphenopteris gopperti*, Dunker (*Palæontographica*, xix. Schenk iv. N.W. Deutschen Wealdenformation, and Bull.

Maryland Geol. Survey, Cretaceous). The fossils strongly recall Wealden types, and according to Mr. T. C. Chow, palæobotanist to the Geological Survey of China, are unlike any material previously reported from North China, and distinctly later in type than the recognised Jurassic forms known in the area.

The age of the overlying basalt which rests on the peneplaned edges of these beds has been roughly fixed by Dr. Andersson's discovery of a sedimentary lens carrying middle Tertiary plant remains, intercalated between two igneous flows.

Further reconnaissance will probably lead to the discovery of other Cretaceous beds with faunal evidence which will permit the accurate determination of these plant horizons. In the meantime they may be provisionally regarded as belonging to the bottom of the lower Cretaceous and comparable to the Wealden of Europe. GEORGE B. BARBOUR.

Yenching University, Peking,
December 10.

The Thirty-two Classes of Crystal Symmetry.

I HAVE just read Dr. J. W. Evans's letter on this subject (NATURE, January 19, p. 80). His object clearly is to arrange and name the classes according to their axes and other elements of symmetry. I have attacked the same problem from another point of view, that of arranging them so as to make clear what classes are derived from others by omission of half their repetitions. The resulting arrangement is very like that of Dr. Evans, the only really important difference being that I include the holoaxial classes with the dicyclic ones (calling them the holo classes). In the list below, the number following each name is that of the corresponding diagram in Gadolin's paper.

Hexadic System (characterised by a hexad axis or by a triad axis with a perpendicular plane of symmetry) :
Holo-centric 45, holo-ditrigonal 49, holo-hemimorphic 52, holo-cheiral 44 ; hemi-centric 51, hemi-ditrigonal 54, hemi-cheiral (hemimorphic) 50.

Triadic System (characterised by one triad axis without a perpendicular plane of symmetry) :
Holo-centric 48, holo-hemimorphic 55, holo-cheiral 47 ; hemi-centric 56, hemi-cheiral (hemimorphic) 53.

Monometric System :
Holo-centric 28, holo-tetrahedral 31, holo-cheiral 27 ; hemi-centric 30, hemi-cheiral (tetrahedral) 29.

Dimetric System :
Holo-centric 33, holo-sphenoidal 40, holo-hemimorphic 37, holo-cheiral 32 ; hemi-centric 36, hemi-sphenoidal 34, hemi-cheiral (hemimorphic) 35.

Trimetric System :
Holo-centric 39, holo-hemimorphic 43, holo-cheiral 38.

Monoclinic System :
Holo-centric 42, holo-hemimorphic 46, holo-cheiral (hemimorphic) 41.

Triclinic System :
Holo-centric 57, holo-cheiral (hemimorphic) 58.

Here a crystal is called centric if it has a centre of symmetry, and hemimorphic if there is one plane at least such that no direction on one side of it is similar to any direction on the other. A word in parentheses does not form part of the name, but if, *e.g.*, we describe a crystal as "dimetric hemimorphic," we mean that it is holo-hemimorphic or hemi-cheiral. A holo class in the monometric system has either dodecahedral planes of symmetry or dyad axes perpendicular to these planes, and in the two hexagonal systems and the dimetric system has either longitudinal planes or transverse dyads ; a hemi class has neither.

Any non-centric class can be derived from the centric class of the same system and prefix by omitting half the repetitions, and any hemi class can be similarly derived from the corresponding holo class, the hemi-cheiral class being in addition derivable from the corresponding holo-hemimorphic or holo-tetrahedral class. (In the first case one of each opposite pair is retained.) Also any triadic class can be derived from the hexadic class of the same name, and if non-centric, from the ditrigonal class of the same prefix. The classes of the monoclinic and triclinic systems behave as if they were holo and hemi classes of the same system, as also do those of the trimetric and monoclinic systems. The last two systems taken together are related to the dimetric system as the triadic is to the hexadic (regarding the monoclinic as hemi and reading sphenoidal for ditrigonal), except that the monoclinic holo-hemimorphic class is not derivable from the dimetric hemi-sphenoidal class.

H. C. POCKLINGTON.

Continental Drift and the Stressing of Africa.

I HAVE read with considerable interest Mr. Wayland's letter in NATURE for December 29, p. 938, but have little to add by way of comment to what I have already written on the subject in these pages, especially as the main principles that determine normal faulting are comparatively simple.

I believe that the sinking of blocks of the earth's crust is usually the result of tension, which causes a deficiency of subterranean material and therefore of subterranean support. In areas of compression any sinking is of a different character. It may occur without fracture in a synclinal fold, or may be the result of load, either from the accumulation of material by surface agencies or over-thrusting by another mass. Normal faults with appreciable hade are only found in areas where tension prevails, though this may be purely local. An anticlinal curvature in a region of compression may determine the occurrence of tension at the surface, but as it is accompanied by excess of subterranean material, it may cause jointing but, for the time being at least, no normal faulting, least of all trough faulting. Subsequent reaction from compression may, however, give rise to a horst or even a trough, bounded by normal faults.

I cannot claim the credit of the hypothesis connecting continental drift with the origin of the moon. That is due to Osborne Fisher. I merely suggested that if this hypothesis has any foundation the possibility that the separation occurred after the earth had become the home of animal and plant life should not be excluded. There is, too, no inconsistency in supposing that the nascent moon attracted the atmosphere and the oceanic waters towards itself, but when it became separated from the earth yielded them to the greater attraction of the latter.

I should like to add that I am well pleased that in Uganda the investigation of the major structures of the rocks, which is so important for understanding the past history of Africa and indeed of the whole world, should be in the competent hands of the present Director of the Geological Survey and his enthusiastic staff. They may be trusted to work them out without any prejudice due to preconceived ideas of their nature. JOHN W. EVANS.

Imperial College, South Kensington,
January 11.

Experiments on *Ciona intestinalis*.

IN NATURE of January 19, p. 84, there appears a letter from Mr. Cunningham in reference to the regeneration of the siphons of Ciona, in which he calls in question a statement of mine in a letter in the issue of November 24. In my letter I attributed the failure of Mr. Fox to get lengthened siphons after amputation to the fact that he cut off only the oral siphon.

Mr. Cunningham says that Dr. Kammerer did not confirm my view in his subsequent letter to NATURE (which incidentally I translated for him and sent to NATURE). This is true; but I received afterwards a letter from Dr. Kammerer in which he explicitly agrees with my explanation and says that he had not realised that Mr. Fox had only cut off one siphon.

It appears that Mingazzini—about whose work Mr. Cunningham learnt from the letter which I translated—succeeded even when he cut off only one siphon. It may, therefore, be the case, as Dr. Kammerer suggested, that Mr. Fox failed, not because he cut off only one siphon, but because he was dealing with a northern race of Ciona.

The importance of the reference to Mingazzini's work lies in this, that this work unequivocally supports Dr. Kammerer's statements: many were inclined to doubt their trustworthiness after the publication of Mr. Fox's letter. E. W. MACBRIDE.

Imperial College of Science,
South Kensington, London, S.W.7,
January 22.

The Stoat's Winter Pelage.

ABOUT a year ago there was some correspondence on this subject in NATURE. I mentioned (February 17, 1923, p. 220) that a stoat frequenting our flower garden had assumed white pelage during the winter of 1921–22, which was unusually mild. The present winter has been equally so thus far; we had eight and nine degrees of frost on two successive nights in November, and scarcely any since. A stoat has been hunting mice in the garden again this season; if it is not the same individual as before, it is probably of near kin to the other, but its coat is all brown at this date. HERBERT MAXWELL.

Monreith, Whauphill, Wigtownshire,
January 27.

Photoelectrons and a Corpuscular Quantum Theory of the Scattering of X-rays.

LORENTZ gives the radius of the spherical electron as ke^2/mc^2, where the value of k depends on the assumptions made as to the distribution of the electricity in the sphere and as to the manner in which it is held together. The value of k, however, is of the order unity for the various assumptions. The writer has recently shown, in a paper on a corpuscular theory of the scattering of X-rays (*Phys. Rev.* 22, 233, 1923), that if an X-ray corpuscle be considered tentatively as a mathematical point moving with the speed of light, and if the value of k be taken as $\sqrt{(8/3)}$, then the electron has a radius such that the mass-scattering coefficient for X-rays in matter is that given by Thomson's theory, namely, 0·2 per gram for the light elements.

As the experimental value of the coefficient is 0·2 for light elements, we may consider that when an X-ray corpuscle hits an electron it is scattered and that when it does not hit it is not scattered. Since on the corpuscular theory the X-ray corpuscle can only do one of two things, namely, hit or miss an electron, and since the hits are wholly accounted for by the experimental value of the scattering coefficient, and also since we cannot suppose any action taking place when the corpuscle misses the electron, it seems then that there can be no true absorption of X-rays in matter. As the true absorption is due to the photoelectrons and the characteristic radiations produced by the primary X-rays, it then follows that there can be no photoelectrons produced.

However, a true absorption coefficient is found experimentally, amounting to about a hundred times the scattering coefficient for certain wave-length X-rays in certain materials. This fact would, therefore, seem to be at variance with the corpuscular theory of scattering. The reply to this objection is that both Thomson's and the writer's scattering theories have been worked out only for the case of free electrons. The writer believes that the above deduction of no photoelectric effect from the corpuscular theory is quite true in the case of an electron vapour. Experimentally it is found that the true absorption coefficient becomes very small if not zero for elements such as hydrogen and helium, and the photoelectric effect must be small in these two gases. It is necessary for the electron to be bound to an atom in order for the photoelectric effect to take place. Furthermore, seeing that the photoelectric effect increases with the atomic weight and also with the energy of binding when a K, L, or any other absorption limit is passed, it seems that the chance of an electron being ejected photoelectrically (*i.e.* such that $mv^2/2 = h\nu - W$) increases with the energy of binding.

As there is no energy of binding in a vapour of free electrons there can be no photoelectric effect, and the production of photoelectrons in ordinary matter by X-rays is not inconsistent with the above theory of scattering. Since at least in the light elements all of the X-ray corpuscles which hit electrons are scattered, the photoelectric effect must be produced by some action between the corpuscle, the electron, and the nucleus to which it is bound.

G. E. M. JAUNCEY.

Physics Laboratory, Washington University,
St. Louis, U.S.A., January 2.

Colour Vision and Colour Vision Theories.

IN reply to Sir Oliver Lodge (NATURE, January 12, p. 50), I have made numerous experiments extending over years on the simple and compound yellow. The results are given in a paper on the simple character of the yellow sensation, *Journal of Physiology*, 1915, page 265. The identity of the compound yellow made with spectral red and green with the simple yellow from a physiological aspect is very remarkable. I have tried without success to distinguish physiologically between the two by means of colour fatigue, colour adaptation or after-images produced by pure spectral colours, but the effect on the compound colour is in every respect the same as that upon the simple colour.

These experiments have to be made with minute accuracy; for example, when on one occasion my assistant left the small aperture for reading the wave-length open and an imperceptible amount of white light was mixed with the compound yellow, the positive after-image at once changed to green. The positive after-image of any yellow object which also reflects white light changes from yellow to green; for example, a yellow card or paper, the lights in the street, the yellow flames of a fire, or a yellow tulip give a yellow after-image which changes to green; the positive after-image of the sun is first yellow, then green, then blue, then violet.

F. W. EDRIDGE-GREEN.

London, January 26.

The Genesis of the Royal Society.

By Dr. IRVINE MASSON.

THE origin of the Royal Society is frequently traced to the meetings of virtuosos in Oxford before the Restoration. In point of fact, these meetings represent the second of four stages which mark the evolutionary process, of which the following brief account is derived chiefly from contemporary works and manuscripts.

We may pass over the several abortive attempts to found educational colleges on a Baconian plan, which were made in the years following 1640; few were conceived in the real spirit of the new philosophy, most were in any case unpractical, whilst the only one which seemed likely to win government sanction—that of Hartlib and Comenius, in 1641—was frustrated by the outbreak of civil troubles.

Of the actual beginning, there is in the British Museum a very definite account from the hand of the Rev. John Wallis, the mathematician, who was himself one of the leaders throughout all four stages of the Society. This account occurs as a side-issue in an otherwise uninteresting polemical tract which he published in 1678; and in 1697 he repeated the main substance of it in a private letter which, by a series of curious chances, found its way into print in 1725. References in the early letters of Boyle, Hartlib, and Petty, and statements by Hooke, corroborate the story at essential points. It is best to quote from Wallis's actual words; and passages from his letter of 1697 are interpolated in square brackets.

"I do acknowledge . . . that those meetings[1] might be somewhat conducing to that of the Royal Society which now is. But (without disparagement to Bishop Wilkins) not, that 'the first Ground and Foundation of the Royal Society'[2] was there laid. Which I take to be much earlier than those meetings there.

I take its first ground and foundation to have been in London [at a time when, by our civil wars, academical studies were much interrupted in both our Universities] about the year 1645 (if not sooner), when the same Dr. Wilkins . . ., Dr. Jonathan Goddard, Dr. Ent, Dr. Glisson, Dr. Scarbrough . . ., Dr. Merrit, with myself and some others, met weekly . . . at a certain day and hour, under a certain penalty, and a weekly contribution for the charge of experiments, with certain rules agreed upon amongst us."

The scope of the inquiries of the "Philosophical College," as they called themselves, or "Invisible College," to use Boyle's term, is next given. Debarring matters of theology and State affairs, they confined themselves to—

"Philosophical enquiries, and such as related thereunto; as physick, anatomy, geometry, astronomy, navigation, staticks [magneticks, chymicks], mechanicks, and natural experiments. We there discoursed of the circulation of the blood, the valves in the veins [the venæ lactæ, the lymphatic vessels]"—thus far the medical sciences—"the Copernican hypothesis, the nature of comets and new stars, the attendants on Jupiter, the oval shape of Saturn [the spots on the Sun, and its turning on its own axis], the inequalities and selenography of the Moon, the several phases of Venus and Mercury; the improvement of telescopes, and grinding of glasses for that purpose (wherein Dr. Goddard was particularly ingaged, and did maintain an operator in his house for that purpose)."

In addition to these astronomical studies, they dealt with—

"the weight of the air, the possibility, or impossibility, of vacuities, and Nature's abhorrence thereof, the Torricellian experiment in quicksilver, the descent of heavy bodies, and the degrees of acceleration therein, with other things of like nature. Some of which were then but new discoveries, and others not so generally known and embraced as now they are [with other things appertaining to what hath been called the New Philosophy, which from the times of Galileo at Florence and Sir Francis Bacon (Lord Verulam) in England, hath been much cultivated in Italy, France, Germany, and other parts abroad, as well as with us in England].

Wallis mentions, in his second account, that the convening of these meetings was, he thought, suggested by Haak, a Palatine German who had settled in England and is otherwise known as a writer on behalf of the Council of State.

The meetings were, says Wallis, held at Goddard's house and at the Mitre Tavern near by in Wood Street. Within a short time, however, they removed to the Bull Head Tavern and, in Term time, to Gresham College. Here they used to attend the weekly astronomical lecture given by Samuel Foster (one of their number), and immediately afterwards they met, either in his rooms in the College, or at some other convenient place; and their numbers increased.

Of the members named, scarcely any were more than thirty years of age. Wilkins, a leading spirit, had been trained at Oxford; Wallis and several of the others were Cambridge men. It is quite clear, from statements made elsewhere by Wallis, that it had been at the University that the seeds of Bacon's principles had been sown in these men, who, born at nearly the same time as the "Novum Organum," became the first agents of its real propagation when they came together in London.

Within a year of the foundation of the club, Robert Boyle, newly returned to England, became their youngest member, and was given an appreciative welcome. Later, his visits from his Dorset manor necessarily became intermittent; but we may note that it was these meetings which first drew him to be "Innitiated among the Spagiriks." At about the same time, Hartlib introduced William Petty, then at the outset of the remarkable career in which he founded on one hand a science—statistical economics—and on the other, the fortunes of his line: both of which account for the way in which his great-grandson, Lord Shelburne, befriended Joseph Priestley and Jeremy Bentham.

The Invisible College continued; but in 1648 and 1649 the parliamentary "Purgation" of the Universities transferred to Oxford the chief corner-stones of the society: one after the other, Wilkins, Wallis, Goddard, Petty, were appointed in the room of deposed

[1] At Wadham College, Oxford.
[2] Quoted from his antagonist, Dr. Holder.

academic heads. It seems that the Philosophical College still went on, but beyond this nothing is known of it for some years; the centre of gravity had shifted, and the second phase is at Oxford.

Wilkins and the others, together with Seth Ward, Bathurst, and Willis the physician, formed a new branch, and for some four years regular and successful meetings were held, while the membership grew. No minutes are known to survive,[3] but there is a set of rules of 1651 which recalls the customs of the parent society, already indicated. The meeting-place was the apothecary's shop under Petty's lodging, which served as the magazine on which they drew for their material.

After a time, when Petty departed to Ireland in 1652 as surgeon to the Forces, the gatherings became less popular; and it was now that they were transferred to Wadham College, where Wilkins kept his collection of curios and instruments. In 1654, Boyle settled in Oxford; and thenceforward there was no lack of experimental matter. Further impetus was added by the accession of that extraordinary pair, Christopher Wren and Robert Hooke—so similar in the trend of their scientific genius, so different in their natures—and in astronomy, physics, chemistry, physiology, the bases of experimental discovery were now being gradually laid or confirmed. Wren was a principal in the first injection of fluids into the veins, together with his senior, Willis; Boyle was amassing that knowledge of chemistry which enabled him to write the Old Testament of the science, "The Sceptical Chymist"; Hooke was developing instruments which in their eventual forms are used to-day.

Hooke in his recollections says that no collective records were kept during this period: and since, in a letter of February 1657, Petty expresses his pleasure at hearing that "the club is revived at Oxford," it appears that for some time formal meetings had been in abeyance. Wallis expressly confirms this; he says that the "set meetings" were in 1659–1660 "disused, and had been for a good while"; and he adds "what was of this nature at Oxford (about experimental philosophy) in these days, was rather at Mr. Boyl's lodgings, than at Wadham College." London, according to Wallis, became the venue, where Rooke's lecture, like Foster's ten years before, attracted them weekly; and it is certain that after 1657, when Wren succeeded to the chair of astronomy at Gresham College, his weekly lecture was the occasion of regular discussions, and it became increasingly the practice of the Oxford virtuosos to come to London to partake in these. This represents the third stage, and it continued, with interruptions, up to the Restoration.

At Gresham College, after Wren's two o'clock lecture on November 28, 1660, twelve being present (Wilkins, Goddard, Boyle, Petty, Rooke, Wren, Lord Brouncker, Ball, Hill, Sir P. Neile, Sir R. Moray, Bruce), they decided to put their gatherings on a formal basis. Wilkins was elected chairman, Ball as treasurer, and Croone as registrar; a provisional set of rules was framed, and a list of forty-one eligible for membership was made. Next week the King's approval was notified, and Moray was elected president; and with the request that Mr. Wren prepare against the next meeting for the pendulum experiment, the concerted work of the new society was inaugurated.

A year and a half later (July 15, 1662) the charter was sealed which formally incorporated "The Royal Society for the Improvement of Natural Knowledge." Lord Brouncker was first president of the Royal Society, Wilkins and Oldenburg (actually the latter only) were the secretaries. The motto "Nullius in verba" was John Evelyn's choice.

It should be understood that the papers communicated were not read with the view of publication; for, during the first ninety years of the Society's existence, no official journal was issued. The Philosophical Transactions, which first appeared in 1665, were, until 1750, a private enterprise of the secretary, published at his own expense and sold to fellows and to the public for his own profit; the Council merely kept a watchful eye upon them, and in some measure acted as guarantor. Frequently a paper which had been delivered to the Society would be copied into the Phil. Trans., appearing there among other scientific news from home and abroad, book-reviews, and articles; but the important researches were usually published by their authors in books, sometimes under the imprimatur of the president. At the same time, the Phil. Trans., in Oldenburg's hands, did valuable propagandist work for science, and, in conjunction with the foreign correspondence which the Society maintained officially, lent a powerful aid to the founders of the scientific societies of Europe, which were largely formed on the London model. The early Phil. Trans. can be fairly described as the NATURE of the seventeenth century.

At Gresham College the Royal Society maintained a research laboratory, and in 1663 it obtained from Boyle the invaluable services of Robert Hooke, who was made its salaried curator of experiments. The subjects for investigation were usually chosen by discussion at the meetings; and the curator or individual fellows were asked to carry out the necessary work at the College or in their own laboratories. The reports on these, and the directions of the Society as to the further course of the work, were recorded by the secretary in the books. Here were also registered the reports of the sub-committees, appointed to investigate industrial processes at home and to organise scientific observations in remote places.

The following notes, selected from the years 1660–1661, give some indication of the varied activities of the Society at this time:—

"The experiment of the compression of water was directed to be tried by Dr. Wilkins and Dr. Petty.

Experiments were made at the Tower of London on the weight of bodies increased in the fire.

Dr. Clarke was intreated to bring in the experiment of injection into the veins.

