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The North Sea Plaice Investigations.[1]

IT is unnecessary to point out that the plaice occupies a unique position in the eyes of the public and hence of the fishing industry in general. Its southern limit of range is the English Channel, its depth range about seventy fathoms, and its ground sand or sandy mud ; its preference is for a temperature of 60°-70° F. It necessarily follows that its chief area is the North Sea, a ground peculiarly important on account of its proximity to centres of population. The annual figures of catch for this area showed a falling catch up to 1914 with an increase of fishing, and the problem set to the scientific staff of the Ministry of Agriculture and Fisheries was to ascertain the facts of this fall in conjunction with the food, breeding habits, and rate of growth of the plaice, and with its environment (nature of the bottom, temperature, salinity, etc.), and, if the fall should be established, to suggest remedies. The report before us sums up the whole position, giving the facts and critically considering the possibility of remedies. There is really nothing more to be said, only to consider whether any attempt is to be made to improve the position or not.

Remedies would necessarily entail some degree of interference with the utilisation of the chief plaice grounds of the area, the southern part of the North Sea, in which the English Ministry is particularly interested, in a manner which is comparable to "stock farming," in which the endeavour is to market the maximum amount of meat per unit area, while, by breeding, keeping up the stock to the maximum number that the land will carry. Here there can be at present no artificial growing of fish food, dependence having to be on the natural supply of animal and free-moving life, which, of course, must fluctuate with fluctuating physical conditions. Then, whereas there are only cattle, sheep, and pigs on a farm, here there are a dozen kinds of fish, more or less in feeding competition with each other, the relative values of which in cash and as food must be determined. The annual production of eggs by each fish varies to hundreds of thousands, of which from each fish only a pair must develop to maturity to maintain the stock. Does it pay to increase the number of spawning fish so as to get a still larger number of eggs, or would it be better to kill off a large percentage of fish before they reach maturity ? Obviously, as there would be waste of substance in unproductive spawning, this entailing the utilisation of fish food to no farming advantage, a reply must be sought in the question as to what extent plaice may be profitably marketed before maturity.

[1] Ministry of Agriculture and Fisheries. Fishery Investigations, Series II., Vol. 7, No. 6, 1924. Report on the English Plaice Investigations in the North Sea during the Years 1921–1923. By J. O. Borley and D. E. Thursby-Pelham. Pp. 96. (London: H.M. Stationery Office, 1925.) 13s. net

Fortunately, to most of these questions science has given answers, as previous reports have shown, but it remained to determine the results of that most gigantic experiment, the closure of the North Sea to fishing vessels during the War, a closure almost complete in the English area. It is shown in the present report that in 1913, 1920, and 1923 there were 24, 33, and 22 thousands of tons of plaice landed from English vessels. These figures point to the conclusion of the experiment, but, lest the fall to pre-War conditions should be deemed to be due to less fishing in 1923, the catch per 100 hours' fishing and per day's absence from port of first-class fishing vessels is computed, the weights of plaice per day caught by a steam trawler in the three years mentioned being 2·1, 3·4, and 1·9 cwt. The whole North Sea is divided up into areas, 1° long. by 0·5° lat., and the figures are worked out for each rectangle in the years 1920 to 1923, and shown in a long series of charts. The analysis goes, however, much further, and the plaice caught are divided into large (above 45 cm.), medium (roughly 34 to 44 cm.), and small (less than 34 cm.), and the numbers of cwt. of each caught per 100 hours' fishing are shown. The breaking up of the area into rectangles does not agree with depths—these are shown by contour lines beneath—nature of the bottom, temperature, currents, etc., but the charts give at a glance an accurate estimate of the adult and semi-adult plaice population of the North Sea, the quality of value for human consumption.

Taking the whole area, a steam trawler in 100 hours' fishing caught in 1920 approximately 7 cwt. large plaice, 8 cwt. medium, and 3 cwt. small, the corresponding figures in 1923 being 2, 4, and 7. We should estimate the food and cash values of the catch in the former year as at least two and a half times greater than in the latter, and the result is an appallingly lessened production of human food and no living wage for the actual plaice fishermen. Foreseeing that any remedy proposed would entail interference with a whole industry, the fullest consideration is given to every figure in a section of the Report entitled "Size Composition of the North Sea Plaice Stock," extraordinary in the knowledge summarised and masterly and concise in treatment. It, in particular, gives the analyses of the results obtained by a number of sea-going fish measurers, who, sailing in commercial vessels, measured upwards of 1,200,000 plaice in the five years from 1919 to 1924; it annihilates any question of differences between "laboratory" and commercial conditions. Lastly, the relation of growth to age in the post-War period is determined, and a full consideration is given to a new post-War method of fishing by the use of seines on the high seas.

Science, having proved beyond a doubt the serious depletion of the plaice in the North Sea by the operations of man, after having made the fullest allowances for natural seasonal fluctuations, now sets out to suggest practical measures. The most attractive of these is transplantation from overstocked to understocked areas, from coastal grounds to such isolated shoals as the Dogger Bank, which has a peculiarly high capacity for supporting plaice. In this connexion the experiments of Mr. Borley, 1904–8, are now classical. We have, too, the work of Petersen, an annual profit of 100,000 kr. since 1908 against an annual expenditure of 5000 kr., figures for transplantation in certain Danish territorial waters and not for the high seas, open to every nationality. A limit of length, below which no fish could be marketed, would seem to be simpler, but it would have to be considerably higher than 22 cm.—the size proposed before the War by the International Council (this is about the size now considered unprofitable by English trawlers), and indeed higher than 25 cm., which was considered desirable by the Council but not proposed as a practical measure; for neither of these limits would prevent steam trawlers and seiners from visiting the small plaice grounds and killing vast numbers of tiny plaice while in search of other fish. A third remedy, an increase in the size of the net's mesh, is not practicable, for the trawl has to catch round as well as flat fishes.

There remains the formation of reserves, where young fish would grow to marketable size and whence they would spread over the whole North Sea, this clearly being the measure favoured by Messrs. Borley and Pelham as being most certain and effective. They clearly prefer complete closure of these reserves to all classes of fishing—any measure which is the same for all would alone appear tolerable to our fishermen—but partial closure is mentioned. The scientific evidence in our opinion is conclusive, and we regard the whole question as now in the hands of the executive to decide in the first instance whether they will try to do anything or not. If it is determined to make the attempt, Britain must either, with other countries, enforce a size limit, which will almost certainly be ineffective, or, better, endeavour by agreement to close, as a first experiment, a small area to all fishing vessels. Such a closure would undoubtedly be attempted, were there a young plaice ground to the west of the North Sea, near England. Unfortunately the only experimental closure of value would have to be on the east side, the difficulties in respect to which, however, are not insurmountable, provided the English Minister for Agriculture and Fisheries has the courage to propose it as a subject of negotiation between all the countries concerned; he will be in a strong position, for all the fishery experts of these countries are agreed as to its desirability and our own fishermen clearly see the necessity for remedial measures.

It is certain that the continuance of the depletion of the plaice stock of the North Sea will lead to a complete disorganisation of the steam trawler industry in its southern part. The owners will either have to lay up their vessels or shift them to ports already overcrowded, while the fishermen will have either to "go on the dole" or to push in to some other part of the industry. It is proved that the danger is a real and immediate one, and, as such, it should surely be faced without delay, while remedial measures are still possible.

J. STANLEY GARDINER.

Faculty Organisation at Cambridge.

THE University Commissioners have published for information certain draft statutes that they are considering on the question of faculty organisation in the University of Cambridge. Among many points of interest to those who may be concerned in administering the new scheme, and to those who will have to live and work under it, a few may be mentioned in a brief preliminary survey. Two schools are created for the scientific studies: the School of the Physical Sciences including the faculties of engineering, mathematics and physics, and chemistry, and the School of the Biological Sciences including the departments of anatomy, botany, genetics, geology, parasitology and zoology, which form one faculty, and the departments of biochemistry, experimental psychology, pathology and physiology, which form a second biological faculty. The remaining faculties, which are not purely literary or belonging to the fine arts, are economics and politics, moral science, agriculture, archæology and anthropology, geography and medicine.

The separate faculties consist of the regular teaching staff working in the faculty. Boards of faculties will be formed, corresponding to the present special boards of studies; the duties of the boards of faculties are to be to provide adequate instruction and facilities for research in their departments and to arrange the examinations in their subjects of study. The boards are to determine the remunerations of the members of the faculty staffs, but there is no indication in the draft statutes that they will actually have the power to handle any funds. This is a very necessary power in connexion with such matters as departmental libraries, and provision should be made for it at some point in the statutes.

The new General Board of Studies is to be a smaller body than the present one and to consist, in addition to the vice-chancellor, of four members elected by the boards of the literary faculties acting in common, four members elected by the boards of the scientific faculties acting in common, and four members of the council elected by the council. A considerable amount of work is to fall upon the new General Board in framing and supervising the educational policy of the University. In dealing with problems affecting a particular faculty, the General Board may have a representative of the faculty board present, and in dealing with matters affecting several faculties it may get help from the council of a School, the kind of super-faculty, advocated by Sir Joseph Larmor and others, for which arrangements have been made in the scientific schools mentioned above.

Amongst clauses of interest in the proposed new statutes on the University teaching officers, we may mention the general adoption of the federated superannuation scheme for universities and arrangements for a sabbatical year—one term's freedom from duty for every six terms during which an officer has discharged the duties of a teaching officer. The question of stipend during an absence of not more than a year is left undecided, perhaps necessarily so. Another important point is that women are to be eligible for all teaching offices in the University. Here, presumably, restrictions will have to be imposed in such cases as that of a divinity professorship carrying with it a canonry at Ely. The basic amount of teaching for University lecturers and demonstrators is also laid down, and a minimum is fixed for the basic rate of pay. The amount of teaching that a University lecturer may give on behalf of a college in the way of supervision is limited, and the permission of the General Board has to be obtained for any other teaching given in full term by the lecturer.

In the attempt to separate the recognised lecturer from the private coach, and to limit the amount of teaching that the lecturer may give, there is presumably a desire to keep the lecturer free to carry on research. With this desire general sympathy must be felt. It is obvious, however, that this part of the scheme can only work satisfactorily if the financial side is also capable of satisfactory adjustment. It will want very careful handling and very careful watching if the University is to steer clear of the danger of driving an impecunious, young, but successful teacher out of its official ranks. Close co-operation of the General Board of the faculties with the faculty boards and with the college councils will be very necessary here. The question must be largely a financial one, and full consideration of it must be deferred until the financial side of the faculty organisation has been developed and made available.

The Founders of American Geology and their Work.

The First One Hundred Years of American Geology. By George P. Merrill. Pp. xxi+773+36 plates. (New Haven: Yale University Press; London: Oxford University Press, 1924.) 27*s.* 6*d.* net.

MR. MERRILL has spared no trouble in collecting material for this history. The imaginings of the earliest speculators on the history of the earth, and sketches of their lives and characters, are presented almost too liberally, so far as regards the first eight chapters of the book. I trust that I shall not appear ungrateful if I say that these chapters leave me with a feeling of bewilderment. The geological paragraphs, in themselves disconnected, are mixed up with biographical matter, while the biographical information, scattered here, there, and anywhere, fails to convey a clear idea of what any one man was thinking at any one time. Obviously a strictly chronological arrangement was impossible, for episodes in the development of geology overlap indefinitely, nor did one geologist wait for the death of another before beginning to publish. Nevertheless, if the author, in developing his theme, had concentrated either on the growth of geology, or on the biographies, his work would have had less the appearance of having been made up of extracts from a notebook.

Chapters ix. to xv., on the other hand, are good examples of historical treatment. Each is devoted to the discussion of some one of the great problems which have exercised the minds of American geologists. The various stages from the initiation of the problem to the solution as accepted to-day are clearly set out, and the comparative progress made in Europe and America can be realised.

The biographical notices, nevertheless, are full of interest. Aided by numerous portraits, they enable us to realise what manner of men they were who founded American geology. One is struck at once by the diversity of professions from which the lure of the rocks drew geologists, early and late, in the United States as in Europe. Lawyers, doctors, ministers, engineers, soldiers, politicians, business men, dentists, all contributed. We are deeply impressed, too, by the immensity of the field that awaited exploration by these men. Physical features and geological agencies presented themselves with a grandeur and on a scale for which there is no room in Europe. The effect of such an environment is apparent. American geologists distinguished themselves, as we learn on p. 663, "in studies tending towards the solution of, first, the fundamental problems of continental uplift and depression as made by Dana; second, in those relating to the physics and structure of mountain ranges, made by Rogers brothers, le Conte, and Dana; third, in those relating to glaciers and glaciation by Agassiz and the elder Hitchcock, and later by Chamberlin; fourth, in those relating to isostasy and physiography, made by Dutton, Gilbert, and Powell in the arid regions; and fifth, in those relating to vertebrate evolution, made by Leidy, Cope, and Marsh." As regards glaciation, however, it should be remembered that Agassiz laid the foundations of his theories in Switzerland, the country of his birth, though he further developed them after his transference to the United States.

The book opens with an account of the Maclurean Era, 1785–1819. Maclure, "the William Smith of America," was born in Scotland in 1763. He made a fortune in business and, after travelling extensively in the Old World, he settled in the United States. There he not only became a liberal patron of science, but also by his own personal exertions in the field, often under extreme privation, he collected sufficient material to enable him to publish the first geological map of America in 1809.

During this era, progress lay chiefly in the hands of men engaged in the so-called learned professions. Mostly self-trained and hampered by the mental attitude of the times, these men were faced by a pathless wilderness of vast extent, inhabited, if at all, by more or less hostile Indians. Observations in the field and the collecting of facts were therefore matters of extraordinary difficulty, but speculations on such phenomena as earthquakes and volcanoes, on the origin of glacial drift, on the structure of the globe and other inviting objects, were not lacking. Maclure, as regards his own views, summed up the matter: "All these speculations . . . can be accounted only as an amusement at present." Men's minds, moreover, were dominated by the belief that the Noachian deluge was a world-wide catastrophe, and that the Scriptural narration of the creation must be taken literally. Thus the bones of a mammoth found at Albany in 1705 clearly corroborated the Scriptural account of a race of antediluvian giants. One may smile at the crudeness of these early speculations, but these men had the sagacity to realise what is not realised by the majority even now, that there were things in the world around them that could be, and ought to be, explained. Yet one almost fears that the author may have been more conscientious than kind in rescuing some of the crudest theorisings from their decent oblivion.

In 1802, when Silliman was appointed professor of chemistry and natural science in Yale, no science was taught in the United States or England. He had some acquaintance with law but none whatever with science, and thus found himself in somewhat the same position as Sedgwick when he became professor of geology at Cambridge. Yet he did more by his teaching than any other man of his day to advance the science of geology. His name is best remembered by his *American Journal of Science,* founded in 1818 and still continuing. But he made some sagacious observations, such, for example, as his terse description of East Rock, New Haven, as a rock that had been melted and ejected among the superior strata, but never erupted like lava. Its form he attributed to erosion. *Silliman's Journal* was largely concerned with geology, and he resented the rivalry of the *Monthly American Journal of Geology* founded by Featherstonehaugh. The monthly journal, though warmly blessed by Murchison, Conybeare, Sedgwick, Buckland, and Greenough, had but a short life.

The origin of basalt was still being keenly debated in 1816. The Neptunists proved its aqueous origin and the Plutonists its igneous origin, each to their own complete satisfaction. In 1816, Emmons gave up his practice as a doctor and took a post on the Geological Survey of New York. Thence arose the great Taconic controversy, a battle royal that led to the shedding of as much ink as any of our controversies in Britain. It will be noticed later on.

Chapter ii. deals with the Eatonian Era, 1820–29. Amos Eaton gave up the law in 1816, when he was forty, and attended lectures by Silliman. Thereafter he travelled thousands of miles, lecturing on natural history and rousing "uncontrollable enthusiasm." He considered "nothing in geology entitled to much confidence, which is purely theoretical," but was not deterred thereby from accounting for the elevation of the continent by a great explosion which rent the crust of the earth in a north and south direction. His great work was the "Index to the Geology of the Northern States," first published in 1818. In 1820 he brought out a second edition, in which many of his earlier opinions were re-stated in his customary emphatic manner. He was a man of forceful character, as might be judged by the portrait forming Plate V.

Scientific methods were now developing. The value of fossils for purposes of correlation, as taught by Cuvier and Brongniart, was being realised, and was tested on the Atlantic Coast Tertiary deposits, hitherto mostly lumped together as alluvium. The igneous origin of trap was adopted from Hutton, Playfair, and Daubeny. Yet at this same time Silliman calculated that the Noachian flood must have risen in America at the rate of 700 feet in 24 hours, on the assumption that the mountains were about 5½ miles high and were submerged by 40 days' rain, with the help of a deluge from the bowels of the earth. The flood proved fatal to the Siberian mammoth and did much other damage. Silliman, as Huxley put it, wrote "with one eye on fact, the other on Genesis."

Chapter iii. introduces the first of five decades of State Surveys, and deals with the years 1830–39. Eaton produced a text-book early in this period, and still strove to harmonise all phenomena with the Biblical account. Sixteen State Surveys were founded, nine of them in the years 1836–40. The number of State Surveys founded in the five decades may surprise British geologists, but it must be remembered that though some of the pioneers had had the intrepidity to attack the wild alone, organised bands of independent resources and capable of self-defence were essential. The object appears generally to have been the exploiting of rocks and minerals of economic value.

During the second decade, 1840–49, geology found a place in educational curricula. The Society of American Naturalists and Geologists was formed in 1847, but was afterwards merged in the American Association for the Advancement of Science, at the first meeting of which geologists took a prominent part. It may be noted that the Geological Society of London had been founded in 1807, and readerships in geology at Oxford and Cambridge in 1813 and 1808 respectively. During the decade much progress was made in the recognition in the United States of the principal formations of Europe. The interpretation of the structure of the Appalachian Chain by the two Rogers was a notable achievement. In the final report (not published until 1858), H. D. Rogers distinguished hypozoic, azoic, and palæozoic, and divided the last into formations named after the period of a day, such as auroral, vespertine, etc., but the European names, Cambrian and Silurian, were preferred. He also enunciated his well-known views on the formation of coal and anthracite, but above all he described what is now known as the "overthrust fault." James Hall's views on palæontology at this time are worth recording. "Changes in the lithological features of a rock . . . are usually accompanied by a greater or less change in the nature of the fossils. In no case, therefore, are to be overlooked either of the three important facts and characters, viz., lithological character, order of superposition, and nature of contained fossils." He is credited with having written not less than 10,000 pages, and either this or something in his methods roused the antagonism of nearly every palæontologist in America. Dana began to publish in this decade.

The third decade (1850–59) was marked by financial depression and starvation of State Surveys. It was notable for a report by Evans on the Bad Lands, previously almost unexplored. In the vast labyrinth of defiles the bones of extinct animals lay in profusion.

Leidy's description of Evans's specimens was the first systematic account of the world-famed Bad Lands fossils. Emmons, Dawson, and Hitchcock were publishing in the United States; Murchison was bringing out "Siluria," and Lyell his 9th edition of the "Principles," in Europe.

In the earlier part of the fourth decade (1860–69) the Civil War temporarily stopped work, but State Surveys were resumed in 1864. Dana's "Manual" appeared during this decade. In 1859 petroleum had been found in a well at Titusville. Sterry Hunt pointed out that petroleum by virtue of its lightness would be found in the crests of anticlinals, a guiding principle in the search for oil to-day. The fifth decade brought further developments in natural gas and oil. Marsh, at his own expense, collected vertebrates in the Western States, among these the remains of toothed birds and extraordinary dinosaurians. Stevenson wrote on the Alleghanies and the origin of coal. Chamberlin, dissatisfied with petrological nomenclature, proposed abbreviations, such as *qua* for quartz, *fel* for felspar, *mi* for mica. Thus a mica-granite became *fel-qua-mi* or *mi-fel-qua* according to the predominance of the constituents. The names were rejected as uncouth, but for sheer monstrosity it would be hard to beat some of the latest names, such as *phyrowyomingose* or *hornblende-trach-phyro-monzonose*.

The second Survey of Pennsylvania in 1874–87 under Lesley emphasised the magnificence of the structures and the great development of Palæozoic rocks in that part of the United States. Lesley, who was outspoken, referring in one of his reports to the chaos that must have prevailed in earliest Archæan times, remarked, "All this . . . is only known to God and Dr. Sterry Hunt, who has described it magnificently."

Chapter viii., dealing with the era of National Survey, opens with words that appeal warmly to us, with the War fresh in our memories. "The period of the Civil War had brought to light a considerable number of men for whom the piping times of peace . . . afforded insufficient opportunities. They were men in whom the times had developed a power of organisation and command. They were, moreover, men of great physical and moral courage." This was the material Hayden found available for his territorial surveys, King for his survey of the 40th parallel, Powell for his exploration of the Rocky Mountains, and Wheeler for his work west of the 100th meridian. The expense, however, of keeping so many separate surveys in progress, with inevitable overlapping, impressed on Congress the necessity for consolidation. In 1879 the United States Geological Survey was founded, a service which is unsurpassed for organisation, efficiency, and wideness of scope.

The controversies on fossil footprints and on Logan's Eozoon form the substance of Chapters ix. and x.

Chapter xi. gives the history of the Laramie Question. The Lignitic beds of Hayden, which occupy vast areas, yielded Tertiary plants and Cretaceous dinosaurs. Thus rose a dispute as to the relative value of plants and animals for purposes of correlation. It was pointed out that Cretaceous rocks in Nebraska yielded a flora that had been referred to the Miocene, and again it was suggested that the evolution of plants had been more rapid in America than in Europe, and that this explained the association of European Tertiary plants with American Cretaceous animals. Eventually the name Laramie was restricted to certain beds which were agreed to be Upper Cretaceous.

The Taconic Question, to which Chapter xii. is devoted, occupied men's minds for half a century, and covered the period of the Sedgwick-Murchison controversy on the same formations. Emmons founded the "Taconic System" and declared it to be older than the Potsdam Sandstone. Others disagreed, but Barrande, on the strength of the trilobites, though without knowing the ground, supported Emmons. Dana and Walcott eventually established the true sequence, which had been completely obscured by faults and folds. The "Taconic" of 1842 was distributed among the Lower Cambrian and Lower Silurian of 1903.

Chapter xiii. gives an account of the development of glacial theories. They commence with talk of convulsions, earthquakes, eruptions, etc. Then the Noachian flood was called in to account for everything. But in 1825 Peter Dobson, a cotton manufacturer, made some truly remarkable observations. He noticed that the boulders had been worn smooth and striated on their under sides, as though they had been dragged in one steady position, and he assumed that they had been held and dragged in ice. He could tell also which end had been foremost by the little ridge extending behind any projecting knob of hard material such as quartz. These brilliant deductions attracted no attention until 1842, when Murchison congratulated "American science in having possessed the original author of the best glacial theory." The greatest advance, however, was due to Agassiz, who arrived in America in 1846 and there developed the views he had formed in Switzerland.

Chapter xiv. relates how the method of micropetrology as initiated by Sorby and developed by Zirkel, was adopted in America in 1873 and became officially recognised as a necessary part of the equipment of a State Geologist.

Chapter xv. on the age of the earth deals with the estimates made by Hutton, Lyell, Playfair, Reade, and

G. H. Darwin in Britain and those of Winchell, Walcott, King, and Gilbert in America. The American estimates varied greatly, but were all far smaller than those made in Europe. Burrell in 1917 restored the balance by an estimate more than three times as large as any of them.

In laying down this book an impression remains of the immense labour which the collecting of such a mass of material must have entailed. The mass indeed is too rich for easy digestion and might have been the better for a little boiling down and arrangement in the earlier chapters. Still the information is all there, available for any one who has the leisure to look for it. The book has been published on the Philip Hamilton McMillan Memorial Fund, and, as the first fruits of her bequest, must be a source of gratification to Mrs. McMillan.

A. STRAHAN.

The Brauner Jubilee Volume.

Recueil des travaux chimiques des Pays-Bas. Publié par la Société Chimique Néerlandaise. Tome 44 (4e Série, T. 6), No. 5, Mai. *Numéro jubilaire en l'honneur du Professeur Bohuslav Brauner, publié par ses amis et élèves en commémoration de son 70e anniversaire, 1855—8 Mai—1925.* Pp. 281-628. (Amsterdam: S.A. d'Éditions scientifiques D. B. Centen, 1925.)

NUMEROUS friends and pupils of Prof. Bohuslav Brauner, the illustrious Director of the Chemical Institute of the Charles University of Prague, have signalised his seventieth birthday by issuing this splendid volume of researches in his honour. It opens with a most delightful "Hommage au Professeur Bohuslav Brauner" written by Prof. Urbain and entitled "Discours sur les éléments chimiques et les atomes." In this brilliant essay, the author, in tracing the development of scientific research concerning the chemical elements and the nature of the atoms, shows the fundamental character of Prof. Brauner's work in the fields of the rare earths, the atomic weights, and the Periodic System of Mendeléeff. Whilst every one is familiar with Prof. Brauner's long and splendid series of researches on the atomic weights, it is well that the younger chemists of the present generation should be reminded of the fact that he it was who discovered that the old "didymium" was in reality a mixture of two elements, neodymium and praseodymium.

The present volume bears ample witness to the fact that Prof. Brauner has done much more than greatly to advance the science of chemistry by his own researches. He has created and built up a great school of chemical research in the land of the Czechs. On the cover of this Jubilee volume there is a picture of the fine Chemical Institute which was founded by his efforts in 1903, whilst the 348 pages contained between the covers include a large number of very interesting researches carried out by his present and former pupils. Although it may appear perhaps a little invidious to single out any of these for special praise, attention may be directed to the series of ten investigations with the dropping mercury cathode, published by Dr. Heyrovsky (professor of physical chemistry in the Institute of Prof. Brauner) and his collaborators.

Amongst the papers contributed by foreign chemists, one is very glad to see that there are two from England, namely, Prof. H. B. Dixon's investigation on "The Ignition of Carbon Disulphide Vapour and its Phosphorescent Flame," and a paper by Dr. J. G. F. Druce on "The Stannonic Acids and Some of Their Derivatives. A New Series of Organic Compounds of Tin."

On his impending retirement from the active direction of the Chemical Institute at Prague, Prof. Brauner will carry with him not only the affection and esteem of his many pupils, but also the highest respect and admiration of chemists all over the world. For upwards of half a century he has held high the torch of science and true learning, and in the annals of chemistry his name and his work will ever be remembered with honour and gratitude.

F. G. DONNAN.

British Butterflies.

Natural History of British Butterflies: a Complete, Original, Descriptive Account of the Life-History of every Species occurring in the British Islands, together with their Habits, Time of Appearance, and Localities. By F. W. Frohawk. Vol. 1. Pp. xv+207+36 plates. Vol. 2. Pp. iv+206+29 plates. (London: Hutchinson and Co., 1924.) 6*l*. 6*s*. net.

MR. FROHAWK is well known to naturalists as an admirable delineator and accurate observer of British lepidoptera in all their stages. The present work amply fulfils the expectations of those who knew that the author was engaged upon the task of describing and figuring every British butterfly in all its phases from egg to imago. The work may fitly be termed monumental; for it represents an immense amount of patient labour carried on through a long series of years, and accomplishes what has never been attempted before, namely, a complete life-history of every species of butterfly that has any claim to be considered British. The ground has been partly covered by the works of Barrett, Buckler, and others, but never before has the assemblage been figured and described as a whole.

The most characteristic feature of Mr. Frohawk's two splendid volumes is the exact and careful description of each larval form in every period of its growth. These details have in all cases been worked out from actual living specimens, and the amount of labour involved in the completion of this task can only be fully appreciated by those who have experimented in the same field. In the case of species that are now extinct in Britain, such as *Chrysophanus hippothoe* and *Zizera semiargus*, or of occasional visitors such as "*Pieris*" *daplidice*, *Argynnis lathonia*, *Vanessa antiopa*, and *Anosia archippus* (*plexippus*), Mr. Frohawk has made use of eggs laid by females obtained from abroad. In spite of all difficulties, the industry and skill of the author have proved equal to the enterprise of describing and figuring, in all these instances, every stage from egg to perfect insect.

It is well known to all students of the lepidoptera that the life-history of the "Large Blue" (*Nomiades arion*) was a mystery which eluded solution by the efforts of every entomologist until the successive discoveries of Mr. Frohawk, the late Dr. Chapman, and Captain Purefoy furnished the key to the puzzle, namely, the extraordinary relations that exist between the larval *arion* and certain species of ant. Of this association an excellent account is given on pp. 144-149 of the present work, and a striking figure, sketched from life, of the larva signalling to the ant when ready to be carried off to the nest of the latter, is provided on a separate plate. It is noteworthy that German larvæ of *C. hippothoe* kept out of doors in England were visited by ants. Many points of bionomic interest in connexion with other species are mentioned in the text.

The artistic skill of the author is well known, and his beautiful drawings have been, on the whole, worthily reproduced. It may, however, be doubted whether the colour-process adopted is the most suitable that could have been chosen for representing very young larvæ of the natural size. Wing-venation also, in the case of small insects, requires a sharper definition than is to be found in some of the illustrations, *e.g.* on Plates 56 and 56A.

The style and get-up of these volumes is in the main excellent. A few slips may be noted: fig. 23 on Plate 12 has no legend; fig. 15 on Plate 37, called a female, must be a male; the "Mazarine Blue" is spoken of as *Lycaena acis* on p. x, and as *Zizera semiargus* on p. xi. An appreciative preface to this fine work has been contributed by Lord Rothschild, whose generous co-operation and continued encouragement are gratefully acknowledged by the author.

F. A. D.

Our Bookshelf.

Handbuch der Pflanzenanatomie. Herausgegeben von Prof. K. Linsbauer. Allgemeiner Teil: Cytologie. Band III/2: Die Zellmembran. Von Prof. Dr. C. van Wisselingh. Pp. viii + 266. (Berlin: Gebrüder Borntraeger, 1924.) 15 gold marks.

BOTANISTS will welcome a general survey on the plant cell membrane from the pen of the Groningen veteran, Prof. C. van Wisselingh. Inequalities of treatment certainly suggest themselves to the English reader when the chemistry of cellulose is handled without citation of Irvine and its physical structure discussed without reference to W. L. Balls (one recent paper is quoted in the appendix); but there is very real compensation in the individual treatment the problems of the cell wall here receive from the viewpoint of a master of micro-chemical method, who avails himself when necessary of the results of as yet unpublished researches.

The usual plan followed in the monograph is a preliminary account of the chemistry of a wall substance, followed by a discussion of its distribution in the cell wall throughout the plant kingdom. As would be expected from the author, the treatment of suberin and chitin is particularly complete, but it is doubtful whether the reactions of the lignified wall have ever been so fully stated before, and the section upon the chemistry of the pectin substances is very full and up-to-date.

Mangin regarded cellulose, pectin, and callose as the three fundamental substances of the plant wall; the importance of pectin is now fully admitted, but van Wisselingh considers that the case for the identity of callose has yet to be made out. For all fat impregnated walls the author reports a new micro-chemical method. Sections are warmed in baryta water for some hours, so that baryta soaps are formed; acids are then released from these and the melting-points of the acids observed with the sections mounted in glycerine.

The section upon the structure and growth of the cell wall is entirely inadequate as a bibliographic treatment, but contains a most interesting statement of the author's own views, in which stress is laid upon the chemical heterogeneity of the wall and the possibility of its micro-chemical demonstration.

Sturly. By Pierre Custot. Translated from the French by Richard Aldington. Pp. 127. (London: Jonathan Cape, Ltd., 1924.) 5*s.* net.

THE zoologist does not need the aid of a poetic imagination to appreciate the wonderful panorama of marine life with its hosts of interesting phenomena and many absorbing problems. Yet it is not surprising that these things should have stirred the imagination of a man of letters and moved him to weave this delightful phantasy, with a sturgeon as the central figure, and the world of marine zoology as the setting. M. Custot has read widely and well, and has supplemented his extensive reading by constant observation of marine animals in the aquaria at Monaco. Sturly, the hero of this fairy tale, is a young sturgeon, born in the waters of the Rhône, whose life, from the time of his enthusiastic and unsophisticated youth to the crowning act of reproduction, is charmingly told.

His adventures among the denizens of the seas during his migratory periods, his impressions of the beauty of form and colour, the phenomena of symbiosis, commensalism and parasitism, the phosphorescence of the deep sea animals, the bizarre form of others and the art of protective resemblance are made the means of introducing the reader to a survey of the whole field of marine life, pelagic, littoral and deep sea. Sturly, under the guidance of a hoary, wise, old Echinus, sets out to probe the mystery and meaning of life, and the steady development of his education to a realisation of that inexorable law of Nature, reproduction of the kind, forms the real theme of the book.

The bitterness produced by the results of his search are removed by the advent of death when a voice from another world soothes his last hours in this, by a promise of a reincarnation and a fuller life in the next. Thus does Sturly solve the meaning of life. We can forgive the author a few minor zoological errors such as the occurrence of Convoluta at 100 fm., the presence of *Melia tessellata* in the Mediterranean, and the description of a copepod as a wood-louse, in the real charm and simplicity of his allegory. The book was worth translating, and Mr. Aldington has done his work well in face of the many technical difficulties involved in finding the right English equivalent for the many unusual names of animals in the original. The book should stir the reader to a desire for an extended knowledge of marine life.

British Museum (*Natural History*). *Fossil Insects*, No. 1: *The British Liassic Dragon-flies* (*Odonata*). By Dr. R. J. Tillyard. Pp. 40+5 plates. *Fossil Insects*, No. 2: *Insects from the Coal Measures of Commentry*. By Dr. Herbert Bolton. Pp. 56+3 plates. (London: British Museum (Natural History), 1925.) 5*s*. each.

THESE memoirs mark a new departure in the publications of the British Museum. Instead of waiting for the time when it would be possible to issue a descriptive catalogue of the entire collection of fossil insects, it has been decided to publish shorter memoirs on portions of the collection whenever specialists can be found to undertake the work. The first two memoirs of the series are written by palæontologists not officially connected with the Museum.

The dragon-flies described by Dr. Tillyard are from the Lias of Leicestershire, Warwickshire, Worcestershire, and Gloucestershire—mainly from the "Insect Limestone" of Lower Liassic or perhaps in part of Rhætic age. The larger number of the specimens were collected by the late Rev. P. B. Brodie. Nearly all the species belong to the sub-order Anisozygoptera, which at the present day is represented by a single genus with two species, one found in Japan, the other in the Himalayas.

The Coal Measures of Commentry in the central plateau of France have yielded an abundant and varied insect fauna, ranging from primitive forms to specialised types regarded as the forerunners of dragon-flies. Nearly all possessed a great span of wing relatively to the size of the body. It is pointed out that only very rarely are two or more insect wings alike in venation—an indication perhaps of rapid evolution in Carboniferous times. Both memoirs are well illustrated with plates and text-figures.

Perseus: or, Of Dragons. By H. F. Scott Stokes. (To-day and To-morrow Series.) Pp. 80. (London: Kegan Paul and Co., Ltd., 1924.) 2*s*. 6*d*. net.

To any who wish to read pleasurably of dragons, this book may be commended. The author ranges with a gossiping humour from Glastonbury to ancient Egypt, devoting some attention to Perseus, St. George, the dragons of Rhodes and Bologna, and other dragons of modern Europe by the way. He begins with a chapter on the characteristics of dragons, touches upon the folklore themes which occur in dragon stories, such as the supernatural birth, the life-token, the magic weapon, and the rescued maiden, and concludes with a summary of Elliot Smith's theories of the diffusion of culture from a common origin. Incidentally to his reference to the theory that the dragon is a folk-memory of antediluvian monsters, notwithstanding the chronological discrepancy, it may be mentioned that it has been suggested in all seriousness to the present writer that the long-necked dance masks shown in Capt. Hurley's recent film "Pearls and Savages" is a reminiscence of the plesiosaurus!

Leaves from a Naturalist's Diary: with Notes on What to Look for Month by Month. By A. R. Horwood. Pp. 192+4 plates. (London, Calcutta and Sydney: G. G. Harrap and Co., Ltd., 1924.) 3*s*. 6*d*. net.

MR. HORWOOD has written a nature study book in the form of a calendar. Interesting or salient points in Nature's yearly cycle are dealt with month by month in separate chapters, and at the end of each chapter is a list of the more important and commoner animals and plants to be found in suitable places during that month. This is the most valuable part of the book, and Mr. Horwood has in some cases given his mere list an ecological value by specifying the kind of habitat in which to look for the species listed. Such lists cannot be expected to be complete, but as a guide to the Nature lover they are useful and should also serve as a basis for a diary in which actual records and other data can be kept by observers. This brief survey of the pageant of Nature for a year is pleasantly written in simple and easy language, and illustrated by four photographs and many quite life-like sketches of typical animals and plants.

The Travel Diary of a Philosopher. By Count Hermann Keyserling. Translated by J. Holroyd Reece. Vol. 1. Pp. viii+336. Vol. 2. Pp. 405. (London: Jonathan Cape, Ltd., 1925.) 36*s*. net.

COUNT KEYSERLING'S reflections on the various modes in which human speculative thought has found expression, and his study of the distinctive character which climate and the aspect of Nature in the different countries of the world has impressed on man's religious and ethical feelings, can now be read by the English student in an excellent translation. The book is delightful to read, on account of the extraordinary power of the author to project himself sympathetically into the most opposite modes of thought. The publication of the original work was interrupted by the War, and that disastrous upheaval, with its outburst of hatreds, casts its shadow over a philosophy conceived in the spirit of peace on earth among men of goodwill.

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.*]

On the generally accepted Explanation of the Zeeman Triplet on a Quantum Basis.

THE explanation of the simple Zeeman triplet on the basis of the quantum theory ostensibly depends on the application of Larmor's theorem.

This theorem may be expressed as follows:

Suppose a system of electrons describing orbits under the action of their mutual repulsions combined with any other forces the directions of which pass through an axis. Then if the system be subjected to the action of a uniform magnetic field H along that axis, the motion of the system is such that it may be represented as a possible motion with H = 0 combined with a precessional rotation as a whole around the axis. When the other forces are central this applies to any direction of H as axis.

In the usual way of applying this theorem to the explanation of the Zeeman effect, the tacit assumption [1] is made that after the imposition of the magnetic field the rotating system is the *same* as before with simply the rotation superposed. This assumption is not only incorrect but would also seem open to two further objections, in that (1) the new orbit ceases to be quantised and (2) the total energy is supposed to be altered by the action of a magnetic field on a moving electron.

That the assumed new orbit ceases to be quantised is easily seen by considering a special case of, say, a circular orbit with its plane perpendicular to the magnetic force. The new path is assumed to be unchanged, but the velocity of the electron to be changed by the Larmor effect (which of course agrees with that calculated from the changed radial force H*ev*). The orbit therefore ceases to be quantised and the quantum law is disobeyed.

It would seem that the most natural way to attack the problem would be by first attempting a discussion of actual orbits. Unfortunately, however, this shows that no effect is to be expected—or if so the magnitude must depend on the square or higher powers of H. We can easily see this by the following considerations of simple cases.

1. Let us suppose the field is imposed by a very gradual increase from zero. The orbits of all electrons will gradually change. As the change is slow we have an adiabatic process and the new orbits will all remain quantised if the original were. But the magnetic field acts transversely on the moving electric charges, and the total energy will therefore remain unchanged. There is thus on the quantum theory no Zeeman effect.

2. Let us suppose the field already constituted and take the case of a circular orbit round a central force in a plane perpendicular to the field H. Then with the usual nomenclature

$$m\omega^2 r = \frac{e^2}{r^2} \pm He\omega r, \quad W = \tfrac{1}{2}m\omega^2 r^2 - \frac{e^2}{r}, \quad 2\pi m\omega r^2 = nh.$$

From the first

$$\frac{e^2}{r^2} = m\omega^2 r\left(1 \pm \frac{He}{m\omega}\right).$$

If we neglect squares of the small quantity $\pm He/m\omega (= x \text{ say})$ we may replace the ω in $He/m\omega$ by its value when $H = 0$. Substituting for ω from the third we find

$$\frac{1}{r} = \frac{4\pi e^2 m}{n^2h^2(1-x)},$$

$$W = \frac{e^2}{r}\left(\frac{1}{2}\frac{1}{1-x} - 1\right) = \frac{4\pi^2 e^4 m}{n^2h^2(1-x)}\left\{\frac{1}{2}\frac{1}{1-x} - 1\right\}$$

$$= -\frac{2\pi^2 e^4 m}{n^2h^2}\frac{1-2x}{(1-x)^2} = -\frac{2\pi^2 e^4 m}{n^2h^2}$$

neglecting x^2 . . . But this is Bohr's value for no field. As this remains unchanged there is no Zeeman effect.

From the above considerations it would appear that the true explanation of the Zeeman effect on the quantum basis yet remains to be given. Doubtless it is to the nucleus that we must look for this. Should, for example, this contain structures analogous to permanent magnets a change of energy by an impressed magnetic force is possible. But it is not the object of the present note to go into this further question.

W. M. HICKS.

[1] Larmor (see "Aether and Matter," p. 343), however, in stating his theorem expressly gives a warning against this assumption.

On the reported $K\beta_4$ Line in the X-ray Spectra of Molybdenum and Palladium.

IN a recent publication A. Leide (*Compt. rend.* 180, p. 1203 (1925)) has reported the results of an investigation of the wave-lengths in the K series of X-rays for elements having atomic numbers between 29 (copper) and 53 (iodine). The spectrograph used had a high resolving power so that the β_1 line was separated into its components. The accuracy was increased by a large number of exposures for each measurement. In addition to the well-known lines α_1, α_2, β_1, β_3 and γ or β_2, he has reported in the case of molybdenum (42) and palladium (46), a line β_4, ascribed to the transitions O_{II}, $O_{III} - K$.

Such transitions are permitted by the principles of selection, but transitions from O_I to K are prohibited. The schemes of electron distribution advanced at present (Bohr, Stoner) place no electrons in the O_{II}, O_{III} sub-levels in the normal states of the molybdenum and palladium atoms, but these elements lie in a portion of the periodic table where inner levels are presumably being filled up as electrons are added, admittedly making the actual electron distribution doubtful in the outermost levels. The presence of this β_4 line for these atoms would lead to the following alternatives: Either the O_{II} and O_{III} levels contain electrons before the first 18 electrons have entered the N shell, or we are here dealing with "semi-optical" X-ray lines, *i.e.* electron transfers from virtual orbits only occupied by electrons in atoms excited in the optical sense. Such orbits would presumably be greatly distorted in the atoms in a solid substance. Such semi-optical lines have been previously mentioned by Siegbahn and his co-workers (*Phil. Mag.* 49, 513 (1925)).

It has occurred to me that there may be some uncertainty as to the existence of this line in the K series spectra of molybdenum and palladium. Recently in this laboratory, in collaboration with Miss Alice Armstrong, a rather extensive reinvestigation of the molybdenum K series spectrum has been carried out, using an ionisation spectrometer. Some of the results of this work were reported to the American Physical Society at its spring (1925) meeting. In the course of the investigation no evidence was found for the presence of this β_4 line described by Leide, though readings were taken in that region of the spectrum in which it should occur. In this region, however, a discontinuity in the white or general radiation always appeared, due to the absorption by the target of its own radiation. This showed itself, for example, in the first order by the fact that the base-line due to general radiation was always much lower on the short wave-length side of the γ line than on its long wave-length side.

This absorption by the target of the radiation which leaves it has been mentioned by other authors, including Walter (*Zs. f. Physik*, 20, p. 268 (1923)). This effect of the K critical absorption in the target substance would produce, in spectra of high resolution, a narrow shelf of constant intensity on the short wave-length side of the γ line, followed by a large decrease in intensity on the short wave-length side of the critical absorption wave-length, which is very close to the γ line. It seems possible that such an effect might be mistaken for a faint line on the short wave-length side of γ, lying between γ and the critical absorption wave-length. The lines reported by Leide were very faint and the wave-lengths given lie within 0·06 per cent. (about 12 seconds of arc) of the accepted values for the K critical absorption limits. The K critical absorption wave-length lies about 45 seconds of arc from the γ line in the first order. Due to the importance which may be attached to the presence of this line in molybdenum and palladium, it is to be hoped that the possibility of confusion on the photographic plate with the absorption limit itself may be removed.

SAMUEL K. ALLISON.

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A Substitute for a Liquid Air Trap for Mercury Vapour in Vacuum Systems.

As is well known, the speed and simplicity of the mercury vapour condensation pump has led to its almost universal adoption in the production of extremely high vacua. It suffers from the disadvantage that, while it rapidly removes gases and vapours from the vessel to be exhausted, it does not remove mercury vapour. Consequently, it is necessary to freeze the mercury vapour in a trap between the pump and vessel to be exhausted, by immersing the trap in liquid air. The cost of making liquid air, the difficulty of getting it in certain laboratories, and, in some researches, the need for keeping the mercury trap in action for several weeks without a break, suggested the desirability of looking for some alternative method.

In our search for an alternative method, we have found that the alkali metals have an extraordinary power for absorbing mercury vapour, and may therefore be used as a mercury trap in place of liquid air. Our practice is to put a small piece of sodium or potassium (a gram is ample) into a trap between the diffusion pump and the apparatus to be exhausted, and to distil it, after the vacuum has been obtained, on to the sides of the trap, thus lining it with the metal for a few centimetres. The trap may be of the usual liquid air type, or it may be merely a bent tube with the metallic lining of distilled metal distributed over the inside surface at and near the bend.

Using an ionisation gauge for the vessel to be exhausted, we have found that the pressure of mercury vapour in it with a potassium-lined trap between it and the pump is certainly less than 5×10^{-9} mm. We have made direct comparisons between the trapping power of a potassium-lined tube and that of the usual liquid air trap, the same ionisation gauge measuring the pressure reduction. We have found that the potassium-lined trap is quite as satisfactory as liquid air. The residual pressures obtained in various tests seem to depend entirely upon the vigour with which the ionisation gauge and connecting tubes were outgassed by heat treatment before the measurements were made, and not at all upon whether liquid air or metallic potassium is used to trap the mercury. We are convinced that the lowest pressure obtained, namely, 5×10^{-9} mm., is partly, and possibly nearly all, due to residual gases owing to insufficient heat treatment, and that this figure is merely an upper limit to the vapour pressure of mercury in a vacuum system beyond a potassium-lined trap.

The passage of several litres of moderately dry air at atmospheric pressure over the potassium has no serious effect on its power to trap mercury vapour, although one might well have feared such would be the case from the discoloration of the surface produced by the air.

From a practical point of view, it is of importance to know how long the alkali metals retain their power to act as a mercury vapour barrier. In one test, in which sodium was the active metal, the pressure in the ionisation gauge beyond the trap after twenty-five days was within 50 per cent. of its initial value (2×10^{-7} mm.). We do not know whether to attribute this slight pressure increase to loss of absorbing power by the metal, or to gradual evolution of gas.

In a second test, we used the first appearance of mercury lines in the spectrum of helium, at less than 0·01 mm. pressure, as a criterion of the diminution of the trapping power of a potassium-lined trap for mercury vapour. The mercury lines did not appear until the eleventh week, in which time the potassium had absorbed a little more than 150 per cent. of its own weight of mercury.

A full account of this work will be published in the *Philosophical Magazine*.

A. LL. HUGHES.
F. E. POINDEXTER.

Washington University,
Saint Louis, U.S.A.,
May 18.

The Oogenesis of Lumbricus.

IN a recently published number of the *Quarterly Journal of Microscopical Science*, Mr. Leslie Harvey, of the department of zoology of the Imperial College of Science, London, has given an account of the cytoplasmic inclusions of the egg of Lumbricus. Mr. Harvey describes yolk formation in this animal, and, on the basis of his work on this one form, criticises my previous investigations on Limnæa, and, by inference, that of my pupils on certain other forms. He merely quotes an old paper of mine, remarking a little discourteously that " a glance at this paper will show that really very little is known about the formation of yolk." He has not mentioned my recent work on Saccocirrus, the only other annelid studied by modern methods, nor has he read Dr. Rogers Brambell's more recent paper on " Yolk " in the *British Journal of Experimental Biology*, where the collected observations of several of my associates are discussed ably, the molluscan oogenesis re-investigated, and the general views on yolk-formation held in this laboratory stated.

Mr. Harvey's main criticism is that he cannot find any metamorphosis of Golgi bodies into yolk in Lumbricus, and that therefore my work on Limnæa and that of my pupils on Patella is under suspicion. Mr. Harvey puts himself in the position of a man who, on the strength of a study of the anatomy of Lumbricus, denies the results of another man who has found a radula and a shell in Patella. Before entering into a criticism of my work on Patella, which has been confirmed and extended by Dr. Ludford and Dr.

Rogers Brambell, he should have examined that form itself, or some other such mollusc.

Regarding the special question of the oogenesis of Lumbricus, it is remarkable to note that Mr. Harvey has hit upon one of those rather uncommon animals that have no proper vitellogenesis. The egg of Lumbricus has no real yolk, but the embryo is nourished in the cocoon by some albuminous substance. It is therefore doubly unfortunate that Mr. Harvey should discredit my work, and that of my associates, on the results obtained by the study of this special atypic annelid. Moreover, had Mr. Harvey read my results on Saccocirrus, he would have noted that I did not claim in that animal that yolk arose from the Golgi elements. Regarding the origin of yolk from Golgi elements, I may mention that Dr. P. Weiner, of the histology laboratory of the University of Leningrad, recently wrote to me that in Myriapoda and Arachnoidea "he had occasion to observe the starting of yolk granules in contact with particles of the Golgi apparatus," and in this connexion some Julus preparations which I have just seen support Dr. Weiner's interpretations. Mr. Vishwa Nath claims that in Lithobius, and Palamnæus, fatty yolk arises from the Golgi elements. In the Julus preparations of Mr. Vishwa Nath the Golgi elements of the egg are found to swell up in a specially definite manner, which is not seen in anything like the same degree in Lithobius, where both Miss King and Mr. Vishwa Nath agree that the heavier yolk is nucleolar in origin.

The complete details of the behaviour of the Golgi apparatus of the Lumbricus oogonium and oocyte, and a discussion on the cytoplasmic inclusions in the eggs of molluscs, annelids, and arthropods, will shortly be given in a joint paper by Mr. Vishwa Nath and myself. J. BRONTË GATENBY.

Trinity College, Dublin,
June 4.

Band Spectra of Lead Isotopes.

No satisfactory explanation seems to have been given as yet of the measurements made by Grebe and Konen (Grebe and Konen, *Phys. Zeits.*, 22, p. 546 (1921)) on the band spectra of lead isotopes. They observed that, in the case of uranium lead, the lines of the band at 4270 showed an average shift to the violet of 0·055 Å, as compared with those of ordinary lead, and that the lines were much sharper in the former case than in the latter.

A very satisfactory explanation is obtained if the carrier of the band is assumed to be, not the heavy Pb_2 molecule, but the lighter PbH molecule. The success of Kratzer (Kratzer, *Ann. d. Phys.*, 71, p. 70 (1923)) and of Mulliken (Mulliken, *Phys. Rev.*, 25, pp. 119, 509 (1925)) in accounting for the bands in the spectra of certain metals on the assumption of a hydride molecule seems to favour the same assumption in the case of lead.

Applying the theory first proposed by Loomis (Loomis, *Ast. phys. Jour.*, 52, p. 248 (1920)) to explain the complex structure of the band spectrum of hydrogen chloride, one obtains, for the wave-length difference between the bands of the hydrides of uranium lead (At. Wt. 206·0) and ordinary lead (At. Wt. 207·2),

$$\frac{d\lambda}{\lambda} = \frac{1}{2}\left(\frac{1}{206} - \frac{1}{207 \cdot 2}\right) = 1 \cdot 4 \times 10^{-5}.$$

Since $\lambda = 4270$ Å, the expected shift is 0·060 Å, a value in very good agreement with the observations. The lack of sharpness of the lines in the case of ordinary lead is of course connected with the fact that the atomic weight 207·2 is only a statistical average.

Further, the moment of inertia of the carrier agrees very well with what we should expect for the PbH molecule. The frequency of the lines in the band can be written

$$\nu = A + 2Bm + Cm^2 \quad . \quad . \quad . \quad (1)$$

where m is an integer and

$$B = \frac{h}{8\pi^2 J'}, \text{ and } C = \frac{h}{8\pi^2}\left(\frac{1}{J'} - \frac{1}{J}\right),$$

J and J' being the initial and final values of the moment of inertia of the molecule.

Now the approximate constancy of the frequency difference between successive lines, combined with the fact that m is always small for the strongest lines of a band, shows that the last term in (1) may be neglected, compared with the second. The mean frequency difference between successive lines is thus equal to $2B$. Since the mean wave-length difference is 1·25 Å, we easily obtain, on substituting numerical values,

$$J' = \frac{h}{4\pi^2 . 2B} = \frac{h}{4\pi^2 d\nu} = 8 \cdot 0 \times 10^{-40}.$$

For PbH this gives a distance between nuclei of $2 \cdot 2 \times 10^{-8}$ cm. in good agreement with what we should expect from crystal data. The radius of the Pb atom, according to the measurements of Owen and Preston (Owen and Preston, Proc. Phys. Soc. Lond., 35, p. 101 (1923)), is $1 \cdot 76 \times 10^{-8}$ cm. To obtain the same moment of inertia with a Pb_2 molecule we should have to assume an incredibly small distance between nuclei.

We may therefore conclude that the carrier of the lead band at 4270 Å is in all probability the PbH molecule. ETIENNE S. BIELER.

Macdonald Physics Building,
McGill University, Montreal, Canada,
May 15.

Petroleum in Uganda.

MY statement, which is quoted in part in NATURE for May 23, p. 815, in the columns of Research Items, under the title "Petroleum in Uganda," with reference to large quantities of oil in the Albertine depression is, I fear, on account of its separation from the context, the omission of seven words and the contributor's remarks upon it, likely to be misunderstood by those who have not read my report, and indeed may possibly deter some from reading the report at all.