Sir Kenelme Digby related that the calcined powder of toades reverberated, applyed in bagges upon the stomach of a pestiferate body, cures it by severall applications. 'But the truth is, Sir Kenelme was an errant mountebank' (Evelyn).

Mr. Boyle brought in an account . . . of the experiment hee made of the compression of aire with quicksilver in a crooked glasse tube. . . .

Dr. Goddard was desired to give an account of his dissection of the chameleon.

That the Society write to Mr. Wren, and charge

[3] Except these which begin in 1683 and continue to 1690, when the Oxford Society appears to have ceased.

him . . . to make a globe of the moon, and likewise to continue the description of severall insects.

A report was made of the trial of the dyving engine at Deptford on Friday preceding, by the amanuensis, who stayed in it eight and twenty minutes under water.

Mr. Henshaw read his History of the Making of Saltpetre.

Mr. Boyle to try the velocity of sounds."

Space does not permit the description here of the great number of tests, measurements, and reports which were brought forth; the names alone must suffice to recall the fundamental character of many of the researches produced. Boyle, Hooke, Wallis, Petty, Wren, Willis, Glisson, of the original fellows; Newton, and Mayow, among those who followed soon, are all household names in their sciences to-day; and the records speak of many others, less familiar now, but still valuable contributors to learning who were rightly honoured in their day.

It is evident from Pepys' and Evelyn's diaries, as well as from surviving correspondence, that the activities and the aims of the Society made a wide appeal among educated people; and there is in the British Museum a long and amusing doggerel poem which shows how strong and affectionate a respect was inspired among its lay supporters of the early 'sixties. Hostile critics were, naturally, not lacking, and it was to answer these that Sprat was egged on by Wilkins and others to write his well-known "History of the Royal Society," and that Joseph Glanvill produced his delightfully vigorous "Plus Ultra."

The fundamental principle upon which the Society was based, as is clear from many documents both official and private, was the Baconian doctrine. Croone writes in 1661—

". . . you may please to understand that this Company do's not take upon it selfe to assert any one hypothesis, but every man is left at present to his Freedom; for they believe that to make any Hypothesis, and publickly owne it, must bee after the triall of so many exp'ments as cannot be made but in a long tract of time."

In the draft of a minute, probably written by Hooke about 1663, and now in the British Museum, we find—

"This Society will not own any Hypothesis, Systeme, or Doctrine of the principles of Naturall Philosophy, proposed or maintained by any philosopher Auncient or Moderne, nor the explication of any phaenomenon, where recourse may be had to originall causes. . . . Nor dogmatically define, nor fix Axioms of Scientificall things, but will question and canvas all opinions, adopting nor adhering to none, till by mature debate and clear arguments, cheifly such as are deduced from legittimate experiments, the trueth of such positions . . . be demonstrated invincibly."

Boyle's "Sceptical Chymist" is, of course, an outstanding exposition of the same theme, upon which the whole existence of the Royal Society rested, and rests.

The Natural History of the Common Eel.

By J. T. CUNNINGHAM.

THE propagation of the eel was a mystery not only to ordinary people, but also to naturalists, from the time of Aristotle to the end of the nineteenth century, and continued to be a mystery for years after the breeding and development of many other fishes, both marine and fresh-water, had been successfully studied and investigated. At present our knowledge of the development of the eel is almost but not quite complete, and the extraordinary facts of the matter have been brought to light chiefly by the adventurous and persevering efforts of the Danish naturalist, Dr. Johannes Schmidt, of Copenhagen, who has published a memoir on his researches in the Philosophical Transactions of the Royal Society of London and has described them in articles in NATURE (August 22, 1912, and January 13, 1923).

The gradual elucidation of the history of the eel started from our knowledge of a very curious group of fishes named Leptocephali, which means "Small-heads." They were so named from the fact that the head is very small in proportion to the body, which is like a narrow ribbon $\frac{1}{2}$ to $\frac{3}{4}$ in. in breadth and from 3 to 6 in. in length. The surfaces of the ribbon are the right and left sides of the fish, so that the breadth is vertical in the natural position, and the whole creature is perfectly transparent. The newly hatched young of many fishes are transparent, but they are usually of minute size, while the Leptocephali are much larger. These remarkable creatures had been collected from time to time, some at the surface of the ocean in various parts of the world, some cast on the shore in England or other parts of Europe. Various species of them were distinguished, but for a long time there was nothing to show what relation they bore to other fishes. It was evident that they were not mature, and some naturalists suggested that they were monstrosities, that they were the young of some ordinary fishes which from time to time were accidentally carried into mid-ocean by currents, and there went on growing in size without advancing in structure, that they were in fact overgrown fish-larvæ which were unable to complete their normal development because they had been removed from their normal conditions of life. Gradually, however, evidence presented itself that these Leptocephali were connected with the eel family.

Although there is only one fresh-water eel in Europe and another very similar in North America, there are many species of the same family in the sea, some living at moderate depths and some in the deep abysses of the ocean. On the Atlantic coasts of Europe there is only one marine species, the well-known conger, which reaches 7 or even 8 ft. in length, but there are several species in the Mediterranean, one of which, the Muræna, was a favourite article of food to the ancient Romans. The species of the eel family are similar in certain important features of structure to the herring family, the salmon family, the carp family, and others, but they are distinguished by the entire absence of the hinder pair of fins. In this and other details of structure, such as the number of the vertebræ, the Leptocephali agree with the eels. In particular the *Leptocephalus morrisii*, several specimens of which form had been captured

on British and French coasts, was considered to be probably the young of the conger. At last in 1886 a specimen of this form, taken at Roscoff in Normandy in February, was kept alive, and in the period between this month and July actually changed into a young conger, which was dark in colour, cylindrical in shape, and shorter than in the original condition.

After this it appeared extremely probable that the various Leptocephali were the normal young forms or larvæ of various species of the eel family, and that the early condition of the common eel was probably a transparent ribbon-shaped Leptocephalus.

In the years 1891–1894 an Italian professor, G. B. Grassi, and his colleague, Signore Calandruccio, studied carefully the Leptocephali which they obtained at Catania, on the east coast of Sicily. In this neighbourhood, especially near Messina, it had long been known that these peculiar fishes were rather abundant. One of them had been distinguished as *brevirostris* or short-snouted. The Italian naturalists now proved that this particular form changed into the common eel, and, as in the case of the conger, the perfect young eel was smaller and shorter than the ribbon-like form from which it developed: the latter reaches the length of $3\frac{1}{4}$ in. with a breadth (or vertical height) of $\frac{2}{5}$ in. (0·4 in.), and it develops into a slender thread-like dark-coloured elver about 2 in. in length.

Elvers, that is to say, young recognisable eels 2 to 3 in. in length, but not less than 2 in., were long known to ascend rivers in enormous numbers in spring. On the banks of the Severn, for example, these little fish can be seen at the right season, March and April, passing up along the banks in countless millions, and the people of the neighbourhood are in the habit of dipping them out of the water with hand nets, and making fish-cakes of them, or otherwise cooking them for food. On the other hand, adult eels are captured in large numbers in autumn passing down the rivers towards the sea, and in Denmark and other places these migrating eels have been shown to be more silvery in colour and to have larger eyes than ordinary specimens. With one or two exceptions none of them have large roes, so that the exceptions must be regarded as abnormal, and the vast majority of eels go down to the sea to breed, and the young eels come up from the sea to the rivers and fresh waters. There is no evidence that the adult eels ever return from the sea after their migration. It is true also that the male eels are usually found in estuaries or near the mouths of the rivers and do not ascend so far as the females.

It was improbable that the eel larvæ should exist only near the coast of Sicily, or only in the Mediterranean, and Dr. Schmidt was first led to give his attention to the subject by the capture of a specimen of *Leptocephalus brevirostris* from the sea near the surface to the west of the Faroe Islands in the far north of the Atlantic. As a result of this it came about that Denmark, where the eel fishery is an important industry, undertook the task of carrying on the investigation of the eel question, and the direction of the work was entrusted to Dr. Schmidt. This work has been continued from 1904 to 1922 with some interruptions. It consisted chiefly in fishing with special nets in order to ascertain where the larval eels were to be found, at what seasons, and what was their size and condition at each part of the sea. The earlier cruises were made in the steamer *Thor*, which was owned by the Danish Government and specially equipped for marine research. It was found that the Leptocephali of the common eel were found in numbers in the Atlantic from the Faroes to Brittany, outside, *i.e.* to the west of, the 500 fathom line, but not to the east of it. It was shown that in August and September the larvæ were undergoing "metamorphosis" or transformation into the perfect eel, and it was evident that the fully developed elvers appearing at the mouths of rivers in spring were derived from the Leptocephali of the previous summer and were at least one year old.

The next task was to discover where the younger larvæ occurred. Those above mentioned were the largest in the Leptocephalus stage, just before metamorphosis, and little less or more than 3 in. in length. The Norwegian naturalist, Dr. Hjort, in an Atlantic expedition obtained 21 specimens to the south and west of the Azores, and these were only 2 in. in length. It was supposed that these were a year younger than the others and that the actual spawning place was between the Azores and Bermudas. Further collections were made, partly from Danish liners on their voyages across the Atlantic between the English Channel and the West Indies, the special towing-nets for young fishes being supplied to them to be used for an hour or so when possible, and partly from a cruise by a special small schooner called the *Margarethe* fitted out for the purpose. This ship was wrecked in the West Indies, but the collections were saved. It was found that the smallest larvæ, from 9 to 21 mm. in length, were taken in spring and summer about lat. 26° N., long. 55° W., that is, in the Sargasso Sea.

Finally, a four-masted motor schooner, the *Dana*, of 550 tons, was specially fitted out for the purpose of these researches. Expeditions on this ship were made in 1920 and 1921, and large numbers of the larvæ were collected at different positions in the western part of the North Atlantic. When the places of capture were plotted out according to the sizes of the larvæ, it was proved that all those less than 10 mm. ($\frac{2}{5}$ in.) in length were taken in the middle of the Sargasso Sea, and the larger sizes at increasingly greater distances from this region. This region must be regarded, then, as the spawning place of the European eel. It extends from 20° to 30° N. lat. and from 50° to 65° W. long. In one haul of two hours' duration in this region in June 1920 nearly 800 specimens were obtained, the largest number being 24 mm., or very nearly 1 in., in length. These are considered to be in their first year, probably hatched a few months earlier. The elvers which reach the coast of Europe are calculated to be three years old. The depth of the ocean in the eel-spawning area is from 3000 to 4000 fathoms.

There is one question on which Dr. Schmidt's evidence does not seem quite conclusive, namely, whether the eel spawns in the Mediterranean, or whether all the larvæ in that sea come from the Atlantic through the Straits of Gibraltar. There are no eels in the Danube, or in the Black Sea or the Caspian or any of the great rivers flowing into those seas. But there are eels in Egypt, in Greece, Italy, and Spain, and in particular a large eel fishery at Comacchio near Venice. We have seen that the particular Leptocephalus which belongs to the fresh-

water eel was first identified on the coast of Sicily, and Dr. Schmidt has stated that the full-grown larvæ were not found by him east of the 500 fathom line, which is inconsistent with the view that they pass through the Straits of Gibraltar. It has been stated, also, that metamorphosed elvers are found at the mouth of the Nile in February, which is as early as, or earlier than, the time of their annual appearance on the west coast of Ireland, although the coast of Egypt is so much farther from the Atlantic breeding place.

On the other hand, Grassi and Calandruccio do not state that they obtained on the coast of Sicily the youngest and earliest stages of the Leptocephalus of the eel. The depth of the sea to the north of Sicily increases to more than 1000 fathoms and it is possible that this is a sufficient depth for eels to spawn in, but if they do spawn there the very young larvæ and the eggs should be captured there. This brings us to the question of the eggs, and Schmidt himself has not yet obtained them from the Atlantic or identified them with certainty. On the other hand, Dr. Raffaele, an extremely able Italian naturalist, studied and described at Naples in 1885–1887 a number of buoyant fish-eggs which, from the characters of the larvæ hatched from them, certainly belong to the eel family. The question is: Was one kind of these eggs the egg of the common eel? One kind had a single oil globule in the yolk, and the youngest of the eel larvæ seen by Dr. Schmidt show a single oil globule in the portion of yolk still unabsorbed. But the larva hatched from this egg, although certainly a Leptocephalus, has not been identified with the larva of the common eel. The question, therefore, whether the eel spawns and develops in the Mediterranean cannot yet be answered positively, though the above facts indicate the possibility, if not the probability, that it does so.

In conclusion, we may mention some remarkable facts concerning both the eel and the conger in the adult state. In the first place, there is a great difference between the sexes in size. The male eel seldom exceeds a length of 18 in., while the females may reach a length of 3 ft. or somewhat more. In the conger the difference is still greater. The present writer made a study of the conger for a considerable time at the Aquarium and Laboratory of the Marine Biological Association at Plymouth. The largest male conger recorded was not quite 2 ft. 6 in. in length, while females 6 ft. in length are common, and specimens up to 8 ft. 3 in. in length are on record. Secondly, although nothing has been seen of mature eels after their descent to the sea, observations of the present writer and one or two others on conger in the aquarium show that both sexes cease to feed when the reproductive organs begin to mature, and they live for three to six months without feeding, and finally die, the females without spawning, the males in a mature condition. When the females die the roes are enormously enlarged though the eggs are not quite mature. But a more extraordinary fact is that the bones have lost all their lime, and become soft as cheese, while the muscles are much reduced. The males before they die get into a much worse condition, the skin becomes ulcerated, the body emaciated, and the eyes so much diseased that the fish is quite blind. It is evident, therefore, that though the female conger is unable to spawn in the aquarium, this process taking place naturally at depths of more than 1000 fathoms, both sexes spawn only once and die a natural death when the reproductive function has been accomplished.

Dr. Schmidt concludes from his discoveries that the fresh-water eel, which lives the whole of its life after its metamorphosis in inland fresh waters, but is hatched and developed in the sea and returns to great depths of the ocean to breed, is to be regarded as properly a marine fish. On the other hand, there is good evidence that the earliest bony fishes were evolved in fresh water, and some of the more primitive forms, such as the carp family, are still confined to rivers and lakes; few of them live exclusively in salt water. Migration from river to sea or sea to river is not uncommon among these more primitive fishes, as, for example, in the salmon family. Here the migration is in the opposite direction from that of the eel; salmon leave the sea and ascend rivers in order to spawn, and go down to the sea to feed and grow. The Pacific salmon (*Oncorhynchus yschawitscha*) offers a case almost as wonderful as that of the eel. It ascends great rivers of N.W. America and N.E. Asia to distances from 1000 to more than 2000 miles from the coast, and, like the eel, spawns only once and then dies.

Obituary.

Rev. Prof. T. G. Bonney, F.R.S.

THOMAS GEORGE BONNEY, whose death on December 10 was referred to in NATURE of December 15, was born at Rugeley on July 27, 1833. His family is of Huguenot origin, and both his father and grandfather, the latter a fellow of Jesus College, Cambridge, were hard-working clergymen of wide and varied interests. After a distinguished career at Uppingham, Bonney entered at St. John's College, Cambridge, and in 1856 took a degree both in the Mathematical and the Classical Tripos.

Bonney was elected to a fellowship at St. John's in 1859 and returned to the College in 1861 as junior dean. A movement was then in progress to secure a wider recognition in the University for the study of natural science: this was joined by Bonney whole-heartedly, and one of the first results was an open exhibition in natural science offered by St. John's. In 1868 he was appointed tutor, and in 1869 lecturer in geology in the College. He had been interested in this subject from boyhood up, and his mathematical training had particularly fitted him for its pursuit. At this time Sedgwick occupied the chair of geology, but was prevented by failing health from exercising his functions as professor. The teaching of geology in the University devolved in consequence upon Bonney, who thus became the founder of the flourishing school which has given pre-eminence to Cambridge in this subject ever since. He was the first to introduce into English teaching the new petrology which had sprung from Sorby's application of the microscope to the study of rocks in thin slices, and his work has since been brilliantly developed by the labours, now continued for many years, of Dr. A. Harker.

As a tutor Bonney realised the ideal. Among those

who had the good fortune to be his pupils in the early 'seventies were Sir J. J. H. Teall, Sir Aubrey Strahan, and Profs. Sollas, Marr, and Watts. All regarded him not merely as a tutor whose duty was to exercise strict discipline, but as a personal friend deeply interested in their welfare. He invited confidence, and there were few subjects he was unwilling to discuss. In country walks where he had but one companion even religion was not "taboo," and the most heretical views were listened to and considered with kindly tolerance. At his hospitable table, conversation over the wine did much to broaden our youthful outlook upon life; and on the numerous occasions when we gathered together at an evening reception in his rooms, we were introduced to some of the leading investigators of the day, and learnt that these princes of our science after all were human.

When quite a young man Bonney was captivated by a love of mountains and mountain climbing—he was at one time president of the Alpine Club—and this led him to take a particular interest in their features and structure, as well as in the phenomena of their attendant glaciers. To these subjects he returned again and again in his published writings. His intimate acquaintance with living glaciers proved of great assistance in his treatment of the manifold problems presented by the Great Ice Age, and his knowledge of the Alps served him equally well when he turned his attention to the surviving remnants of the great mountain chains of the past. Thus after a study of the folded complex which is all that remains in Devonshire of the ancient Armorican mountains he concludes "with perfect justice that this great series of folds scarcely yields in importance to the existing chain of the Alps and the gneiss of the Eddystone finds its parallel in the gneiss cores of those mountains."[1]

Bonney was among the first to recognise the truth of Nicol's views on the age of the so-called "newer" gneiss of the north-west Highlands of Scotland, but notwithstanding his familiarity with the great overthrusts which distinguished the Caledonian chain, he was never able fully to accept the evidence for the existence of those horizontal movements which, even on a grander scale, have affected the Alps. This has led to the rather unfair remark that Bonney was inclined to be sceptical of discoveries which he had not made himself.

Of the many important contributions which Bonney made to our knowledge of the stratified rocks, we may cite as of especial importance, first, his explanation of the Bunter beds of the Midlands, which he regarded as fluviatile deposits derived in large part from the Torridon beds of Scotland, and next, his account of the Pre-Cambrian rocks of Charnwood Forest. Prof. Watts, who afterwards studied this area in detail, was deeply impressed with the accuracy and completeness of Bonney's observations, and once remarked that Bonney had left but little for his successors to discover.

The relation of igneous to sedimentary rocks was a question in which Bonney took great interest at a time when extreme views on metamorphism were in fashion, and he impressed upon his pupils the fallacy of the Huttonian view which imagined the igneous rocks to turn into the sedimentary and the sedimentary back again into the igneous in a recurring cycle.

Though a great traveller and remarkably active in the field, Bonney was equally at home with the microscope: his petrological studies are numerous and important, and his name will always be associated with such rocks as serpentine, picrite, luxullianite, eclogite, lherzolite, and the matrix of the diamond. Palæontology he left severely alone; his only incursion into this field was when he investigated the structure of *Eozoon Canadense* and rightly concluded that it was no fossil but merely a kind of rock.

Besides his contributions to the literature of scientific societies, which number some hundreds, Bonney published several books on geological subjects, of which the more important are "The Story of our Planet" (1893), "Charles Lyell and Modern Geology" (1895), "Ice Work" (1896), and "Volcanoes" (1898). He was president of the Geological Society in 1884–6; Boyle lecturer, 1890–92; Rede lecturer, Cambridge, 1892; vice-president of the Royal Society, 1899; president of the British Association, 1910–11.

A scientific career was not enough to exhaust the energies of this many-sided man: he was also a clergyman and frequently officiated in the ministrations of the Church; he was Whitehall preacher 1876–1878, and on several occasions was chosen to deliver the sermon in connexion with annual meetings of the British Association. A selection of his sermons is published in four volumes.

On his retirement from active life Bonney made his home in Cambridge, but did not resign himself to idleness; he still found a pleasure in teaching and acted as a volunteer demonstrator in the petrological department of the Geological School, performing his duties as faithfully and regularly as in a paid post, and this he continued to do until incapacitated by a lingering illness which terminated by euthanasia on December 10, 1923. A memorial service was held in St. John's College and attended by a large concourse of mourners, among whom were many well-known dignitaries and many of his former students.

If, reflecting on this life so manifold in its interests, so industrious in their fulfilment, we venture to ask what is the outstanding feature it most deeply impresses on us: the answer will undoubtedly be its human qualities. When in 1895 a crowd of his former students met in University College, London, to present him with a portrait of himself, this was the feeling that prevailed among them, and found expression in the words of one of those present, who spoke of "the tutor we feared, the master we reverence, and the friend whom we love and respect."

WE regret to announce the following deaths:

Prof. C. K. Clarke, since 1907 professor of psychiatry and dean of the medical faculty from 1907 until 1920 in the University, Toronto, aged sixty-nine.

Prof. G. H. Quincke, For. Mem. R.S., from 1875 until 1907 professor of physics in the University of Heidelberg, aged eighty-nine.

M. J. M. E. Stephan, correspondant of the Paris Academy of Sciences and honorary director of the Observatory of Marseilles, on December 31, aged eighty-six.

[1] Suess, "The Face of the Earth," vol. ii. p. 89. (English translation of "Das Antlitz der Erde.")