I am well aware that the mere occurrence of seepages can never be any criterion of the existence of recoverable supplies; but in that part of the report from which the quotation is taken I am discussing oil formation, not oil accumulation, upon which successful exploitation depends. The results of our chloroform tests (referred to in the seven words missing from the quotation) are sufficient to establish the validity of my general statement as to quantity, quite apart from seepages: quantity is one thing, a recoverable supply is another.

Because more than one British dependency in Africa is at present trying to decide whether it will or will not have a geological survey, the contributor's supposition expressed in the last four lines of the item under consideration would appear unfortunate. Is it not wise to be hopeful, and to remember that some rift valley oil fields are already known?

E. J. WAYLAND.

MR. WAYLAND clearly shows in his excellent report that petroleum has formed in the Lake Albert depression, and I quoted from him to this effect. I consider, however, that neither seepage nor positive result of chloroform tests constitutes sufficient grounds on which to discuss " magnitude " of such formation, hence the omission in the quotation of six (not seven) words concerning these tests does not affect my comment. Regarding future prospects of petroleum development in Uganda, I agree with Mr. Wayland that it is wise to hope, since hope (unlike oil) springs eternal, but I still feel that the storehouses of petroleum of which he speaks may prove to be like the famous cupboard of the nursery rhyme, though this may be due to my conceptions of the laws governing distribution of oil within the earth's crust being somewhat different from those of Mr. Wayland. On the other hand, it is to be hoped that those responsible for initiating geological surveys in British dependencies are actuated by wider considerations than the possible chance of finding oil; there are other natural resources in the world besides petroleum, and this, quite apart from an obvious scientific motive, should be adequate economic reason for the governments concerned to follow the good example of Uganda.

THE WRITER OF THE NOTE.

Paramagnetism and the Electronic Configuration of the Atom.

IN a recent note[1] Foëx has directed attention to the fact that two samples of a paramagnetic salt, well defined chemically and placed in identical conditions, can possess very different magnetic properties, apparently corresponding to distinct states of the paramagnetic ion in the salt. This diversity of the magnetic states has been known for some time for the case of solutions of the salts.[2] Thus a concentrated solution of ferrous ammonium sulphate exists in four states: 26 magnetons with a positive molecular field, 26·5 without an appreciable molecular field, 27 and 27·5 with a negative molecular field.

It now appears that the same salt can exist in two distinct magnetic states also for the solid substance, one with 26 magnetons and a positive molecular field,[3] and another with 27·5 magnetons and a scarcely appreciable negative molecular field.[4] Similarly, anhydrous cobalt sulphate can exist in two magnetic states. Thus the measurements of Théodoridés,[5] Ishiwara,[6] and Jackson,[7] all indicate one state with 25 magnetons, while Honda and Ishiwara[8] found a variety with 24 magnetons and a very small positive molecular field.

The differences can scarcely be attributed to experimental errors or to impurities present in the salts. It seems highly probable that these salts can actually exist in two forms which are identical so far as chemical composition is concerned but are different magnetically.

Russell[9] has recently suggested that the active and passive states of iron, nickel, and cobalt may correspond to different structures of the atom. Thus he supposes that, while active iron possesses an electronic configuration of 2, 8, 14, 2 in the 1st, 2nd, 3rd, and 4th quantum orbits respectively, passive iron may correspond to either of the arrangements 2, 8, 13, 3, or 2, 8, 15, 1. Similarly, active nickel may correspond to the configuration 2, 8, 16, 2, and passive nickel to 2, 8, 17, 1.

It is here suggested tentatively that the different magnetic states of the ions of iron (Fe″) and cobalt (Co″) may also correspond to different internal configurations of the electrons. Thus the ordinary ferrous ion would possess the configuration 2, 8, 14, 0, and the other magnetic state might be produced by the transference of one of the fourteen electrons in the incomplete 3rd quantum orbit to the 4th quantum orbit, or by a redistribution of the 3rd quantum orbit electrons among the various levels, 3_1, 3_2, and 3_3, of this orbit.

If this were the case, it would be expected that the solid salt or solutions of the salt would possess different absorption spectra when existing in the different magnetic states. This point could readily be tested, and the results would serve to confirm or refute the suggestion.

L. C. JACKSON.

The Davy-Faraday Laboratory,
The Royal Institution,
London, W.1, May 23.

[1] *Comptes rendus*, 1925, 180, 919.
[2] *Ann. de Phys.*, 1921, 16, 174.
[3] *Ibid.*
[4] Measurements of Kamerlingh Onnes and Oosterhuis and of Jackson. See Jackson, Phil. Trans., 1923, 224, 1.
[5] *J. de Phys.*, 1922, 3, 1.
[6] Sc. Rep. Tohoku, 1914, 3, 303.
[7] *Loc. cit.*
[8] Sc. Rep. Tohoku, 1915, 4, 215.
[9] NATURE, 1925, 115, 455.

A Luminous Spider.

ONE day in Central Burma the trail in the jungle was exceptionally difficult. It was long past noon when I realised that the return journey would be equally long and tiring. Camp lay on the other side of a long range of hills, and there was a short cut from the main trail that would save several miles, but this trail was faint. I reached the supposed cut-off about dusk and followed it upward. Darkness came on swiftly, and my pony began to stumble. Somewhere we had missed the trail, for at intervals I could still glimpse the crest of the hills, and I knew my general direction.

Fireflies sparkled here and there. Presently a few feet away I saw a ball of light as large as one's thumb. It was stationary. Tying the horse, I approached it as carefully as possible, finding it surrounded by thorny bushes. It did not move, and I pressed the brush aside until I was directly over it, and then struck a match. There, in full view, was a spider, its large oval abdomen greyish, with darker markings. Still it did not move, and as the match died out its abdomen again glowed to full power, a completely oval light, similar in quality to that of the fireflies. Remembering native tales of poisonous insects, I wrapped a handkerchief around one hand, parted the brush with the other, and when close enough made a quick grab. Alas! the handkerchief caught on a stick before I could encircle the spider, and my treasure scurried away. I followed as quickly as possible, but the light soon disappeared under stones, brush, or in some burrow, for I never saw it again.

Many nights I searched in the jungle and questioned natives and white officers who had passed through that district, but apparently no one else had reported a luminous spider, nor can I find record of any known elsewhere.

Burmese never leave their houses after dark on account of their fear of spirits, so it is not surprising that the natives had never seen one, but some other traveller may be so fortunate as to capture one of these spiders.

The place where I saw the specimen was between the villages of Kyawdaw and Thitkydaing, Pakkoku District, about one hundred and twenty miles west of Mandalay, Burma, in April 1923.

BARNUM BROWN,
Associate Curator.

Department of Vertebrate Palæontology,
American Museum of Natural History,
New York City, May 29.

The Relations between Sunspots, Terrestrial Magnetism, and Atmospheric Electricity.

By Dr. C. CHREE, F.R.S.

THE existence of a relation between sunspot frequency, or area, and the phenomena of terrestrial magnetism and atmospheric electricity is a question on which a reasoned statement of opinion may be opportune.

Two elements may be connected and yet not stand in a linear relationship. When nothing is known, there are advantages in a graphical method, such as that employed by W. Ellis[1] when comparing diurnal magnetic ranges at Greenwich with Wolf's sunspot frequencies. But when there is reason to anticipate a linear relationship, it is better to use Wolf's formula

$$R = a + bS,$$

where S denotes sunspot frequency, and R is a quantity such as the diurnal range of a magnetic element. a and b are constants which can be determined by least squares. Obviously a is the value of R when $S=0$. As the average range of S between sunspot maximum and minimum approaches 100, $100b/a$ is a convenient measure of the importance of sunspot influence. In the case of magnetic daily ranges $100b/a$ usually exceeds 0·5, and not infrequently 1·0. If $100b/a$ is a small fraction, the sunspot influence, even if real, is unimportant. The closeness with which Wolf's formula fits the observations is measured by the correlation coefficient r. As b shows the sign of the correlation, whether positive (*i.e.* element increasing with S) or negative, we shall treat r as a numerical quantity. It cannot exceed 1, which represents a perfect fit. A low value such as 0·3 implies that the sunspot relation is very doubtful.

In the case of terrestrial magnetism, a linear sunspot relation seems fairly established for the range of the regular diurnal variation, whether of declination (D), horizontal force (H), or vertical force (V). Further claims have been made. Thus Leyst[2] believed the secular change of D to be considerably faster at sunspot maximum than at sunspot minimum, but further investigation has not confirmed this. Declination may be east or west, and numerically increasing or diminishing; thus acceleration of the secular change signifies different things at different places. *A priori* the force components H and V seem more likely to possess an 11-year period. Unfortunately, with ordinary instruments, H and V determinations are less reliable than those of D, and it is doubtful whether the annual values available have the accuracy necessary for determining the reality of a sunspot influence, which is certainly not large.

Diurnal range may signify the range of a diurnal inequality based on hourly values, or the difference between the extreme instantaneous values of the day, usually called the absolute range. In most if not all of the earlier work by Wolf, Ellis, and others, range meant the diurnal inequality range, or some analogous quantity. Older data were mostly from eye readings taken at two fixed hours, at Milan, for example, at 8 A.M. and 2 P.M. If the observation hours are the hours of maximum and minimum in the mean diurnal inequality for the year, they will give in the case of the whole year the same range that hourly readings give. If the hours of maximum and minimum vary in different months, the range derived from hourly readings may in some months sensibly exceed that from readings at two fixed hours. But these are minor differences, and the older observations may be regarded as establishing the validity of Wolf's formula for the mean diurnal inequality of the year. In general, D was the element considered, but Ellis also included H. It is not claimed that Wolf's formula with invariable values of a and b agrees closely with observation in every year of, say, 50 years. But, so far as is known, whenever Wolf's formula has been applied to any 11 years, b has proved to be plus, and $100b/a$ has been substantial. This has been true whether the diurnal inequality has been derived from quiet days or from ordinary days. At Kew the value obtained for $100b/a$ from the quiet days of 1890 to 1900 was 0·71 for D, and 1·07 for H. Ordinary days gave very similar results. Fairly similar results have been obtained at many stations, the value of b/a being usually decidedly higher for H than for D. The fit of Wolf's formula is generally good, and sometimes extremely close. For the period 1911 to 1921, in the case of the mean diurnal inequality at Kew, r was 0·96 for D, and 0·95 for H.

Instead of the range of the mean diurnal inequality for the year, we may take the arithmetic mean of the ranges of the diurnal inequalities for the 12 months. The two quantities usually differ, but similar results are obtained.

Instead of considering the whole year, we may apply Wolf's formula to different seasons, or even individual months of the year. The fit for an individual month, *e.g.* the Januaries of an 11-year period, may be indifferent, but it is usually good for a 4-month season, *e.g.* May to August (summer), or November to February (winter). We may calculate a and b from the range of seasonal diurnal inequalities, or we may accept as the seasonal values of a and b the arithmetic means of the a's and b's calculated for the included months separately. The most outstanding result is that, at least in higher latitudes, b/a is considerably larger for winter than for summer. Thus at Pavlovsk, 1890 to 1900, the value of $100b/a$ for H from all days was 1·77 in winter, as against 0·98 in summer.

The absolute daily range is larger than the inequality range, and is more affected by disturbance. It, too, shows the sunspot influence clearly, but with a less close fit of Wolf's formula. An interesting example[3] is afforded by the years 1892, 1893, and 1894, with sunspot frequencies of 73·0, 84·9, and 78·0 respectively. The ranges of the mean diurnal inequalities in D at Kew for ordinary days were 9'·85, 10'·7, and 9'·8; while the mean absolute ranges from all days were 17'·7, 15'·6, and 16'·5. Thus 1893, the year of sunspot maximum, had the largest inequality range, but its mean absolute range was distinctly inferior to those of the adjacent years. The result appeared in H as well

[1] Phil. Trans., 171, p. 541.
[2] *Bull. de la Société Impér. des Naturalistes de Moscou*, 1909, p. 160.
[3] Phil. Trans., A 208, pp. 215 and 226; A 216, p. 261; and Chree, "Studies in Terrestrial Magnetism," pp. 177, 178.

as D, and the order of the inequality ranges was the same for quiet as for ordinary days.

The difference between sunspot maximum and minimum years is partly a matter of disturbance, but both classes of years contain days practically free from disturbance, and the quiet days from sunspot maximum years tend to have larger ranges than the quiet days from sunspot minimum years. The relation between sunspots and magnetic disturbance is much less definite than that between sunspots and the regular diurnal inequality. In a general way, disturbance is least at sunspot minimum. In the 11 years 1890 to 1900 at Kew there were 29 (Greenwich) days with H absolute ranges not less than 250γ, but none of these occurred in the three years nearest to a sunspot minimum. On the other hand, some years of many sunspots are also quiet. For example, 1893, a year of sunspot maximum, had no H range so large as 250γ, while 1892 and 1894 between them had 24 such ranges. Again, some of the very largest magnetic storms have occurred in years of comparatively few sunspots. Thus 1921, with a sunspot frequency little more than half that of the average year, had a succession of highly disturbed days during May, to which the previous 60 years afforded only one parallel.

The existence of a specific relation between individual sunspots and individual magnetic storms is a vexed question, on which a general agreement cannot be claimed. The magnetic character of an individual day certainly cannot be inferred from the sunspot area or frequency for the day. The 660 selected quiet days of the 11 years 1890 to 1900 had 41·15 as their mean provisional sunspot frequency, as compared with a mean of 41·03 from all days of the year. When the 5 days of highest sunspot area from each month of these 11 years were considered, the corresponding mean daily H range at Kew exceeded the average from all days by only 3 per cent. Most magnetic storms last only one or two days, few so much as four days; but a large sunspot is seldom so short-lived as this. The natural inference is that if the sunspot is the immediate cause of the magnetic storm, its effectiveness must be largely restricted to one particular stage of its development, or else to a very limited range of position relative to the earth. The investigation above referred to suggested an enhanced diurnal range in H for some days subsequent to the attainment of a maximum sunspot area on the sun, the largest range appearing 4 days subsequent to the maximum area.

The phenomenon most suggestive of an influence associated with specific small solar areas is the 27-day interval in the sequence of magnetic storms. The interval seems well established, and its most natural explanation, as suggested by Mr. Walter Maunder, is the existence for a number of solar revolutions of a comparatively narrow cone of radiation which sets up a magnetic storm whenever it crosses the earth. A difficulty is that the 27-day interval seems as well established for quiet as for disturbed conditions. A curious phenomenon, some cases of which were recently discussed by Father Cortie,[4] is that after a number of recurrences of disturbed conditions at 27-day intervals, quiet conditions intervened, to be succeeded by further sequences of disturbed conditions. On the other hand, when we proceed by 27-day steps from a selected quiet day, we sometimes hit on a highly disturbed day. These phenomena suggest the possibility that a limited solar area may emit a radiation, which at one stage enhances and at another stage diminishes the ionisation of the upper atmosphere. If the radiation consisted at one stage of free ions, and at another stage of ejected matter which loaded up the ions naturally present in the upper atmosphere, the 27-day interval in quiet conditions would be intelligible. This suggestion was made originally in a frivolous spirit, but it may be more worthy of consideration than was originally supposed.

The possibility of a sunspot influence in atmospheric electricity seems to have occurred independently to several people, including the present writer.[5] It has recently been the subject of two papers by Dr. L. A. Bauer.[6] In the first of these, which dealt with the potential gradients recorded at the Ebro Observatory, Tortosa, he concluded that mean yearly values of potential gradient (P) and its diurnal range both increased with sunspot frequency. As a check, the writer[7] applied Wolf's formula to five sets of Kew potential gradient data, from two periods 1898 to 1909, and 1910 (or 1911) to 1920 (or 1921). The results were so far favourable to Dr. Bauer's conclusions in that a positive value of b resulted in four cases. But the fifth case gave a negative value, and the values of $100b/a$ were all small, the four positive values averaging only +0·17, and the corresponding values of r averaging 0·49.

In his second paper (*l.c.* p. 186) Dr. Bauer expresses somewhat modified views, including

(*a*) "The probability is high that . . . potential gradient and its diurnal and annual ranges . . . are subject to sunspot influence."

(*c*) "During 5 of the past 7 sunspot cycles the potential gradient and ranges . . . generally increased with increasing sun-spottedness. For the remaining 2 sunspot cycles, the potential gradient and ranges . . . apparently decreased with increasing sunspot activity."

The epochs in which the relation is supposed to have been negative seem to be 1845–1855 (station Brussels) and 1886–1897 (stations Perpignan, Lyons, and Greenwich).

Some knowledge of the observational uncertainties is a desirable prelude to a consideration of the results. Suppose we take a water-dropper, the most efficient type of "collector." When the electrograph is working, the tube discharging the jet is connected to the needle of a quadrant electrometer. One pair of quadrants is maintained at a constant potential $+v$, and the other pair at $-v$, the sensitiveness varying with v. Suppose we break the connexion to the jet, and connect the needle to a variable source of potential. Raising the potential step by step, put marks on the paper on the recording drum answering to the voltages 100, 200, etc. Now remove the source of potential, and connect the needle to the discharge tube. For simplicity, suppose the air surrounding the jet to remain for some time at +100 volts. On turning the jet on, the electrometer reading gradually rises, reaching a stationary

[4] Proc. Roy. Soc., vol. 106, p. 19.

[5] Phil. Trans., A, vol. 206, p. 303.
[6] *Terrestrial Magnetism*, vol. 27, p. 1; vol. 29, pp. 23 and 161.
[7] Proc. Physical Society, vol. 35, p. 129.

position in, say, 30 seconds. But the reading answering to the stationary position will be sensibly less than 100 volts, unless the insulation of the water tank and discharge tube is really good, and the deficiency is greater the poorer the insulation and the less efficient the collector.

Again, the potential at the site of the collector is usually a good deal lower than it would be at the same height above level ground remote from buildings. Thus, however good the insulation, the readings require multiplication by a factor to give true potential gradients, and unless the position of the collector and its environment (and the insulation of the water-dropper) are invariable, the factor varies with time.

The necessity for a reduction factor was generally unrecognised until comparatively recently, while changes calling for alteration in the factor are practically certain to have occurred in the older installations. Insulation is very hard to maintain good, especially with the older types of insulators. It generally suffers from damp weather, and some years are much damper than others. The outcome is that unless a reduction factor is regularly determined and applied, the absolute potential gradient and its diurnal and annual ranges, as deduced from the curves, may fluctuate as insulation is better or worse. They will also naturally alter with the growth of trees or shrubs, or modification of buildings near the collector.

Kew has probably a longer record from a fairly modern electrograph than any other observatory, and Dr. Bauer has suggested the utilisation of the earlier records. The curves prior to 1898 were unfortunately not tabulated, with the exception of one or two years, and the heavy labour required to do so now has not appeared justifiable in the absence of determinations of a reduction factor before that date.

To gauge the probability of Dr. Bauer's conclusions, his notation and methods must be understood. He employs two formulæ:

$$P-P_m=s'(S-S_m) \quad . \quad . \quad . \quad . \quad (A);$$

and

$$P-P_m=s(S-S_m)+t(T-T_m) \quad . \quad . \quad (B).$$

Here S represents Wolf's sunspot frequency, P the absolute value or the range of potential gradient, T the year, and the suffix m denotes the mean for the period considered. s', s, and t are constants determined by least squares. (A) is simply a variant of Wolf's formula, with s' written for b. (B) differs through the addition of a term varying linearly with the time. The correlation coefficient is called r'_s in the case of (A) and r_s in the case of (B). Dr. Bauer attaches most weight to (B), but gives no adequate justification for its use. The question is important because r_s is usually larger than r'_s, so if (B) is admissible the case for a sunspot influence appears stronger than it otherwise would. Cases are conceivable in which (B) would be justified, *e.g.* if besides an 11-year period there were a much longer period, say 100 years, or if some gradual change had been in progress in the apparatus or its environment, which might reasonably be supposed a linear function of the time. But some positive justification seems called for in each specific case. The fact that the t-term usually improves the agreement with observation is no sufficient argument in its favour, because, with two constants at our disposal instead of one, that is only to be expected. When t is small, s and s' differ but little, but when it is large, they usually differ considerably in size and sometimes even in sign. Large values of t appear more especially in the older series of observations used by Dr. Bauer, especially those for St. Louis, Perpignan, Brussels, and Greenwich. But they also occur in the case of some of the more recent data, including some from Kew. In 4 out of 7 cases at this station in Dr. Bauer's Table 5, p. 169, *l.c.*, s is positive, while s' is negative. In fact, the adoption of the two-term formula converts a vote against to a vote for a positive correlation.

One most important modern station, the uncorrected data from which might have called for a t-term, is dismissed by Dr. Bauer in the following words (*l.c.* p. 24): "Unfortunately as regards the Potsdam observations, various changes . . . especially during the period 1914–19 when no control observations . . . could be made, have introduced discontinuities . . . so as to make unsafe the utilization of the observations." This view has recently been controverted by Dr. Kahler, of Potsdam,[8] who claims that the mean annual values of potential gradient now published are satisfactory. Dr. Kahler adds that they do not support a sunspot influence, but he gives no figures. As the Potsdam series is longer than most, and the station has a high reputation for staff and equipment, it has seemed desirable to apply a Wolf's formula to the mean yearly values given by Dr. Kahler, treating them on parallel lines with data from Kew and Eskdalemuir. The results from the three stations are as follows, the unit for a and b being 1 volt per metre:

Quantity.	Period.	Station.	a.	b.	100 b/a	r.
Mean annual value	1904–23	Kew	309	+0·303	+0·098	0·37
,, ,, ,,	,,	Potsdam	211	−0·216	−0·102	0·34
,, ,, ,,	1911–21	Kew	312	+0·444	+0·142	0·56
,, ,, ,,	,,	Potsdam	205	−0·143	−0·069	0·46
,, ,, ,,	,,	Eskdalemuir	236	+0·440	+0·186	0·83
Range mean annual	1911–21	Kew	152	−0·114	−0·075	0·23
Diurnal inequality	1912–21	Eskdalemuir	110	+0·115	+0·105	0·25

The year 1911 was omitted in the final case at Eskdalemuir owing to some special uncertainties.

One of the outstanding things was the opposition between the Kew and Potsdam data from 1911 to 1921. At Kew the departures of S and P from their mean values agreed in sign in 9 of the 11 years, while at Potsdam they differed in 10.

Referring to Dr. Bauer's own tables of results, there seem to be only three of his stations—Tortosa and Eskdalemuir with at most 14 years' observations, and Kremsmunster with only 8—which supply in all the cases considered positive values for s and s', and several of these values are quite small.

The data from Kew and Potsdam are suggestive either of no direct sunspot influence, or of a comparatively trifling influence liable to be masked by weather effects. Less conflicting results may be obtainable from regions having a less variable climate, but lower latitudes have been as yet very poorly represented.

A sunspot influence acting in different directions at

[8] *Ergeb. der met. Beob. in Potsdam in den Jahren* 1921, 1922, *und* 1923, p. viii.

different places at the same time, and affecting the results at one station in opposite directions at different epochs, is something quite unlike the sunspot influence recognised in the diurnal variation of terrestrial magnetism. Its acceptance does not seem justified without much more observational support than it has yet received.

Some remarks in § 47 of Dr. Bauer's second paper (*l.c.* p. 184), if they stood alone, or even if they followed the conclusions on p. 186, might be interpreted as not inconsistent with the conclusions reached here. If, however, he really regards the existence of a sunspot influence in atmospheric electricity as quite an open question, a more explicit statement is desirable, as several recent references to his work assume a relation to have been established.

Note added June 3.—Since the above was in print, a further paper by Dr. Bauer has appeared in the March number of *Terrestrial Magnetism*, in which he dissents from Dr. Kahler's conclusions.

An International Campaign against Sleeping Sickness.

AMONG the limited number of post-War changes that it is possible to regard with satisfaction, not the least is an enhanced sense on the part of representatives of European nations of their responsibilities towards what are known as native races. Conspicuous manifestations of this new spirit have been shown by the British Government, and recent action on the part of the League of Nations is evidence of similar breadth of view. In 1922 the Provisional Health Committee of the League appointed a Committee of Experts, under the chairmanship of Dr. Andrew Balfour, for the purpose of collecting information as regards sleeping sickness and tuberculosis in equatorial Africa, and making certain recommendations with reference to these diseases. The members of the Experts Committee, in addition to the chairman, are Dr. E. van Campenhout, Director of the Public Health Service at the Belgian Ministry of the Colonies; Prof. Gustave Martin, formerly head of the French Sleeping Sickness Mission in French Equatorial Africa; and Dr. A. G. Bagshawe, Director of the Tropical Diseases Bureau, London. This Committee, which met for the first time in November 1922, submitted to the Health Committee of the League two most valuable Reports; and the outcome of the recommendations included in the second of these was an International Conference on Sleeping Sickness, which assembled last month in London, and was presided over by Mr. W. Ormsby-Gore, Under-Secretary of State for the Colonies. All of the countries interested in tropical Africa, namely, Belgium, France, Great Britain, Italy, Portugal, and Spain, were represented at the Conference by well-known authorities on tropical disease.

As most people are already aware, thanks to the prominence given to the matter by the daily press, among the recommendations that the delegates to the Conference have unanimously decided to make to the Council of the League of Nations, and to their respective Governments, is the formation of a small international commission for the investigation of sleeping sickness problems in Africa itself. It is suggested that this Commission shall consist of a few specialists in tropical disease furnished by the Powers interested in Africa, with the addition of a biochemist and an entomologist with local knowledge; and that it shall also include the well-known authority Dr. K. Kleine, the value of whose recent researches in Northern Rhodesia and elsewhere on the therapeutic effect of "Bayer 205" is widely recognised.

Since Uganda and the regions adjacent to Lake Victoria furnish the most suitable field for the study of the problems selected, it is proposed to make Entebbe the headquarters of the Commission, and to place the latter under the presidentship and control of Dr. H. Lyndhurst Duke. The necessary expenditure, to which the respective Governments, the Health Organisation of the League of Nations, and scientific research institutions of certain countries, are to be invited to contribute, is estimated at some 10,000*l*. It is suggested that the Commission shall assemble at Entebbe at the end of next December, or in January 1926, and that it shall work for twelve months, after which it will submit a special report to the League of Nations Experts Committee. Guided by Dr. Duke, the Commission will apply itself in the first instance to a study of "the research methods and laboratory technique at the Entebbe Institute and its field laboratories, as well as the field work and measures taken against sleeping sickness in the Protectorate of Uganda and the infected districts of Tanganyika."

After inspecting the methods and highly promising results of Mr. C. F. M. Swynnerton's experiment in the control of *nagana*-carrying tsetse-flies at Shinyanga, Tanganyika Territory, the Commission will settle down to "joint laboratory investigations as to the methods of work which are most suited for research into the several problems referred to it" by the Conference. It is understood that these problems include, among others: the question of the existence, nature, and determining factors of any human immunity to trypanosomiasis; the comparative value from various aspects of trypanocidal agents; the function of wild and domestic animals as breeding grounds for the virus; and the possibility of *Trypanosoma gambiense*, the causal agent in trypanosomiasis as conveyed by *Glossina palpalis*, assuming the form known as *Trypanosoma rhodesiense*, and so becoming capable of dissemination by *Glossina morsitans*.

In addition to its proposals for the Commission, the International Conference has also advised the adoption of a number of highly important administrative measures, including arrangements for periodic official conferences, and frequent interchange of information between administrative and medical officers on both sides of boundaries between infected countries; the devising of means for giving legal effect to recommendations of the medical service engaged in the campaign against sleeping sickness; and methods for the control and reduction of trans-frontier native traffic in infected areas.

It must not be thought that, at the present time, before the proposed International Commission is yet in being, little or nothing is being done by the governments and medical services concerned to combat sleeping sickness. Sleeping sickness and *nagana*, the kindred disease of domestic stock, are scourges which in greater or less degree, according to the physical and other conditions of localities, affect or threaten all countries and peoples in tropical Africa wherever the insect carriers of trypanosomes, the various species of Glossina or tsetse-flies, exist: that is to say, within roughly parallel lines drawn from the Senegal River to Somaliland, and from the southern boundary of Angola to Zululand in the south-east. In Africa to-day the tsetse-fly problem, with its contingent maladies, is more important than any other, and, in addition to its direct effect upon human life, is more than anything else retarding progress and development. Thus all European nations with a stake in the African continent, all those represented at the recent Conference, are vitally affected, and all are keenly alive to their danger.

Fortunately, with regard to sleeping sickness in general, there is no need to sound an alarmist note. Although in the Mongalla and Bahr-el-Ghazal Provinces of the Anglo-Egyptian Sudan, into which the disease has recently been introduced from French Congo, Belgian Congo and Uganda, the position is one of some anxiety; and though elsewhere, as in parts of Cameroons, French Equatorial Africa and Belgian Congo, there are foci of varying intensity, in no country nowadays is there anything comparable to the great epidemic of sleeping sickness that started on the northern shore of Lake Victoria in 1901. In the course of this outbreak the population of the districts affected, originally about 300,000, was reduced by two-thirds in six years. The energetic methods taken to combat the disease, including wholesale removals of natives, closing of areas, and clearing of lake and river margins, are too well known to need recapitulation. Their success is shown by the results detailed by Dr. G. D. Hale Carpenter, Senior Medical Officer in charge of Sleeping Sickness, Uganda, in his Report for 1920–21. In the course of a tour of inspection covering some 1750 miles, Dr. Carpenter examined no fewer than 54,600 natives, among whom he found only 264 cases of sleeping sickness.

Since the Uganda outbreak, the campaign has been waged energetically, often with a large measure of local success, not in British dependencies alone, but also in those of almost all other countries as well. It is impossible to read the Reports of the Committee of Experts, to which reference has already been made, without being filled with admiration for the work carried out by the medical services and administrations concerned. In the matter of sleeping sickness, as it affects the native populations of Africa, "the white man's burden" has been shouldered with goodwill. In French Equatorial Africa the labours of the medical services, often sadly handicapped by insufficiency of personnel and equipment, and in the face of difficulties which only those familiar with the conditions of tropical African travel can fully appreciate, have been directed especially towards the systematic *atoxylisation* of the sick. This line of policy not only effects a proportion of cures in the early stage of the disease, but also—what is even more important—by removing the trypanosomes from the peripheral blood, prevents persons already infected from endangering their neighbours by way of the local tsetse. By means of this system excellent results have already been obtained, and in some instances great epidemic foci appear to have been stamped out; the method has already been introduced into Uganda by Dr. Carpenter. In the case of African natives, however, it is often difficult to ensure that no sick person contrives to escape examination by a medical officer on tour; and in this connexion it may be noted that the appointment, in threatened districts, of special administrative officers to deal only with sleeping sickness affairs, as is already the practice in the Lake Victoria area of Uganda, was urged emphatically by Dr. Carpenter in 1923.

Without entering further into the technicalities of the campaign against sleeping sickness as at present conducted, or dwelling upon well-known methods for the local abolition of *Glossina palpalis*—the most formidable but by no means the only tsetse-fly carrier of the disease—it is hoped that enough has been said to indicate some at least of the conditions as they now exist, before the appointment of the International Commission. At the recent meeting of the second Imperial Entomological Conference, at which the tsetse-fly problem was discussed, Dr. Andrew Balfour referred in optimistic terms to the beneficial results likely to accrue from "the association for a considerable time of two such brains as those of Dr. Kleine and Dr. Lyndhurst Duke." On the same occasion it was pointed out by Mr. Ormsby-Gore that the Commission is bound to have great educative value, not only on public opinion in Europe, but also on local administrations in Africa. We heartily wish it success.

E. E. A.

Current Topics and Events.

IN February 1825, Faraday was appointed director of the laboratory of the Royal Institution, and his first act after appointment was to invite the members to evening meetings in the laboratory. These evening meetings developed into the Faraday evening discourses which have remained a feature of the Institution unto this day. It was accordingly very appropriate that the celebration of the centenary of the discovery of benzene by Faraday should be inaugurated on June 12 by the Friday evening discourse on "Faraday as a Chemist" by Sir William Pope. Elsewhere in this issue we print Sir William Pope's discourse together with papers read on the occasion of the centenary celebrations on June 16. Sir William Pope first referred to Faraday's youth and early scientific training and then passed on to a brief discussion of his chemical investigations. Faraday analysed caustic lime from Tuscany, repeated and extended E. D. Clarke's work on the oxy-hydrogen blowpipe, and he burnt diamonds. He discovered the substances now known as hexachloroethane, tetrachloro-ethylene, and hexachlorobenzene before he isolated benzene in 1825. Steel alloys and optical glass were studied for several years and a large number of gases were liquefied for the first time. He determined the composition of naphthalene and investigated the action of chlorine on benzene in sunlight, in this way discovering *p*-dichlorobenzene.

Gold films, solutions of colloidal gold and electrochemical researches nearly complete the list of his chemical investigations. Sir William Pope laid stress on the significance of the discovery of benzene in view of later important technical and scientific developments, and he referred to the marvellous suggestiveness of much of Faraday's work. He also described Faraday's pre-eminence as an experimenter, his greatness as a scientific theorist, his versatility, and his innate but undeveloped mathematical ability. The fruit of Faraday's labour has not yet all been gathered; a hundred years hence the Friday evening lecturer will have an even more wonderful tale to tell of discoveries inspired by the work and thought of Michael Faraday.

A SMALL but interesting exhibition has been arranged and is now on view at the Science Museum, South Kensington, commemorating the centenary of the discovery of benzene by Faraday. Amongst the exhibits shown at the Science Museum are two original specimens of benzene, prepared and labelled by Faraday, which were bequeathed to the Museum in 1911 by Mr. H. L. Barnard—it will be remembered that Faraday married Sarah Barnard—and an autographed photograph of himself which was bequeathed to the Museum by Miss Jane Barnard. The original cabinet in which Faraday stored the specimens of benzene and which contains many other specimens of his chemical discoveries, including the polished weldings of steel and platinum and the alloys produced with Mr. Stodart in 1821 in the search for a non-rusting steel, is also on view. Other interesting exhibits show the importance of benzene to the synthetic dye industry and illustrate the distillation of coal-tar, from which benzene is obtained on a commercial scale. A series of models of the principal space formulæ proposed for benzene, showing the relative space arrangements of the atoms within the molecule, is not only instructive but emphasises the importance with which benzene has been regarded since the time of its discovery.

THE trial in the United States of Mr. Scopes, for teaching evolution in a State-supported Tennessee school, promises to become a *cause célèbre*. It is attracting widespread attention, and a bewildering array of legal authorities has been enlisted on both sides. The defence is being financed by the American Civil Liberties Union, which has secured the help of many distinguished barristers, including Mr. Bainbridge Colby, a former Secretary of State in Wilson's cabinet. He will be supported by numerous advisers representing the Modernists, the champions of free speech, and scientific experts. Mr. W. J. Bryan will take part as one of the counsel for the prosecution. The Tennessee Text Book Commission has introduced a new text book of biology for use in the State schools, which states, in reference to animals resembling man, that " none of them are to be thought of as a source or origin of the human species." Take no thought of the past as well as of the morrow seems to be the desire of the Fundamentalists as to the history of man.

THE leading article in NATURE of June 6 on " An Imperial Research Committee " contained reference to the possible effect of the salt-tax in India on the efficiency of the native population, the suggestion being that the taxation of this vital commodity had the effect of reducing its consumption. Dr. F. Maitland Gibson, lately director of the King Institute of Preventive Medicine in Madras, in a letter to the editor dated June 13, takes exception to this statement. During his twenty years' residence in India the salt-tax was never higher than one halfpenny per pound. The daily physiological requirement of salt per head of the population addicted to a vegetarian diet has been estimated at 30 grains. On that basis, the effect of the tax on the consumption of salt should be negligible. Even if the consumption of salt far exceeded physiological requirements the effect of the tax would scarcely be felt even by the poverty-stricken Indian, and should be a smaller factor in reducing consumption than the manipulation of prices by salt dealers. Dr. Gibson would probably agree, however, that political and psychological factors must also be taken into account in connexion with this tax. For political reasons—for example, non-co-operation—the Indian might refuse to buy any salt, while the fact that a certain commodity is taxed, to whatever amount, might also lead to greatly reduced consumption by peoples living continuously on the poverty-line. But whatever the effect of this particular tax, it can be argued that it is wrong in principle to tax vital commodities before other and more equitable means of raising revenue have been exhausted.

AN appeal has been issued from Government House, Nairobi, for subscriptions to the Coryndon Memorial Fund, with which it is proposed to improve and to extend the existing natural history museum in the Kenya capital. This is an object which should not only make its appeal to scientific workers on its intrinsic merits, but also because the late Sir Robert Coryndon was probably unique among British colonial governors in his appreciative understanding of the importance of scientific research and the educative value of carefully selected and properly cared for exhibits of naturalists. In spite of the pressing problems involved in the administration of the most difficult colony in British possession, he found time, in the year preceding his tragically sudden death, to make a comprehensive survey of the Victoria Nyanza territories and to furnish a stimulating and invaluable report to the Secretary of State for the Colonies, in which he stressed the importance of a unified research service for the Lake area. A few years before, while Governor of Uganda, he gave an impetus to medical and veterinary research, and to him can be attributed the growth of the scientific spirit in that Protectorate. Reference has been made already in NATURE to the appeal he made on November 20 last year to his fellow-countrymen for support for the Amani Institute. This formed part of a general plea for more generous encouragement of scientific research. The fact that on that occasion he specifically commended the enlargement and proper equipment of the Nairobi Natural History Museum to the attention of his audience as a worthy object for support lends emphasis to the appropriateness of the projected tribute to his memory. His life was devoted to the service of the British Empire, and he had the highest conception of the function which science fulfils in its development.

IN connexion with our note of last week on Dr. J. W. L. Glaisher's jubilee of fellowship of the Royal Society, it is of interest to recall a long-forgotten episode as to the assistance he gave fifty years ago towards the publication of Peter Gray's "Tables for the Formation of Logarithms and Anti-Logarithms to Twenty-four or any less Number of Places," an 8vo work issued in 1876. Gray states that he allowed some manuscripts of his to lie by for a number of years owing to printing difficulties. At length an abridgment of his papers was made and communicated to the *Assurance Magazine*. These papers were afterwards collected and published in 1865. This tract, after some years, came under the notice of Mr. T. Warner, F.R.A.S., of Brighton, who opened a correspondence with Gray, and finally offered a most handsome contribution towards the expenses of printing the whole set of tables. Having (he says) mentioned the circumstance to two gentlemen interested in such matters, they each offered quite spontaneously a liberal contribution in supplement of Warner's gift. The two who gave this gratifying proof of interest were Dr. J. W. L. Glaisher, F.R.S., and Mr. H. D. Hoskold, a mining and civil engineer of Dean Forest, Gloucestershire. Dr. Glaisher made a number of valuable suggestions in the course of printing.

LAWRENCE ROOKE, astronomer and mathematician, who died on June 27, 1662, was an active member of the group who were concerned in the promotion of experimental philosophy. He was chosen to succeed Samuel Foster in the professorship of astronomy at Gresham College in 1652, and in 1657, upon Dr. Whistler's resignation of the chair of geometry at the College, was permitted to exchange that of astronomy for it. Educated at Eton, he was for a while at Cambridge, but in 1650 he transferred himself to Wadham College, Oxford, with the view of studying under Dr. Wilkins, then Warden, and Dr. Seth Ward, the Savilian professor of astronomy. It will be recalled that it was after one of Wren's lectures at Gresham College, in 1660, that the company "withdrew for mutual conversation into Mr. Rooke's apartment," there to discuss a project for a new college or society for physico-mathematical learning. At a meeting of the Royal Society on June 13, 1661, Rooke was desired to bring in a relation of the satellites of Jupiter and the height of the atmosphere. Next month he read his paper of observations of the eclipses of the satellites of Jupiter, for which thanks were given him. On October 9, 1661, Rooke, with Croune and Dr. Pope, were appointed a committee to view propositions for inquiries in foreign parts.

ROOKE's death, in his fortieth year, had a tragical aspect. The Marquis of Dorchester, who had a great regard for him, was accustomed to entertain him at Highgate, bringing Rooke by coach on Wednesdays to the Royal Society's meetings at Gresham College. One day in the heat of early summer, Rooke walked into London (so we are told) and "took cold, which occasioned a fever, and that put an end to his life at his lodgings in Gresham College," on the very night, which he had for some years awaited, wherein to finish accurate observations of the satellites of Jupiter. So intent was he to the last upon completing his theory of that planet, wanting but one observation more (which might be made on the night of his death) to perfect that theory, he desired Dr. Pope to go to the Royal Society and request some person to do it. The Bishop of Exeter (Dr. Ward) intended to erect a monument to his memory, but instead of that gave the Royal Society, in memory of his friend, a large pendulum clock, by Fromantel, which was set up in the actual room at Gresham College where the circle of philosophers met; afterwards it was removed to the hall of the Society in Crane Court, Fleet Street.

AFTER an absence of four weeks, Captain Amundsen's aeroplanes returned to Spitsbergen on June 18, having reached lat. 87° 44′ N., long. 10° 20′ W., a distance of 136 miles from the Pole. Amundsen's preliminary account of the journey is published in the *Times*. The aeroplanes on leaving Spitsbergen encountered fog for a few hours, and when the weather cleared, were too far west. A more easterly course was laid, but it was decided to land in order to get definite bearings before continuing the flight, since at 1 A.M. on May 22, after eight hours' flying, half the petrol had been consumed. The only possible landing place was a water lane through the pack. Both planes were gripped in the ice, but eventually, after 24 days' work, one of them was released. It showed signs of strain but was undamaged. With a greatly reduced load it was possible to start this machine from a levelled stretch of ice on June 15. In 8½ hours, North Cape of Spitsbergen was reached, and there a passing sealer was met and carried the explorers to King's Bay. To the farthest point the planes flew 621 miles at an average speed of 93 miles per hour. Capt. Amundsen believes that but for a head wind causing leeway, he could have reached the Pole with the petrol he carried. The two 370 h.p. Rolls Royce Eagle IX. engines of each aeroplane worked without a hitch. The geographical results of the expedition are practically confined to a sounding of 2051 fathoms at the place of descent. This confirms the conception, founded on Nansen's work, of a deep polar basin and dispels any probability of land on the European side of the Pole.

THE members of the Inter-State Post-Graduate Assembly of America visited Edinburgh on June 18-20. On June 18 the visitors assembled in the M'Ewan Hall, where an address of welcome was given by the Vice-Chancellor of the University, Sir Alfred Ewing, following which the honorary degree of LL.D. was conferred on Dr. Charles H. Mayo of

Rochester, Minnesota. During the three days clinics were arranged in the Royal Infirmary in the departments dealing with medicine, surgery, gynæcology, and the diseases of ear, nose, throat, and eye. There were also clinics in the Sick Children's Hospital and the Maternity Hospital. Demonstrations and exhibits were arranged by members of the staffs of the departments of surgery, midwifery, pathology, bacteriology, and tropical diseases of the University and of the laboratory of the Royal College of Physicians. An evening reception was given on June 18 by the Lord Provost, Magistrates and Council of the City at Inverleith House, kindly placed at their disposal by Prof. Wright Smith, Regius keeper of the Royal Botanic Garden, Edinburgh, and a visit was made to the historical apartments in Holyrood Palace on the afternoon of June 19.

THE Deutsches Museum von Meisterwerken der Naturwissenschaft und Technik at Munich, described in our issue of April 25, p. 611, was opened on May 7 with every mark of national rejoicing. The Museum, as its name implies, is devoted to applied science, and has for its aim the spread of knowledge of the great discoveries and inventions upon which rest the material civilisation of to-day. The festivities commenced on Tuesday, May 5, with a procession of allegorical cars, representing the principal branches of science, through the decorated streets of the city. On the day following the business meeting took place and was attended by ministers, mayors of large cities, leading industrialists, representatives of the Verein deutscher Ingenieure, of the universities, and of some foreign countries; the representative from England was Mr. H. W. Dickinson of the Science Museum, South Kensington. On May 7 a symbolical play, specially written for the opening by Gerhart Hauptmann, Germany's leading living poet, was performed.

THE Museum building, commenced in 1906, is an imposing structure, to the designs of Gabriel and Emanuel von Seidl, situated on an island in the river Isar. In plan the building is roughly 100 m. square, and the whole ground floor is occupied by exhibition space, but in the three floors above, a well 60 m. square gives the necessary lighting. The floor space amounts to about 35,000 sq. metres. At one corner is a tower 64 m. high, and there are three domes devoted to astronomy. The exhibits have been chosen with good judgment. Very great use is made of interiors, and as examples we may mention a scythe forge of 1803 from the Black Forest, the alchemist's laboratory of the middle ages, and a paper-mill of 1708. With these may be classed realistic representations of stone, ore, coal, and salt mining situated below the floor level of the Museum. Nor must mention of the planetarium in the astronomy section be omitted. By projection apparatus images of the fixed stars, or of the sun, moon, and planets, are thrown on a domed ceiling, and their apparent motion over a long period is reviewed in a few minutes. The apparatus has created the keenest interest, and several similar instruments have been ordered; we should like to see such an apparatus set up in Great Britain. The Museum is in no sense a State institution, but owes its existence mainly to the labours of Ing. Dr. Oskar von Miller, a well-known electrical engineer, now in his seventy-first year. It is a monument of what can be done by personality, scientific knowledge, ordered imagination, and organising ability, even when interrupted by the War, the subsequent revolution, and the inflation of the currency.

THE Department of Scientific and Industrial Research is carrying out a series of investigations into adhesives. Some of this work has direct industrial application; some of it is of the nature of purely scientific research, *e.g.* investigations into the chemistry of gelatin and the mechanism of adhesion. It is hoped that the more strictly scientific investigations will enlarge the present range of industrial application. It has now been suggested by a prominent firm in the industry that it should be brought into closer contact with the fundamental scientific work, and it is prepared to contribute towards the cost. The Department has accepted this suggestion and is prepared to make similar arrangements with other interested firms for this part of the work, and to furnish progress reports from the Committee in charge, on the understanding that they will on their part communicate any information of general interest they may obtain from their own investigations based upon the results of the Committee's researches. Particulars of the scheme can be obtained from the Secretary, Department of Scientific and Industrial Research, 16 Old Queen Street, Westminster, S.W.1.

ONE of the main functions of the Fuel Research Board of the Department of Scientific and Industrial Research is a survey and classification of the coal seams in the various mining districts by means of physical and chemical tests in the laboratory, supplemented where desirable by large scale tests at H.M. Fuel Research Station, East Greenwich, or elsewhere. The Board has decided that the best way to carry out this work is by means of local committees representing the local colliery owners and managers, the local branch of the Institution of Mining Engineers, the Fuel Research Board, and the Geological Survey of Great Britain, as well as outside scientific interests. Each committee is charged with the duty of supervising the work of the physical and chemical survey in a coal mining area; and in this way the survey becomes of practical value from the commencement, since local knowledge and experience are made available, and the seams to be investigated and the general programme of work are decided by those who are able to estimate most correctly the relative importance of the problems to be solved. The seams selected undergo physical and chemical examination by local investigators appointed for the purpose, after which a final selection is made of those seams likely to justify experiments on a technical scale in order to test their suitability for particular uses or methods of treatment. Committees have for some time been actively at work in the Lancashire and Cheshire and in the South Yorkshire areas, and another committee has recently been appointed to deal with the North Staffordshire area. The North Staffordshire Colliery Owners' Association and the North Staffordshire Institute of Mining Engineers are co-operating in the work.

THE British Museum (Natural History) is to be congratulated on the rapid progress which is being made with the issue of its series of picture postcards illustrating various aspects of natural history. The latest additions include two further series in colour of British birds (summer visitors), an additional two series, also in colour, of British flowering plants, a set of restorations of fossil reptiles, a group of British Crustacea, and a series illustrating colour change in flat fishes, the last three series in black and white. Of these, the most interesting, because perhaps the most original, are those of the fossil reptiles. They are reproduced from drawings made by Miss Alice B. Woodward, and are remarkably natural in their general effect, suggesting a much less virile and more decadent group of animals than the majority of restorations tend to convey. The cards are admirably and clearly reproduced, and maintain the high standard set by their predecessors.

THE Trustees of the British Museum have published a second edition of the valuable handbook to the ethnographical collections which has been out of print for some little time. Mr. T. A. Joyce is again responsible for the text—in this edition with the assistance of Mr. H. J. Braunholtz. Where necessary the text has been modified to bring it into agreement with the growth of anthropological knowledge since the first edition was published in 1910, and a certain amount of supplementary matter has been added. The most considerable addition, however, is in the illustrations. Eighteen text-figures have been added, making two hundred and ninety-three in all, and five plates, bringing the total number up to twenty. Of these illustrations the most interesting are those figuring additional examples of African art, and in particular may be mentioned the very fine ivory mask from Benin. Notwithstanding the increased cost of printing, the price of the handbook has been raised from two shillings to two and sixpence only. Even in the board covers which have taken the place of the cloth of the earlier edition, this is remarkable value.

THE report for 1924 of the Director of the National Botanic Garden at Kirstenbosch, South Africa, records a gallant struggle to continue the development of this wonderful garden site near Cape Town in the face of great financial difficulties. It is, however, regrettable to learn that during the year expenditure upon the Garden, already ridiculously small, had to be cut down owing to reduced revenue, the Government contribution to revenue remaining at the same figure as previously. The University of Cape Town has now established the Bolus Herbarium at Kirstenbosch on a site allotted by the Trustees of the Garden, so that facilities for scientific work on the spot are considerably improved. During the present year, with aid from the Government on the pound for pound principle, the Harold Pearson Memorial Hostel should be completed, with accommodation for a lady warden and about ten residents and servants.

THE Kew Hand-Lists of Herbaceous Plants were issued in the first place to show what species are actually grown at Kew, and also to reduce, if possible, the nomenclature in use in gardens to something like a standard. Possibly on account, particularly, of this second aim, the Kew Hand-Lists have always been found of very general use, and the second edition of the Hand-List of Herbaceous Plants, issued in May 1902, has long been out of print. A new edition appeared in January of this year, but this appears as three lists, (1) Herbaceous Plants, (2) Rock Garden Plants, (3) Hardy Monocotyledons. A new edition of the Hand-List of Trees and Shrubs (excluding Coniferæ) grown in Kew has also been prepared. This list has been revised in accordance with the International Rules of Nomenclature.

THE subject of climatic changes is arousing great interest in the United States at present, and is being attacked along several different lines. Palæoclimatology is a borderland science; it lies between meteorology, geology, botany, and zoology, and no specialist in only one of these subjects can be fully qualified to deal with all aspects of the problem. It is a case for team-work, and we accordingly welcome the publication, in the *Scientific Monthly* for May, of a series of papers read at the December meeting of the American Association for the Advancement of Science on the subject of "Ancient Climates." Meteorology is represented by Dr. W. J. Humphreys, who gives an account of the possible causes of climatic changes, and glacial climatology by Dr. E. Antevs, while S. S. Visher presents an account of Huntington's "Solar-cyclonic hypothesis." Prof. A. P. Coleman deals with the geological aspects of ice-ages, Dr. T. W. Stanton reports on the Mesozoic invertebrates, and Dr. David White discusses the plants of the Upper Palæozoic. The papers are sufficiently interesting taken by themselves, and are rendered more so by their juxtaposition, but the reader is not given any help in considering their bearing on each other. We should like the authors to have met round a table afterwards, and to have formed themselves into a committee with power to co-opt representatives of other sciences such as chemistry and astronomy. A joint report by such a committee would be of outstanding importance in the study of ancient climates.

THE Academy of Sciences of Russia will celebrate its bi-centenary at Leningrad and Moscow between September 6 and 14 next. Foreign representatives are being invited and will receive special hospitality.

A SPECIAL general meeting of the Royal Astronomical Society will be held in the rooms of the Society on Friday, July 24, at 4.30 P.M. It is hoped that a number of foreign astronomers who will be in England in connexion with the meeting of the International Astronomical Union will be present and will speak about their work.

MR. L. S. AMERY, Secretary of State for the Colonies, has consented to receive at the Colonial Office, on

July 7, a deputation which will discuss with him the question of the further development of the work of the Imperial College of Tropical Agriculture for the whole Empire. The deputation, which will be introduced by Lord Burnham, will be of a thoroughly representative character.

WE much regret to announce the deaths of Mr. W. J. Dibdin, formerly chief of the Chemical and Gas Department, London County Council, and a leading authority upon the subject of purification of sewage by micro-organisms in contact and slate beds, on June 9, aged seventy-four years, and of Mr. D. B. Dowling, geologist on the Canadian Geological Survey since 1891, who was known for his work on the formation of coal, aged sixty-six years.

ACCORDING to the Singapore correspondent of the *Times*, the Council of the King Edward the Seventh College of Medicine has announced that the Rockefeller Foundation has presented to the college 350,000 dollars for the endowment of chairs of bacteriology and biochemistry, on condition that the Government founds an extra chair of biology and agrees to equip and maintain the three departments.

THE seventy-eighth annual meeting of the Palæontographical Society was held at Burlington House, London, on June 19, Mr. E. T. Newton, president, in the chair. In the annual report of the council, regret is expressed at the decreasing support received from English public libraries and local societies, but the renewal of subscriptions from the countries of central Europe and new subscribers from the United States of America are noted. New monographs of the Upper Eocene Flora and of Dendroid Graptolites were announced. Prof. H. L. Hawkins and Messrs. L. R. Cox, A. W. Oke, and G. W. Young were elected new members of council. Mr. E. T. Newton was re-elected president, Mr. Robert S. Herries was re-elected treasurer, and Sir A. Smith Woodward was re-elected secretary.