Current Topics and Events.

OUR recent article on "Government Publications and their Distribution" (NATURE, December 29, p. 925), aiming at preciseness, dealt only with publications having a distinct scientific bias, but another aspect of Government publishing is discussed in a lengthy editorial article on "Official Publications" in the *Electrical Review* of January 11. The writer is in "complete agreement" with our plea, and cites many cases where industrial and humanitarian progress is likely to be prejudiced through the present policy of H.M. Stationery Office. He points out that reports such as those of mine inspectors, and of chief and sub-inspectors of factories and workshops, are placed, on account of their cost, beyond the reach of many who would benefit by them and were accustomed to peruse them. Yet the former contain hints of vital importance to men employed underground, and the latter not only exposed the "abominable" as well as the enlightened conditions of work in various industries, but "indicated the official measures that had been taken to secure improvements by means of warnings, prosecutions, and so forth, and suggested other and new means for securing that working conditions should improve simultaneously with the progress of civilisation." We also note that "all that even the Technical press is provided with [in the matter of reviewing] is an official list every few days of new publications that are on sale, so that it may know *which to buy* for the purpose of acquainting readers with the nature of their contents"—an arrangement which seems to be neither good propaganda nor good business from the publishers' point of view.

AT a meeting held at the Mansion House on January 31, the British Empire Leprosy Relief Association appealed for 250,000*l.* for a campaign to extend the use of the improved treatment of leprosy as an aid to the reduction and eventual eradication of leprosy from the Empire. Messages were read from the Prince of Wales as patron, and the Viceroy of India, and donations of 100*l.* from both the King and the Prince of Wales were announced. The Lord Mayor commended the appeal, and Lord Chelmsford as chairman of the general committee, and the Duke of Devonshire and Sir Sydney Olivier, Secretary of State for India, supported the proposals. Sir Humphry Rolleston, president of the Royal College of Physicians, spoke on the history of leprosy and its prevalence in Great Britain in the Middle Ages, and stated that there is good reason to believe that Sir Leonard Rogers had found in the fatty acids of certain oils a remedy that bade fair to be a real cure, and he was followed by Sir Leonard himself, who gave a brief outline of recent researches, and pleaded for help to bring the new remedies within reach of lepers in the British Empire, in which work we are at present far behind the Americans. Our leading article this week suggests what might be done to improve existing conditions.

THE early efforts of those English pioneers in science, who, through their regular gatherings, received, promoted, and promulgated inquiries and papers on various aspects of natural knowledge, must always compel attention, especially when we recall, among the group thus engaged, the names of Boyle, Evelyn, Wren, Wallis, Glisson, and Hooke. Dr. Birch's "History of the Royal Society" (4 vols., 4to, 1756), a scarce work, contains voluminous original details covering the period 1660–87, relative to the movements of the "new philosophy." It is, however, unindexed, and hence is at best a perplexing miscellany, though it has a saving scheme of chronological presentment. We propose giving in a weekly column some selections from Birch's accounts, in the belief that they will prove of interest to readers of NATURE. The first group of these extracts appears elsewhere in the present issue.

A NEW laboratory for marine biological research was opened at Batavia on December 12 last. This, the first of its kind to be established close to the equator, offers great opportunities to naturalists desirous of investigating the problems of marine life in the tropics. For the zoologist there are rich fields of study round Batavia, including the river fauna of the Tji Liwung, the brackish life in the estuary and coastal ponds, and the varied marine fauna of the Sea of Java. For the botanist, there is a fine collection of East Indian beach and coast plants in the garden surrounding the laboratory, and easy access to the famous Botanical Gardens at Buitenzorg. The station consists of two main buildings, the laboratory facing the sea, and the aquarium behind it. The buildings are well equipped and are lighted throughout by electricity. In the laboratory a large room has been fitted up for the use of visiting naturalists, five of whom can be accommodated at the same time. They have at their disposal certain of the aquarium tanks and table-aquaria, as well as two boats for collecting fresh material, one a motor-boat, the *Max Weber*, working in the vicinity, the other a steamer of 322 tons displacement, the *Brak*, for longer voyages. The water for the aquarium is brought in by lighters from the open sea and stored in underground reservoirs. It is kept circulating through the tanks at a fairly even temperature by continuous pumping night and day, the whole water-content of the aquarium being renewed if necessary eleven times in the twenty-four hours. Naturalists wishing to work at Batavia are invited to apply to the Director of the laboratory, Dr. H. C. Delsman.

THE opening of the Imperial College of Tropical Agriculture in Trinidad in 1922 has involved as the almost necessary consequence the commencement of a journal dealing with the same subjects as does the College. We are therefore able to extend a welcome to *Tropical Agriculture*, the official journal of the Imperial College of Tropical Agriculture, the first number of which has just appeared, and, as is very often the case with first numbers, contains several more or less special articles by distinguished authors. The general arrangement and the contents of the journal are distinctly good. A paper of unusual interest is that of Prof. Dunlop upon Trinidad cacao, in which he analyses the causes of the depression in

this industry, which is just now badly in need of economic readjustment. Notes from other tropical countries form a novel feature of some interest, and book-notes, reviews, notes on recent research, college news, and a chapter upon the trend of the markets in various tropical products complete an interesting number. The price of the journal (6*d*. per month for 16 quarto pages) is moderate.

FOR the last decade, the French Jesuit Father Licent has been exploring the fossiliferous deposits of northern China, and has sent some valuable collections to Paris, including a fine series of remains of Pliocene mammals. A year ago he was joined by Father Teilhard de Chardin, professor of geology in the Catholic University of Paris, who has had much experience of collecting in the caverns and rock shelters of France and Spain, and was associated with the late Mr. Charles Dawson in collecting from the river gravel at Piltdown, Sussex. According to a despatch from Peking published by the *Manchester Guardian* on January 31, Fathers Licent and Teilhard have now made an important discovery of human remains at a depth of sixty metres in a river deposit in northern Kansu, through which the existing river Shara Osso Goh has cut a deep gorge. There seems to be evidence of six individuals, and one well-fossilised skull with retreating forehead and large orbits may prove to be of special interest. No lower jaw was found. With the human remains there occur numerous bones of rhinoceros, horse, bison, camel, deer, elephant, and other mammals. One horse is said to be no larger than a collie dog. We learn from another source that at least ten well-preserved skulls of rhinoceros have been obtained, and that they closely resemble the skull of the ordinary woolly rhinoceros. With the human and other remains there are also numerous small rude implements of quartzite. When these discoveries are studied in detail they will probably add much to our knowledge of palæolithic man.

DR. ARTHUR SMITH WOODWARD will retire in May next from the keepership of geology in the British Museum which he has held since 1901.

THE Hugo Müller lecture of the Chemical Society will be delivered by Prof. J. Joly on Thursday, February 28, at 8 P.M., in the Lecture Hall of the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W.1.

A TECHNICAL assistant for the investigation of the fireproofing of fabrics is required by the Royal Aircraft Establishment, South Farnborough, Hants. Applications, giving full particulars of qualifications, and quoting reference A.25, should be sent to the Superintendent of the establishment.

A SCIENTIFIC assistant is required in the experimental department of H.M. Signal School, R.N. Barracks, Portsmouth, whose duties will be concerned with the development of receiving apparatus for wireless telegraphy. Applications, giving full particulars of experience, etc., must be sent by February 23 to the Secretary of the Admiralty (C.E.), Admiralty, S.W.1.

WE announced recently that a prize of 1000 dollars was being offered by a member of the American Association for the Advancement of Science for a notable contribution to science reported at the Cincinnati meeting. We now learn from *Science* that the prize has been awarded to Dr. L. E. Dickson, professor of mathematics at the University of Chicago, who is known for his monumental "History of the Theory of Numbers."

THE following committee has been appointed by the Secretary for Scotland "To consider and advise regarding the general organisation and finance of Agricultural Education and Research in Scotland":—Lord Constable (chairman), Sir James Adam, Mr. David Black, Mr. Joseph F. Duncan, Captain Walter E. Elliot, Miss Elizabeth S. Haldane, Mr. James Keith, Dr. George Macdonald. The secretary of the Committee is Mr. A. McCallum, of the Board of Agriculture for Scotland.

DR. S. Z. DE FERRANTI has been awarded the Faraday medal of the Institution of Electrical Engineers. The medal is awarded by the Council of the Institution not more frequently than once a year, either for notable scientific or industrial achievement in electrical engineering or for conspicuous service rendered to the advancement of electrical science, without restriction as regards nationality, country of residence, or membership of the Institution, and the award to Dr. de Ferranti is the third to be made. Dr. Ferranti was a pioneer in the supply of electricity, and his early grasp of the fundamental principles of electric power supply has had a profound and world-wide influence.

THE Rt. Hon. Viscount Leverhulme has been awarded the Messel medal of the Society of Chemical Industry. Lord Leverhulme, who is an old member of the Society, will deliver the Messel memorial lecture at the forthcoming annual meeting to be held in Liverpool on July 9 and succeeding days. The award arose out of a bequest in 1921 by Dr. Rudolf Messel, the well-known chemical manufacturer, to the Society of Chemical Industry. Dr. Messel had been president and honorary foreign secretary of the Society, and to perpetuate his memory the Council decided to award biennially a medal, to be called the Messel medal, to an eminent man distinguished either in chemical science or in chemical industry, who should be asked to deliver the Messel memorial lecture on the occasion of the annual meeting of the Society. The first award was made in 1922 to Prof. Henry E. Armstrong, who delivered his lecture at the annual meeting in Glasgow in 1922.

THE annual general meeting of the Institute of Metals will be held at the Institution of Mechanical Engineers, Storey's Gate, Westminster, on Wednesday and Thursday, March 12 and 13, commencing each day at 10.30 A.M. The presidential address will be delivered by Prof. T. Turner in the morning of March 12. A number of important communications are due for presentation and discussion at the meeting. The annual dinner of the Institute will be held at the Trocadero Restaurant on Wednesday, March 12. In

connexion with the meeting a ballot for the election of members and student members will be taken at noon on February 28, and those elected as a result of the ballot will have the privilege of membership for the extended period ending June 30, 1925. It is interesting to note that, for the first time in the Institute's history, the membership passed the 1500 mark on December 31 last.

MR. GEORGE A. MACMILLAN, chairman of the Committee of the British School at Athens, has written to the *Times* announcing that Sir Arthur Evans has made over to the trustees of the School his property at Knossos, in Crete. The gift thus includes the sites of the Palace of Minos and the Little Palace, and the headquarters house, Villa Ariadne, with its garden and vineyard, where Sir Arthur has carried out archæological investigations extending over the last quarter of a century. It was here that Sir Arthur made the discoveries which have enabled him to trace the rise of Cretan civilisation and to correlate it with that of Egypt. All Sir Arthur's rights as owner and excavator of the Palace are being vested in the British School, which will also have charge of the museum of illustrative stratigraphical material arranged in the magazines of the Palace. It is hoped that the revenue from the property will soon provide sufficient funds for maintenance, but, in the meantime, Sir Arthur is taking steps to supplement these sources of income and to provide for future endowment. The villa, which will probably become a summer school for the British School at Athens, will serve, it is hoped, as an archæological station for British research in Crete and the South Ægean.

AT the annual meeting of the Royal Microscopical Society held on January 16, the following officers and members of Council were elected to serve for the ensuing year :—*President :* Mr. A. Chaston Chapman. *Vice-Presidents :* Prof. F. J. Cheshire, Mr. E. J. Sheppard, Dr. C. Singer, Dr. C. Tierney. *Treasurer :* Mr. C. F. Hill. *Honorary Secretaries :* Mr. J. E. Barnard and Dr. J. A. Murray. *Members of Council :* Mr. C. Beck, Mr. S. H. Browning, Mr. H. G. Cannon, Dr. C. Da Fano, Mr. M. T. Denne, Prof. R. Ruggles Gates, Mr. T. H. Hiscott, Dr. R. J. Ludford, Mr. R. Paulson, Mr. D. J. Scourfield, Mr. J. Wilson, and Dr. H. Wrighton. *Librarian :* Mr. F. Martin Duncan. *Editor :* Dr. J. W. H. Eyre. *Curator of Instruments :* Mr. W. E. Watson Baker. *Curator of Slides :* Mr. E. J. Sheppard.

THE triennial prize of the "Fondation George Montefiore" will be awarded in 1925. It is given for the best paper on any electrical subject and its applications to industry which has been published or read during the years 1923–25. The awarding committee consists of ten electrical engineers, five of whom are Belgian, the chairman being the Director of the Institute. Every intending candidate should send in twelve copies of his paper either printed or typed to the Secretary of the Fondation George Montefiore, rue Saint-Gilles, 31, Liége, Belgique. The prize on this occasion amounts to 22,500 francs. The papers may be in either English or French. After the title of the paper the candidate should write "Travail soumis au concours de la Fondation George Montefiore, session de 1923 (1925)." The last day for receiving papers is April 30, 1925.

A CELEBRATION of the jubilee of the Physical Society of London is being arranged for the three days March 20–22, March 21 being the fiftieth anniversary of the first meeting of the Society, at which a paper was read by Prof. J. A. Fleming. Details have not yet been completely decided upon, but it is probable that the first two days will be devoted to a reception, to the delivery of the Guthrie lecture, and to the recounting of reminiscences by original fellows and other fellows of long standing, including, it is hoped, Prof. Fleming and Sir Oliver Lodge. Members and fellows of kindred societies are being invited to take part in the proceedings, and it is expected that representatives of foreign physical societies will be present. On March 22 a banquet will be held at the Connaught Rooms, Holborn, to which fellows will be able to bring guests. Many distinguished guests of honour are being invited by the council. The occasion promises, therefore, to be one of quite exceptional interest and importance in the history of the Society.

PROF. MORTON PRINCE, of Tufts College Medical School, Boston, Mass., is now in Great Britain, where he will deliver several public lectures, including in particular three at the invitation of the University of London, to be given at University College. Prof. Prince has long enjoyed an international reputation, especially on account of his investigations into cases of multiple personality. His "Sally Beauchamp," who had four personalities claiming to have nothing in common save tenancy of the same body, has become a household word among psychologists ("The Dissociation of a Personality" (1906)). At least equally interesting was his subsequent case of "B. C. A.," described in "My Life as a Dissociated Personality," *Journ. Abnorm. Psych.*, iii. To him we are further indebted for a very notable book on "The Unconscious" (1914), which supplies an almost inexhaustible wealth of facts and views on this fascinating topic. Among his other activities, Prof. Morton is the editor of the *Journal for Abnormal Psychology*.

AMONG the many conferences to be held at the forthcoming British Empire Exhibition at Wembley, the first World Power Conference should be of especial interest and importance to technical and scientific men. An official preliminary announcement states that the Conference is being promoted by the British Electrical and Allied Manufacturers' Association (Inc.) in co-operation with technical, scientific, and industrial organisations in Great Britain, Australia, Canada, India, and most of the more important foreign countries; each of these countries will have its own national committee, and representatives of these committees will constitute the international executive committee. The Conference is being organised on a very comprehensive scale. There will be five divisions, devoted respectively to power resources, power production, power transmission and

distribution, power utilisation, and general (economics, standardisation, education, etc.), each of these being subdivided into sections, which will number twenty-one in all. The charge for membership will be 2*l.*, and this sum will entitle members to admission to the Exhibition during the period of the Conference, June 30–July 12; to purchase, for a nominal amount, advance copies of papers to be read; and to participate in official tours to works, hydro-electric stations, and other places of interest in Great Britain, Norway and Sweden, and on the Continent, after the Conference has ended. Applications for membership, and all inquiries, should be addressed to the secretary of the World Power Conference, 36 Kingsway, London, W.C.2.

RAINFALL of 1923 is dealt with in considerable detail in the *Times* of February 4, the article being prepared by the Superintendent of the British Rainfall Organization of the Meteorological Office, Mr. F. J. W. Whipple. A preliminary survey is made from the much fuller details which will constitute later the annual volume of "British Rainfall" with its 5000 or more stations in the British Isles. The outstanding incidents referred to are the great thunderstorms of July, and the continued rains in Lancashire and North Wales producing floods in November. In February the rainfall was three times the average over an area from Cornwall to Staffordshire. In many places it was the wettest February on record, at Ross-on-Wye the wettest for at least 105 years. May was very wet in the north-east of Scotland; at Keith in Banffshire the fall was four times the normal and the highest for a forty years' record. In the British Isles as a whole the rainfall in February was 211 per cent. of the average, while in England and Wales it was 245 per cent. of the average. There was an excess of rain over the British Isles in every month except January, March, June, and December. Statistics are given for more than 200 stations. The rainfall for the year was above the average nearly everywhere; the largest excess occurred in the west; while there was a deficiency along the east coast and in some localities in Central England. The highest totals as yet available are 238 in. at Borrowdale, The Stye, Cumberland, and 189 in. at Snowdon, Carnarvon. The least rainfall for the year was 19·5 in. at Shoeburyness. In London, at Camden Square, the rainfall for 1923 was 27·03 in., which is 2·56 in. more than the normal.

Our Astronomical Column.

THE RELATIVE VELOCITY OF BLUE AND YELLOW LIGHT.—Allusion has already been made in this column to Prof. Harlow Shapley's proof of the practically perfect identity of speed of light of all colours, based on observations of the variable stars in the globular clusters. The proof is given in detail in Proceedings of National Academy of Sciences, Nov. 1923. Inspection of the photographic and photo-visual light curves shows that the best phase to select for comparison is the passage through median magnitude on the ascending portion of the curves; the ranges of variation are different for the different colours, but the curves intersect in the middle of the ascending portion.

The photo-visual plates require an exposure of 20 minutes with a yellow screen; this is suspended for a short interval at mid-exposure, when the ordinary photographic plate is exposed; the mean epoch of both plates is therefore the same.

The final result for the difference of times to travel over an estimated distance of forty thousand light years is 10 seconds, with a probable error of 60 seconds. That is to say, the speeds do not differ by more than 1 in 20,000,000,000, though the wavelengths differ by some 25 per cent.

The result is a proof of the very small amount of absorbing matter that can exist in the intervening space. The possibility of the phases in the two colours differing by a whole period was excluded by observing several variables of different periods.

D'ARREST'S COMET.—*Popular Astronomy* for January reports another early observation of this comet by Mr. J. E. Mellish at Wilmette, Ill., on October 4 at $14^h\ 30^m$ G.M.T. He describes it as large and faint, about 12′ in diameter, without central condensation; approximate position R.A. $18^h\ 10^m$, S. Decl. 20°; motion probably southward. Clouds prevented further observations, and unfortunately he did not communicate his discovery, which would probably have led to observations elsewhere. Prof. Van Biesbroeck, who has himself been observing D'Arrest's Comet during December at the Yerkes Observatory, noticed that Mr. Mellish's position agreed well with that comet, so there is no doubt of the identity.

All who discover undoubted comets should communicate the fact with the utmost speed; in case of doubt as to its nature one should wait until the object has moved visibly among the stars. The southern hemisphere has been left to do decidedly more than its share of cometary discovery in recent years. There should be a good prospect of success for energetic searchers in the northern hemisphere.

THE MOST DISTANT CELESTIAL OBJECT EVER MEASURED.—A Harvard Observatory Bulletin recently received contains a discussion by Prof. Harlow Shapley of the distance of the object No. 6822 of Dreyer's New General Catalogue of nebulæ. This is described as a miniature of the Magellanic Clouds, being an aggregation of faint nebulæ and stars.

Three of the methods used in the case of the globular clusters were applied:

(1) Comparison of its angular diameter with those of the Magellanic Clouds, assuming equal real dimensions, gives distance 300 to 500 kiloparsecs (this word being used for 1000 parsecs).

(2) Comparison of the size and brightness of the nebulæ with those in the Clouds; the mean magnitude is given as 15·7 in No. 6822, and 9 to 11 in the Clouds. This gives a distance of 280 to 500 kiloparsecs.

(3) The brightest stars in the object are of magnitude 18·5; assuming these to be reddish super-giants (their colour is inferred from their relative faintness on photographs) of absolute magnitude −3 to −4, the distance comes out 250 kiloparsecs.

Hence in round numbers we may take the distance as a million light-years, five times the distance found for the farthest globular cluster. It is inferred to be external to our sidereal system. The distances of the Magellanic Clouds were adopted as follows; large Cloud, distance 35, diameter 4·4 kiloparsecs; small Cloud, 25 and 1·6 kiloparsecs respectively.

Research Items.

THE BRAIN OF NEANDERTHAL MAN.—Prof. R. Anthony of Paris, who has for some time been engaged in the study of the endocranial cast of the skull from La Chapelle aux Saints, has published a summary of his results in the Bulletin of the Société d'Anthropologie of Paris. He compares the brain of Neanderthal man with that of the primates and of modern man in some considerable detail. Subject to the limitation that material is scanty and that our information is derived from Europe only, and further that Neanderthal man represents a vanished race rather than a stage in human evolution, it would appear that by the middle Pleistocene, or even before, man had already developed a brain of normal volume, and the essential features of the Neopallium had become apparent. The distinctive characters of the Neanderthal brain are its form as a whole and certain details in the folds which recall more primitive types. As regards the intellectual capacity of Neanderthal man, while the volume of the brain would support a favourable view of his intelligence, allowance must be made for the character of the convolutions, which are such as to suggest a mentality of low development. The frontal lobes, the centres of intellectual development, are restricted as compared with modern man. On the other hand, the parietal areas of association which are connected with vision and hearing are well developed.