LORD BALFOUR is to deliver the presidential address at the statutory meeting of the recently formed Institute of Philosophical Studies, to be held at the Royal Society of Arts on June 29 at 4.30. The Institute has the patronage of an imposing array of names. The objects are excellent but very indefinite as set forth in the only prospectus we have received. If the aim of philosophy is "to see life steadily and to see it whole," and if the directors in furthering this aim propose "to disentangle our beliefs from a confused jumble, and to purify them of a great many irrelevancies," it would be useful if they would give some definite idea of their mode of procedure. The Institute does not propose to compete with the universities, though it will arrange lectures in all branches of philosophy and encourage research in any of its departments.

BULLETIN No. 12 (1924) of the New South Wales Department of Mines deals with coke and the by-products arising from its manufacture. The text contains numerous statistics and is well illustrated by photographs. After a brief historical introduction, the various coals and types of ovens are described, followed by detailed descriptions of the coking process as carried out in various Australian works.

WE have received a copy of Circular No. 12 of the Engineering Experiment Station of the University of Illinois, entitled "The Analysis of Fuel Gas." The pamphlet gives a description of the apparatus developed at the University of Illinois for the purpose of analysing fuel gas, and contains a synopsis of the methods best adapted to this type of apparatus. These methods are in the order of procedure necessary for carrying out the analysis. A comprehensive review of methods to be used with other types of apparatus is included in the appendix of the circular, which may be obtained from the Engineering Experiment Station, Urbana, Illinois.

THE April catalogue of Mr. C. Baker, of 244 High Holborn, London, W.C. 1, contains full descriptions of more than 2500 pieces of second-hand scientific apparatus. The photographic section, which was included in recent catalogues, has been omitted, and is to be published as a separate pamphlet in accordance with the pre-War custom. The present catalogue is noteworthy on account of the wide selection of astronomical instruments offered for sale. These include reflecting and refracting telescopes, mounted both equatorially and in the altazimuth manner, transit and meridian instruments, object glasses and eyepieces, mirrors and flats, stands and mountings, sidereal clocks, etc. The number of instruments of each type is exceptionally large, the equatorial refractors, for example, numbering twelve, and ranging in aperture from 3-in. to 8-in., and in price from 35*l.* to 595*l.* A 7-in. Cooke photo-visual refractor with accessories is included. All the instruments advertised are guaranteed to be in adjustment.

APPLICATIONS are invited for the following appointments, on or before the dates mentioned:—A part-time assistant-lecturer (woman) in hygiene (infant welfare work and personal hygiene) and demonstrator in bacteriology at King's College for Women (Household and Social Science Department), Campden Hill Road, W.8—The Secretary (June 30). Two assistant lecturers (one with special qualifications in science) in the department of education of the University College of the South-west of England, Exeter—The Registrar (July 2). A second assistant in zoology in the University of Aberdeen—The Secretary (July 8). An assistant in pathology in the University of Aberdeen—The Secretary (July 8). An assistant in the Nautical Almanac Office—The Secretary, Civil Service Commission, Burlington Gardens, W.1 (July 9). A demonstrator in chemistry in the University of Aberdeen—The Secretary (August 8). A lecturer in education in the University of Manchester—The Internal Registrar. An assistant in the department of geology of the Queen's University of Belfast—The Secretary. A lecturer in biology with special qualifications in zoology, and a lecturer in chemistry, at the Portsmouth Municipal College—The Secretary, Offices for Higher Education, Municipal College, Portsmouth.

Research Items.

THE SAN BLAS INDIANS.—Recent references to the San Blas Indians of Panama in connexion with the occurrence of "White Indians" in Darien, and their uprising against the control of the Panama Government a month or two ago, give a topical interest to an article on these tribes by Mr. A. F. Loomis in *Scribner's Magazine* for June. They now number about 30,000. Those who live on the coast are skilled sailors, their canoes, logs hollowed by elementary tools without keel or deck, going out to sea when the weather is too rough even for coasting-schooners. Little is known of them; no one not of their race is allowed to remain within their territory at night. The women wear gold nose-rings, but the most characteristic feature of their dress is an upper garment of appliqué work which is made of pieces of coloured material sewn on to a cloth foundation in most intricate and highly conventionalised patterns. Large flat discs of beaten gold are worn pendent from the ears. Armlets and anklets of beads are wrapped so tight as to stunt the extremities. The marriage ceremony consists in carrying the groom to the girl's house and placing him in her hammock, whence he flies for two nights in succession. On the third night he lifts her veil and sees her face for the first time. The next morning he leaves his father's house, and the eating of the meal the bride has prepared concludes the marriage rite. The son-in-law resides with the bride's father and virtually becomes his servant.

EXCAVATIONS AT MARGIDUNUM.—In describing pottery from a well of Claudian age at Margidunum (Notts) in the Journal of the Society for the Promotion of Roman Studies, vol. 13, pts. 1-2, Dr. Felix Oswald gives a brief account of the general results of his excavations, which have extended over several years. This camp formed a link in the chain of frontier posts established between Severn and Trent in A.D. 47. Previously it was unknown except by name. The site covers about 8 acres. The mud surface due to marshy ground was cleared away by the Romans and about six inches of river sand substituted. Drainage ditches flowing into the first of five outer ditches have furnished some of the earliest evidences of Claudian occupation in the pottery, which often shows La Tène features, Claudian sigillata ware, a coin of A.D. 41, and a tinned bow brooch almost identical with a tinned fibula from Ham Hill, Dorset, which has been dated A.D. 40-50. The persistence of La Tène features in the pottery suggests that local native industries were not suppressed but rather that there was an increased demand. Under Nero and Vespasian iron was smelted in rectangular pits with side gulleys exactly as in Africa to-day. The fort was twice destroyed by fire, possibly by Boudicca and by the Brigantes, and was abandoned before the end of the first century.

A NEW BRITISH LAND PLANARIAN.—Mr. E. Percival records (*Quart. Journ. Micr. Science*, March 1925) the finding of a new British land planarian—*Rhynchodemus britannicus*. He collected specimens in Yorkshire under large stones and logs which had lain undisturbed for a considerable time, always on moist clay or loam, and associated with earthworms and slugs, never with centipedes and carnivorous beetles. The planarian, which is extremely contractile, may attain a length of 90 mm., and is 1·5 mm. broad when in the extended condition. The anterior end tapers gently to a fine point, and just behind the tip is a single pair of minute eyes. The colour is variable—sulphur-yellow, salmon-pink, or dirty grey, and the ventral surface is paler, the mid-ventral region being practically white. The mouth is mid-ventral and about the middle of the length of the worm, and the genital pore 5-8 mm. farther back. Mr. Percival gives a brief account of the anatomy, which is similar to that of other species of Rhynchodemus. The cocoons are 2 to 3 mm. in diameter. The planarian feeds on earthworms, sucking up the partly decomposed tissues of the worm and leaving only the cuticle, but how the worms were killed could not be ascertained. In one specimen many spores of a gregarine, probably Monocystis, were present in the endoderm cells, no doubt ingested while feeding on an earthworm. Two examples of this new species have also been collected at Stockport, and the author thinks that a specimen found at Plymouth probably also belonged to this species, in which case this new planarian would appear to be widely distributed in England.

THE DEVELOPMENT OF EGG FRAGMENTS.—Prof. C. V. Taylor and Prof. D. H. Tennent give a preliminary report (Carnegie Institution of Washington, Year Book 23) on the development of fragments of the egg of the sea urchin *Lytechinus* (*Toxopneustes*) *variegatus*, which they studied in the Tortugas Laboratory. The methods of micro-dissection were employed, *i.e.* the eggs were cut with very fine glass needles manipulated in a moist chamber on the stage of the microscope under fairly high magnification. A preliminary experiment was carried out to ascertain whether the operative technique would cause the parthenogenetic development of the egg; 50 eggs were pricked with the tip of the micro-needle but none developed. Eggs were transected in the vertical or the horizontal plane into two halves, one nucleated and the other not. When these halves, transferred to watch glasses, had rounded off, sperms were added, and by careful treatment many fragments both nucleated and non-nucleated were reared to the pluteus stage. 122 pairs of such fragments were studied. Cleavage followed insemination in 74 of the nucleated fragments and in 66 non-nucleated portions. The cleavage of both fragments is not, as stated by Delage, identical and as in the normal egg—one of the fragments follows the normal mode, but in the other the cleavage which should have given rise to the micromeres was an equal division of the cells of the vegetative half, and this division occurred shortly after the equal division of the four cells of the animal half of the fragment.

BIRDS AND BUTTERFLIES OF EAST AFRICA.—The Journal of the East Africa and Uganda Natural History Society takes a high place among publications devoted to the description and bionomics of local fauna. A recent issue (No. 21, March), under the editorship of Dr. V. G. L. van Someren, contains the opening parts of two excellent faunistic papers, dealing respectively with the birds and butterflies of Kenya and Uganda. The former of these papers, which is the work of the editor, gives a good account of the Guinea-fowls of the region, and is illustrated by a plate representing seven of the species, together with a diagram explaining the nomenclature of the external parts of a bird, and a chart showing the elevations from the lake level to the coast at Mombasa, with the various avifaunal areas. Careful descriptions are given of the adult and the successive immature stages of the plumage in each species, and valuable notes are appended on the distribution, courtship, nesting, and feeding habits of this characteristically African group of game-birds. The following paper, on the butterflies of the same region, is the joint work of Canon K. St. A. Rogers and Dr. van Someren. The species dealt with are those of the genera Danaida and Amauris. An admirable series of photographs accompanies the paper, in which are depicted numerous examples of the eggs, larvæ, and perfect insects of many of the forms described. As in all the work of Canon Rogers, great attention is paid to points of bionomic interest, and we may be permitted to trace in his careful notes on distribution, mode of flight, relative distastefulness, mimicry, etc., the influence of the Hope Department at Oxford, the studies pursued in which place owe so much to the activity and perseverance of Canon Rogers as a collector. It is to be hoped that these contributions to the natural history of East Africa, so well begun, may be pressed to an equally valuable conclusion.

VIRUS DISEASES OF THE HOP.—E. S. Salmon and W. M. Ware briefly describe two virus diseases of the hop, "nettle head" and mosaic, in the *Gardener's Chronicle* for May 9. In connexion with the interesting work they are doing at Wye in raising new strains of hop of commercial promise, the authors had occasion to send out a new seedling for trial in the hop-gardens. This seedling, while itself apparently resistant to mosaic, has thus come under suspicion as a carrier of mosaic to the susceptible varieties around it, thus recalling Bewley's experience with tomato plants and the similar suggestion made by Atanasoff (*Phytopathology*, March 1925) that the potato varieties Ashleaf and Koksiaan (equivalent to Jersey Non Such), themselves very resistant to stipple-streak, may transmit it to varieties, which are then swept away by its ravages. Only experiment can settle such questions, and as virus diseases are most certainly transmitted by grafting, Salmon and Ware describe successful methods for grafting hops.

RHODODENDRONS FROM KWEICHOU, CHINA.—Twelve more flowering plants are figured in the plates in Part III. of Volume 150 of *Curtis's Botanical Magazine*; they range from an old-established horticultural favourite like *Begonia manicata* Linn., introduced from Mexico before 1840, to a cultivated cypress drawn from the temple groves of Yunnan, China, *C. Duclouxiana* Hickel. A rhododendron from the Chinese province of Kweichou, *R. Lyi* Léveillé, provides the occasion for a very interesting discussion by the editor, Dr. Otto Stapf, of the limestone area in this province, studied first by the French missionaries and later also described by Sir Alexander Hosie in his book "On the Trail of Opium." Kweichou has the reputation of being one of the deforested provinces of China, but in this dry limestone plateau, with peaks climbing to more than 2000 m., with a temperate climate save in the deeply cut valleys where it is subtropical, rhododendrons are described as growing in profusion. The limestone is said to be triassic in character. It will be interesting to learn whether the rhododendrons gathered from this area prove tolerant of limestone soils in Great Britain.

RATOON COTTON.—Some observations upon the fibre obtained from ratooned cotton plants in Queensland were mentioned recently in these columns (NATURE, January 31, p. 171). James Templeton, botanist to the Ministry of Agriculture, Egypt, in Bulletin No. 55 of the Technical and Scientific Service of the Ministry, discusses the causes which have led to the disappearance of ratooned cotton from the Egyptian supply. Templeton points out that after its introduction in 1921, cotton was usually grown as a perennial crop, and that the change to cultivation as an annual may be traced to a practice prevailing upon the better lands when the cultivators were compelled by Mohammed Aly to grow the plant, although then a relatively unprofitable crop. The perennial method of cultivation still persisted over large areas, until prohibited by the Government in 1912 as part of a campaign against insect pests thought to be harboured over winter by the standing crop. Templeton finds no evidence that the cultivation of the plant as a perennial was given up because ratooned cotton proved to be of inferior quality. As the result now of actual experiment he records with Sakellarides an increased yield of lint in the second year with quality probably not inferior. Furthermore, in the second year, the loss from boll-worm attack has not been so great as in the first year.

EXTINCT ELEPHANTS IN ENGLAND.—The elucidation of the inter-relationship of the many forms of Pleistocene elephants is a most difficult problem, especially when it is remembered how fragmentary the evidence is. A valuable paper has recently been published by Dr. Sandford in the Quarterly Journal of the Geological Society, vol. 81, No. 321, on "The Fossil Elephants of the Upper Thames Basin." This paper, together with one on "The River Gravels of the Oxford District" in the same journal for 1924, form an opening attack by Dr. Sandford on the general problem of the evolution of the elephants of the period. The author finds *E. antiquus* of an archaic type in the Handborough Terrace Level and in the Wolvercote Channel, a later level, specimens of a smaller form of the species which appear to be akin to the small form found at Barrington and in the Forest Bed. *Elephas primigenius* occurs in the Summertown-Radley Terrace and *E. antiquus* is again found in a level overlying this, which points to a warm phase following a colder one.

TIDES AND CURRENTS IN NEW YORK HARBOUR.—Under this title the U.S. Coast and Geodetic Survey has recently published a connected account by H. A. Marmer of the chief movements of the various tidal waters in the neighbourhood of New York. Observations at a large number of stations both on shore and off shore have been taken at various times, partly by the Survey itself and partly by the U.S. Engineer Office, and these afford material for a descriptive account which is exceptional in its completeness. An idea of this completeness may be gathered from the fact that the pamphlet contains 70 tables and 52 diagrams. Fort Hamilton, which occupies a central position in the region considered, is chosen as the standard station, and the characteristics of the tidal elevation at this place are summarised in 48 non-harmonic constants. Harmonic constants are given for the currents at Scotland Light Vessel, Ambrose Channel Light Vessel, and the Narrows, the results for each of the first two of these stations being based on hourly observations extending over 87 days. In several instances the elevation-gradients transverse to the current are connected with the currents and the earth's rotation in close agreement with dynamical theory. The currents in East River turn about half an hour after the waters at its two ends reach the same level, while the non-periodic flow from the Hudson River decreases in strength from the surface downwards. The monograph closes with a set of 13 maps, showing the states of the tide and current for each hour relative to the time of high water at Fort Hamilton. The pamphlet is well written and shows a regard for precision which is very welcome.

MEASUREMENT OF ATMOSPHERIC HUMIDITY.—Hygrometric tables have been prepared by the Meteorological Office, Air Ministry, for the computation of relative humidity, vapour pressure, and dew point from readings of dry and wet bulb thermometers exposed in Stevenson screens (H.M.S.O., 1s. 6d. net). The tables have been brought into use for obtaining data for publication from the commencement of the current year. Hitherto the tables in use in Great Britain were based on constants known as Glaisher's factors, said to be drawn up on an empirical formula. The new tables have been freshly computed on the basis of Regnault's formula and may be taken as practically identical with similar tables prepared by the Austrian Meteorological Service—with a light air blowing. They are not suitable for factories or store-rooms, unless precautions are taken to secure adequate motion of the air. The tables are, strictly, more scientific than those hitherto used in England and are in agreement with the best in use in other countries. Formulæ are given so that in countries where temperatures are common outside the scope of the tables, it is recommended to expand the table by computing other values. The preface by Dr. G. C. Simpson, the Director of the Meteorological Office, states that the results given by Glaisher's tables are in practical agreement with those obtained from the most recent tables based on Regnault's formula. Hygrometric tables based on Glaisher's factors were expanded and issued for private circulation by the Meteorological Office nearly half a century ago, and it is a satisfaction to know that the results used for so many years differ so slightly from the results which are the best obtainable to-day. The tables are very concise.

VAPOUR PRESSURES OF FUEL MIXTURES.—Considerable attention has in recent years been devoted to the problems of vapour pressure of those liquids or liquid mixtures used as fuels in internal combustion engines. Such matters as loss incurred on handling or storing fuel, internal pressures developed in tanks or other containers used for transporting fuel, fire risk, and the facility with which fuel is vaporised in carburettors all depend on the vapour pressure of the liquid at or just above ordinary temperatures. Mr. J. Stanley Lewis discussed this subject recently at the Institution of Petroleum Technologists, and gave the results of several careful vapour-pressure determinations on binary and ternary mixtures. Starting with hexane and benzene, he showed that there is a rise in vapour pressure caused by traces of water, and that calcium chloride as a desiccant is inefficient. The author employed phosphorus pentoxide more satisfactorily in this connexion. He next gave results of vapour-pressure determinations on fractions of petrol and mixtures of the fractions, on mixtures of benzene with hexane and cyclohexane, and on motor benzol with No. 1 and No. 3 petrol. Other mixtures investigated include benzene and alcohol, ethyl alcohol and No. 1 petrol, ethyl alcohol and No. 2 petrol, and alcohol and water. An example of a ternary mixture is given by the fuel benzol and alcohol plus the small amount of water existent in commercial alcohol, while a petrol-alcohol-water mixture constitutes a similar case. Briefly stated, the addition of one component to a mixture of the other two raises the vapour pressure, and for a given concentration of a ternary mixture there will be a fourth (highest) maximum vapour pressure. In binary fuel mixtures, where the two components are completely immiscible, the vapour pressure of the mixture is the sum of their partial vapour pressures; where there is partial or complete miscibility the vapour pressures vary according to the degree of concentration of the components, and may lie between or be higher or lower than that of either component.

FATIGUE STRENGTH OF STEELS.—Messrs. Aitchison and Johnson presented the results of an investigation on "The Effect of Grain upon the Fatigue Strength of Steels" at the May meeting of the Iron and Steel Institute. This work was carried out on behalf of the Engineering Research Board of the Department of Scientific and Industrial Research, which made a grant towards its cost. The test results have been obtained by examining a complete series of specimens, commencing with a large steel cast ingot, followed by specimens at different stages of forging, the final specimen representing a reduction in cross-sectional area of 96 per cent. of the original casting. In addition, tests were made upon commercial mild steels, high quality nickel chromium steel, Staffordshire wrought irons, and Armco iron. The report deals mainly with the mechanical properties, particularly the fatigue strength of steels when tested parallel to and at right angles to the direction of elongation during forging. The authors find that the direction of the grain has a marked influence upon the ductility recorded in the tensile test, and upon the toughness as measured by the impact test. The maximum stress of the material is not appreciably different in the two directions, nor is there such a large difference in the fatigue strength as had been anticipated. The authors always found that the values of this property were higher in specimens cut parallel to the direction of forging than in those cut at right angles. The maximum difference found is 16-17 per cent.

LITHIUM SOLUTIONS IN LIQUID AMMONIA.—C. A. Kraus and W. C. Johnson have recently measured the vapour pressures of solutions of lithium in liquid ammonia. The results, published in the March issue of the Journal of the American Chemical Society, afford no evidence of the existence of compounds of the alkali metals with ammonia of the nature of ammonium groups. The saturated solution contains 3·61 molecules of ammonia per atom of lithium.

MAGNETIC PROPERTIES OF SILVER HALIDES.—Recent work by A. Garrison, recorded in the March issue of the Journal of the American Chemical Society, shows that silver chloride is diamagnetic and becomes less so on illumination, whereas the bromide and iodide are slightly paramagnetic and become more so on exposure to light. These changes on illumination are instantaneous. It is pointed out that a change in the magnetic permeability would naturally accompany an increase in electrical polarity, an occurrence which is suggested by the fact that the absorption of light causes the halides to be more soluble in water and better conductors of electricity.

SOAP SOLUTIONS.—An interesting paper by J. W. McBain and G. M. Langdon on the equilibria underlying the soap-boiling processes appears in the Journal of the Chemical Society for April. The investigation consisted in the examination of the sodium palmitate—sodium chloride—water system, and phase rule diagrams are given for a series of temperatures. In any soap system the following phases can exist: lamellar crystals, crystalline curd fibres, anisotropic liquid "neat soap," anisotropic liquid "middle soap," and isotropic liquid. Soap-boiling operations depend on the equilibria between these phases. "Neat soap," "middle soap," and "isotropic solution" are three forms of soap solution proper; the first two are anisotropic (doubly refracting). Isotropic liquid solutions of sodium palmitate form a phase which includes wholly colloidal and wholly crystalloidal solutions within the temperature range investigated. Pure water and pure anhydrous liquid sodium palmitate are miscible in all proportions above 316°. The contents of the commercial soap pan behave approximately as a simple three component system, apart from crystallisation.

The South-Eastern Union of Scientific Societies.

ANNUAL CONGRESS AT FOLKESTONE.

THE thirtieth annual congress of the South-Eastern Union of Scientific Societies was held at Folkestone on June 3-6 inclusive. At the opening meeting and before leaving the chair after his year of office, Sir Richard Gregory presented in the name of the Union an illuminated address to Mr. H. Norman Gray, former secretary to the Union. Sir John Russell, director of Rothamsted Experimental Station, then assumed the presidential chair, and delivered his address on "The Place of Science in Rural Life." He traced the changes in the manner of manuring since the empirical days of the ancients, citing as an instance the twelfth-century writer, Idn-el-Awam, who said that human blood stimulated decomposition of manure-heaps and gave a valuable fertiliser. Science was first introduced into rural life when in 1834 Boussingault began analysing his crops and manures. In comparing the output per man on a Sussex farm it was stated that in 1881 it took 117 man-hours to grow one ton of wheat, but only 82 in 1921. "A clod of earth is a storehouse of wonders which are being patiently explored in the experimental stations and colleges."

In the Botanical Section Mr. A. G. Tansley, F.R.S., drew a large audience to hear a paper on "The Vegetation of the Southern English Chalk." He explained the various ecological factors of the chalk, and touched upon plant communities, the pioneer vegetation, the chalk grassland, the chalk scrub, the chalk woodlands, beech forest, the succession of vegetation on the chalk, and the factors arresting the succession in various stages.

In the Geological Section Mr. A. G. Davies directed attention to the many sections that are being temporarily exposed in the progress of excavations for new arterial roads. Mr. Davies has done a good deal of work around London, and in particular dealt with the widening of the main Brighton road at and about Merstham, and cuttings and borings between that point and London, the latter part being examined in detail in the boring of the Tube from London to Merton, the strata covering from the base of the Chalk to the top of the London Clay. An interesting and fruitful section at Woodfield Hill showed an exposure of 400 yards in the *Holaster planus* zone, with a continuous section of the Chalk Rock or Reussianum band, perhaps one of the finest sections of Chalk Rock in Britain. Much new palæontological work has been done on the section. From the Clapham Road portion of the Tube in the London Clay the "sea-serpent" of Owen, *Ophida toliapicus*, was rediscovered after the lapse of nearly a century.

Mr. D. Ward Cutler made a valuable contribution in his paper on "Life in a Garden Soil." There is a vast assembly of little-known creatures in a piece of garden soil. It had long been suspected that in sewage beds the conversion of ammonia into nitrate was not a chemical but a biological process, but not until 1880 was it shown that the process involved two stages, associated with two organisms, and the organisms were isolated in artificial culture. All decomposition and purification of the soil is now known to be due largely to the activities of bacteria.

The Regional Survey Section listened with interest to Mr. Geo. L. Pepler on "Surveys as Preliminaries to Town Planning," and in the Zoological Section Mr. E. C. Stuart Baker gave a brilliant address on "Field Naturalists and Evolution," to illustrate which he brought many cuckoos' eggs from his collection, showing gradations in size and markings between the eggs of the foster parent and those of the cuckoo from decided diversity to perfect resemblance.

In pursuance of the custom of recent years of bringing to notice the uses of the cinema for educational purposes, a lecture was arranged at the Picture Theatre, at which some hundreds of children were present, when Dr. Clarence Tierney lectured to them on "Some of Nature's Secrets." Mr. E. A. Martin raised some controversial points in his paper on "Some Controversial Points in Anthropology." He suggested that the differences of opinion as to the age of the human jaw discovered in Kent's Cavern should be adjudicated upon by a committee of experts. In dealing with the pictorial representations of the human form on palæolithic cave-walls, he made the suggestion that we may have here preserved what were really monstrous forms of the human race, when the species was scarcely fixed and the race was still in a plastic condition.

Many interesting excursions were made, amongst them being one to what has been called the finest Roman site in the south-eastern counties, and another to Dungeness point, rendered famous of late years on account of the supply of fresh water which is to be found within three or four feet of the gravel surface.

The Calculation of World Temperatures.

MATHEMATICAL expressions giving the variation of air temperature with such factors as time and latitude have been obtained by a number of different meteorologists by evaluating the several coefficients in a Fourier series. Mostly the investigations have been confined to conditions existing in a particular locality, and in only a minority of cases have world conditions been considered. When only one locality is considered, the task is comparatively straightforward. If, however, the whole world is dealt with, the accuracy of the results will be limited by the number of observing stations existing over the earth, and more particularly by their distribution. To obtain satisfactory mathematical relations a series of observations extending over a considerable number of years is necessary. Over the more densely populated parts of the earth it is usually possible to make a selection of stations which shall be fairly representative of the whole area, but over many large areas no information exists at all. Over other large areas the observing stations are very sparsely distributed, and to obtain results which are true on the average for the whole area is correspondingly more difficult.

The author in the publication before us[1] has dealt first with the simpler case, taking Brussels as the locality to be considered, and afterwards he has extended the investigation to cover the whole globe. This very considerable task was undertaken during the War, when night astronomical observations at the Royal Observatory of Belgium were forbidden by the German military authorities.

The maximum, minimum, and mean temperatures for Uccle extending over a period of 75 years have been extracted from *L'Annuaire Météorologique* for 1908 and used to establish general mathematical expressions which will give for any date in the year the

[1] "Expression analytique des variations de la température de l'air.' Par H. Philippot. Pp. 48. (Bruxelles: M. Hayez, 1924). 5 francs.

mean temperature, mean maximum, mean minimum, absolute maximum, and absolute minimum temperatures. The values of each of the five elements for every day in the year are stated in tabular form.

In extending the relations to different parts of the globe, recourse has been made to Hann's "Lehrbuch der Meteorologie" for information relating to 143 stations, coastal and inland, scattered over the two hemispheres, and the results for Brussels and Nertchinsk are added to these. Expressions have been obtained for the same five temperature means and extremes for all of these stations, while for 26 of them more exact expressions have been calculated. The accuracy of these latter expressions may be gauged when it is stated that the difference between the observed and calculated monthly mean temperatures in no case amounts to 1° C., and in most cases is a small fraction of this amount.