NATIVE CULTURE IN CALIFORNIA.—Among the contributions to the Phœbe Apperson Hearst Memorial Volume which is published as vol. xx. of the University of California Publication in American Archæology and Ethnology, is a study of Californian culture by Mr. A. L. Kroeber, in which he has attempted a classification of local ethnic data in their developmental sequence. He suggests, with reservation, four successive stages. The first period is one of a relatively simple and uniform culture resting on a food supply of seeds, molluscs, fish and small game. In the second period, northern influences (probably Athabascan and Algonkin) from the Pacific coast, and South-Western affiliations, not yet specifically Pueblo, become apparent, while coiled basketry and a totemic sib organisation fall within this period. In the third period, localised cultures become differentiated, and although the cultural flow from the North Pacific coast and the South-West continues, its effects are restricted geographically by these local cultures. In the south it is marked by the growth of cosmogonies showing the influence of Mexico in the death of a great god. Along the Colorado agriculture, with other elements, was introduced from the Pueblos, or from Sonora. The fourth period is marked by the growth and completed development of the special features of modern Californian culture, while the absorption of northern and south-western culture, though continuing, becomes less direct. Dates are suggested tentatively: for Period I., 2000–1500 B.C. to B.C. 500; for Period II. 500 B.C.–A.D. 500; for Period III. A.D. 500 to approximately A.D. 1200, and for the fourth from that date to the present day.

ARCHÆOLOGICAL DISCOVERIES AT BYBLOS.—In the *Times* of January 29, Prof. Pierre Montet describes the principal results of the excavations at Jebeil, the ancient Byblos. Among the early discoveries in 1919 was a bas-relief representing a Pharaoh in adoration before the god and goddess of Byblos, and two shrines, one Syrian and one Egyptian. These yielded a number of objects, among which were vases from Egypt bearing the names of kings of the Ancient Empire, such as Unas, Pepi I., and Pepi II. What is, however, unquestionably the most important discovery was made in the present season when an underground chamber, which proved to be a royal burial place, was entered and an obsidian jewel casket mounted in gold was found, on the lid of which was an hieroglyphic inscription embodying the name Maākherurā, the prenomen of Amenemhat IV., who reigned from 1800–1792 B.C. This is the first definite evidence of date to be found, and enables an Amenemhat mentioned on a vase previously discovered in another chamber to be identified as Amenemhat III. The name of the Prince who was a contemporary of Amenemhat IV. is given on a bronze sickle or *harpé* as Yp-schemu-Abi. These inscriptions establish the fact that the Phœnicians employed hieroglyphic script with phonetic values identical with those of Egypt, three centuries before the adoption of cuneiform.

JĀBIR IBN ḤAYYĀN.—Vol. xv. (December, 1923) of Sudhoff's *Archiv f. Gesch. d. Med.* contains an article by Prof. Ruska on the list of writings ascribed to Jābir in the "Kitāb al-Fihrist," and on the authenticity of some of the tracts published by Berthelot in "La Chimie au moyen âge" (1893). Most of his results are in agreement with those of E. J. Holmyard (Proc. Roy. Soc. Med., 1923, xvi. 46-57; cf. NATURE, 112, 876), and the following points may therefore be taken as definitely established: (1) Jābir lived in the second half of the eighth century, under Hārūn al-Rashīd. (2) His reputation as the founder of Islāmic chemistry is justified. (3) In his treatment of the subject, Berthelot made many grave errors, which completely vitiate his arguments. (4) Geber and Jābir are one and the same. (5) The Latin works ascribed to him may or may not be genuine. (6) They are, however, based on previously existing Arabic works and do not represent (as Berthelot maintained) *European* contributions to chemistry. The Geber problem has thus advanced a further stage towards solution.

PROTECTIVE COLOUR.—Some apparently meaningless pictures in *The Brooklyn Museum Quarterly*, vol. x., No. 4, directed attention to an article on "Camouflage in Nature and in War" by Mr. Gerald H. Thayer, son of the late Abbott H. Thayer. While defending the reality and the selection-value of protective colour, he is not such "an extremist" as he holds his father to have been. After dealing with the well-established principles of counter-shading and picture-pattern, Mr. Thayer discusses change of shape by appendages and distortion or dazzle, both of which are the methods suited to moving objects. Admitting the value of Mr. Norman Wilkinson's work on ships, he revives and enforces his father's suggestion of spotless white and counter-shading of horizontal fully-illuminated surfaces with a delicate grey. "The belief that white is *bound* to show, and *especially* at night," is, he says, "a popular error." We agree that it is an error, and it seems a pity that Mr. Thayer's plan has never been given a fair trial.

FUNCTIONS OF PITUITARY GLAND.—There has been much divergence of opinion among investigators as to the effects of removal of the pituitary gland. N. M. Dott reports a careful reinvestigation of the question from the University of Edinburgh in the *Quarterly Journal of Experimental Physiology* (vol. xiii., 1923, p. 241). He finds that complete removal is always fatal within a fortnight. The posterior lobe (pars nervosa and pars intermedia) may be excised without producing any obvious effects. Partial removal or injury of the anterior lobe (pars glandularis) was regularly followed by characteristic symptoms: depression of temperature, lethargy, fatness, delay in

bone growth, and degenerative changes in the thyroid and genital glands. The polyuria, which is such a marked feature of some pituitary derangements, is attributed to irritation of the pars intermedia, the removal of which has no obvious effect on the animal.

GROWTH *IN VITRO* OF SINGLE CELLS.—The fact that organisms, up to a certain point of crowding, have a favourable influence on one another has been illustrated by a variety of observations. Pearl, for example, showed that the fly Drosophila lives better at a concentration of individuals in space much above the minimum. Brailsford Robertson with the protozoon Enchelys found that the number of individuals arising from two is much more than twice those generated from one in the same time in drops of water of equal volume; Cutler and Crump (*Bioch. J.*, xvii., 1923, 878) have failed to confirm this with Colpidium. More bacteria must be transferred to a litre of culture medium to start a successful subculture than are required for 5 c.c. A. Fischer now publishes (*Journ. Exp. Med.*, xxxviii., 1923, 667) an interesting example of what is doubtless the same general phenomena. By an ingenious technique he isolates individual connective-tissue cells in artificial cultures and finds that the single cells never grow, whereas growth takes place readily when the cells are numerous and close to one another. Loneliness is evidently undesirable. The observations of Carrel, Drew and others have shown that extracts of tissues contain varying quantities of substances which promote the growth of cells in artificial cultures, and it may be presumed that it is something of the same kind diffusing out from living cells which stimulates their immediate neighbours.

SEX CHROMOSOMES IN PLANTS.—It has until recently been supposed that sex chromosomes were only found in animals. But in 1917 Allen found an unequal XY pair in the liverwort Sphærocarpos. Santos (1923) demonstrated such a pair in Elodea, Kihara and Ono in *Rumex acetosa*, and Miss Blackburn (NATURE, Nov. 10, 1923, p. 687) in *Lychnis alba*. Winge (Comptes-rendus Lab. Carlsberg, vol. 15, No. 5) has now described sex chromosomes in the common and the Japanese hop, in *Melandrium* (*Lychnis*) *album* and in *Vallisneria spiralis*. It is therefore likely that they will be found in dicœcious plants generally. In all these cases except the last, an unequal XY pair has been observed. In Vallisneria, however, there appears to be no Y chromosome present. It is thus a remarkable fact that where the dicœcious condition has developed independently in different families it is accompanied by a differentiation of sex chromosomes.

MOLLUSCA FROM THE SALT RANGE, PUNJAB.—A considerable collection of molluscs was made in the Salt Range by Theobald so long ago as 1850–52, and now Dr. Sunder Lal Hora has brought back thence further collections. These gatherings have just been dealt with in a paper, followed by a supplemental note, by Dr. Annandale and H. Srinivada Rao (Rec. Ind. Mus., xxv., pp. 387-98 and 601-602). The authors record some twenty-four species of gastropods, four of which are apparently endemic and two bivalves. They describe two new species in the paper, but have regretfully to acknowledge in the supplemental note that one, the form which they mistook for a new Eulota, was after all a well-known Bensonia. The study of the Indian land snails is not so easy by far as that of the aquatic. In their note, too, the authors direct special attention to the existence of *Limnæa gedrosiana*, A. and P., and of a dwarf form of *Bithynia tentaculata*, Linn., on the east side of the Indus and south of the Himalayas, but as regards the latter fail to define its relationship to the *B. tentaculata*, var. *kashmirensis* of Nevill (Hand List, ii. p. 39), likewise a dwarf form, from Sringar, which lies also, we believe, in the district just specified.

INHERITANCE RATIOS IN PEAS.—In 1905 the late Mr. A. D. Darbishire began a series of experiments in determining the frequency of the four types derived in successive generations from a cross between a yellow-wrinkled (YW) and a green round (GR) pea. Since his death in 1915, the experiments have been continued by others, and Mr. G. Udny Yule (*Journ. Genetics*, Nov. 1923) has now published a biometrical analysis of the results obtained in F_{12} to F_{17}. The types of plants obtained are found to differ significantly from the 9 : 3 : 3 : 1 ratio. There is a deficiency of GW and an excess of YR seeds, but differential death-rates will apparently not explain the result. In following lines of descent through several generations, some lines agree very well with Mendelian expectation, while others are shown by a variety of tests to depart significantly from it. An analysis of the distributions in individual pods shows no significant divergencies, but in the "populations" of the various generations unexplained divergencies are found to occur.

RHINE PLANTS AND ANIMALS IN EASTERN ENGLAND.—Dr. W. G. N. v. d. Sleen writes to us from Haarlem, directing attention to the occurrence in Eastern England of Rhine plants and molluscs which do not occur in the rest of Great Britain. The evidence is contained in a paper by Dr. Th. J. Stomps, of Amsterdam, in the November (1923) issue of *Tijdschrift van het Koninklijk Nederlandsch Aardrijkskundig Genootschap*, on the plants, and in an earlier paper by Dr. v. d. Sleen, on the Cromer Forest Beds, the Chillesford Clay, etc. Of the species known to Dutch botanists as typical "Rhine plants," *Silene Otites*, *Artemisia campestris*, *Eryngium campestre*, and *Erucastrum Pollichii* are found in England only in the east. Other important species occurring along the Dutch and the German Rhine are confined, or nearly confined, to the "Breckland," a sandy area in south-west Norfolk and north-west Suffolk. Among these are *Ornithogalum umbellatum*, *Herniaria glabra*, *Scleranthus perennis*, *Phleum Boehmeri*, and *Muscari racemosum*. Among freshwater molluscs we find *Segmentina nitida*, *Vivipara vivipara*, *V. contecta*, *Assemania grayana*, *Bythinia leachii*, *Unio tumidus*, *U. pictorum*, *Anadonta anatina* (*piscinalis*), *Sphaerium rivicola*, *Dreissensia polymorpha*, which are common along the German and Dutch Rhine and in eastern England, but not in the waters draining into the Irish Sea. Dr. v. d. Sleen considers that these facts support the conclusions of Harmer and Prestwich, that in pre-glacial times the Rhine entered England in the neighbourhood of Walton and left it at Cromer. He would like to see a comparison of the small freshwater Crustacea and of the fishes of eastern England with those of the Dutch and German Rhine, and would be glad to help any English student of the subject with information on distribution of the species in the latter areas.

CRUDE OIL OF SARAWAK.—Sarawak is to-day second on the list of oil-producing countries included in the British Empire, yielding, in 1922, 403,394 tons of petroleum. The present weekly output is about 11,000 tons. Comparatively little is generally known of this oil or of the conditions under which it occurs and is produced. Mr. J. Kewley's paper on this subject at a recent meeting of the Institution of Petroleum Technologists was therefore welcome. The oil of Sarawak comes from the Miri district, 150 miles south of Brunei Bay. It is obtained from Miocene beds. It is a reddish brown liquid of average

specific gravity of 0·902, and is of the naphthenic type; but a paraffin base oil occurs in deeper sands, as is frequently the case with East Borneo petroleum. The products obtained from the Miri crude oil are benzine (about 14 per cent.) with specific gravity 0·786, kerosene with 0·850 gravity (very high and consequently not of too good a burning quality), and fuel-oil, which is valuable for furnace work and also for Diesel engine use. The gravity of the fuel-oil is 0·930. This oil is refined at the Lutong refinery, where there are two plants of the Trumble type in operation. From the refinery the products are loaded by means of submarine pipe-lines on to tankers anchored off the shore. The crude oil, like the petroleum of Borneo generally, is of more than ordinary technical interest.

MILK TESTING BY HYDROGEN-ION DETERMINATIONS.—In 1921 Mr. Cooledge devised a method for the control of milk supply based on hydrogen-ion determination and taking the place of bacteriological examination. A special broth culture medium is prepared and is brought to a P_H value of 7·0 by the addition of acid or alkali by comparison with a colorimetric standard, brom-thymol blue being used as the indicator. Test-tubes of standard size (1·8 × 16 cm.) receive 10 c.c. of this broth, and to each is added 1 c.c. of a 1 in 10 dilution (=0·1 c.c. of milk) of the milk to be examined. The tubes are then incubated at 37° C., and hourly observations up to 8 hours are made to determine the change of tint of the indicator. By comparison with a set of standards, nine P_H values ranging from 7·2 to 5·8, with intervals of 0·2, can be determined. The greater the number of bacteria present in the milk, the greater and quicker will be the change of P_H value in the direction of acidity. For the different readings, "scores" are given. Thus a milk giving a P_H value of 5·8 after one hour's incubation receives only 25, while one which after eight hours' incubation does not exceed 6·7 receives 100. The method seems to work well in practice, and milks containing a large number of bacteria, and therefore of poor keeping and hygienic qualities, can be picked out in the course of an hour or two, whereas a bacteriological examination necessitates a delay of at least twenty-four hours (Michigan Agriculture College, Techical Bull. No. 52). In a later study by Mr. Cooledge, the method has been applied to check the temperature conditions in pasteurising plants, samples being taken from various points in the apparatus. In this way faults in the process may be located to a particular point in the apparatus (*ib.* No. 124).

RAIN IN THE NETHERLAND INDIES.—In Verh. No. 8, vol. 1, Part 3, of the Royal Magnetic and Meteorological Observatory of Batavia, published under the superintendence of Dr. C. Braak, there is a brief English summary as well as the full discussion in Dutch. The discussion deals with rainfall in varied considerations, its yearly and seasonal amounts, changes with monsoon, variation of amount with height above sea level, daily variation, intensity during short intervals, periods of drought, rain observations made at sea, and influence of forests on precipitation. During the monsoon changes, rainy periods are experienced, and on exposed mountain ranges continuous rains are frequent, where the monsoon when passing obstructing mountain ridges is forced to ascend. On the mountain sides the amount of rain in 24 hours ranges above 14 in., and in many places is between 16 and 18 in., the maximum being 20·1 in. observed at Besokor on January 31-February 1, 1901. The high monthly rainfall totals in places are due to the same fact, the continuous forced ascension of the wind. The mountainous nature of most of the Islands has a marked influence on the rainfall. It is suggested that the high rainfall in the East Indian Archipelago is unique in comparison with any other extensive connected area. The annual amounts in places exceed 118 in.; the largest amount, 270 in., occurs at Kranggan (Java). Rainfall is shown to increase usually with height above sea level, but at great heights rainfall decreases again. The discussion adds much valuable information to the study of the world's rainfall.

SPECTRA AND ATOMIC STRUCTURE.—In his address at the conference of German Physicists at Bonn in September 1923, Prof. Paschen dealt with recent progress in the attempt to discover the structure of the atom by spectroscopic investigation. The issue of the *Physikalische Zeitschrift* for October 1, 1923, reproduces the address. Prof. Paschen contrasts the unchanged experimental methods with the great advances which have been made in the interpretation of the results they have given during the last ten or twenty years. The development of the Combination Principle by Ritz and its interpretation in terms of the dynamics of the atom by Bohr and Sommerfeld, the discovery in Bohr's laboratory that the Stark effect produces lines excluded by that principle, the investigation of the "terms" which reproduce the lines of elements with higher atomic numbers, the discovery of the duplication and triplication of these "terms," and the recent work of Landé extending the law of doublets to quartets, sextets, and octets, are all dealt with. While Prof. Paschen believes that Bohr's interpretation of the experimental facts is of permanent value and stimulates research to an extraordinary degree, he thinks the necessity for the introduction of new hypotheses to explain the facts accounts for the sceptical attitude of many towards it.

STABILITY OF AMMINES.—Mr. G. L. Clark describes in the *American Journal of Science* (vol. vii. p. 1, January 1924) a long series of measurements of the stabilities of ammines of inorganic salts, as indicated (usually) by the temperature at which the vapour pressure of the ammine rises to 100 or to 760 mm. He finds that in ammines of comparable type, the stability increases with diminishing atomic volume of the co-ordinating metal, *e.g.* in the series Cs, Rb, K, Na; Tl, Ag, Cu; Ba, Sr, Ca; Cd, Zn, Mn, Cu, Fe, Co, Ni. On the other hand, it also increases as the anion becomes more bulky, *e.g.* from Cl to Br to I and from MoO_4 to WO_4, CrO_4, SO_4 and SeO_4, the last series of radicals being arranged in the order of increasing molecular volumes of the acid anhydrides MoO_3, etc. In some cases regular numerical relations are observed, *e.g.* the stabilities of the bivalent anions $[Co6NH_3]$ and $[Ni6NH_3]$, as measured in absolute temperatures for the same vapour pressures, are in the ratio 1 : 1·075, the nickel forming the more stable ammines. In general, it appears that the ammonia is attracted solely by the cation, unlike water, which may also be attracted by the anion, and therefore shows more complex relationships; the smaller the metallic cation the more room there is to pack molecules of ammonia round it without breaking up the lattice; increase in the size of the anion also leaves more room for the ammonia, and hence increases the stability of the ammines. Exceptions occur in the case of some of the lower ammines, *e.g.* chlorides give more stable monammines and diammines than do iodides. On the other hand it is quite in accord with the rule that only the iodide of barium can form a decammine. The paper includes a list of thirty-three new, or formerly doubtful, ammines, some of which are only stable at low temperatures, even in an atmosphere of ammonia.

The Geographical Distribution of Snowfall.

SNOWFALL is scarcely less important than rainfall in the general economy of the earth's surface, and has an even greater latitudinal range over that surface, being entirely excluded only from the inter-tropical lowlands, whereas rain is nearly excluded from the polar regions as well as very high mountains in all latitudes. It is strange that so little attention has been paid to the study of the geographical distribution of snow as such apart from its rainfall equivalent when melted. One welcomes, therefore, a short paper, "Sulla distribuzione geografica della neve," by G. Ferrara (*La Meteorologia pratica*, Anno iv., No. 2, 1923), who gives a general survey of snowfall conditions for the whole globe, together with special statistics, with a map, for Italy.

The average annual number of days on which snow falls, as based on a 10-year period, is very small all over the peninsular and insular parts of Italy, except, of course, in the mountains, being, to quote a few figures, 0·7 at Palermo, 1·4 at Naples, 1·6 at Genoa, 1·7 at Rome, and 3·5 at Florence. In continental Italy, as dominated by the great plain of the Po between the Alps and Apennines, the figures increase to 4·1 at Como, 5·6 at Padua, 8·1 at Milan, 10·5 at Parma, 10·8 at Bologna. But even these latter figures strike one as very small for a region with a winter which, if relatively short, is very sharp at its depth and marked by a fairly regular snow-canopy. They may be contrasted with the generally higher frequencies at stations in the British Isles with a longer winter (M.O. Book of Normals, Sect. IV. *b*, 1923). Only in the extreme south-west of Ireland and England, which project into warm water, is the annual number of snow-days less than 10; in all other parts it is above that figure, among the higher values being: Stornoway and Wick, 25; Sheffield and Stonyhurst, 26; Sunderland, 28; Aberdeen, 34; Buxton, 38; and Balmoral, 50, the last two stations being 1000 feet above sea-level. On the summit of Ben Nevis[1] (4400 feet) it snows on 170 days in the year, or about as often as it rains in London with only 13 snow-days. The British figures, however, are based on 40 years' records, the Italian only on 10. Also the comparability may be slightly affected by undisclosed differences in the standard of estimation—often the bugbear of those who want to compare the climatological statistics of different countries.

Returning for the moment to northern Italy, the important feature which Ferrara brings out is that there is considerably less snow near the southern foot of the Alps, as typified by Como, sheltered from polar winds and exposed to sunshine, than near the northern foot of the Apennines, as typified by Parma and Bologna, where the conditions are reversed. It may be noted that the high southern Apennines of the Abruzzi, and other provinces, enveloped as they are in the moisture of the Mediterranean Sea, is in winter, the rainy season in the Mediterranean, one of the snowiest mountain systems in Europe, only saved from perennial accumulations by their moderate altitude and by the heat and drought of the Mediterranean summer.