To progress from the results for individual stations, the earth's surface is divided into belts of 10° of latitude. For each belt the mean latitude is obtained for the stations contained in the belt and also the mean of their respective temperatures. The results obtained for the successive belts are then integrated to obtain a mean temperature for the whole globe and for each hemisphere. The values obtained are: (1) for the whole globe, 15°·61 C.; (2) for the northern hemisphere, 16°·15 C.; and (3) for the southern hemisphere, 15°·07 C. These results are somewhat higher than those given by Angot in his "Traité de météorologie." This may to a certain extent be accounted for by the fact that no allowance has been made by the author for the relative amounts of land and water in his successive belts of 10° of latitude, as was done by Spitaler and Forbes in their calculations. The difference between the observed mean temperature at any place and the value calculated for that latitude gives a measure of the effects of topography and local conditions, such as nearness to the sea, the direction of prevailing winds, the influence of ocean currents, etc. These effects of continentality and oceanity have further been considered as equivalent to a change of latitude, and examples are given for different places the mean temperature of which is equal to that for latitudes considerably nearer the equator or the poles.

The amplitude of the temperature oscillations has been similarly considered, because this is also dependent upon latitude, and the difference between the observed and the calculated amplitude will again be due to local conditions, the climate being more or less equable than is general for the latitude. The effects of continentality and oceanity on both mean temperature and its amplitude are shown on charts.

A possible allocation of dates is suggested for the meteorological seasons based on temperature changes. The dates for the change of seasons would be those where the maximum, minimum, and mean temperatures were passed. To a first approximation for places outside the torrid zone, the dates obtained (January 22, April 24, July 24, and October 23) are about one month later than the corresponding astronomical seasons.

The author concludes that the really determining factor in temperature is latitude, and that the other conditions, topographical or local, give rise only to more or less important perturbations the effects of which can be obtained by direct observation alone. R. S. R.

Botanical Exploration in China.

The *Anzeiger* of the Vienna Academy of Sciences for 1924, which has recently been issued, contains, among other interesting matter, parts 25-30 of Dr. H. Handel-Mazzetti's "Plantae Novae Sinenses." They add another century of new species and varieties of Chinese plants to those included in the earlier numbers. There is no definite plan in the selection of the plants described as new. The descriptions are rather in the nature of gleanings obtained in the course of the author's elaboration of the extensive material which he collected during his five years' exploration work in China, and of preliminaries towards a full account of his expedition. This, we understand, is almost ready for the press, and as Dr. Handel-Mazzetti is not only a highly competent botanist and an experienced traveller—he has done good work in Kurdistan and Upper Mesopotamia—but also a naturalist with a very comprehensive and thorough training, we are eagerly looking forward to its publication.

Dr. Handel-Mazzetti went to China with Camillo Schneider, the well-known dendrologist, early in 1914 on behalf of the Austrian Dendrological Society and with the support of the Vienna Academy of Sciences, the immediate object of the expedition being the Upper Yangtse basin between 27° and 30° N. The travellers left Yunnan-fu in March 1914 and devoted themselves during the spring and early summer to the exploration of the Yalung basin in southern Szechuan and of the north-western corner of Yunnan. When Schneider left in July for America, Handel-Mazzetti continued the work alone. He returned to Szechuan in the autumn, going afterwards to Mengtse and Manhao on the Red River and, in the spring of 1915, to Yunnan-fu, whence he started for the Likiang range, crossed the Mekong, and penetrated to the watershed of the Salween and the Kiukiang, the easternmost tributary of the Irawadi. The next year was given up to the exploration of the Upper Salween basin as far as its western and northern boundaries. After having spent the winter of 1916–1917 at Yunnan-fu, Handel-Mazzetti turned his attention to the botanically very incompletely known provinces of Kweichou and Hunan. He traversed southern Kweichou from west to east and reached Changsha in Hunan towards the end of 1917. The following summer saw the explorer in Central and South-West Hunan. After another winter in Changsha, which was spent in preparing his extensive collections for despatch to Europe, Handel-Mazzetti left China, arriving in Vienna in the early summer of 1919.

Dr. Handel-Mazzetti published preliminary accounts of the floral zones and plant-formations of West Szechuan and Yunnan in the *Anzeiger* in 1916, 1917, and 1920, and a revised account in Engler's "Botanische Jahrbücher," Band 56, with a map (1921), whilst a similar account dealing with the flora of Kweichou and Hunan appeared in the *Sitzungsberichte* of the Vienna Academy in 1919. A preliminary report on his exploration in Yunnan may be found in the *Mitteilungen* of the Geographical Society of Vienna in 1919 and a paper "Ergebnisse der Expedition Dr. Handel-Mazzetti's nach China, 1914–1918. Neue Aufnahmen in N.W. Yunnan und S. Setschuan," accompanied by a map, in the *Denkschriften* of the Vienna Academy in 1921. The latter contains important contributions to the glacial geology of the country and is repeatedly referred to in J. W. and C. J. Gregory's recent memoir on "The Geology and Physical Geography of Chinese Tibet" (Phil. Trans. Roy. Soc., London, Ser. B., Vol. 213). Dr. Handel-Mazzetti, who is an excellent photographer, has also made a fine collection of slides (partly coloured), many of which are of great beauty. O. S.

University and Educational Intelligence.

CAMBRIDGE.—The Council of the Senate has nominated Mr. Ernest Harrison, senior tutor of Trinity College, for the post of Registrary of the University, on the resignation of Dr. J. N. Keynes.

The special Board of Biology and Geology has nominated P. R. Cuvati, to use the University Table at Naples.

An annual grant of fifty guineas is to be made from the University to the Marine Biological Station at Plymouth.

The honorary degree of Doctor of Science has been conferred on Prof. J. Joly, professor of geology and mineralogy in the University of Dublin, and on Dr. A. P. Maudslay, distinguished for his contributions to the archæology of Central America and Yucatan.

DURHAM.—Dr. Thomas Alty, lecturer in physics, has accepted an invitation to a chair of physics in the University of Saskatchewan. Dr. Alty was Oliver Lodge fellow and prizeman of the University of Liverpool in 1921, and while at Trinity College, Cambridge, he worked with Sir J. J. Thomson at problems of bubble-surfaces; this research he has developed while in his post at Durham.

Three further lectureships have been established in the departments of applied mathematics, geology, and botany; these have been filled respectively by Mr. E. F. Baxter, assistant lecturer in mathematics at the University of Sheffield; Mr. William Hopkins, research student of Armstrong College, Newcastle; and Miss Elsie Phillips, Isaac Roberts scholar and demonstrator in botany at the University of Liverpool. The report of the Department of Pure Science at Durham shows that during this, its first session, ten papers on original work will have appeared and that the entry-list for 1925–6 is full.

LEEDS.—On the nomination of the Senate, Prof. J. W. Cobb has been elected Pro-Vice-Chancellor of the University in succession to Prof. Jamieson, whose term of office expires at the end of this month. The Council has agreed to co-operate with the City Council in extending an invitation to the British Association to hold its annual meeting in 1927 at Leeds.

LIVERPOOL.—The honorary degree of D.Sc. has been conferred on Sir J. C. Irvine, Principal and Vice-Chancellor of the University of St. Andrews; and the honorary degree of D.Eng. on Sir Dugald Clerk, formerly Director of Engineering Research at the Admiralty, the distinguished authority on gas and oil engines.

LONDON.—Miss Helene Reynard has been appointed Warden of the Household and Social Science Department, King's College for Women. Miss Reynard, who was for some years resident junior bursar of Girton College and is now treasurer and secretary of Somerville College, will take up her new duties early in October.

MANCHESTER.—The following appointments in the Faculty of Technology have been made: Dr. T. K. Walker to be lecturer in applied chemistry; and Miss Marion Chadwick and Mr. A. Hancock to be assistant-lecturers in applied chemistry.

OXFORD.—The annual report of the Delegates of the University Museum, lately published, contains a detailed account of the teaching given and the researches performed in the various scientific departments of the University, together with a notice of the additions made during the past year to the Museum collections. These, in several of the departments, have been both numerous and interesting. The list of accessions to the Pitt-Rivers museum covers five large quarto pages.

Preparations for the visit of the British Association in 1926 are in active progress. Some of the committees have already met, and an office has been secured for the local secretaries.

The Boyle Lecture, delivered by Prof. J. Joly, dealt with the geological age of the earth, estimated by the carrying of salt into the sea by rivers, and by the radioactive decay of thorium and uranium. The results of these different methods were shown to be fairly accordant.

In the Halley Lecture, delivered on June 17, Dr. W. W. Campbell, President of the University of California and Director of the Lick Observatory, discussed the position and constitution of the star-group to which the solar system belongs, in relation to the stellar universe.

The members of the Universities Commission are nearing the end of their labours. The Statutes of all or most of the Colleges have now undergone their final revision.

MR. BERNHARD BARON, of Brighton, has given a sum of 10,000*l.* to the Jewish University in Jerusalem.

SINCE the Imperial College of Science and Technology, South Kensington, was founded by Royal Charter in 1907, questions of its relationship to the University of London have been under discussion. The College includes as integral parts the Royal College of Science, the Royal School of Mines, and the City and Guilds (Engineering) College, and it possesses the fullest equipment for the most advanced training and research in various branches of science. Unlike University College and King's College, it is not incorporated in the University of London, though for the purpose of internal degrees of the University it was admitted as a school of the University in the Faculties of Science and Engineering in 1908. The courses of work at the College do not, however, follow the University syllabuses, being distinctive from them both as regards method and content. In spite of this, many of the students take science degrees in the University in addition to their College diplomas; indeed, the diploma courses are of equal standard to those required for honours degrees at the University. The duplication of effort and examination thus involved will in future be avoided through a scheme which has been accepted by the governing body of the College and the University senate for the conduct of final B.Sc. (Special) and B.Sc. (Eng.) examinations for students of the College. The University has adopted the College examinations as its own and will appoint the internal examiners of the College to be its own examiners while it will, in addition, appoint its own external examiners. The scheme is a simple, business-like arrangement that might be made between any first-class college and any recognised university; but it really represents a very big step in principle, and marks the beginning of an entirely new era in university education. It means that the Imperial College retains its individuality in methods of training while the University examinations are subordinated to the teaching instead of, as hitherto, the teaching being controlled by the examinations. For this satisfactory solution of a long-standing problem Sir Thomas Holland, Rector of the Imperial College, is largely responsible, and we congratulate both the College and the University upon the friendly spirit in which the scheme now established has been discussed and secured.

Early Science at Oxford.

June 24, 1684. Mr. Musgrave further informed the Society that if ye Jugular veins in men communicate one with ye other, in ye same manner, as they did in his Dog, we may then argue hence, that bleeding in ye jugulars, is more proper in some distempers of ye head, than severall physitians (who suppose no considerable communication between ye brain, and externall jugulars) will allow.

It was ordered, that ye Eclipse of ye Sun, on ye 2nd of July next, be strictly observed, and that all things necessary for that purpose be made ready by that day.

Mr. Walker mentioned a Barometer he has, ye tube of which, at about 27 inches from ye open end, turnes in an obtuse angle, for ye better observing ye ascent of ye quicksilver. He was desired to shew it ye Society at ye next meeting.

June 26, 1688. The thanks of the Society are returned to Mr. President, for a letter communicated by him from Mr. Hillyer, being a farther account of customs and religion of ye Indians.

In consideration of the great pains and trouble Dr. Wallis has been at in the care of printing *Aristarchus*, the Society give order that their thanks be returned to the Doctor.

Ordered that an *Aristarchus* be sent to Dr. Garden, one to Dr. Middleton. To the Vniversitys of Aberdeen, and Glascow, Edinborough and St. Andrews. To Mr. Molineux, and the Provost and Library of Dublin. To Mr. Ash. To Mr. Jessop. To Dr. Lister. To the Secretarys of the Royall Society, and the Library of the Society, and the President of the Royal Society. To Dr. Chamberlain. To Mr. Flamstead. To Dr. Pitt. To the Vice-chancellor and Publick Library. To Mr. Halley. Ordered that Mr. Charlet deliver one from the Society to Mr. President.

The Tutenage of Japan was shewed to the Society, being used for paper to wrap up goods, or make sacks: Of the same sort being thicker are made the tea-pots. It is a metall finer than lead or tin, but neither the one nor the other. The thanks are returned to Dr. Hide for his communication of the heads of some Japan matters he has communicated to ye Society.

June 29, 1686. Mr. Caswell communicated part of a letter from Mr. Halley, wherein he acquaints him that he intends to try some experiments concerning the specific gravity of the air. A discourse of Dr. Lister's read, concerning the improvement of *Agriculture*.

July 1, 1684. Mr. Walker presented his Barometer, mentioned in ye Minutes of ye præceding week, to ye Society; ye tube of it, at ye distance of (about) 27 inches from ye upper end, was bent, in an angle of 108 degrees, for ye better observing ye motion of ye quicksilver, which, in ye sloaping part of this tube, does rise, and fall, 2½ inches, for one inch in a tube exactly perpendicular.

Mr. Bernard was pleased to acquaint ye Society, that a spot in ye Sun was seen by Mr. Caswell on Thursday last, and by himself at ½ hour after 7 in ye morning, at which time it was not far from ye rim of ye Sun: it appeared to be a thick firm spot, and to take ye same course, with that observed, not long since, by Mr. Flamsteed, (*vid.* Minutes of May 27, 1684;) for it passed over near ye center of ye Sun. He tells us farther, that he looked after it again on ye Monday following but could not see it; it had made its exit. We are promisd a more full account of this matter.

Dr. Bathurst informed ye Society, of a relation he lately received out Somersetshire, concerning ye great damage done to ye beans in that county, by vast numbers of caterpillars.

Societies and Academies.

LONDON.

Royal Society, June 18.—Lord **Rayleigh**: Luminous vapour from the mercury arc and the progressive changes in its spectrum. This investigation deals with the luminous stream of vapour observed when mercury distils away from the arc *in vacuo*. The lines of the arc forming known spectrum series are for the most part strongly developed in the vapour stream. An exception is line 1850 $1P$—$1S$, which is strong in arc, but inconspicuous in vapour. Higher members of various series appear in greater relative intensity in vapour than in the arc. The continuous spectrum of mercury, not noticeable when the vapour first emerges, becomes more conspicuous as the vapour matures. In the limit the spectrum tends to consist simply of line 2537 and continuous spectrum. If the vapour is passed through a metal tube maintained at negative potential, the luminosity of the line spectrum in general tapers down to a sharp point, beyond which it disappears. Line 2537 behaves differently. Much of its light tapers down to a point which, however, is beyond the place where the other lines are extinguished, but a residuum is of a different origin and does not admit of extinction. The light of the band spectrum also passes on.—J. C. **McLennan** and G. M. **Shrum**: On the origin of the auroral green line 5577 Å and other spectra associated with the aurora borealis. In studying the effect of large admixtures of helium on the spectrum of oxygen, a hitherto unknown line has been photographed. The wave-length of this line has been found to be $5577{\cdot}35 + 0{\cdot}15$ Å. It is very sharp and is subject to great fluctuations in intensity. Evidence has been produced to prove that this line is identical with the auroral green line $\lambda = 5577{\cdot}350 + 0{\cdot}005$ A. This line must be attributed to some hitherto unknown spectrum of oxygen, and it is not a limiting member of the ordinary band spectrum of oxygen. Helium has been used to bring out the bands of nitrogen, with an intensity distribution similar to that found in the aurora. The possibility of metastable helium acting as the exciting agent in the auroral spectrum has been discussed.—J. C. **McLennan** and A. B. **McLay**: On the series spectrum of gold. Absorption spectra of the vapours of gold, silver and copper in the Schumann region have been investigated. The second members of principal series of doublets in the gold arc spectrum are $\lambda = 1646{\cdot}71$ (I vac.) and $\lambda = 1665{\cdot}75$ (I vac.). Similarity exists between the term systems gold I, copper I, and zinc II, in respect of their inverted δ terms, and the term systems of gold I and copper I in respect to certain special π terms. The term systems silver I and cadmium II have not been shown to include either inverted δ terms or the special type of π terms mentioned.—W. A. **Bone**, D. M. **Newitt** and D. T. A. **Townend**: Gaseous combustion at high pressures, Pt. V. The authors describe further experiments upon the explosion of hydrogen—air and carbon monoxide—air mixtures at initial pressures up to 175 atmos. It is shown, *inter alia*: That, in general, and except where N_2-activation intervenes, as in carbon-monoxide-air explosions, time for the attainment of maximum pressure diminishes as initial pressure increases. The "corrected" Pm/Pi ratios for explosion of any and all mixtures investigated increased in notable degree with initial firing pressure, due probably to increasing opacity of the gaseous medium to the radiation emitted during explosions. There were no signs of "after-burning" in any of the explosions when Pi exceeded about 10 atmos., although it could usually be detected when $Pi = 3$ atmos.—W. T. **David**: The effect of infra-red radiation upon the rate of combustion of inflammable gaseous mixtures. Two types of apparatus were employed: In one, radiation from an electrically-heated wire coil was passed into the explosion vessel through a window of fluorite or quartz. Pressure-time curves were taken during the explosion of identical mixtures, first when radiation was passed into the explosion vessel, and then when no radiation was passed in. In the other, gaseous mixtures were exploded in a vessel the interior surface of which was silver-plated, and could, therefore, be made either reflecting (by polishing) or absorbent (by coating with dull black paint); by this means it was possible to vary the radiation density of those types of radiation emitted by the burning gases during the explosion period. Pressure-time curves were taken during explosion of identical mixtures taken first when the walls of the vessel were polished, and then when blackened. For hydrogen and air, carbon-monoxide and air, and methane and air mixtures, an increased rate of combustion was found in all cases when the superimposed (first type) or increased (second type) radiation could be absorbed by the reacting gases. Absorption of radiation by reacting gases promotes combustion; intra-molecular energy (rotational and vibrational) of reacting molecules is the factor (or one factor) concerned in combustion.—R. K. **Schofield** and E. K. **Rideal**: The kinetic theory of surface films. Surface tension—concentration curves for aqueous solution of a number of capillary active organic substances give evidence in the case of dilute solutions in support of the unimolecular character of the adsorbed films. The analogy between the lowering, F, of the surface tension, and a three-dimensional gas or osmotic pressure, postulated by Traube, has been critically examined. For weak solutions when F exceeds some 10 dynes per centimetre, the surface phase is relatively highly condensed, and the equation $F\ (A-B) = x RT$, analogous to that of Amagat connecting the pressure and volume of highly compressed gases, is obeyed. In this equation, A is area occupied by a gm. mol. of active substance at interface, B is limiting area of a gm. mol. under high compression, and $1/x$ is a measure of lateral molecular cohesion. The values of x for fatty acids show that at a water-air interface, lateral molecular cohesion increases with length of hydro-carbon chain. There is little or no cohesion between such molecules at a water-benzene interface. Sucrose molecules do not cohere at water-mercury interface.—H. M. **Macdonald**: The condition that the ratio of the intensities of the transmitted and reflected electric waves at the interface between two media is independent of their plane of polarisation. For a state of steady electrical oscillation between a closed surface separating two different dielectric media and a conductor inside this surface, the condition is that the ratio of the specific inductive capacities of the two media is equal to the ratio of their magnetic permeabilities. For a medium in which the ratio of the specific inductive capacity to the magnetic permeability is constant, the intensity is constant along a ray which cuts the surfaces of constant specific inductive capacity orthogonally; when the surfaces of specific inductive capacity are concave towards an inner surface, and the specific inductive capacity diminishes outwards, the path of any other ray is concave towards the inner surface. —C. V. **Raman** and L. A. **Ramdas**: The scattering of light by liquid boundaries and its relation to surface-tension. Parts I. and II.—H. **Weiss**: The application of X-rays to the study of alloys.—F. R. **Weston**: The flame spectra of carbon monoxide and water gas. The results of a spectrographic study of the flame of carbon monoxide, burning in air and various other supporting atmospheres, are described. In the flame of pure (undried) carbon monoxide, two sets of independent interactions occur simultaneously:—(*a*) *direct* interactions between CO and O (*without any intervention of steam*), exciting radiations which give rise to the continuous and banded parts of the spectrum and to the characteristic blue colour of the flame, and (*b*) interactions between CO and OH_2 molecules, which originate the "steam-lines" in the spectrum. When hydrogen is gradually added to the burning gas, the relative proportions of the first-named interactions diminish rather rapidly.

CAMBRIDGE.

Philosophical Society, May 18.—J. F. **Lehmann** and T. H. **Osgood**: The passage of electrons through small apertures. The velocity distribution was investigated in a beam of electrons emerging through an aperture in an anode to which they were accelerated by potential differences varying from 200 to 1000 volts. For holes in thin sheet copper, the percentage of electrons in the beam with velocities equivalent to the accelerating field, as measured by retarding potentials, varied from 1 to 80 as the diameter of the hole was increased from 0·13 to 3·24 mms. With copper capillary tubes of the order of 1 cm. in length, the percentages were much higher for a given diameter, a 0·4 mm. tube giving an 80 per cent. beam. This was the maximum attained under the experimental conditions.

PARIS.

Academy of Sciences, May 25.—M. **d'Arsonval**: A new direct-current generator giving 500,000 volts. In principle this consists of a condenser charged to high potential by means of a high-tension alternating current; the alternations being separated by a two-electrode valve. With a potential of 600,000 volts (continuous) a spark passes between 50 cm. spheres, 28 cm. apart: the current is about 30 milliamperes. —Jean **Perrin**: Remarks on the preceding communication. If the range of the generator described can be extended to 5 million volts, it should be possible to act on the atomic nuclei and carry out transmutations on a tangible scale.—A. **Desgrez**, H. **Bierry**, and F. **Rathery**: Inorganic phosphates and hypoglycæmia produced by insulin. The injection into an animal of a suitable dose of a solution of sodium or potassium phosphate, with a P_H approximating to that of the blood, intensifies and prolongs the hypoglycæmia caused by injections of insulin.—C. **Camichel**, L. **Escande**, and M. **Ricaud**: The flow of viscous liquids round an obstacle. The effect of varying velocity of flow is shown in four photographic reproductions.—R. **Kœhler** and C. **Vaney**: A new gastropod producing galls on the spines of *Dorocidaris tiara*.—M. Gustave **André** was elected a member in the section of Rural Economy, in succession to the late L. Maquenne.—B. de **Kerékjártó**: Families of surfaces and of curves.—Bertrand **Gambier**: The asymptotic transformation of M. Bianchi and the curve of M. Picard of ruled surfaces the generators of which belong to a linear complex. —R. H. **Germay**: Implicit periodic functions and periodic solutions of partial differential equations.—N. **Lusin**: The projective ensembles of Henri Lebesque.— —. **Eydoux**: The flow of liquids with and without velocity potential. Application to turbine buckets.—Boris **Stetchkine**: The determination in an incompressible fluid of the velocity potential due to a vortex tube.—P. Lecomte du **Noüy**: An apparatus for the rapid measurement of the surface tension at the surface of separation of two liquids. The influence of temperature.—Stephane **Dombrowsky**: The regime of concentrations established by lateral diffusion in a convection current.—M. **Lardry**: Study of the propagation of short waves (in wireless telegraphy). An account of the phenomena observed (fading, scintillation) of signals of wave-lengths of 450, 115, and 50 metres at distances between 180 and 4500 kilometres. The superiority commonly attributed to the shorter wave-lengths was not confirmed.—E. **Briner**: Remarks on the origin of radioactivity. It has been advanced as a difficulty against the acceptance of the theory of the spontaneously explosive atom, that the enormous emission of energy accompanying this change is irreconcilable with the exothermic synthesis of the elements starting with their primordial constituents, protons and electrons. The author shows by analogies drawn from the destruction of chemical molecules that there is no real incompatibility between the radioactive atom, the destruction of which frees a large amount of energy, and the exothermic formation of the atom.—Mlle. Berthe **Perrette**: Contribution to the study of the isotopy of lead. A comparison of lead extracted from a pitchblende (Belgian Congo) with an atomic weight of 206·14 and ordinary lead of atomic weight 207·2. The densities were: radio-active lead, 11·278; common lead, 11·336; and both had the same atomic volume. In the comparison of the arc spectra, the Fabry and Perot interference method was used, the diameters of the rings formed by the corresponding lines of the two isotopes being measured. All the lines have shown a difference in the same sense with an increase in the wave-length for the lead with the lowest atomic weight.—Nobuo **Yamada**: The long range particles emitted by the active deposit of thorium. The experiments described prove that the active deposit of thorium emits only one group of α particles of 11·5 cm. range, in addition to the ordinary α rays. The two other groups found by Bates and Rogers were not confirmed.— — **d'Huart**: The absorption of water vapour and of some other vapours by the surface of glass. An apparatus is described and figured which can be used to measure the amount of water vapour adsorbed by glass surfaces. It can also be used to determine the vapour density of very volatile liquids.—Paul **Pascal**: Magnetochemical researches on the formation of closed chains and nuclear groups in organic compounds.— — **Grandadam**: The purification of potassium and sodium cyanides. Their melting points. The purification of the alkaline cyanides can be effected by solution and recrystallisation in liquid anhydrous ammonia. The melting points were determined in a silver crucible in an atmosphere of dry nitrogen, using a gold-silver thermocouple. Sodium cyanide melts at 564° C., potassium cyanide at 634° C. —F. **Bourion** and J. **Picard**: The kinetic study of the reduction of mercuric bromide by sodium formate —V. **Auger**: A new type of alkaline borates; the pentaborates.—Pierre **Lesage**: Inheritance of the early character and the conservation of this character in old seeds.—P. **Lavialle**: The antipodes and the chalazian region of the ovule of the Dipsaceæ.—Jules **Amar**: Cellular hydration and vitality.—J. **Cluzet**, A. **Rochaix**, and Th. **Kofman**: The variations of the agglutinating power of a mixed immunoserum under the influence of a continuous electric current.—A. **Vandel**: Physiological amixia and incipient species in the isopod *Tricohniscus* (*Spiloniscus*) *provisorius*.—Phillippe **Bunau-Varilla** and Emile **Techoueyres**: Induced antisepsis or, in other words, the microbacidial action exercised at a distance, without material contact, on a bacterial dilution by a very dilute solution of sodium hypochlorite.

Official Publications Received.

Bulletin of the National Research Council. Vol. 10, Part 1, No. 51, March: Radioactivity. Report of Committee on X-rays and Radioactivity, National Research Council. By A. F. Kovarik and L. W. McKeehan. Pp. 203. (Washington: National Academy of Sciences.) 2.25 dollars.

Observatoire de Zi-ka-wei. Notes de sismologie, No. 6: Étude sur le ondes de dilatation et les ondes de condensation. Principaux sismogrammes, 1924. Par le R. P. E. Gherzi. Pp. 22+6 planches. (Zi-ka-wei, Chang-hai.)

Annual Report of the Auckland Institute and Museum for 1924–1925, adopted at the Annual Meeting held February 27th, 1925. Pp. 37. (Auckland, New Zealand.)

Journal of the College of Agriculture, Hokkaido Imperial University, Sapporo, Japan. Vol. 15, Part 3: An Enumeration of the Butterflies and Moths from Saghalien, with Descriptions of new Species and Subspecies. By Dr. S. Matsumura. Pp. 83-196+plates 8-11. (Sapporo.)