In Europe as a whole, parts of Russia, Poland, Rumania, Hungary, Switzerland, Germany, and the central plateau of France are mentioned as countries having a copious snowfall, while in some of the valleys of Transcaucasia the amount of snow which falls in an average winter is said to amount to 5 to 7 metres (15 to 21 feet), though whether this is actual accumulated depth without drifting or simply the aggregate of successive falls separated by thaws is not stated. One misses in this paper any reference to snowfall in the British Isles, which, under the influence of the ocean climate, is more erratic and transitory than on the mainland of Europe—a fact which tends to conceal its real magnitude. The normal falls during the winter and spring months in the Highlands of Scotland and the northern part of England are undoubtedly heavy. Moreover, in a country like England, where the winter climate is *damp* rather than cold, with a mean winter temperature at sea-level slightly below 40° F., there is a much greater difference between the snowfall of uplands and lowlands than is the case in countries where the mean winter temperature is below the freezing-point. Thus those who live in London and other of the great lowland cities often have little realisation of the severity of the visitations in regions like the Cheviots, the Peak of Derbyshire, and, rather less often, Dartmoor in Devonshire.

Since snow, like sand, is, in large quantities, one of the most formidable of natural agencies, it must be accounted fortunate that the two conditions essential to heavy snowfall, namely, cold and humidity, tend to limit one another. The fact that temperature and vapour tension tend to rise and fall together, except perhaps in regions cut off from supplies of moisture, is a very effective safeguard against excessive snowfall, and reduces the area of the globe where the requisite conditions for heavy snowfall exist. It is known that the snowfall of the polar regions, though constant, is not so intense as the winter fall in warmer latitudes.

In the heart of Asia, too, the winter snowfall is relatively light, partly because of the extreme cold and partly because the physical configuration of the Continent cuts off moisture-bearing winds, both of which factors reduce the vapour tension too low for much snow. Consequently it is in some of the peripheral regions of Asia where the enormous snowfalls occur, for example in Kamchatka, the mountains of Japan, and the plateaus of Afghanistan, Persia, and Asia Minor. Similarly in North America the snowfall is heavy on the Atlantic coast and in the mountains of the Pacific coast, but light in the interior plains. On the other hand, regions like western Europe, with a high degree of winter humidity and storminess, are liable to be too warm for sustained snowfall, and much of the winter precipitation is in the form of rain. Finally, it should be emphasised that occasional light falls of snow at sea-level make a much closer approach to the tropics than is commonly supposed, and statements to the effect that snow is "unknown" in the vicinity of the 30th parallel N. or S. should, as a rule, not be taken literally. Moreover, it does not require, even in such low latitudes, an elevation above sea-level greatly exceeding 2000 feet for the occurrence now and then of very heavy snowfall. This is true of the plateaus of Algeria and Morocco, as also of those in South Africa. In February 1921 a snowstorm of unusual intensity swept Palestine, depositing some 3 ft. of snow in a day on the Judean plateau, upon which stands the city of Jerusalem. Similarly in the uplands of Natal in early spring, about late August or September, when the South African winter drought begins to break and there are cold southerly winds, experiences are sometimes reminiscent of the Pennines and other high moorlands of England, especially in the corresponding months of February and March, when livestock is lost and lonely homesteads blockaded by huge drifts in every accentuated snow-spell.

L. C. W. BONACINA.

[1] Readers should be reminded of the permanent snow-beds in corrie round Ben Nevis, and other parts of the Grampians, which of recent years have been proved to exist. They are maintained chiefly by small avalanches blown off overhanging cliffs.

National Union of Scientific Workers.

THE proceedings at the annual Council meeting of the National Union of Scientific Workers, held at the Imperial College of Science on January 26, were enlivened by a spirited discussion on the position of the general secretary, Major A. G. Church, now that he has been elected member of Parliament for Leyton (East). The suggestion was made that his personal association with a political party might give the Union a political complexion, but the majority of the representatives present were evidently of the opinion that the more scientific workers there were in Parliament, irrespective of party, the more likelihood there would be of science exercising its proper influence in national affairs.

Mr. F. T. Brooks (Cambridge), in presenting the sixth annual report, emphasised the need for more propaganda among leaders of industry and public bodies in order that the importance of science to the nation should be more fully appreciated. During the year, a number of public meetings were arranged in different centres of industry, presided over by representatives of Chambers of Commerce and other public men. A *questionnaire* had been addressed to all members of the last Parliament with the view of ascertaining their attitude towards research and the public endowment of research institutions, and an offer had been made to certain industrial undertakings to put at their disposal the services of the Research Council, with the view of their making proposals for the proper utilisation of science in their industries. The fact is fully appreciated by the Executive of the Union that upon fuller recognition of the potentialities of science depends the welfare of the scientific workers who are being turned out from our universities yearly. It is hoped that the prominence given to this question at the forthcoming British Empire Exhibition at Wembley through the efforts of the British Science Guild will have far-reaching effects.

For the past two years at least, the claims made by the Union to the Treasury and other Government departments for the improvement of the salaries and conditions of service of scientific workers in Government departments have been weakened by the prevailing conditions of scientific workers in industry and in the universities. The attitude of the administrative heads of departments is demonstrated in the terms of the report of the committee on the pay of State servants. In this report it is stated that while the salaries of administrative officers cannot be based upon those which can be obtained by men of similar standing in outside professions, those of the scientific and technical officers were rightly based upon the current market rates. The Union will continue to press for a new inquiry into the position of civil servants engaged in scientific and technical work, and the setting up of the new Civil Service National Whitley Council, representation on both sides of which shall be confined mainly to scientific and technical officers. On the existing National Whitley Council, science has practically no voice, and to this fact can be attributed the want of success which has attended the efforts of the Union to obtain any measure of justice or equity of treatment.

Dame Helen Gwynne-Vaughan, the retiring president, in her address dealt with the need for a federation of scientific bodies with the view of the ultimate creation of a General Scientific Council similar to that of the General Medical Council; this would lead to the ideal of science as a self-governing profession.

Prof. G. H. Hardy, of Oxford, was elected president of the Union for the ensuing year, while Dr. J. W. Evans was unanimously elected president of the Research Council.

Orographical Compensation in Northern India.

A CONSIDERABLE discussion has arisen in recent years regarding the precise meaning of the gravity variations revealed by the geodetic survey of India. The Himalayan region and bordering plains in the foreground, which are of special interest because of Archdeacon Pratt's mathematical development of the theory of mountain compensation, have formed the subject of revived discussion on account of the novel suggestion of subterranean rifting, made by Sir Sidney Burrard and his colleagues of the Indian Trigonometrical Survey and criticised by Mr. R. D. Oldham and the late Sir Henry Hayden of the Geological Survey. The geologists considered that insufficient allowance had been made for the low density of the large mass of alluvium in the foreground, and an analysis of the data by Mr. R. D. Oldham (Mem. Geol. Surv. Ind., xlii., part 2, 1917) developed this aspect of the question as a partial explanation of the observed deficiency in gravity. Since 1917, further data have been published by the Survey officers and by Prof. A. Alessio as the result of the Filippi expedition to Central Asia. These results have been examined by Mr. R. D. Oldham in a paper recently published in the Records of the Geological Survey of India (vol. lv., part 1, 1923), and he concludes that the fuller observations now available confirm the conclusions given in his previous memoir.

In one of the professional papers of the Survey of India (No. 18, 1921) Col. H. McCowie criticised Mr. Oldham's method of computation from an "imaginary range," but the method adopted was the only one possible without an organised computing staff with full topographical data, and the adoption of a simplified topography was frankly for the purpose of obtaining a sufficient approximation in results to estimate the relative values of the alternative theories. Other methods which have been criticised were similarly adopted in the absence at the time of data for a sufficient number of stations, and these, having now been supplied, permit of more precise computations being made.

Along the outer Himalaya there is a zone of superelevation where the defect of density, or compensation, corresponds to a lesser altitude than that of the surface, and along a parallel zone at the foot of the hills there is a region of over-depression of the surface, and consequently excessive deficiency of gravity. These two conditions, according to Mr. Oldham, can be sufficiently explained, when allowances are made for the rock densities, by assuming for the earth's crust a degree of rigidity which prevents it from taking up immediately and fully the flexures which followed the Himalayan uplift and coincident Gangetic depression.

A bye-product of Mr. Oldham's original line of argument was his conclusion that the excess of mass in the outer Himalayas would not continue over the whole range, but would disappear into the interior, and the results obtained during the course of the Filippi expedition to Central Asia seem to show that this is so.

University and Educational Intelligence.

CAMBRIDGE.—The University of Cambridge Commissioners have authorised and directed the University to limit to December 31, 1925, the tenure of all officers appointed after the present date, except where the person before election shall have undertaken to hold the appointment subject to conditions that may be made or approved by the Commissioners.

An offer of 5000*l.* has been made to the University by Mrs. Pinsent, Sir Francis and the Hon. Lady Darwin for the purpose of promoting research, by studentship or otherwise, into any problem which may have a bearing on mental defects, diseases, or disorders. In the letter in which the offer is made, the donors express the belief that the racial and social problems involved by the existence of such large numbers of mentally incapable persons in the community are of great national importance, and that their solution may have far-reaching effects. The gift is made in memory of Hume C. Pinsent, scholar and fellow of St. John's College; Erasmus Darwin, exhibitioner of Trinity College; David Hume Pinsent, scholar of Trinity College; and of Richard Parker Pinsent, exhibitioner of Balliol College, Oxford.

Mr. T. T. Barnard, research student of King's College, has been elected to the Anthony Wilkin studentship for research in ethnology and archæology in Southern Sumatra; Mr. R. A. Webb, research student of Gonville and Caius College, to the Charles Abercrombie Smith research studentship at Peterhouse.

The Army Council has asked the University if it would be willing to undertake the examination qualifying Royal Engineer officers to receive engineer pay. In view of the prominent part which the Department of Engineering takes in the training of Royal Engineer officers, the Special Board of Engineering Studies recommends that the University should undertake this work.

LONDON.—Dr. A. W. Porter has been appointed as from August 1, 1923, to the University chair of physics tenable at University College. Prof. Porter has been a lecturer and assistant professor at University College, and, since 1913, University reader in thermodynamics.

Mr. E. C. Rhodes has been appointed to the University readership in statistics tenable at the London School of Economics. From 1919 to 1922 Mr. Rhodes was assistant in the Department of Applied Statistics at University College, London, and since 1922 has been lecturer in charge of the Department of Mathematics at University College, Leicester.

The following Doctorates have been conferred: *D.Sc. in Zoology*, Rev. S. G. Brade-Birks (South-Eastern Agricultural College), for a thesis entitled "Notes on Myriapoda; the Economic Status of Diplopoda and Chilopoda and their Allies." *D.Sc. in Chemistry*, Mr. Sri Krishna (King's College), for a thesis entitled "Synthesis of Derivatives of Thianthren and Phenothioxin."

THE annual meeting of the Association of Technical Institutions will be held at the Clothworkers' Hall, Mincing Lane, London, E.C., on February 29-March 1, under the presidency of Lord Emmott. Papers will be read during the meetings by Mr. H. Dempster Smith (Manchester) on "Engineering Economics"; Principal C. Coles (Cardiff) on "Non-Resident Students in Technical Institutions"; and Principal A. R. Sage (London) on "Technical Training for the Building Trades."

Early Science at the Royal Society.

February 1, 1676. Read a letter from Mr. Leewenhoeck relative to observations with his microscope.

February 3, 1663. Mr. Hooke's account both of the weight of the air in a large receiver 119 English wine pints, and of the proportion of the weight of the air to the weight of the water, was read. It was ordered that whoever make report of an experiment but once made, should repeat it, for the sake of more accuracy and certainty.

1669. Mr. Hooke produced a contrivance of his to try whether a mechanical muscle could be made by art, performing without labour the same office which a natural muscle doth in animals.

1675. The reading of Mr. Newton's observations on colours was continued.

1685. Dr. Papin for the entertainment of the Florentine envoy showed again the experiment of water boiling *in vacuo*.

February 4, 1662. Dr. Charleton moved, that the eyes of some animals might be frozen, in order to see their structure the better. The operator was ordered to freeze some cats' eyes against the next meeting, if the frost should hold.

1668. Two experiments with balls were made to verify Dr. Wren's laws of motion.

1674. Mr. Hooke declared that he had made some discovery of the structure of a muscle by inspection with a microscope.

February 5, 1661. Dr. Wren was desired to think of an easy way for an universal measure, different from that of a pendulum.

1673. An experiment was made with Mr. Lister's styptic liquor upon a dog, by opening one of his crural arteries lengthwise without cutting it asunder.

1679. The method of making experiments was further discoursed of; that they should be made in order to prove a theory propounded: but Sir William Petty was of opinion, that they would be more faithfully made and delivered if they were not made to help out a theory because that might prepossess and bias the experimenter.

February 6, 1660. A committee was appointed for considering of proper questions to be inquired of in the remotest parts of the world.

1666. A letter was read from the Duke of Brunswick to Mr. Oldenburg containing both his desire to be made acquainted with the experiments made, and his offer of communicating in return what should come to his knowledge in Germany and out of Italy.

1667. Mr. Oldenburg read a letter sent by John Denis, M.D., professor of philosophy and mathematics at Paris, relating to a late cure of an inveterate phrensy by the transfusion of blood.

1678. Mr. Henshaw mentioned M. du Pont's papers, which were in the hands of Mr. Evelyn, about the way of setting in new teeth artificially.

February 7, 1677. A discussion concerning mildews.

February 8, 1664. Mr. Bagnall produced a bag-full of *lapis amiantus* or *asbestos*. He was desired to procure more of it, in order to the making of paper.

1687. Ordered that money be laid out for erecting a pole in the quadrangle of Gresham College for management of a telescope.

February 9, 1670. Mr. Hooke being asked whether the air-vessel for a man to sit in was yet ready, answered that it was, and that he intended to make some experiments in it.

1686. Ordered that a committee who will voluntarily meet once a week in Dr. Pope's lodgings be allowed a fire and candle at the Society's charge.

Societies and Academies.

LONDON.

Royal Society, January 31.—A. **Mallock**: Summary of the results obtained from experiments made during the years 1918–1923 of the effects of temperature on the properties of metals. The results relate to the properties of iron and steel in the neighbourhood of the critical temperature. The principal change which occurs at that temperature is an abrupt alteration in specific heat, which, as the metal passes to the high-temperature state, is reduced to about one-third of its previous value. The coefficients of rigidity and thermal expansion undergo no discontinuous change. The rigidity decreases slowly as the temperature rises to a low red heat, but at higher temperatures the change is rapid. At a bright red heat the metal still retains elastic properties, but with greatly increased viscosity, and thus oscillations which depend on rigidity are quickly damped out. The presence of small quantities of silicon, sulphur, phosphorus, and manganese in the samples used prevents any absolute conclusion being formed as to the effect produced by carbon alone, but it is clear that carbon lowers the critical temperature, and prolongs the time occupied in changing from the high to the low temperature state while the metal is cooling.—A. K. **Goard** and E. K. **Rideal**: Catalytic and induced reactions. Pt. I.: An electrode of special type has been devised whereby it is possible to effect the comparison of the potentials of certain substances which behave irreversibly towards the platinum electrode. The action of cerous salts in effecting the induced oxidation of potassium arsenite, and the catalytic oxidation of five reducing sugars, have been investigated from the point of view of oxidation potential. In the former case the potentials observe the order: Cerous salt (inductor)—arsenite (acceptor)—equilibrium mixture—perceric salt; in the latter, the order: Reducing sugar—cerous salt—perceric salt. Pt. II.: Schönbein's reaction (the separation of iodine from potassium iodide solution in the presence of hydrogen peroxide and ferrous salts) conforms to the schemes for coupled and catalytic reactions described in Part I. of this paper. Direct evidence has been obtained of the formation of a peroxide of iron by the action of hydrogen peroxide upon ferrous sulphate in neutral solution; it decomposes according to a mono-molecular law. This peroxide has been shown, by the method of electrometric titration under special conditions, to possess the essential formula Fe_2O_5.—H. B. **Dixon** and G. **Greenwood**: On the velocity of sound in gases and vapours, and the ratio of the specific heats. The velocity of sound in certain vapours and condensable gases was determined by timing the passage of a sound-wave between the two ends of a coiled lead pipe filled with the vapour or gas between 20° C. and 100° C., and comparing the rates with the velocity of sound through air in the same pipe. From the velocities found in the pipe the velocities in the "free" gas are calculated, and from these results the specific heats of the gases and vapours are computed.—J. R. **Partington** and A. B. **Howe**: The ratio of the specific heats of nitrogen and of oxygen. The adiabatic expansion method of determining accurately the ratio of the specific heats of a gas has been applied to nitrogen and oxygen. The gas was contained under pressure in a spherical copper globe of about 60 litres capacity, immersed in a water-bath maintained at constant temperature by means of an electrical thermostat, and is put into communication with free air so that equalisation of pressures takes place adiabatically. Pressure was measured on an oil manometer. The bolometer was used in conjunction with an Einthoven string galvanometer and a post-office box. The galvanometer was used as a null instrument, the lowest temperature attained during expansion being reproduced by adding ice to the bath. The temperatures were determined by a standardised mercury thermometer. The following values were obtained:

	c_v.	c_p.	C_v.	C_p.	γ
Nitrogen at 20° C.	0·1759	0·2470	4·929	6·922	1·4045±0·0003
Oxygen at 20° C	0·1581	0·2204	5·056	7·051	1·3946±0·0002

S. **Barratt**: The absorption spectra of mixed metallic vapours. In an absorption band spectrum, which is developed only in mixtures of the vapours of sodium and potassium, contrary to previous statements, the line $1S - 2p_2$ of magnesium has been observed in absorption.—E. P. **Metcalfe** and B. **Venkatesachar**: On selective absorption by luminous mercury vapour. The absorption of the components of the 5461 Å group ($1p_1 - 1s$) by luminous mercury vapour has been examined, with the aid of a Lummer-Gehrcke plate and an absorbing column 100 cm. long. All the satellites are strongly absorbed, under suitable conditions, with the exception of −·237 Å, which is also absorbed, but to a much less degree. The ratio of emission to absorption is fairly constant for all the lines, except −·237 Å. All the resolved satellites, except −·237 Å, have been reversed on a continuous bright background. The absorption and reversal of the lines 5769 Å (1P − 2d′) and 5791 Å (1P − 2D), for which the absorption centres are the same, and in the state 1P, have been observed. Two satellites of 5769 Å (·044 Å and −·050 Å) have been reversed. The effectiveness of long columns as radiators of weak lines is brought out by the observation of the feeble satellite −·112 Å of 5679 Å in the light radiated from the end of a 100 cm. column carrying a current of 0·06 ampere per sq. cm.

Association of Economic Biologists, December 7.—R. S. **Troup**: Our tropical forests and their economic significance. The area of tropical forest within the British Empire is probably not less than 750,000 square miles, much of which is at present inaccessible or commercially unprofitable. Forests should be regarded as so much capital producing a steady interest or increment, and exploitation should extend to the utilisation of this increment while the capital is maintained and improved in quality. A definite forest policy having been laid down, the following steps are indicated: (1) reservation of areas to be retained permanently as forest, (2) settlement of rights, (3) demarcation, (4) detailed survey, and (5) preparation of working plans for the regulation of fellings and the conduct of regeneration and other works. So far as the utilisation of timber and other forest products is concerned, much research work remains to be carried out, for which purpose a Forest Products Research Board under the Department of Scientific and Industrial Research has recently been set up. Steps are also being taken to provide for the more efficient training not only of forest officers but also of research officers in specialised branches of forestry.—M. **Grabham**: *Pseudococcus sacchari* and its associates in Madeira. Sugar cane was introduced into Madeira early in the fifteenth century, but was wiped out in 1877 by a fungus, probably *Aspergillus fulvus*. *Pseudococcus sacchari* is known to have been present before the arrival of the Aspergillus, and the attack of the fungus was probably facilitated by the puncture of the coccid. After 1877 no sugar was grown for quite three years; then the Bourbon cane hitherto planted was replaced by the Yuba cane from Natal. The Pseudococcus either

survived or was reintroduced, and has latterly enormously increased owing to the fostering care of the introduced Argentine ant. Though no control measures are undertaken, the Yuba cane flourishes and shows no deterioration in the crystallisable sugar yield. The Pseudococcus appears to have few parasites, and Coccinellid predators are thoroughly removed by the Argentine ant. A widely diffused red staining of the sheath accompanies the Pseudococcus attack. Its nature has not yet been satisfactorily determined.

January 18.—E. B. **Poulton**: The relations of pure and applied biology (Presidential address).

Mineralogical Society, January 15.—Dr. A. E. H. Tutton in the chair.—A. F. **Hallimond**: The chemical classification of the mica group. Muscovite and phengite can be represented as mixtures of the molecules $K_2O \cdot 3Al_2O_3 \cdot 6SiO_2 \cdot aq.$ and $K_2O \cdot (Fe,Mg)O \cdot 2Al_2O_3 \cdot 6SiO_2 \cdot aq.$, the amount of water being somewhat variable. The best-known lithia micas are represented as follows: Lepidolite, $K_2O \cdot Li_2O \cdot 2Al_2O_3 \cdot 6SiO_2 \cdot aq.$; cryophyllite, $K_2O \cdot Li_2O \cdot (Fe,Mg)O \cdot Al_2O_3 \cdot 6SiO_2 \cdot aq.$; polylithionite, $K_2O \cdot 2Li_2O \cdot R_2O_3 \cdot 6SiO_2 \cdot aq.$ In the same way the dark micas can be represented as mixtures of phlogopite, $K_2O \cdot 6(Mg,Fe)O \cdot Al_2O_3 \cdot 6SiO_2 \cdot aq.$, and two biotite types, namely, $K_2O \cdot 4(Fe,Mg)O \cdot 2Al_2O_3 \cdot 6SiO_2 \cdot aq.$ and $K_2O \cdot 6(Fe,Mg)O \cdot 2Al_2O_3 \cdot 6SiO_2 \cdot aq.$ In the most acid biotites (from granite) the Al_2O_3 is somewhat greater, with a corresponding replacement of (Fe,Mg)O. Al_2O_3 is, of course, often replaced by Fe_2O_3, $(OH)_2$ by F_2, etc. Graphical formulæ of oxidic compounds (salts) can be simplified by writing the connecting group –O– as a single symbol. The above empirical formulæ can be represented as salts of the single-chain hexa-silicic acid with K,Mg,Fe, etc., and with a diacid alumina group $Al_2(OH)_2O$, in which hydroxyl is replaceable by fluorine. The greater acidity of the white micas is accounted for by the presence of three acid groups –Si : O : Si– in the chain; biotite results from the addition of 3(Fe,Mg)O to these groups, to form a normal salt; the most basic dark micas contain $Al_2(OH)_2O_2R$ in place of the simple group $Al_2(OH)_2O$, the aluminium becoming "amphoteric" when the solution is very rich in (Fe,Mg)O.—A. **Brammall** and H. F. **Harwood**: Gold and silver as accessory minerals in the Dartmoor granite. Visible gold occurs as scanty minute specks in a porphyritic oligoclase-quartz-orthoclase rock containing a pale green fibrous amphibole and abundant sphene, together with apatite, zircon, monazite, and, occasionally, tourmaline. The silver has not been observed in hand specimens; assays show that it is usually in excess of the gold. The rock occurs as large loose boulders on Bittleford Down and at a few other localities.—Arthur **Russell**: Topaz from Cornwall, with an account of the localities, old and new, at which it is found. All the hitherto recorded occurrences of topaz in Cornwall are described, and new ones at Castle-an-Dinas Wolfram Mine, St. Columb Major; Belowda Beacon Mine, Roche; Beam Mine, St. Austell; and Mulberry Mine, Lanivet. At several localities, topaz is present in considerable quantities in the cassiterite-wolfram lodes; at Belowda it is especially abundant with tourmaline.

Royal Meteorological Society, January 16.—Dr. C. Chree, president, in the chair.—C. **Chree**: Reflections on various subjects, including meteorology and sun-spots. Modern correlation methods applied to the question of the relationship between sun-spot frequency and meteorological, electrical, and magnetic phenomena show the importance of employing a long period of years. The results obtained from single 11-year periods are widely divergent in the case of meteorological data. A difficulty in arriving at conclusions being the length of the sun-spot cycle, it is important to study any plan of arriving at results from shorter periods. So far as magnetic phenomena are concerned, the difference between years of many and few sun-spots is of the same nature as the difference between magnetically disturbed and quiet days. The incidence of quiet and disturbed magnetic conditions is the same all over the earth, but the difference between the two sets of conditions appears to be particularly prominent in high latitudes. There were now issued from de Bilt international lists of quiet and disturbed days, 5 of each class per month. The meteorological data from these two sets of (Greenwich) days from stations representative of different parts of the earth might be contrasted. The new observatory in Shetland, from its high latitude, should be a promising station for the purpose.

Royal Microscopical Society, January 16.—Prof. F. J. **Cheshire** (Presidential address): The design of the petrological microscope. The design of this instrument has been prejudicially affected by the fact that the original petrological microscope was made by the simple addition of polarising adjuncts to the ordinary microscope. Its design should be considered *de novo*. As regards the necessary polarising elements, the day will soon arrive in which, to economise spar, greater use will have to be made of the reflecting polariser, which is better adapted for low-power work than the ordinary nicol prism. Further, there are serious objections to mounting the analyser immediately above the objective; a new eye-piece should be designed which would permit of the mounting of the analyser between the last lens vertex and Ramsden circle without so much sacrifice of angular field as is necessary with the Huygenian eye-piece. The petrological microscope suffers from the fact that several of the five primary focal planes are inaccessible. This point should be specially considered in the design of the petrological microscope; as many focal planes as possible should be made accessible for the introduction and withdrawal of the auxiliary polarising elements.

CAMBRIDGE.

Philosophical Society, January 21.—Sir Ernest Rutherford in the chair.—Sir Joseph **Larmor**: An early formulation by Stokes of the theories of the rotatory polarisations of light.—H. F. **Baker**: Theorems for a cubic curve in space.—E. H. **Hankin**: On the angle of incidence in soaring flight.—H. W. **Turnbull**: Canonical forms of the quaternary cubic associated with arbitrary quadrics.—C. G. F. **James**: Complexes of conics and the Weddle surface.—S. **Brodetsky** and G. **Smeal**: On Graeffe's method for complex roots of algebraic equations.—J. **Brill**: On the problem of four bodies.

DUBLIN.

Royal Irish Academy, January 14.—Prof. Sydney Young, president, in the chair.—J. K. **Charlesworth**: The glacial geology of the north-west of Ireland. The region investigated covers some 4300 square miles. It was invaded by an ice-sheet from Scotland moving in general in a westerly direction and the western limits of which coincided roughly with the line of Lough Swilly and curved round the eastern end of the Sperrin Mts. on to the shoulders of Slieve Beagh in Co. Monaghan. Later glaciers, centred in the Donegal hills, flowed outwards to the Atlantic on the south-west, west, and north, while on the east they swept over the Sperrin

Mts. and Slieve Gallion down the Valley of the Bann, over the site of Lough Neagh in the direction of Belfast, and on the south-east towards the Central Plain. The sequence in time of the two ice sheets is proved by superposition of boulder clays in Co. Derry. A re-advance of Scottish ice along the north Irish coast to the mouth of Lough Foyle succeeded a partial recession of the Donegal ice. The successive stages in the retreat of the Irish glaciers are marked by abundant moraines and by marginal drainage phenomena.

PARIS.

Academy of Sciences, January 14.—M. Guillaume Bigourdan in the chair.—Ed. and G. **Urbain**: The simultaneous presence of celtium and yttrium earths in some zirconium minerals. Zircons from four places of origin, malacon from two, and a specimen of Brazilian badeleite were examined from the special point of view of the presence of yttrium earths and of celtium. All these zirconium minerals were proved to contain rare earths and celtium, the proportion of celtium increasing with the proportion of yttrium earths.—P. A. **Dangeard**: Sexual reproduction in *Marchantia polymorpha* in its relations with cellular structure. At the moment of impregnation the oosphere of Marchantia contains, besides the female nucleus, three structures to which the name of vacuome, plastidome, and cytome are given. These three structures are transmitted to each generation without discontinuity.—Paul **Marchal**: Contribution to the study of the evolutive cycle of *Eriosoma lanigerum*.—André **Blondel** and Jean **Rey**: A new verification of the law of perception of light flashes at the limiting range: the case of very short durations.—A. **Rateau**: Hovering flight against the wind. A mathematical proof of a formula giving the principal laws of the Katzmayr effect.—M. Félix Lagrange was elected correspondant of the Academy for the section of medicine and surgery, in succession to M. Bordet, elected foreign associate.—Ph. Le **Corbeiller**: The substitutions of the complex modular group which preserves a quadratic form with complex coefficients.—Paul **Mentré**: Complexes with quadruple inflectional focus.—E. **Cartan**: Similar connexion of surfaces.—Ervand **Kogbetliantz**: The absolute summation of series by arithmetical means.—A. **Vakselj**: The linear differential equation of the second order with four singular points.—D. **Menchoff**: The convergence of series of orthogonal functions.—A. **Kolmogoroff** and G. **Seliverstoff**: The convergence of Fourier's series.—Constant **Lurquin**: A fundamental proposition of probability. A discussion of the Bienaymé-Tchebycheff criterion.—R. **Risser**: Waves of emersion in a canal of given width.—P. **Noaillon**: Reply to the observations of M. Pascal on superficial circulation.—André **Metz**: The interpretation of Michelson's experiment. A criticism and correction of a recent communication by M. Brylinski on this subject.—J. **Le Roux**: The co-ordination of movements and the notion of time.—H. **Chipart**: The propagation of light in media possessing periodic structure.—N. **Perrakis** and A. **Massol**: A method of determination of micro-miscibilities. An account of a method for the study of the miscibility of alcohol, water, and petrol, in which the temperature is kept constant and one of the constituents added until the turbidity point is reached.—Mlle. Germaine **Cauquil**: The esterification of cyclohexanol and of some of its homologues. In equimolecular proportions at 95° C., the systems cyclohexanol-acetic acid, *o*-methylcyclohexanol-acetic acid, and dimethyl-1.3.4-cyclohexanol-acetic acid give equilibria at 55·6 per cent., 49·8 per cent., and 47·5 per cent. respectively. The esterification velocity constants were measured for the three alcohols.—A. **Damiens**: The power of spontaneous transformation of yellow mercuric iodide.—Mlle. Suzanne **Veil**: The evolution of the cupric hydroxide molecule in the presence of water. Measurements of the changes in the coefficient of magnetisation corresponding with the colour changes of cupric hydroxide in water.—V. **Auger**: Two attempts to replace the theory of ions by a theory based on the molecular theory of water. A critical discussion of the views put forward by Armstrong (*Comptes rendus*, June 25, 1923, p. 1892) and by Kling and Lassieur (*Comptes rendus*, July 9, 1923, p. 109).—Maurice **Piettre**: The proteids of lactoserum. Their separation by the acetone method.—J. **Thoulet**: The circulation of the ocean.—L. M. **Bétancès**: The primitive cell of the blood.—L. **Bounoure**: The endodermic dorsal derivatives and first genital outline in the tailless batrachians.—Jacques **Benoit**: The signification of the right rudimentary genital gland in the hen. This gland, hitherto regarded as the right rudimentary ovary, should be considered as having the value of a rudimentary testicle.—Y. **Manouelian** and J. **Viala**: *Encephalitozoon rabiei*, the parasite of hydrophobia.—L. **Panisset** and J. **Verge**: Immunity in bird diphtheria and contagious epithelioma in poultry.

CHRISTIANIA.

Scientific Society, October 26.—Prof. Halvdan Koht, president, in the chair.—H. H. **Gran**: The melting of the snow as the chief of the main causes of the increasing production of organic substance in the sea near the coasts of Northern Europe in the springtime. The determination of the production of organic substance was made by quantitative determination of the plankton, by determination of the changing concentration of oxygen in the water, and by determination of the fertilising power of the water.

November 17.—Prof. H. Goldschmidt in the chair.—Johs. **Lindeman**: Colloids and the stability of colloid solutions. The stability of a colloid system (the hydrosol of ferric hydroxide) is greater if it is formed in the presence of nuclei.

WASHINGTON, D.C.

National Academy of Sciences (Proc. Vol. 9, No. 11, November).—A. H. **Compton**: The quantum integral and diffraction by a crystal. From considerations of energy and momentum principles and the quantum postulate, expressions for diffraction by a crystal grating are obtained. Bragg's expression for the diffraction of X-rays by a crystal is derived from the equations.—W. **Hovgaard**: The principle of minimum energy and the motion of fluids. In the case of an incompressible fluid filling completely a region between two boundaries subject to prescribed motions, the motion of the fluid is irrotational under the condition of minimum energy. It is shown further that, given that the motion of the liquid is irrotational, the motion is of necessity always one of minimum energy.—P. W. **Bridgman**: The volume changes of five gases under high pressures. The gases used were hydrogen, helium, ammonia, nitrogen, and argon; the maximum pressure was 15,000 kg./cm.^{2} and the temperature about 60°. Gas under a pressure of 2000 kg./cm.^{2} is introduced into a cylinder filled with kerosene and additional pressure is applied by a piston. The volume decrease is greatest for the monatomic gases though at very high pressures, nitrogen retains great compressibility owing to its complex structure. The densities under 15,000 kg./cm.^{2} pressure are calculated: hydrogen 0·1301,

helium 0·340 and nitrogen 1·102, *i.e.* greater than the densities of the liquid phases at atmospheric pressure (0·070, 0·1456, and 0·85 respectively) or the solid phases.—C. **Barus**: (1) Achromatic and superchromatic fringes with a calcite rhomb. The effects of plate glass and Iceland spar compensators on the fringes produced by a modified interferometer are described. (2) Vibration of the air filament in quill tubes: single telephonic exciter.—T. W. **Richards** and W. T. **Richards**: Preliminary attempt to measure gravimetrically the distance-effect of chemical affinity. A horizontal plate of aluminium 6 cm. square, hanging from one arm of a balance, was exactly counterpoised and allowed to rest very nearly on flat surfaces of various metallic oxides, sulphur, iodine, and bromine. The sulphur and iodine were cast on plate glass and mica was interposed when the halogens were used, separating the surfaces by 0·02 mm. and 0·01 mm. respectively. With the oxides, the plates were probably less than 0·001 mm. apart. In no case was any attractive effect so great as 0·1 mg. observed. The force of chemical affinity must decrease very rapidly with increase of separation of the attracting atoms.—L. W. **Yolton**: The effects of cutting the giant fibres in the earthworm, *Eisenia foetida* (Sav.). Operated worms showed the normal creeping movements, but a sharp stimulus such as causes a normal worm to contract was not transmitted beyond the wound.—H. **Shapley**: On the relative velocity of blue and yellow light (*v.* NATURE, p. 206).—F. B. **Sumner**: Size-factors and size-inheritance. From a statistical treatment of a series of rabbits, Castle has concluded that genetic agencies affecting rabbits are general in action, influencing all parts of the body in the same direction, and that this probably applies to all vertebrates. From studies of the deer-mouse, this view is contested.—H. L. **Smith**: A generalisation of Volterra's derivative.

Official Publications Received.

Comité International des Poids et Mesures. Procès-Verbaux des Séances. Deuxième Série, Tome 10, Session de 1923. Pp. vii+122. (Paris: Gauthier-Villars et Cie.)

Statens Meteorologisk-Hydrografiska Anstalt. Årsbok, 4, 1922. V: Hydrografiska mätninger i Sverige. Pp. 35+5 planscherna. (Stockholm.) 7 kr.

Memoirs of the Geological Survey of India. Vol. 45, Part 2: The Gwalior and Vindhyan Systems in South-Eastern Rajputana. By Dr. A. M. Heron. Pp. vii+129-189+plates 27-42. (Calcutta: Geological Survey of India.) 3 rupees.

British Research Association for the Woollen and Worsted Industries. Report of the Council, 1923. Pp. 17. (Headingley, Leeds.)

The Institution of Gas Engineers. Eighth Report of the Research Sub-Committee of the Gas Investigation Committee of the Institution of Gas Engineers ("Fairweather" Recording Calorimeter). Pp. 97-174. Ninth Report (Aeration and Air Injection). Pp. 175-229. Tenth Report (The Manufacture of Blue Water Gas). Pp. 293-375. (London: 28 Grosvenor Gardens.)

Poradnik dla Samouków, T.4: Krystalografja, Wskazówski Metodyczne dla Studjujacych. Pp. xiv+228. (Warszawa: Im. Mianowskiego.)

Diary of Societies.

MONDAY, FEBRUARY 11.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS, INC. (at Holborn Restaurant) (Annual General Meeting), at 2.30.—Sir George Croydon Marks: Industry and Invention.

ROYAL COLLEGE OF SURGEONS OF ENGLAND, at 5.—Prof. W. S. Handley: General Peritonitis.

BRITISH PSYCHOLOGICAL SOCIETY (Education Section) (at London Day Training College), at 6.—T. P. Tomlinson: Intelligence Tests in City and Urban Schools.

ROYAL GEOGRAPHICAL SOCIETY (at Æolian Hall), at 8.30.—L. S. Fortescue: Persian Azerbaijan and the Western Elburz.

TUESDAY, FEBRUARY 12.

ROYAL INSTITUTION OF GREAT BRITAIN, at 5.15.—Prof. J. Barcroft: The Respiratory Pigments in Animal Life and their Significance (1).

KING'S COLLEGE ENGINEERING SOCIETY (at Institution of Mechanical Engineers), at 5.30.—Vice-Admiral Sir George Goodwin: Economics as applied to Mechanical Engineering

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN (Scientific and Technical Group), at 7.—Dr. F. C. Toy and S. O. Rawling: A New Electric Density Meter, dispensing with the Eye.

INSTITUTION OF WELDING ENGINEERS (at Institute of Marine Engineers, Inc.), at 7.—J. R. Booer: Some Chemical Aspects of Welding.

QUEKETT MICROSCOPICAL CLUB, at 7.30.—D. J. Scamfield: Presidential Address.

WEDNESDAY, FEBRUARY 13.

ROYAL COLLEGE OF SURGEONS OF ENGLAND, at 5.—Prof. R. L. Knaggs: Osteogenesis imperfecta.

INSTITUTION OF CIVIL ENGINEERS (Informal Meeting), at 7.—H. J. F. Gourley and others: Discussion on The Capacity to be provided in Service-Reservoirs.

ROYAL SOCIETY OF ARTS, at 8.—Prof. H. Maxwell Lefroy: The Preservation of Timber from the Death Watch Beetle.

THURSDAY, FEBRUARY 14.

ROYAL SOCIETY, at 4.30.—Dr. C. Chree and R. E. Watson: Atmospheric Pollution and Potential Gradient at Kew Observatory, 1921 and 1922.—Prof. E. Wilson and E. F. Herroun: The Electrical Conductivity of Magnetite.—C. E. T. Mann: The Determination of Coefficients of Diffusion in Gels by means of Chemical Analysis, and a Comparison of Results obtained from those yielded by the Indicator Method.—C. E. P. Brooks: The Difference-Periodogram. A Method for the Rapid Determination of Short Periodicities.—Prof. J. Proudman and Dr. A. T. Doodson: The Principal Constituent of the Tides of the North Sea.—D. H. Bangham and F. P. Burt: The Behaviour of Gases in Contact with Glass Surfaces.

LONDON MATHEMATICAL SOCIETY (at Royal Astronomical Society), at 5.—E. A. Milne: The Star and the Atom. (Lecture.)

ROYAL INSTITUTION OF GREAT BRITAIN, at 5.15.—Sir William Bragg: The Crystalline Structure of Organic Substances (2).

INSTITUTION OF ELECTRICAL ENGINEERS (Joint Meeting with the Physical Society of London), at 6.—Continuation of Discussion on Loud-Speakers for Wireless and other Purposes.

SOCIETY OF DYERS AND COLOURISTS (London Section) (at Dyers' Hall, Dowgate Hill), at 7.—Prof. J. F. Thorpe: Staining and Dyeing.

OPTICAL SOCIETY (Annual General Meeting) (at Imperial College of Science and Technology), at 7.30.—T. Smith: The Addition of Aberrations.—J. W. Gifford: The Choice of Wave-lengths for Achromatism in Telescopes.—E. F. Fincham: A New Form of Corneal Microscope.—D. Baxandall: The Troughton Dividing Engine (1793).

INSTITUTION OF CHEMICAL ENGINEERS (at Engineers' Club, Coventry Street), at 8.—D. M. Newitt: The Transport, Storage, and Distribution of Hydrochloric Acid, with an Account of a Complete Modern Installation.

INSTITUTE OF METALS (London Local Section) (at Institute of Marine Engineers, Inc.), at 8.—W. B. Clarke: Metals for Lamp Manufacture.

BRITISH PSYCHOLOGICAL SOCIETY (at University College), at 8.30.—Extraordinary General Meeting to discuss the formation of branches of the Society.

FRIDAY, FEBRUARY 15.

INSTITUTION OF PUBLIC LIGHTING ENGINEERS AND SUPERINTENDENTS (at 197 High Holborn), at 2.—Inaugural Meeting.

GEOLOGICAL SOCIETY OF LONDON, at 3.—Annual General Meeting.

ROYAL SOCIETY OF ARTS (Indian Section), at 4.30.—Sir Richard M. Dane: Salt Manufacture in India.

ROYAL ASTRONOMICAL SOCIETY, at 5.—Geophysical Discussion.—Dr. C. Chree: Periodicities in Terrestrial Magnetism.

ROYAL COLLEGE OF SURGEONS OF ENGLAND, at 5.—V. E. Negus: The Mechanism of the Larynx.

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN (Pictorial Group), at 7.—Annual Meeting.

JUNIOR INSTITUTION OF ENGINEERS, at 7.30.—Prof. D. S. Capper: Some Suggestions for Road Transport Development.

ROYAL INSTITUTION OF GREAT BRITAIN, at 9.—Dr. J. H. Jeans: The Origin of the Solar System.