Imperial Department of Agriculture for the West Indies. Report on the Agricultural Department, Grenada, January–December 1924. Pp. iv+11. (Trinidad.) 6d.

The Science Reports of the Tôhoku Imperial University, Sendai, Japan. Second Series (Geology). Vol. 7, No. 2: A Geological Problem concerning the raised Coral-Reefs of the Riukiu Islands and Taiwan; a Consideration based on the Fossil Foraminifera Faunas contained in the raised Coral-Reef Formation and the youngest Deposits Underlying It. By Hisakatsu Yabe and Shôshirô Hanzawa. Pp. 29+6 plates. (Tokyo and Sendai: Maruzen Co. Ltd.)

Indian Medical Research Memoirs. Memoir No. 3. Supplementary Series to the *Indian Journal of Medical Research*. Provisional List and Reference Catalogue of the Anophelini. Part 1: Provisional List of Species. Part 2: Descriptive Synopsis. By Lt.-Col. S. R. Christophers. Pp. 105. (Calcutta: Thacker, Spink and Co.) 1.12 rupees; 2s. 6d.

Department of Commerce: Bureau of Standards. Miscellaneous Publication of the Bureau of Standards, No. 63: Report of Board of Visitors to Bureau of Standards of the Department of Commerce for the Secretary of Commerce. Pp. iv+14. (Washington: Government Printing Office.) 5 cents.

Hundredth Annual Report of the Committee of the Bath Royal Literary and Scientific Institution for the Year 1924. Pp. 16. (Bath.)

Aeronautical Research Committee. Reports and Memoranda, No. 960 (E. 13): Variation of Engine Power with Height. By H. L. Stevens. (B. 4. Engines 50, T. 1952.) Pp. 8+11 plates. 9d. net. Reports and Memoranda, No. 961 (E. 14): The Variation of Engine Power with Height. By H. M. Garner and W. G. Jennings. (B. 4. Engines 51, T. 1964.) Pp. 3+6 plates. 6d. net. (London: H.M. Stationery Office.)

Proceedings of the Royal Society of Edinburgh, Session 1924–1925. Vol. 45, Part 3, No. 18: The Equation of Conduction of Heat. By Marion C. Gray. Pp. 230-244. 1s. 6d. Vol. 45, Part 3, No. 19: Note on Professor Whittaker's Atomic Model. By John A. Eldridge. Pp. 245-248. 9d. Vol. 45, Part 3, No. 20: Unilateral Vasoligation on the Senile Male of the Domestic Fowl. By F. A. E. Crew. Pp. 249-251. 6d. (Edinburgh: R. Grant and Son; London: Williams and Norgate, Ltd.)

The Physical Society of London. Proceedings. Vol. 37, Part 4, June 15. Pp. 195-267. (London: Fleetway Press, Ltd.) 6s. net.

Diary of Societies.

MONDAY, June 29.

Aristotelian Society (at University of London Club), at 8.—Prof. W. H. Moberly: Some Ambiguities in the Retributive Theory of Punishment.

TUESDAY, June 30.

Royal Dublin Society, at 4.15.

Royal Anthropological Institute (Indian Section), at 8.15.—H. de B. Codrington: Periods in Indian Archæology.

International Congress of Radiology (at Royal Society of Medicine), at 8.30.—Reception.

WEDNESDAY, July 1.

International Congress of Radiology (at Central Hall, Westminster), at 2.30.—Official Opening.—At 9 p.m.—Duc de Broglie: Absorption of X and γ Radiations and the Secondary Radiations which accompany them (Silvanus Thompson Memorial Lecture).

THURSDAY, July 2.

International Congress of Radiology (at Central Hall, Westminster), at 10 a.m.

FRIDAY, July 3.

International Congress of Radiology (at Central Hall, Westminster), at 10 a.m.; at 9 p.m.—Sir Berkeley Moynihan, Bart.: The Relationship of Radiology and Surgery (Mackenzie Davidson Memorial Lecture).

Geologists' Association (at University College), at 7.30.—Prof. W. W. Watts: The Geology of South Shropshire (Lecture).

SATURDAY, July 4.

International Congress of Radiology (at Central Hall, Westminster), at 10 a.m.

British Mycological Society (Phytopathological Excursion to Cambridge).—Prof. Sir R. H. Biffen and F. L. Engledow: The Inheritance of Disease Resistance.—F. T. Brooks and W. C. Moore: Silver-leaf Disease.—N. J. G. Smith: Helminthosporium Disease of Cereals.—D. Weston: The Control of Bunt in Wheat.—R. C. Woodward: Apple Mildew.—Mrs. M. N. Kidd: Fungal Invasion in Apples in Relation to Senescence.—S. M. Wadham: Clover Rot.—A. Smith: Perennial Rust Mycelia.—Prof. Nuttall, Dr. Hare, and Mr. Tait: Fungi Pathogenic to Man.

Physical Society of London (at Oxford).

Supplement to NATURE

No. 2904 JUNE 27, 1925

The Centenary of the Discovery of Benzene.

MICHAEL FARADAY.

A FEW weeks ago we published a special supplement in connexion with the centenary of the birth of Huxley: this week we are presenting a supplement containing the principal addresses which were delivered in the Royal Institution during the celebration of Faraday's discovery of benzene. Whereas Huxley's reputation is based as much upon his championship of evolution, of freedom of thought, and of enlightened education, as upon his researches in biology, the fame of Faraday rests almost entirely upon his striking contributions to scientific knowledge. His ambit was thus more circumscribed than that of Huxley, but his discoveries were more revolutionary, both in their effects on the development of theory and in their subsequent practical applications. In the latter connexion we refer more particularly to his discoveries of magneto-electric induction and of benzene. The electrical industries, together with the industries based upon benzene, constitute overwhelming proof—if proof be needed—of the value of research in pure science.

In attempting to estimate the place of Faraday among the world's great men, one is at a loss whether to value highest his superb skill as an experimenter, the originality and perspicacity of his thought, or his greatness as a man. Comparisons are no less difficult than they are odious, but few would gainsay that in view of the scanty material means he had at his disposal, and of the fact that he did not rely upon pupils or assistants, Faraday has had few, if any, equals as an experimenter. In the sphere of thought, he was not only a master of deductive and inductive reasoning, but also he possessed the priceless gift of a vivid and disciplined imagination. Much of his work was far in advance of his time, and hence we find his ideas still inspiring scientific research, his experimental discoveries still being transformed into great and growing industries. His views on the nature of electricity and magnetism, and on the correlation of the different forms of energy, foreshadowed in a remarkable way the results of later investigations; but, as Helmholtz said, "New ideas need the more time for gaining general assent the more original they are, and the more power they have to change the broad path of human knowledge."

Faraday's gift of original thought was most conspicuous in his purely physical work, and except in the border-line region of electro-chemistry, his chemical discoveries were mainly the outcome of great experimental skill. Thus his discovery of benzene did not result from any previous train of reasoning or concatenation of ideas, but from brilliant technique. Though chemists and physicists may dispute possession of his scientific soul, we believe that he was a physicist *au fond*; his chemistry was not, however, the "dirty part of physics," in the words of Prof. Cohen's amusing quotation. It is quite probable that our successors will cease to regard chemistry and physics as separate sciences, and if they do, Faraday, before all others, will rank as the artificer of the union. "Talent may frolic and juggle, genius realises and adds," said Emerson, and Faraday's supernormal gifts of insight and experimental skill will always mark him out as one of the greatest master-builders of physical science.

To Faraday's character as a man, we have most eloquent tributes from Tyndall, Bence Jones, Gladstone, Dumas, and others. Actuated by a laudable if unscientific motive, biographers are apt to discard material which reflects adversely upon those whose lives they describe. In the case of Faraday they cannot lay themselves open to this imputation; his failings were extraordinarily few, and his real life was quite as beautiful as any romantic or hero-worshipping biographer could imagine it to have been. Except in the sphere of religious belief, Faraday and Huxley had many common traits. Each had a very strong sense of justice, and an unswerving respect for truth, to which was added an unquenchable enthusiasm for the verities of science. The lives of both were permeated by the highest moral purpose, and no one who tries to follow in their footsteps can but feel that great as were their contributions to natural knowledge, even greater were their characters as men.

Faraday as a Chemist.[1]

By Sir William J. Pope, K.B.E., F.R.S., Professor of Chemistry, University of Cambridge.

Michael Faraday was born in 1791, as the son of a working blacksmith in London. During the distress of 1801, when corn rose to more than 9*l*. a quarter, his family received public relief, and one loaf of bread was allotted weekly to the nine-year-old child. His systematic education was rudimentary in character, for in his thirteenth year he became errand-boy to a bookseller in the neighbourhood of Manchester Square, and was entrusted with the duty of distributing the Sunday newspapers.

So lowly an introduction to life might seem to furnish but a slight foundation for a great scientific career. Yet Faraday became Director of the Laboratory of the Royal Institution in his thirty-fourth year, and succeeded Sir Humphry Davy in the chair of chemistry in 1827; on his death in 1867 he was mourned by practically every learned academy in the civilised world as one of the foremost of the great chemists and physicists of the first half of the nineteenth century. Many of Faraday's discoveries and much of his mode of interpreting chemical observations still persist as sources of inspiration to the chemist of a century later. The task of tracing the career of this great scientific luminary, of trying to decipher the stages in his major discoveries and of learning how his dominating position in science was attained, is an interesting one; it is also an illuminating one as showing how the exercise of industry and ability can reduce to negligible proportions the effect of faulty early education and of absence of family support.

Faraday was apprenticed as a bookbinder to his employer in 1805; his indentures note that "in consideration of his faithful service no premium is charged." He has told us that whilst an apprentice he read a great number of scientific books which came under his hands, and the correspondence which he left shows that he was in the habit of discussing with keen enthusiasm a large variety of scientific topics; he attended a few lectures on natural philosophy by certain private individuals who were in the habit a century ago of advertising such discourses. Early in 1812 a customer of his master's shop enabled him to attend four of Sir Humphry Davy's lectures in this theatre; we are told that he sat in the gallery just above the clock, and that he carefully elaborated his notes upon the experiments shown and the explanatory discourses. Faraday's contemporary correspondence makes it clear that he became captivated by the charm of manner and the skill in exposition and experiment of the master; he got into contact with Davy, and on March 1, 1813, was appointed by the Managers as assistant in the Laboratory of the Royal Institution.

[1] Discourse delivered at the Royal Institution on Friday, June 12.

Faraday's scientific career had commenced, but it had commenced in circumstances which would have discouraged any but the most intrepid. The first piece of work in which he was called upon to assist Davy consisted in experiments on the newly discovered nitrogen chloride; six weeks after he came to the Royal Institution he was writing to a friend describing the injuries from which he and his master were suffering by the premature explosion of this capricious substance. Although this frequency of bodily hurt must have been very disconcerting to an entire novice in chemical experiment, Faraday seems to have accepted it without demur or complaint, and as a necessary incident to the occupation which he had now definitely determined to adopt. Indeed, a month later he writes his friend at some length, and with no little perspicacity, upon the conduct of lectures and the behaviour of lecturers. He observes that "polite company expect to be entertained not only by the subject of the lecture, but by the manner of the lecturer; they look for respect, for language consonant to their dignity, and ideas on a level with their own." This youth of twenty-one years of age was by no means unprecocious; he observes that "a lecturer should appear easy and collected, undaunted and unconcerned, his thoughts about him, and his mind clear and free for the contemplation and description of his subject."

In the autumn of 1813 Sir Humphry Davy left England for an extended tour through France, Italy, and Switzerland, taking Faraday with him as assistant and amanuensis. This journey, which lasted about eighteen months, appears to have been the only occasion on which Faraday left England for any length of time, and it undoubtedly exercised a great influence on his future life. The travellers carried chemical apparatus with them, visited a large number of foreign chemists, and themselves experimented on the novel problems laid before them. They experimented with the newly discovered element, iodine, with which Ampère provided them, and of course prepared the explosive nitrogen iodide; they visited Chevreul's laboratory, and attended a lecture by Gay-Lussac. Leaving Paris they drove across the Alps into Italy; at Genoa they studied the electrical discharge from the torpedo fish, and spent some time in Florence burning diamond with the aid of the great burning-glass in the Accademia del Cimento; they visited Vesuvius, made the acquaintance of Volta, and Faraday made copious notes on the firefly and the glow-worm.

They collected the natural inflammable gas at Pietra Mala, and identified it as methane in the laboratory of the Florentine Academy.

This lengthy journey, much of it in a country with which England was at war, must have been of inestimable benefit to Faraday; he acquired some acquaintance with the outside world, and the insularity and indeed petulance which he occasionally displayed in his letters concerning the manners and customs of people with whose language he was unacquainted, reveal his need for the wider experience thus afforded him. He saw the commanding position which Davy's genius as an experimental philosopher had acquired for him in European science, and, what was possibly of even more permanent importance, he had occasion to realise that the homage deservedly paid to his great master had led, perhaps, to some deterioration in those personal qualities which might be expected to accompany intellectual eminence.

In May 1815 Faraday recommenced work at the Royal Institution, and shortly afterwards took possession of living apartments in this building. It must be remembered that this period was one of extraordinary interest in connexion with chemical science. The sound experimental work of the previous century had freed the natural philosopher from the mystical and metaphysical trammels imposed by the alchemists, and had just led, through the work of Lavoisier, to an appreciation of the fact that quantitative measurements of weights and volumes had become the basis of an imminent great development in chemistry. Shortly before, Davy had overthrown Lavoisier's view that oxygen was the acid-forming element, had shown that hydrogen chloride contains no oxygen, and had proved that " oxymuriatic acid " was an elementary substance which he called chlorine; he had displaced caustic soda and caustic potash from their position as elements, and isolated from them the elementary metals sodium and potassium. Dalton had just enunciated the atomic theory, and Avogadro had stated his famous hypothesis that equal volumes of gases contain the same number of molecules under similar conditions of temperature and pressure; both these fundamental statements of principle were destined to survive to the present day as logical deductions from experimental observation. The next few years were to see the popularising of chemical science by the introduction of Davy's safety lamp for use in coal mines, an invention which was probably greater than any other asset in determining the increasing industrial activities of Great Britain.

This was the atmosphere in which Faraday found himself when he made his permanent home at the Royal Institution in 1815; his publications of the succeeding few years show that he occupied himself busily in expanding his knowledge of science and in developing his remarkable talents as an experimenter.

Faraday's first contribution to chemical knowledge was a very modest one, and consisted in the examination of an Italian lime of volcanic origin; this was published in 1816, and was followed by some comments by Humphry Davy. His next essay was more ambitious. In 1816 the professor of mineralogy at Cambridge, E. D. Clarke, published a paper on the uses of the oxy-hydrogen blowpipe, an instrument which had been introduced by the American chemist, Robert Hare, in 1802. But whilst Hare fed hydrogen and oxygen separately into the blowpipe, Clarke proposed actually to use a mixture of the two gases in the requisite proportion; this involved the introduction of some device for preventing the flame from striking back and causing the explosion of the mixed gases in the reservoir. At this time Davy had perfected his safety lamp for use in the coal mines, and during this work had been led to reflect upon the various ways in which flame could be prevented from travelling through a body of inflammable gas; at Davy's suggestion Clarke caused the mixture of hydrogen and oxygen to pass through a short capillary of glass before entering the blowpipe. The explosion wave was extinguished by the cold walls of the capillary, and thus the risk of the explosion of the reservoir of gas was diminished; the risk was not entirely avoided, for Henry Gunning, in his " Reminiscences of Cambridge," notes the dangerous character of the oxy-hydrogen blowpipe as used by Prof. Clarke, who was a somewhat eccentric and superficial enthusiast. At all events, Clarke succeeded in volatilising gold and in burning diamond with his blowpipe, and in 1817 Faraday published a note describing the repetition and extension of Clarke's results; it will be recognised that no little experimental skill had to be exercised in order to avoid the occurrence of a disastrous explosion. Shortly after, Faraday described an apparatus in which Davy's experiment of burning diamond can be performed in an enclosed space; the diamond is carried in a platinum capsule suspended in a glass globe filled with oxygen, and a jet of hydrogen, ignited by an electric spark, is used to heat the diamond to its ignition temperature.

Faraday's earlier papers were of the nature of short notes, and were published in the *Quarterly Journal of Science*; this was the organ of the Royal Institution, and had been started by Brande in 1816. Faraday's first paper in the Philosophical Transactions of the Royal Society appeared in 1821, and described the discovery and properties of hexachloroethane, $CCl_3 . CCl_3$, and its conversion into tetrachloroethylene, $CCl_2 : CCl_2$. Six months later he described and analysed another compound of carbon and chlorine, which Dr. Hugo Müller showed later to be hexachlorobenzene, C_6Cl_6; by a curious coincidence Faraday thus had a simple derivative of benzene in his hands several years before he discovered benzene itself.

It is remarkable that in these papers, and in their author's other incursions into organic chemistry, no trace is found of a kind of mysticism which attended the treatment of carbon compounds almost until the middle of the nineteenth century. Lavoisier had shown that the majority of chemical substances produced as the result of animal or vegetable life contain carbon, and we still retain the name organic as descriptive of the carbon compounds. About 1760 the French naturalist, Buffon, stated that "there exists a living organic substance, universally distributed throughout all animal or vegetable substances, which serves equally for the nutrition, for the growth, and for the reproduction of animals and vegetables." Even in 1849 Berzelius wrote that "the elements seem to obey quite other laws in living nature than in inorganic nature; the products which result from the reciprocal action of the elements thus differ in the two cases. If we could succeed in learning the cause of this difference we should hold the key to the theory of organic chemistry; but this theory is so well hid that we have no hope of discovering it." The same idea of the existence of a vital force as provocative of chemical changes in living matter is common to these two writers, separated by nearly a century. The hexachloroethane and the tetrachloroethylene were typical organic compounds; they were produced from ethylene, which in turn had been prepared from alcohol obtained by the fermentation of sugar. It is characteristic of Faraday's broad outlook upon chemistry that he should have dealt with organic compounds as subject to the same laws as govern chemical substances in general; in this modernity of conception he anticipated many of his successors.

Whilst this work was in progress Faraday was engaged in an investigation of the alloys of steel in conjunction with James Stodart; this had for its object the improvement of steel intended for the manufacture of cutting instruments and the diminution of the tendency to rust. A large number of new alloys were prepared and studied; some, such as those with platinum, had little tendency to rust, those with rhodium could be forged and tempered, and the silver-steel alloys were used for some time for the manufacture of such articles as fenders. Although Faraday occasionally presented his friends with razors forged from certain of his new alloys, the work found no considerable technical applications; the modern extensive use of nickel-steel and chromium-steel, both of which Faraday prepared, suggests that the work was in advance of the needs of the times.

Another piece of work undertaken in 1822 led to results of far-reaching importance. Humphry Davy had shown that the supposed solid chlorine obtained by cooling moist chlorine is really a hydrate of this element; Faraday determined the composition of this unstable compound as, roughly, $Cl_2 . 10H_2O$, but the exact composition is not yet known. On sealing the substance up in an inverted V-shaped tube, and warming the arm containing the chlorine hydrate, Faraday observed that chlorine was given off, and became condensed to a yellow liquid in the empty arm; the hydrate had decomposed and the evolved chlorine had been liquefied by the pressure set up during its liberation. On cooling the arm containing the liquid chlorine to 0° C. and then opening the tube, part of the chlorine boiled off and the remainder became, in consequence, so cooled that it remained liquid under atmospheric pressure. Faraday estimated that the temperature so attained must have been lower than $-47°$ F., and, as we now know, it is about $-47°$ F. He also found that chlorine could be liquefied at ordinary temperatures by four or five atmospheres pressure. The novel device of liquefying a gas by taking advantage of the pressure set up in a closed vessel by liberating the gas in a closed vessel, was clearly capable of wide application, and its inventor immediately used it for the liquefaction of sulphur dioxide, hydrogen sulphide, chlorine dioxide, nitrous oxide, cyanogen, ammonia, and hydrogen chloride. His interest in the subject aroused, he proceeded to liquefy a number of more refractory gases by cooling them under pressure in a bath of solid carbon dioxide and ether, and also succeeded in converting hydrogen bromide, hydrogen iodide, sulphur dioxide, hydrogen sulphide, nitrous oxide, ammonia, and other gases into crystalline solids. The systematic study of the liquefaction of gases initiated by Faraday provided the foundation for much of the most brilliant work done within these walls by another great experimental genius, the late Sir James Dewar.

We now arrive, in this brief survey of Faraday's chemical work, at the moment of that important discovery which laid the foundation of more than one-half of modern organic chemistry and of one of the most important branches of chemical industry; this was the discovery of benzene, which was announced to the Royal Society on June 16, 1825.

Early in the last century the Portable Gas Company was engaged in making illuminating gas by dropping whale or cod oil into a furnace maintained at a red heat; the inflammable gas produced by this process of destructive distillation was subjected to a pressure of about thirty atmospheres and stored in portable vessels. These latter were then transported to private houses and other buildings, and the gaseous contents burnt for illuminating purposes. During the process of compression a liquid was deposited, each 1000 cubic feet of gas yielding nearly a gallon of this oil. Faraday subjected this condensed liquid to careful examination, and separated from it a compound of carbon and hydrogen which he termed bicarburet of hydrogen; he made a detailed study of this substance, and the analytical results which he obtained, translated into the modern nomenclature, give its molecular composition as C_6H_6.

The memoir in which Faraday describes the isolation of this hydrocarbon is written in very simple language, but it reveals throughout the handiwork of a genius in experimentation and of an unrivalled master in the interpretation of experimental results. Thus, at this early date, and with the very modest appliances at his hand, the experimenter separated benzene in a state of purity from a very complex mixture; he found that it solidified on cooling, and gave its melting-point as 5·5° C., the correct melting-point being 5·44°. He determined the composition of the hydrocarbon by a method so ingenious that it might well tax the skill of the modern worker. He evaporated the hydrocarbon into a known volume of oxygen, noted the increase in gaseous volume, exploded the mixture in the eudiometer and noted the diminution in volume, then treated it with caustic potash solution and observed the further diminution in volume due to the removal of the carbon dioxide. The data thus obtained give the proportion of carbon to hydrogen, and also the density of benzene vapour as compared with hydrogen as the standard; Faraday hence calculated the vapour density as 39, which is the correct value.

This exhibition of real mathematical power as a mode of unravelling a complicated skein of quantitative data was followed by a profound study of the chemical behaviour of the new substance. Faraday noted that chlorine is without action on benzene in the absence of sunlight, but that when the mixture is exposed to sunlight, vigorous action occurs with evolution of hydrogen chloride; he succeeded in separating the solid chlorination product, obviously *p*-dichlorobenzene, from the liquid residue containing the *o*-isomeride. This was the first occasion on which the catalytic activity of sunlight in promoting the action of halogens on the aromatic hydrocarbons had been observed, and it is perhaps superfluous to remark that this particular aspect of catalytic activity is still growing in importance and is still a subject for scientific study.

Many other points in this memoir of Faraday's might well call for distinction, but it will suffice to recall the comment passed upon the paper by Berzelius: "One of the most important chemical investigations which has enriched chemistry during 1825 is without doubt that of Faraday on the oily compounds of carbon and hydrogen obtained by compressing the gases obtained by the decomposition of fatty oils." The great Swedish chemist, himself the intellectual giant of the quantitative chemistry of his day, was impressed less by the new facts recorded than by the consummate art exercised in their elicitation and by the conviction that a new epoch had dawned in organic chemistry.

The bicarburet of hydrogen which Faraday separated from the gas obtained by the destructive heating of an animal oil was prepared by an entirely different means some ten years later. Mitscherlich obtained it in 1834 by distilling benzoic acid with lime, and proposed to give it the name benzin because of its relation to benzoic acid, which in turn derived its name from its original source, gum benzoin; Liebig objected to this name and proposed that it should be named benzol. Liebig's statement, made in 1834, that benzol could be obtained from coal, is possibly based on a misreading of Faraday's paper in which he states that he had not been able to obtain it from coal-tar. The presence of benzol in coal-tar seems to have been first noted by John Leigh in 1824, and this observation was confirmed by Hofmann in 1845; in 1849 Mansfield was manufacturing benzol on a factory scale from coal-tar, and indeed lost his life in 1856 as the result of a fire which occurred whilst he was preparing the compound. The name benzol still survives as descriptive of the technical product, but the chemical name of the substance has now become benzene.

Benzene is the first member of a long series of compounds of carbon and hydrogen, the so-called aromatic hydrocarbons, which are closely related in chemical constitution and chemical behaviour. The second member of the series is toluene, C_7H_8, which was discovered by Pelletier and Walter in 1837, and is also separated in large quantities from coal-tar. Before discussing the modern importance of this particular series of aromatic hydrocarbons, it may be well to refer to others with which Faraday was closely associated.

The hydrocarbon naphthalene was observed as a crystalline deposit in an apparatus used by Garden in 1819 for the distillation of coal-tar; its separation from coal-tar was described by John Kidd, the professor of chemistry at Oxford, in January 1820. The chemical composition of naphthalene was determined by Faraday early in 1826; Faraday prepared the two isomeric derivatives, now known as the naphthalene α- and β-sulphonic acids, and contributed further particulars concerning the behaviour of this hydrocarbon. The interest aroused in the components of coal-tar by Faraday's remarkable work on benzene and naphthalene led to a rapid increase in our knowledge of the composition of this raw material. In 1832 Dumas and Laurent separated anthracene from it, and, up to the present time, some thirty aromatic hydrocarbons, and more than that number of other aromatic compounds, have been extracted from this product of the distillation of coal.

It is worth while, if merely as an object-lesson exhibiting the vast influence which can be exerted on the world's affairs by some originally modest piece of scientific research, to consider the scope and magnitude of the progress made as a result of Faraday's discovery of benzene one hundred years ago.

The whole of the great coal-tar colour industry sprang from Faraday's study of coal-tar. In 1856 the late Sir W. H. Perkin made the first coal-tar colour, Perkin's Mauve, from coal-tar benzene; and at the great Exhibition of 1862 a large number of such artificial colouring matters were displayed. So rapid had been the progress made during half-a-dozen years that in 1862 Hofmann was able to write as follows concerning benzene:

"For years the newly discovered compound could claim scientific interest only. In this investigation, as indeed throughout the whole series of his immortal researches, Faraday's object was the elaboration of truth for its own intrinsic value and beauty; and in the same spirit has the work been continued by those who, after Faraday, engaged in the further scientific examination of the subject. Nobody, in those early days of benzol, when the substance simply existed as a laboratory curiosity, dreamed of the brilliant career looming in the distance for this body, nor of the marvellous transformations it was destined to undergo."