SATURDAY, FEBRUARY 16.

SCHOOL NATURE STUDY UNION (in Botanical Theatre, University College), at 3.—Prof. J. A. Thomson: Some Unsolved Problems of Everyday Natural History.

PUBLIC LECTURES.

SATURDAY, FEBRUARY 9.

HORNIMAN MUSEUM (Forest Hill), at 3.30.—E. Lovett: The Origin of Children's Toys.

WEDNESDAY, FEBRUARY 13.

ROYAL INSTITUTE OF PUBLIC HEALTH, at 4.—Dr. P. C. Varrier-Jones: Settlements for Tuberculosis.

UNIVERSITY COLLEGE, at 6.—Prof. Karl Pearson: The Contributions of Sir Francis Galton to Photography.

THURSDAY, FEBRUARY 14.

KING'S COLLEGE, at 5.30.—Dr. E. W. Scripture: What the Voice looks like.

FRIDAY, FEBRUARY 15.

BEDFORD COLLEGE FOR WOMEN, at 5.15.—Sir F. W. Keeble: The Influence of Biological Discovery on Human Progress—A Forecast.

KING'S COLLEGE, at 5.30.—Dr. H. Lamb: The Internal Constitution of the Earth. (Succeeding Lectures on February 22 and 29.)

SATURDAY, FEBRUARY 16.

HORNIMAN MUSEUM (Forest Hill), at 3.30.—Dr. C. A. Raisin: Glaciers and Ice-work of the Past.

Supplement to NATURE

No. 2832 FEBRUARY 9, 1924

The Spectra of the Lighter Elements.[1]

IT is well known that the immediate acceptance of the Bohr atom by physicists was largely due to its quantitative success in explaining the spectra of hydrogen and ionised helium. While the problem of the general atom containing two or more electrons is much more complicated, Bohr, by making use of his Principle of Correspondence (Supplement to NATURE of July 7), has already shed considerable light upon it. In consequence of this, much stimulus has been given to the study of optical and X-ray spectra, particularly those of the lighter elements. The older data have been re-examined in the light of the new Bohr atom, and further lines of experimental approach suggested by it have been initiated. At the recent meeting of the British Association at Liverpool, many of the leading workers in this subject were present, and took part in a general discussion upon it opened in Section A by the president, Prof. J. C. McLennan. The subjoined synopsis of the remarks of the principal speakers will be read with interest by all students of physical science.

(1) PROF. J. C. MCLENNAN, F.R.S.

Optical spectra originate in displacements of the outermost electron in an atom of any element or of the outermost electron in an atom ion of an element. X-ray spectra originate in the reorganisation of the electronic system of an atom when an inner electron is removed by any agent from the atom.

In seeking to determine the structure of atoms generally, and of those of the lighter atoms in particular, it has become a matter of considerable importance to determine the spectra of the elements in the ultra-violet region between the lowest limits attainable with ruled reflection gratings and the highest limit attainable by the use of the cleavage planes of crystals.

From the work of Lyman, Millikan, and others, it has been made clear that spectra, including wave-lengths shorter than $\lambda = 300$ Å, can be photographed quite readily with concave ruled reflection gratings.

By means of such gratings, Millikan was able to photograph the spectrum of carbon to $\lambda = 360{\cdot}5$ Å, that of aluminium to $\lambda = 133$ Å, and that of copper to $\lambda = 150$ Å. With a concave grating ruled in the National Physical Laboratory, Teddington, Simeon has photographed the spectrum of carbon to $\lambda = 595{\cdot}1$ Å. With a similar grating, Mr. R. J. Lang has recently photographed, in the Physical Laboratory of the University of Toronto, the spectrum of carbon to $\lambda = 312{\cdot}7$ Å, and the spectra of calcium, titanium, vanadium, chromium, manganese, cobalt, arsenic, molybdenum, antimony, tellurium, cerium, tungsten, thallium, bismuth, and uranium to $\lambda = 223$ Å. About 3000 new wave-lengths have been recorded and measured by him.

By passing light through a narrow slit, Holweck has shown that ordinary diffraction patterns can be obtained that suffice to measure wave-lengths as short as 50 Å. For wave-lengths so short as 45 Å he has shown that the reflecting power of a highly polished bronze mirror is only 3 per cent. For radiation between $\lambda = 130$ Å and 13 Å, the latter being approximately the longest X-ray wave-length determined by the use of crystals, the only method of determining wave-lengths that has been successfully applied involves the use of the relation $Ve = h\nu$ where the potential V defines the speed in a vacuum of electrons bombarding an element and ν is the highest frequency of the radiation emitted by this element under such bombardment. Using this method, Holweck has determined the mass coefficients of absorption by thin films of celluloid and by various gases for all wave-lengths between $\lambda = 1140$ Å and 10 Å. We have then in these mass coefficients a means of identifying any wave-length in this region.

It is well known that the frequency of a line may be represented as the difference between two spectral terms ν_1 and ν_2. In an exhaustive analysis of the K, L, M, and N X-ray wave-lengths of the elements between uranium and magnesium, Bohr and Coster have determined and tabulated the values of $\sqrt{\nu/R}$ for the various spectral terms, R being Rydberg's constant. They have thus evaluated the K, L, M, N, O, and P energy levels characterising the atoms of these elements.

Curves representing values of $\sqrt{\nu/R}$ are shown in Fig. 1, the dotted portions of the curves being filled in from such optical spectral data as were available. According to this scheme the atoms of the heaviest elements include 1 K energy level, 3 L energy levels, 5 M levels, 7 N levels, 5 O levels, and 3 P levels. With lighter elements the P levels are non-existent, and with still lighter ones the O levels drop out, and so on.

When the numerous optical spectra recently obtained for the extreme ultra-violet region are sorted into series, it will be possible to check up the validity of the Bohr-Coster scheme of levels for the lighter elements.

In the meantime, through the brilliant work of Fowler and Paschen (see *infra*), the series spectra for the atom ions Mg(II) and Al(III) and Si(IV) have been identified and shown to have the same characteristics apart from the Rydberg constant as the arc spectrum of Na(I). The values of $\sqrt{\nu/R}$ for the first and last members of these spectral series are given in Table I., and are plotted in Fig. 1. There is evidence that similar series will soon be identified for the elements lithium, beryllium, boron, and carbon, and

[1] Contributions to a discussion in Section A of the British Association at Liverpool on September 18.

for the elements potassium, calcium, scandium, and titanium. Data relating to these are also given in Table I. It will be noted that in discussing the question of energy levels, it is the value of $\sqrt{\nu/R}$ for the last member of a series that is important.

A method that has been used with some success in an attempt to determine the characteristic X-rays of the lighter elements is that adopted by Dember, Richardson, and Bazzoni, Dandourian, Hughes, Kurth, Holtzmark, and latterly, in Toronto, by McLennan and Miss Clark and by Miss Levi. It has given results that in a measure confirm the views of Bohr and Coster.

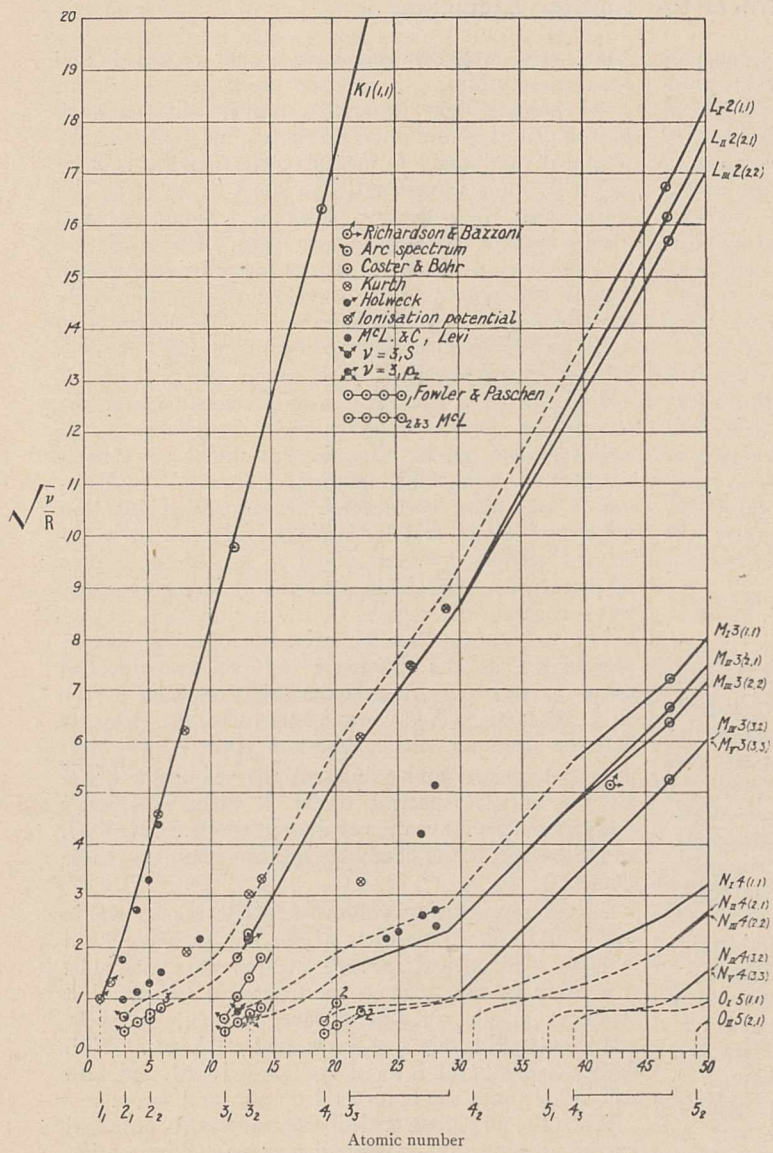

FIG. 1.

In this method, an element used as an anticathode was bombarded in a high vacuum by electrons with various speeds. The energy of the bombarding electrons derived from selected electric fields was increased by steps, and the critical values were determined that were necessary and just sufficient to cause the bombarded element to emit its characteristic radiations with measurable intensities. These characteristic radiations were detected and their intensities measured by their photoelectric action on an insulated electrode of nickel or of silver.

The method followed consisted in plotting curves with the values of the accelerating potentials of the electrons as abscissæ and the measures of the photoelectric effect divided by the values of the corresponding electronic currents as ordinates. The electrons were obtained from a heated tungsten filament maintained at a constant temperature.

At certain critical accelerating voltages it was found that these curves showed marked and abrupt kinks or changes of curvature, and these changes were taken to connote the beginning of the emission by the bombarded element of its characteristic radiations.

Tables II., III., and IV. contain the results obtained by the author and his students as well as those obtained by others by this method. From these results the corresponding values of $\sqrt{\nu/R}$ were calculated. The values are given in the Tables and are plotted in Fig. 1. For the K levels, it will be seen the results agree with those of the Bohr and Coster scheme. For the L levels, the values obtained for $\sqrt{\nu/R}$ are slightly greater than those demanded for the light elements by Bohr and Coster's graphs. As regards the M levels, the values obtained, apart from a few results which may have had their origin in the ejection of more than one electron from the level, support the Bohr-Coster view.

As this photoelectric method and the absorption method used by Holweck appear to be the only ones available at present for identifying wave-lengths in the region between $\lambda = 10$ Å and $\lambda = 140$ Å, it would seem advisable to extend their use until all the characteristic radiations that the lighter elements can be made to emit have been identified. We shall then be able to reach definite conclusions regarding the energy levels in the atoms of these elements.

The plan followed by de Broglie of determining the magnetic spectrum of electrons ejected from atoms subjected to radiation of specific wave-lengths is also likely to prove as successful with atoms of light elements as with those of the heavier ones, in the determination of energy levels.

(2) Prof. R. A. Millikan.[2]

The author published in 1921 (Proceedings U.S. National Academy of Sciences, vol. 7) a summary of his results on the exploration in the extreme ultra-violet of the radiations which can be emitted by the second ring or shell of electrons in the atoms of atomic number 2 to 13 (helium to aluminium). The pro-

[2] Prof. Millikan was at the last moment prevented from attending the meeting. The above is a summary compiled from his 1921 paper and the contents of a letter to the president of the Section, dated August 14, 1923.

gression in optical spectra which the development of an ultra-violet technique has made possible is exceedingly interesting and simple and very like that exhibited by X-ray spectra. Some of the results of this work are embodied in the graph shown as L_α in Fig. 2, which includes the corresponding graph for K_α lines from helium upwards taken from the work of others.

In the author's opinion it has been definitely proved that the L_α series continues with its main characteristics unchanged throughout the whole range of atomic numbers from uranium (92) to neon (10). Further, it is shown by several examples that optical spectra are quite like X-ray spectra in that large gaps occur between the frequencies due to the electrons in successive rings or shells. Thus the aluminium atom, atomic number 13, when excited by condensed sparks *in vacuo* emits no radiations whatever of wave-length between 144·3 Å and about 1200 Å where its M spectrum, that due to one of its three outer electrons, begins and extends with considerable complexity into the visible. A similar result is obtained with magnesium.

The continuation of this work to the summer of the year 1923 leaves the general outline of the author's results unaltered. Further, all the lines which he has published and some others now found in the L spectrum of sodium and magnesium are predicted exactly by the Bohr theory. The observed line at 134 Å in aluminium appears to be predicted by the Bohr theory. Moreover, two of the lines at about 600 Å which Paschen has predicted as belonging to the aluminium atom, when it has lost all three of its outer electrons, are found on the author's plates in exactly the right position. Similarly, he has found the silicon series in the extreme ultra-violet corresponding to Fowler's predictions as to the silicon spectrum when all the valency electrons are stripped off.

Finally, the author has the best of evidence that the lines which he defined as the L_α lines of boron, oxygen, nitrogen, and fluorine are due to the corresponding atoms when the valence electrons are all gone. There may be differences of opinion as to whether these lines ought to be called L_α lines or not, but with the definition given in his 1921 paper the author considers that there can be no serious objection to this notation. The complete paper of Mr. Bowen and himself, shortly to be published, will contain the identification of some thousand new lines due to substances of small atomic number.

(3) Prof. A. Fowler, F.R.S.

It would seem that on the present occasion the spectra of the lighter elements are of special interest in relation to the connexion between X-ray and optical spectra. It is therefore unfortunate that our knowledge of the series arrangements in many of these spectra is still very meagre. Progress has been made, however, with regard to the spectra of some of them at successive stages of ionisation, and the results appear to have a definite bearing on the question under consideration. It may be useful to recall briefly how these successive ionisations are revealed by the spectra.

It is common knowledge that, so far as we know them, the spectra of the elements of the same chemical group are all of similar character. Thus, the elements of Group I. give spectra consisting of doublets, as exemplified by the familiar series of sodium. Elements of Group II., on the other hand, give triplets, as illustrated by magnesium, zinc, and cadmium. In

TABLE I.

Optical Spectra Data.

Element.	At. No.	λ (Å).	Crit. Pot. V.	$\sqrt{V}$.	$\sqrt{\nu/R}$.	Investigator.
		II PERIOD.				
Lithium . .	3	6708	1·84	1·36	0·37	Tables.
		2299	5·364	2·315	0·63	
Beryllium . .	4	3131	3·935	1·98	0·538	Suggested.
Boron . . .	5	2497	4·938	2·22	0·603	,,
		2089	5·903	2·43	0·661	
Carbon . . .	6	1335	9·24	3·04	0·827	,,
		III PERIOD.				
Sodium I . .	11	5889·963	2·096	1·45	0·393	Tables.
		5895·930				
		2412·6	5·1115	2·26	0·615	,,
Magnesium II .	12	2795·523				
			4·417	2·1	0·517	Fowler.
		2802·698				
		825·0	14·94	3·86	1·04	,,
Aluminium III .	13	1854·670	6·6	2·57	0·699·	Paschen.
		1862·899				
		435·0	28·35	5·32	1·45	,,
Silicon IV . .	14	1393·9	8·84	2·97	0·808	Fowler.
		1402·9				
		274·6	44·90	6·7	1·82	,,
		IV PERIOD.				
Potassium . .	19	7664·94	1·607	1·27	0·345	Tables.
		7699·01				
		2857·0	4·313	2·077	0·565	,,
Calcium . .	20	3933·644	3·13	1·77	0·481	,,
		3968·465				
		1044·0	11·81	3·43	0·932	,,
Scandium . .	21	...	...	...	...	...
Titanium . .	22	1631·4 (1)	7·55	2·75	0·747	Suggested.
		1666·9 (2)				

each group, corresponding lines, and the limits of squares of the atomic weights. Some of the lighter elements depart to some extent from these general rules.

TABLE II.—K Levels.

Element.	At. No.	λ (Å).	Crit. Pot. V.	$\sqrt{V}$.	$\sqrt{\nu/R}$.	Investigator.
Hydrogen . .	1	913·4	13·5	3·67	0·998	Ionis. Potential.
Helium . .	2	502·0	24·5	4·95	1·35	Ionis. Potential.
Lithium . .	3	290·0	42·6	6·5	1·77	Levi, McLennan and Clark.
Beryllium . .	4	117·0	105·4	10·25	2·79	Levi, McLennan and Clark.
Boron . . .	5	83·57	146·8	12·11	3·295	Levi, McLennan and Clark, Holtzmark.
Carbon . . .	6	47·0	262·5	16·2	4·41	Levi, McLennan and Clark.
,, . .	6	42·75	287·0	16·94	4·61	Holtzmark, Hughes.
Oxygen . .	8	23·8	517·7	22·75	6·19	Kurth.
Magnesium . .	12	9·5	1298·16	36·03	9·8	Coster.
Potassium . .	19	3·44	3586·81	59·89	16·29	,,

TABLE III.—L Levels.

Element.	At. No.	λ (Å).	Crit. Pot. V.	$\sqrt{V}$.	$\sqrt{\nu/R}$.	Investigator.
Lithium . .	3	966·0	12·75	3·6	0·98	McL. and C., Levi.
Beryllium . .	4	727·5	17·0	4·1	1·12	McL. and C., Levi.
Boron . . .	5	510·3	24·0	4·89	1·33	McL. and C., L., Hughes, Holtzmark.
Carbon . . .	6	368·0	33·7	5·8	1·58	McL. and C., L., Hughes, Holtzmark, Kurth.
Oxygen . .	8	248·0	49·6	7·05	1·92	Kurth.
Fluorine . .	9	197·0	62·7	7·9	2·15	Levi.
Magnesium . .	12	266·4	46·24	6·8	1·85	Coster.
Aluminium . .	13	175·5	70·22	8·38	2·28	,,
,, . .	13	193·5	63·67	7·98	2·17	Holweck.
,, . .	13	100·0	123·21	11·1	3·02	Kurth.
Silicon . .	14	82·5	149·35	12·22	3·32	,,
Titanium . .	22	24·5	502·9	22·42	6·1	,,
Iron . . .	26	16·3	755·9	27·49	7·48	,,
Copper . . .	29	12·3	1001·7	31·6	8·6	,,
Silver . . .	47	3·27	3770	61·4	16·7	Coster.
,, . . .	47	3·52	3503·46	59·19	16·1	,,
,, . . .	47	3·698	3331·4	57·72	15·7	,,

TABLE IV.—M Levels.

Element.	At. No.	λ (Å).	Crit. Pot. V.	$\sqrt{V}$.	$\sqrt{\nu/R}$.	Investigator.
Sodium . .	11	2412·6	5·11	2·26	0·615	Limit of doublet series.
Magnesium . .	12	1621·4	7·6	2·77	0·75	Limit $\nu=(3, S)$.
Aluminium . .	13	2071·2	5·95	2·44	0·664	Limit $\nu=(3, p_2)$.
Titanium . .	22	85·3	144·5	12·02	3·27	Kurth.
Chromium . .	24	203·0	60·8	7·8	2·12	Levi.
Manganese . .	25	184·0	67·0	8·2	2·23	,,
Cobalt . . .	27	52·3	235·6	15·35	4·18	,,
,, . . .	27	134·0	92·2	9·6	2·61	,,
Nickel . . .	28	155·0	79·6	8·9	2·42	,,
,, . . .	28	122·84	100·3	10·01	2·72	,,
,, . . .	28	34·8	354·8	18·84	5·12	,,
Molybdenum .	42	34·6	356·0	18·89	5·14	Richardson and Bazzoni.
Silver . . .	47	17·103	720·38	26·84	7·3	Coster.
,, . . .	47	21·00	586·61	24·22	6·6	,,
,, . . .	47	22·14	556·96	23·6	6·42	,,
,, . . .	47	32·91	374·42	19·35	5·26	,,

When we consider the *arc* spectra of the elements as a whole, we find a remarkable alternation of doublet and triplet series from group to group, so far as the series have been identified. Most of the elements of Group III. are known to give doublets, while triplets are known to occur in silicon and lead of Group IV. Very little is known of Group V., but there are indications that the arc spectra will be found to consist of doublets. Several elements of Group VI. definitely yield triplets, and in manganese of Group VII. we again find triplets. Doublets and triplets thus occur alternately as far as Group IV., and probably as far as Group VI., but the rule breaks down at Group VII.

It has been found that the *spark* spectrum of an element is of the same type as that of the arc spectrum of the element which precedes it in the periodic table. This is seen very well in the comparison of the arc and spark spectra of calcium, strontium, and barium, shown in Fig. 3.[3] The atoms giving the spark lines of an element have therefore presumably the same distribution of electrons as that in the neutral atoms of the element of atomic number one smaller. That is, they have lost an electron, or have become ionised. The *qualitative* evidence of ionisation afforded by such a change in the type of spectrum is of distinct value when the regular series have not been established.

corresponding series, generally advance towards the red with increasing atomic number, and the separations of doublets or triplets increase roughly as the

[3] The enhanced doublets are indicated by Greek letters; π=principal series, σ=sharp series, δ=diffuse series. The corresponding pairs of Mg are outside the range of the diagram, in the ultra-violet. Triplets of the neutral atoms are indicated by p, s, d.

Following Bohr's theory, however, we also have in several spectra complete *quantitative* evidence of ionisation. When sufficient members of the series have been identified, the "series constant" can be calculated. If it turns out to be 4R (*i.e.* four times the hydrogen constant) the theory indicates that the corresponding atoms have been singly-ionised, or have each lost one electron. This was proved for helium and the alkaline earths some years ago.

Since then, some of us have endeavoured to produce series spectra of multiply-ionised atoms, for which the series constant would have the theoretical values 9R, 16R, and so on.

In this connexion, Paschen has been at work on aluminium while I have been working on silicon.[4] It is particularly fortunate that these are adjacent to each other in the sequence of atomic numbers, and follow magnesium, which I had previously investigated very fully. It will simplify matters to consider the theoretical prediction first, the theory, of course, being that of Prof. Bohr. The accompanying diagram (Fig. 4) will aid in making matters clear. It is to be understood that this is purely diagrammatic and does not profess to represent the real orbits of the electrons; it simply means that electrons which are placed in the same ring have the same principal quantum number. The theoretical expression for the series constant C is shown on the right of the diagram, e being the charge of the electron, and E representing the net charge of the remainder of the atom with respect to the external electron which generates the spectrum by its outward excursions. The atomic numbers are those indicated on the diagrammatic representations of the nuclei. It should first be noted that doublets and triplets alternate in the spectra of the four neutral atoms represented, and that the series constant for these spectra may be supposed, with accuracy sufficient for our present purpose, to be identical with that for hydrogen.

In view of the different spectra which may be given by the same element, it has been found convenient to designate the spectra at successive stages of ionisation by numerals, I for the neutral atom, II for the singly-ionised atom, and so on. When Mg is singly-ionised, the structure becomes similar to that of Na(I), with the difference that the series constant is 4R. While Al(I) gives doublets, with R for the constant, Al(II) may be expected to give triplets, with 4R for constant, and Al(III) to give doublets of the sodium type, with 9R for constant. In the same way, the successive spectra of Si(I), Si(II), Si(III), and Si(IV) may be expected to consist respectively of triplets, doublets, triplets, and doublets, with values of the series constant changing from R to 4R, 9R, and 16R.

These predictions have been fulfilled in the most remarkable manner. All the chief series involved in the diagram have been actually produced, and have been found to have the character and constants expected. Series which ought to resemble each other according to the theory appear to do so in every detail. A notable example is the abnormality of the satellites in the diffuse triplets of Si(III), which Paschen has also found in the corresponding triplets of Al(II); it is very probable that a similar abnormality will be found in the diffuse triplets of Mg(I) when adequate resolving power is employed to exhibit the satellites. The general correspondence is also shown by a comparison of the series terms of the spectra of the atoms which appear in the same vertical column of the diagram.

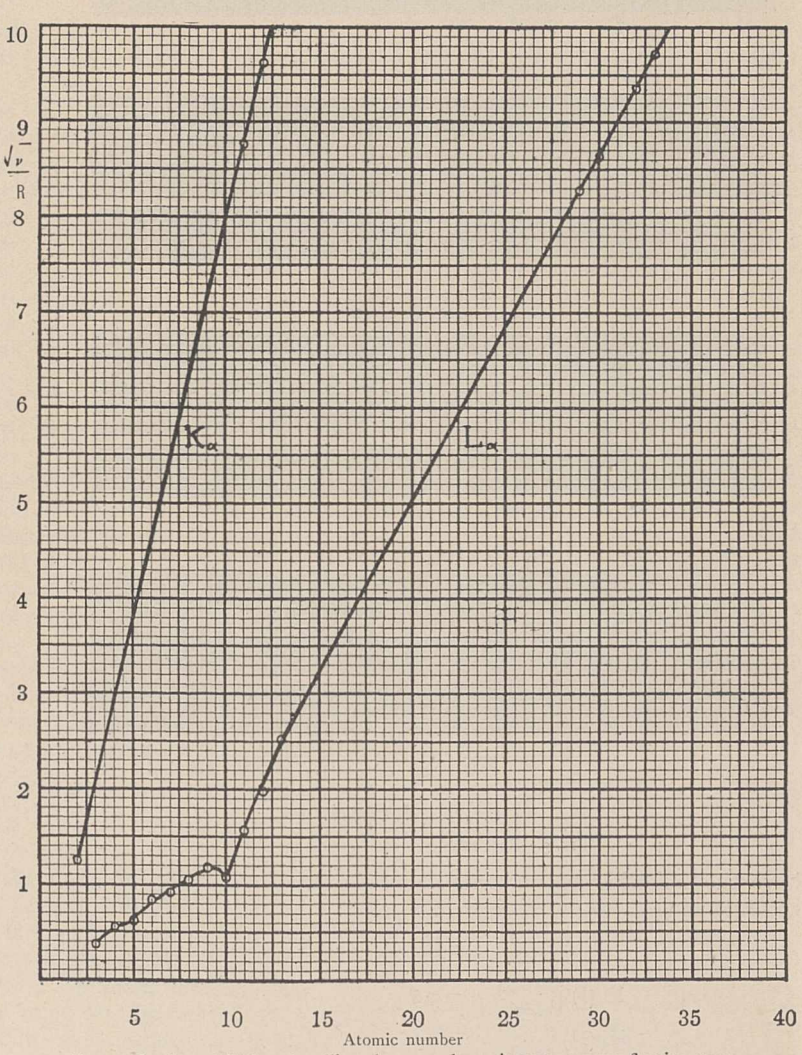

FIG. 2.—L_α lines of lithium, beryllium, boron, carbon, nitrogen, oxygen, fluorine, neon, sodium, magnesium, and aluminium.

[4] It might be mentioned that silicon was first selected for investigation on account of its astrophysical interest. The lines representing successive stages of ionisation of this element appear in stars which there is every reason to believe are at successively higher temperatures. The complete series data for the four spectra, and the ionisation potentials deduced from them, may be expected to find an important application in fixing the scale of stellar temperatures.—A. F.

It should be observed, as shown in Fig. 5, that with increase in the ionisation, corresponding lines are necessarily displaced to shorter wave-lengths, and that the separations are also increased. Thus, we

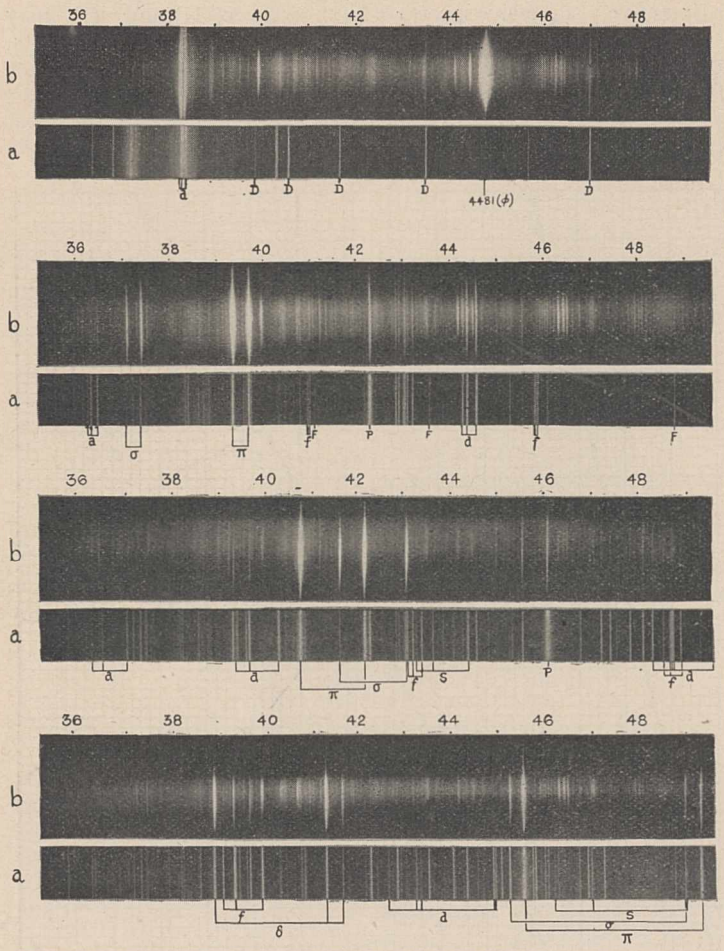

FIG. 3.—Spectra of the alkaline earth metals.

have the following approximate values for the lines corresponding to the "D" lines of sodium:

	λλ.	Separation ($\Delta\nu$).
Na(I)	5890 5896	17·2
Mg(II)	2796 2803	91·5
Al(III)	1855 1863	238
Si(IV)	1394 1402	460

Thus, for the higher degrees of ionisation the chief lines must occur in the region of short wave-lengths; the lines which occur in the ordinary region of observation belong to secondary series.

Incidentally, it may be noted that this displacement of the chief lines enables us to recognise more completely the characteristics of series which appear in the infra-red in the spectra of the neutral atoms. Thus, series which occur in the infra-red in Na(I) are represented in Si(IV) by series which appear in the blue, and can consequently be more completely investigated. Also, the larger scale of the doublets or triplets leads to a more complete knowledge of the fine structure of the components.

The discussion of the spectra at the higher stages of ionisation does not depend upon the observation of faint or doubtful lines; all the chief lines involved have, in fact, been produced with great intensity. Photographs of the spectra also show very clearly that the successive changes of the spectrum accompany successive increases in the intensity of the discharge.

Mg

All these observations are sufficiently accounted for on Bohr's theory by the loss of electrons, one by one, from the outer ring. But there is no reason to suppose that the process must stop at the outer ring. The alkali metals, with only one electron in the outer ring, give distinctive spark spectra, and so an electron normally in the second ring must become effective. Hence, there appears to be no theoretical reason why there should not be, say, a fifth spectrum of silicon, with 25R for the series constant, and its main lines at very short wave-lengths, since even Si(IV) has its limit so far down as λ275.

Ca

Sr

The first main point I wish to make, therefore, is that, apart from any question of X-rays, the spectra of most of the elements may be expected to exhibit very short wave-lengths when very powerful discharges are employed. A limit only appears to be set by the number of electrons available for removal, and the energy that can be effectively applied for their removal. At the same time, it is to be remembered that, theoretically, all these high-frequency spectra will be accompanied by lines of lower intensity in the less refrangible parts of the spectrum.

Ba

Millikan's direct photographic observations may now be examined in the light of these conclusions, and I would first point out that the "vacuum spark," used as a source by Millikan, does not appear to be any more disruptive than the discharges employed by Paschen and myself.

Among the elements in the second row of the periodic table—in which elements there are three rings or energy levels, K, L, M—Millikan has photographed the spectra of aluminium, magnesium, and sodium by purely optical methods. In each spectrum he has found a short wave-length which he regards as L_α; by which I suppose he means a radiation produced by the fall of an electron from the occupied M ring to the L ring from which an electron has been expelled. In magnesium, a line at λ232 is considered to be the L_α line, and since there are no lines between this and λ1700, where the lines of Mg(II) become visible, and no indications of lines in any part of the spectrum which can

be attributed to Mg(III), the assignment is probably correct. A similar conclusion holds for the spectra of aluminium and sodium. Thus, the consideration of optical spectra offers no opposition to Millikan's view that he has directly photographed the L radiations of aluminium, magnesium, and sodium, and that Moseley's linear law for L_α extends as far as sodium.

I am in less agreement with Millikan as regards the elements from lithium to fluorine which he has also

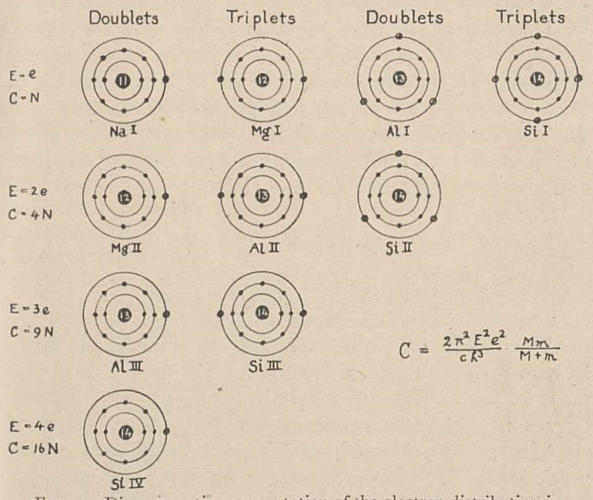

FIG. 4.—Diagrammatic representation of the electron distribution in neutral and ionised atoms. (N = Rydberg constant.)

observed. In the atoms of these elements there are only two occupied rings, or levels, the K and the L. If we wish to extend the X-ray notation to ordinary spectra, the spectra produced by the *outward* excursions of electrons normally in the outer ring must be called the L series. But it seems to me that a difficulty arises when there is more than a single electron in the outer ring, as two or more L spectra are then possible, one associated with the neutral atom, and others with the singly- or multiply-ionised atoms. Millikan has apparently taken no account of this, and his suggested L_α lines in the different elements are inconsistent, for an ionised atom is very different from the corresponding neutral atom. In lithium and boron, the suggested L_α lines belong to the neutral atoms, while in beryllium he has selected a line of the ionised atom. The lines suggested for the other elements are probably enhanced lines, but it is not possible at present to say what degree of ionisation they represent. Millikan's suggested extension of the L_α curve to the lighter elements, which actually shows a discontinuity, therefore seems to me very doubtful.

My own view is that it serves no useful purpose to attempt to extend X-ray nomenclature to ordinary spectra. We are accustomed to associate X-rays with very short wave-lengths, and we might well restrict the term "X-ray radiations" to those produced by transitions to inner orbits of electrons from outer orbits which are normally occupied by electrons. If we do so, the elements from lithium to fluorine would have no L radiations; those from sodium to chlorine no M radiations; and so on.

What we need is a far more extended knowledge of the series arrangements in the spectra of the various elements concerned in the discussion, but the work is likely to be laborious, and results may not be available for a considerable time.

(4) Prof. Niels Bohr.

The quantum theory of atomic structure rests upon the assumption that any permanent change in the state of an atom must consist in the complete transference of the atom from one to another of a manifold of distinguished states, the so-called stationary states. This manifold is classified by ascribing to each stationary state a set of integers, the so-called quantum integers. Although it is impossible on the basis of the laws of classical mechanics to account for the existence and stability of the stationary states, it has nevertheless been possible, by the application of mechanics for the description of the motion in these states, to develop a theory which has been able to account in considerable detail for the properties of atoms with one electron. In such atoms the orbit of the electron can be considered as a superposition of harmonic oscillations, and the number of quantum integers which are used to fix certain mechanical properties of the motion is equal to the number of independent periods in the motion, the so-called degree of periodicity. In the case of atoms with more electrons a direct extension of this theory is not possible, since the general solution of the mechanical equations of motion leads to orbits of a very complex type which cannot be simply represented as a superposition of harmonic oscillations.

In order to obtain a basis for the introduction of

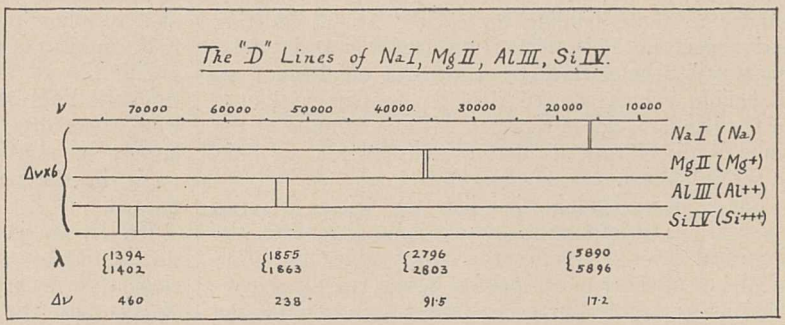

FIG. 5.—Relative positions and separations of the corresponding principal pairs of Na(I), Mg(II), Al(III), and Si(IV).

quantum integers in such cases it seems necessary to abandon a rigorous description of the motion based on classical mechanics. This view is also suggested by the circumstance that the problem with which we meet as regards the motion in the stationary states of such atoms is intimately related to the problem of the stability of the stationary states of atoms with one electron. In fact, the interplay between the various electrons in the atom presents a problem similar to that of the interaction between atoms with one electron

each or between a free electron and an atom. In the latter case the non-mechanical character of the stability of the stationary states is most beautifully brought to light by experiments which show that by a collision no interchange of energy can take place between an electron and an atom unless the atom is transferred by the collision from its original state to another stationary state.

Now a principal source of information in regard to atomic structure is found in the examination of series spectra, where, according to the quantum theory, we have to do with stationary states in which one electron moves in an orbit very much larger than those of the other electrons in the atom. Since over the larger part of the orbit the force exerted on this electron by the rest of the atom will coincide closely with the attraction from a point charge, the orbit may be described as a sequence of loops, each of which is nearly a Keplerian ellipse. Without attempting a closer mechanical description of the interaction between the outer electron and the rest of the atom, it is now natural from the results of the experiments on collision between atoms and free electrons to conclude that the interaction will not involve an interchange of energy, and that consequently the various orbital loops of the outer electron will correspond to motions of a particle around a point charge all having the same energy. It is, therefore, a result of great interest that on the basis of this conclusion alone it is actually possible on the general principles of the quantum theory to explain the empirical formulæ which have been established for the values of the terms in series spectra. The explanation of these formulæ has hitherto been attempted on the assumption of special fields of force exerted by the atomic residue on the outer electron, but it is important for the general argument to note that their validity is to a large extent independent of the nature of this force field, and that, in fact, we must expect for excited molecules, as we meet them in band spectra, results similar to those holding for excited atoms emitting series spectra. This result is confirmed in an interesting way by the work of Fowler on the band spectrum of helium, which showed that the fundamental lines of the bands could be represented by a formula of the same Rydberg type as that established for the lines of series spectra.

For a closer examination into the origin of series spectra it is of importance that it is possible, from the empirical laws governing the remarkable limitation of the combination of spectral terms, to draw conclusions as regards further details of the orbit of the outer electron. Thus, on the basis of the general correspondence principle, we conclude from these laws that in the case of excited atoms the successive loops of the orbit of the outer electron will be similar in shape, and will be oriented relative to each other in such a way that the motion may be described as a plane periodic orbit on which is superposed a uniform rotation in the plane of the orbit as well as a slow precession of this orbital plane. It is clear that such a regular type of motion cannot in general be accounted for by a rigorous application of the laws of classical mechanics to the interaction between the outer electron and the atomic residue. On the contrary, the above-mentioned conclusions may rather be considered as empirical deductions from the spectral evidence, providing us with information as to the details of the interaction between the electrons in the atom. The point to be emphasised is that it appears possible, by proceeding in this manner, to arrive from experimental evidence on spectra step by step in a rational way at a classification of the orbits of the electrons in the atom which offers a foundation for the detailed interpretation of the relationships between the physical and chemical properties of the elements.

(5) Other Speakers.

Following the principal speakers, Dr. D. Coster (Copenhagen) gave a more detailed account of his work with Prof. Bohr, referred to in the remarks by the opener, Prof. McLennan. He showed how the more or less sharp irregularities or "elbows" in the curves in Fig. 1 above are related to the position of the elements concerned in the periodic system. The point where an elbow occurs is where a new class of orbit first appears, a conclusion giving valuable information as to the formation of inner groups which is in accordance with Bohr's recent views of atomic structure.

The recent discovery of hafnium, atomic number 72, enabled Coster to investigate this region of the curves, and he announced that he had found that an elbow occurred at the point 71 where the rare earths end, the element 72 belonging to a fresh group. Coster has further deduced from his photographs the percentage of hafnium present in various ores. When a mixture of substances is used as an anticathode the intensity of a given line in the X-ray spectra will be proportional to the number of atoms present of the particular element giving rise to it. He obtained photometric curves from the lines of hafnium on the X-ray photographs from these ores and checked the method by adding known amounts of tantalum, the next element to it in the periodic table, to which it is closely related.

Dr. H. Robinson referred to work he himself had carried out by the photoelectric method in which the element in question is illuminated by homogeneous X-rays and the velocities of the emitted electrons measured by their deflexion in a magnetic field. An advantage of this method is that it gives the terms, that is to say, the energy levels, directly. An accuracy of one in a thousand may be obtained in relative measurements. The absolute values are probably not so accurate but they show a general agreement with the work of Bohr and Coster.

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