Since the early days when Hofmann was moved to use these words, the development of coal-tar colour manufacture has proceeded with progressive rapidity; the number of coal-tar colours now recognised as of technical value is of the order of 1200. Whilst the earlier artificial dyestuffs, although brilliant in colour, were often fugitive to light or to washing, we are now in possession of coal-tar colours which are more fast to light and to washing than indigo, madder, or any of the stable dyestuffs known to our ancestors. Many of the newer aromatic artificial dyes persist even when the fabric on which they are deposited has rotted away. The late Lord Playfair, and many other chemists, saw that the coal-tar colour industry was likely to influence in a remarkable manner the industrial fortunes of Great Britain. Hofmann put this view forward in 1862 in a remarkable passage:

"For, if coal be destined sooner or later to supersede, as the primary source of colour, all the costly dyewoods hitherto consumed in the ornamentation of textile fabrics; if this singular chemical revolution, so far from being at all remote, is at this moment in the very act and process of gradual accomplishment—are we not on the eve of profound modifications in the commercial relations between the great colour-consuming and colour-producing regions of the globe? Eventualities, which it would be presumptuous to predict as certain, it may be permissible to forecast as probable; and there is fair reason to believe it probable that, before the period of another decennial Exhibition shall arrive, England will have learned to depend, for the materials of the colours she so largely employs, mainly, if not wholly, on her fossil stores. Indeed, to the chemical mind it cannot be doubtful that in the coal beneath her feet lie waiting to be drawn forth, even as the statue lies waiting in the quarry, the fossil equivalents of the long series of costly dye materials for which she has hitherto remained the tributary of foreign climes. Instead of disbursing her annual millions for these substances, England will, beyond question, at no distant date become herself the greatest colour-producing country in the world; nay, by the strangest of revolutions, she may ere long send her coal-derived blues to indigo-growing India, her tar-distilled crimsons to cochineal-producing Mexico, and her fossil substitutes for quercitron and safflower to China, Japan, and the other countries whence these articles are now derived."

This pronouncement of Hofmann is interesting in that it involves two propositions, one correct and the other incorrect. The instinct and wide experience of the chemist told him, and told him correctly, that the coal-tar dyes were destined largely to replace the vegetable colouring matters and to provide the textile manufacturer with increased opportunities for the production of new effects; but when he took for granted that the new discovery would find vigorous commercial development in the country of its birth he was forming an opinion on a subject less his own than chemical science. Within a few years Great Britain was exporting coal-tar to Germany for dyestuff manufacture, and, whilst artificial colour manufacture languished here, Germany forged ahead and soon dominated all others in the new industry. Indigo-planting and indigo preparation did indeed dwindle into insignificance, largely because no concerted effort was made to apply scientific methods to the improvement of methods which had remained unchanged for perhaps a thousand years; but it was Germany which exported artificial or coal-tar indigo to India and not Great Britain.

It has just been hinted that scientific cultivation and scientific methods of separation might have enabled natural indigo to hold its own against artificial indigo produced from the components of coal-tar; there is indeed solid foundation for the belief that natural indigo, had its production not been woefully mismanaged, would never have been supplanted by the artificial material. It would appear likely that the percentage of colouring matter yielded by the indigo plant might be greatly increased by scientific breeding and by improved methods of extracting the colour; the percentage of sugar obtained from the sugar beet by judicious selection of seed and careful development of methods of extraction was raised from little more than 5 per cent. to about 20 per cent. on the weight of the beet. Furthermore, and for reasons which need not now be discussed, it seems clear that natural indigo is of distinctly greater value as a dyestuff than the artificial product. These facts were realised by the Government of India many years ago: a scheme of research work was launched, financed by the State, and notable advances were made in the manufacture of natural indigo. But at the moment when it had become clear that indigo planting could be given a new and profitable lease of life, the Indian Government, apparently from motives of economy, abandoned the research scheme; the considerable expenditure of money which had been incurred thus represented, for all practical purposes, an extravagant waste of money. It seems at first sight irrational to spend a large sum of money in proving the truth of a scientific forecast as to how a particular scientific industry can be made to flourish and to abandon the project at the moment of fructification; at the same time, the fact that this remarkable method of procedure is the standard method adopted by British Governments would suggest that it has a sound economic basis.

Whilst little or nothing was done to stimulate the cheap production of natural indigo, neither effort nor money was spared in the attempt to manufacture coal-tar indigo in the German colour works; it has been stated that 2,000,000*l.* was spent on chemical research and technical development before synthetic indigo was put upon the market. The vast amount of chemical and technical experience gained during this great enterprise did not lead to the production of indigo alone; many compounds closely allied to indigo and possessing value as dyestuffs were also made. Included among these is the traditional Tyrian purple, which is contained in the secretions of a small marine snail.

Again, the competition amongst coal-tar dyestuff manufacturers led to new developments in connexion with the manufacture of entirely novel dyes of like stability to indigo, although belonging to entirely different classes of chemical compounds. Many of these, grouped together as the so-called "vat-dyestuffs," are derivatives of the hydrocarbon anthracene which has been previously mentioned; they can be produced from anthracene separated from coal-tar. But coal-tar anthracene is costly, whilst the two hydrocarbons with which Faraday was so closely associated, benzene and naphthalene, can be extracted from coal-tar in large quantities at but little expense. As an illustration of the thoroughness with which chemical skill has been applied to the solution of the economic problems which arise in the manufacture of artificial colouring matters may be quoted the fact that the cheap raw materials, benzene and naphthalene, can now be used instead of anthracene itself in the manufacture of the dyestuffs relating to anthracene. Naphthalene can be partially burnt in the air so as to yield phthalic acid; this phthalic acid can be caused to condense with benzene to give anthraquinone. The anthraquinone thus manufactured can be used to replace that previously obtained from the costly anthracene, and can be utilised in the manufacture of the better-class vat-dyestuffs.

Whilst the manufacture of coal-tar dyes grew to vast dimensions owing to wise development and exploitation, other industries and fields of knowledge also benefited. In course of time it was found that Faraday's benzene was the starting material for many aromatic substances of use in medicine, in photography and in many other arts. Furthermore, the coal-tar hydrocarbons, benzene and toluene, are the raw materials from which the high explosives, picric acid and trinitrotoluene, are manufactured. At the outbreak of the War, no picric acid was being made from benzene, and no trinitrotoluene had ever been made on a large scale in Great Britain. This was of course well realised on the Continent; to what extent the known unpreparedness of Great Britain for the manufacture of the staple high explosives was a factor in precipitating war cannot now be ascertained.

The set of great industries involved in the manufacture of artificial dyestuffs, pharmaceutical products, and military and naval high explosives are thus closely allied. Faraday's discovery of benzene and its analogues is also important in connexion with liquid fuel used in the ordinary internal combustion engine. Certain of the naturally occurring petroleums contain large proportions of aromatic hydrocarbons, such as benzene, and the fact that a petroleum from Borneo, containing about 20 per cent. of benzene and toluene, was available in 1914, was a very material relief to the difficult situation created by the impossibility of immediately preparing large quantities of raw materials from coal-tar for the manufacture of high explosives. Benzene and toluene from coal-tar are now largely used for blending with petrol from overseas and for improving its efficiency as a fuel.

In the year 1825 Faraday undertook, at the request of the Council of the Royal Society, a lengthy and laborious experimental study of the manufacture of optical glass; the investigation extended over four years, and was fruitful in that it provided a great deal of accurate and precise data as to the conditions to be desired or to be avoided in the making of glass for optical instruments. The notable positive result of the work was the discovery of the so-called heavy glass, which consists largely of a lead borosilicate and has very high refractive power. The expenses incurred in carrying out this work were amongst the objects of a violent attack levelled against the president and Council of the Royal Society in 1830 by Sir James South. The "heavy glass" was destined later to serve in Faraday's discovery in 1845 of the rotation of the plane of polarisation of light when passed through a transparent medium in a strong magnetic field; this property, that of magnetic rotatory power, took its place amongst the important physical constants of chemical substances as a result of the work of the late Sir W. H. Perkin.

Yet another brilliant piece of Faraday's experimental chemical work remains to be mentioned. He had noted that films of beaten gold of some 1/280,000th of an inch in thickness are translucent, and that the transmitted light is green in colour; from this observation he was led to study the transmitted colour of still thinner films of gold and other metals, and to the conclusion that glass, fused with the addition of a trace of a gold salt, owes its ruby colour to the diffusion throughout the mass of minutely divided gold. The reduction of metallic gold in aqueous solution also engaged his attention, and he concluded that the bright red-coloured solutions thus obtained owed their colour to the diffusion of minute particles of metallic gold throughout the liquid. These coloured and apparent solutions of metallic gold in water are very stable; their study by Faraday in 1857 was an obvious prelude to the classical studies of colloidal solutions published by Thomas Graham, the Master of the Mint, in 1861.

So far I have dwelt, perhaps with too much insistence, on Faraday's pre-eminence as an experimenter, and, possibly again in too accentuated a manner, with the world-extended influence of his chemical work on the subsequent history of our planet. Such possible defects call for an apology. Faraday came forward as an experimental genius at a time when the chemist was forced to work with the aid only of ordinary domestic appliances, and when he had to make for himself every item of the apparatus which he desired to use. His "Chemical Manipulation," published in 1829, provides a fund of information concerning details of chemical experimentation of which the chemical student of to-day is entirely ignorant. We have progressed so far in our experimental study of chemical phenomena that the investigator is now but little dependent on his own manipulative skill, and has become largely subservient to the ingenuity of the scientific instrument maker. Again, an apparently non-utilitarian experimental discovery made in one generation seems naturally to become the corner-stone of some gigantic industrial development in the next decade. A perusal of Faraday's experimental work furnishes ample material in support of this thesis; and, to come nearer to the present day, many of those present to-night had the privilege of witnessing those fundamental experiments on the liquefaction of gases, shown in this theatre by Sir James Dewar, which have become the foundation of great industries.

It would be a mistake to attempt to measure the achievements of Faraday on a scale derived from a consideration of the immediate material benefits to the world which have accrued from his work. Probably no man, with the possible exception of Newton, has ever exercised throughout a century such a persistent directive impulse to the activities of a huge body of scientific workers. This is the more strange in that Faraday was essentially a solitary worker; the long list of his published papers includes but two in which he is named as a joint author. It would almost seem that the man was endowed with such consummate skill as an experimenter that any collaborator of his day would have impeded the progress of a joint investigation. It might perhaps have been anticipated that one so much accustomed to work alone, and as a pioneer far ahead of most of his contemporaries, would have tended towards narrow specialisation and have gradually lost interest in other branches of scientific activity by reason of intense cultivation of his own field of investigation. Some justification for such an expectation may be sought in the fact that although he was the first secretary of the Athenæum Club, he resigned the position after one year of office, and that he declined nomination to the presidency of the Royal Society on the ground that it would impede his experimental work. But the lengthy correspondence of Faraday with Schönbein, Liebig, Whewell, Wheatstone, Agassiz, Dumas, Wollaston, Herschel, de la Rive, Gay-Lussac, and a host of other great contemporaneous scientific men, shows that his interests were widespread, and that he bore always in mind his primary concern for the advancement of natural philosophy as a whole. One of the most acute judges of his fellow-men, the Count Camillo Cavour, records an appreciation which is worthy of quotation; he found Faraday "without a waistcoat, in a ragged old coat, looking for all the world like a sixteenth-century savant. But one can see that he has great rapidity of perception and quickness of decision—two qualities which lead almost instinctively to these great discoveries. There is not a scrap of scientific conceit about him."

In this conservation of a wide scientific interest, so difficult for an isolated worker, the nature of Faraday's duties in the Royal Institution must have played a great part. One of his major tasks consisted in expounding the results of current scientific progress to a cultured, though not a specialist audience; his sense of responsibility towards that audience led him so to train his powers that he became the most efficient popular exponent of science of his day. His lectures to children on the chemical history of a candle show that he was an unrivalled master of lucidity of exposition and a genius in the device of simple but convincing illustrations.

It must not, however, be imagined that Faraday confined himself to the discovery and exact statement of experimental facts without thought for their theoretical significance. His respect for a bold and far-reaching generalisation, put forward as a mathematical interpretation of facts—and this is what is meant by a theory—is expressed in many of his writings. He begins one of his papers with the following passage:

"That wonderful production of the human mind, the undulatory theory of light, with the phenomena for which it strives to account, seems to me, who am only an experimentalist, to stand midway between what we may conceive to be the coarser mechanical actions of matter, with their explanatory philosophy, and that other branch which includes, or should include, the physical idea of forces acting at a distance; and admitting for the time the existence of the ether, I have often struggled to perceive how far that medium might account for or mingle with such actions generally, and to what extent experimental trials might be devised, which, with their results and consequences, might contradict, confirm, enlarge, or modify the ideas we form of it, always with the hope that the corrected or instructed idea would approach more and more to the truth of nature, and in the fulness of time coincide with it."

The literature of science may be searched in vain for a more sympathetic and a more accurate definition of the relation which should exist between the pure experimenter and the mathematical interpreter of the observed facts: and because Faraday was both. Clerk Maxwell, who was the first to translate Faraday's brilliant conceptions into mathematical language, and to apply to them all the powerful methods of the mathematical workshop, observed that:

"The way in which Faraday made use of his idea of lines of force, shows him to have been in reality a mathematician of a very high order—one from whom the mathematicians of the future may derive valuable and fertile methods."

This is the deliberate opinion of one who was not given to exaggeration, and who, in the course of a short life, contributed more perhaps than any other to the development of mathematical physics in the Victorian period. That Clerk Maxwell's judgment was sound is obvious to all who have had occasion to study the remarkable series of experimental researches in electricity published by Faraday between 1831 and 1860; early in these classical investigations Faraday succeeded in forming very clear ideas concerning the manner in which an electric current operates in the decomposition of water or of salts in solution. He showed that when water is electrolysed the quantity decomposed is exactly proportional to the quantity of electric energy which has passed, and that the products of the decomposition can be collected and measured "with such accuracy as to afford a very excellent and valuable measurer of the electricity concerned in their evolution." He showed further that in all cases the quantity of chemical decomposition is exactly proportional to the quantity of electricity which has passed through the electrolyte, and that a given quantity of electric energy liberates chemically equivalent amounts of the metals during the electrolysis of metallic salts. In this way Faraday was able to determine a series of numbers representing the electrochemical equivalent of the elements, and to show that the electrochemical equivalent is the same as the chemical equivalent. It remained for a later worker, Sir Edward Frankland, to formulate the conception of valency, to point out that the true atomic weight of an element, divided by the valency, gives the chemical equivalent, and so to pave the way for securing the atomic theory in its present impregnable position. The work of Faraday on electrolysis was one of the essential steps taken during the nineteenth century to realise what Newton foresaw when he remarked:

"It seems probable to me that God in the beginning formed matter in solid, massy, hard, impenetrable movable particles, of such sizes and figures, and with such other properties, and in such proportion to space, as must conduce to the end for which He formed them; and that these primitive particles, being solids, are incomparably harder than any porous body compounded of them, even so hard as never to wear or break in pieces; no ordinary power being able to divide what God Himself made one in the first creation."

But still more far-reaching consequences resulted from Faraday's electrochemical work; he often expressed his conviction that the forces termed chemical affinity and electricity are one and the same, and he had been led to associate a definite quantity of electricity with the liberation of the atomic unit of an element from combination. There must thus exist a definite minimum unit of electricity; and, as Helmholtz indicated more definitely in 1880, not only matter but also electricity itself has an atomic structure. The discoveries of the last thirty years, which have resulted in the isolation of the atom of negative electricity—the electron—and the identification of the atom of positive electricity with the positively charged hydrogen atom, are the logical outcome of the work of Faraday.

To the chemist the discussion, applications, and extension of Faraday's electrochemical conceptions have been a fruitful source of inspiration and progress for nearly a century; as time passes on, those conceptions are seen to increase continually in fundamental significance. It cannot be doubted that when the second centenary of the discovery of benzene is honoured in this theatre a hundred years hence, my successor will be able to point to consequences still more fundamental and far-reaching, of the work and thought of perhaps the greatest experimental genius the world has ever seen.

The Faraday Benzene Centenary.[1]

By Prof. Henry E. Armstrong, F.R.S.

An indescribable feeling of deepest reverence thrills those who know that they are within a holy of holies when standing at this table whence Davy and Faraday and Dewar disclosed their discoveries to the world.

Consider the immensity of outlook it commands. A few days ago, the glories of Tut-ankh-Amen's most wonderful tomb were depicted, in minute detail, upon the screen behind me. We could realise that man stood higher, in the decorative arts, several thousand years ago, than he does to-day—that man was then deeply reverent in his beliefs. In stark contrast is the change in our civilisation—we call it advance—made within the past century, through the application of the discoveries discoursed of within these walls: in large measure fired by the tiny spark first shown to the world, at this table, in 1831. What reverence have we for such a discovery? Our men of letters pay no heed to it. The public at large has no knowledge thereof.

Chemists desire to show, by this commemoration, that they are persons mindful of the words of the ancient poet and preacher:

Let us now praise famous men
And our fathers that begat us.
The Lord hath wrought great glory by them
Through His great power from the beginning.
Such as did bear in their kingdoms,
Men renowned for their power,
Giving counsel by their understanding
And declaring prophecies:
Leaders of the people by their counsels
And by their knowledge of learning meet for the people,
Wise and eloquent in their instructions.

"Of them that have left a name behind them," Faraday is one of the greatest, certainly the greatest experimental philosopher the world has yet known. A Sandemanian, deeply religious, from his childhood upwards, throughout life, he advisedly kept his "science" apart from his religion but his moral faith was ever the background of his scientific productivity. His work was all conceived and executed in a deeply religious spirit. It will only be by following his example that wisdom will be made the religion of the people. He painted himself, his attitude during the whole of his career, in a lecture he gave in 1816, when only twenty-five years old, in saying—

"The philosopher should be a man willing to listen to every suggestion but determined to judge for himself. He should not be biassed by appearances; have no favourite hypothesis; be of no school and in doctrine have no master. He should not be a respecter of persons but of things. Truth should be his primary object. If to these qualities be added industry, he may indeed hope to walk within the veil of the temple of nature."

Speaking at this table, in May 1854, addressing His Royal Highness, the Prince Consort, who occupied the chair, Faraday said: "I take courage, Sir, from your presence here this day, to speak boldly that which is on my mind." The lecture was on "Mental Education." In it he dealt with the need of self-education, through attention to "natural things," with the object of improving the faculty of judgment and making it proportionate.

"I will simply express my strong belief," he said, "that that point of self-education which consists in teaching the mind to resist its desires and inclinations, until they are proved to be right, is the most important of all, not only in things of natural philosophy but in every department of daily life."

The lecture was a profession of the attitude of mind in which he had accomplished his work.

Taking courage to speak boldly, in the presence of your Grace, I would say that even the world of science, to-day, is in great need of following counsel such as Faraday gave in his incomparable lecture. We are too prone to speculate—often too inconsiderate in speculation—too little alive to our own individual ignorance—

[1] Address delivered at the Royal Institution on June 16, the Duke of Northumberland in the chair, at the celebration of the centenary of the discovery of benzene by Faraday.

too little bent upon cultivating that breadth of vision and proportionate judgment which is at the root of scientific method. Overcome by the ecstasy of practical achievement, we are too little mindful of the public interest: we are doing too little to make scientific method a public possession. Faraday's dream is in no way fulfilled: the spirit of science in no way enters into our commerce, into our industry, into our public life.

Our best way to praise famous men is to take to heart the lessons of their lives. Consider what Faraday did, at this table, to accomplish the exhortation—"Suffer little children to come unto me." He introduced the Children's Christmas courses and in all his lectures endeavoured to come down to the level of his hearers. How different this from our modern practice—our entirely selfish use of jargon.

We seek to-day to direct attention to Faraday's special greatness as a chemist. He is generally thought of in connexion with electrical discovery but it is significant that he began his career as a chemist: that he grew up in the severity of a proper chemical discipline: just at the time, however, when electricity was coming into vogue. Inspired by his great master, Humphry Davy, fascinated by the wonderful use Davy had made of the electric current in liberating the alkali metals and in discovering the nature of so common a substance as lime, gifted with marvellous power of insight and unhampered by the mass of detail which encumbers our modern thought, he could not do otherwise than recognise the reciprocal inseparable nature of chemical and electrical phenomena. He ultimately proclaimed the essential unity of chemical and electrical change—not yet generally recognised by chemists, though in these days even matter is regarded as of electrical origin. We have yet to acknowledge Faraday's prescience and the consequences of this, his prime discovery.

The range of his chemical activity is astounding, the more when we consider his slender equipment and the fact that he did almost everything himself. As one of the earliest workers in organic chemistry, he stands pre-eminent. He not only discovered the hydrocarbon benzene but also three of the five chlorides of carbon; moreover he was the first to study the sulphonic acids, a class of compound now of the first technical importance. His achievement in making these acids was akin, in principle, to that by which Montgolfier's balloon was changed into the air-ship of to-day, by the introduction, into the car, of the internal combustion engine with its propeller. Naphthalene is an unwieldy hydrocarbon which floats upon water but cannot swim in it, being insoluble—Faraday, by introducing the elements of sulphuric acid, made it soluble and mobile. The discovery has been of infinite service in the dyestuff industry. Faraday was one of the first to examine caoutchouc. His name is associated, for all time, with the liquefaction of the gases. He also studied alloys of iron, optical glass and gold in the finely divided state—each an inquiry of major consequence. Many minor issues were examined, always with perspicacity.

The discovery upon which we base this commemoration, that of benzene, will always rank as one of the most fundamental discoveries of chemistry. If not the entire hub of the organic section of our chemical universe, benzene is at least a major part thereof. Our edifice, in fact, has two foundation stones: one, the simple carbon atom, which can be extended endlessly, as links are, in a chain; the other, a closed complex unit or block of six carbon atoms, ranged as in the diamond and associated symmetrically with six atoms of hydrogen. This latter we call benzene. It is, in fact, just a bit of diamond, mounted and preserved in hydrogen, as though this were *aspic*. The beauty of the diamond, however, is as nothing compared with that of benzene in the eyes of its many mistresses.

Faraday separated benzene from the products of the decomposition of oil by heat. He seems to have taken an interest in these products so early as 1818 but did not come into possession of the material for their study until April 26, 1825. Beginning the investigation on this date, he soon isolated benzene and may be said to have discovered it on May 24, the day on which he first determined its composition, by an operation itself a wonderful experimental "tour de force"; the memoir in which he submitted his discovery to the Royal Society is dated June 16. Having studied a material such as he used and knowing its complexity, I marvel at the rapidity with which he carried out the inquiry and the accuracy of his deductions. It is a work of astounding genius.

In those days, formulæ were scarce known. Dalton had but recently put forward his atomic theory. Faraday, however, was already alive to their use and called his product bicarburetted hydrogen, C_2H, the value then assigned to carbon being half the present value. He gives the data for the molecular formula, C_6H_6, though molecular formulæ were unthought of then. About ten years later, the hydrocarbon was prepared from benzoic acid, by Mitscherlich, who altered the name to *benzin*, which Liebig changed to *benzol*. Later (1834), the systematist Laurent introduced the use of the terminal *ene* (ène); alternatively, he proposed the name *phêne* (from φαίνω, to shine), whence phenyl.

The classic academic event in the history of benzene was the introduction by Kekulé, in 1860, of the conception of a closed system of carbon atoms typified by the world-renowned hexagonal formula. He has told us how the idea first came to him when going home to his lodgings on the top of a London bus. Since then, benzene and its derivatives have been the subject matter of a vast volume of inquiry by all the nations: German chemists, however, were long the leaders.

Attention was first specially directed to the presence of benzene in coal tar in 1845. The process of extracting it was devised, in 1849, by Mansfield, working in Hofmann's laboratory in Oxford Street, London. To-day, the gases formed on heating coal to redness, either in manufacturing town's gas or metallurgical coke, are most carefully stripped of benzene and allied hydrocarbons. Our output of "crude benzol" is estimated at 22,000,000 gallons, which is mostly used as motor fuel. Certain petroleums contain considerable quantities of benzene hydrocarbons.

Benzene only acquired technical importance from 1856 onwards, when our countryman, William Henry Perkin, entered upon his great adventure, at the age of nineteen. He not only discovered the first aniline colour, mauve: he also founded the artificial dyestuff industry. To-day, the natural colouring matters are all but displaced by dyestuffs, often superior, derived more or less directly from benzene.

Nothing that has happened since Faraday made his discovery would have given the philosopher greater pleasure than the advance in our knowledge of the origin of colour—a subject which once filled his mind. Turning to his remarkable correspondence with the Swiss chemist, Schönbein, whose name comes next to those of Priestley and Lavoisier in the history of oxygen, we find Schönbein, in a letter dated Oct. 17, 1852, writing to him as follows:—

"Entertaining the notion that in many, if not in all cases, the colour exhibited by oxycompounds is due to the oxygen contained in them or, to express myself more distinctly, to a peculiar chemical condition of that body, I have continued my researches on the subject and obtained a number of results which I do not hesitate to call highly curious and striking. . . . I am nearly sure that you will be pleased to repeat the experiments, for either by mere physical means or by chemical ones you may make and unmake or change the colour of a certain substance without altering the chemical constitution of those matters. To my opinion, that wonder is performed by changing the chemical condition of the oxygen of the oxycompound."

To this Faraday replied on December 8:—

"Your letter quite excites me and I trust you will establish undeniably your point. It would be a great thing to trace the state of combined oxygen by the colour of its compound, not only because it would show that the oxygen had a special state, which could in the compound produce a special result—but also because it would, as you say, make the optical effect come within the category of scientific appliances and serve the purpose of a philosophic induction and means of research, whereas it is now simply a thing to be looked at. Believing that there is nothing superfluous or deficient or accidental or indifferent in nature, I agree with you in believing that colour is essentially connected with the physical condition and nature of the body possessing it and you will be doing a very great service to philosophy if you give us a hint, however small it may seem at first, in the development or, as I may even say, in the perception of this connexion."

Before you are two specimens, one of quinol, the other of quinone, one colourless, the other coloured—yellow. Quinone is the type of all organic colouring matters. In quinol, the simple molecule of water, H·O·H, less an atom of hydrogen, is introduced twice into benzene, in place of two of its atoms of hydrogen: it is colourless. Remove from it two atoms of hydrogen, one from each of the two OH groups: the product, quinone, is yellow in colour. It is as Faraday supposed—the condition of the oxygen is altered and certain centres in the molecule become active absorbents of the light waves.

I have ventured to hang upon the inward wall of this great fortress of science, which Faraday occupied to such wonderful purpose, "a banner sable, trimmed with rich expense," bearing a strange device emblematic of benzene. Faraday's initial is enclosed within the hexagon which symbolises his discovery. This symbol is one that we may aver will last for all time, as upon it may be welded all the facts relating to benzene. It is probably the most significant symbol ever devised, for it has veritable volumes of meaning in the chemist's seeing eye. From it the colours irradiate—though not precisely in prismatic order. Colour, at its first appearance, is either yellow or blue, according to the type of compound, yellow being always associated with simplicity of type. As molecular complexity is raised, yellow is gradually intensified and passes into the richest red. Blue, in like manner, becomes intensified and may pass into green, which is the forerunner of black. The changes are due either to changes in the weighting of the absorbing centres or to their cumulative repetition and co-operative action.

Behind me is a curtain of wondrous texture and colour, dyed with *Jade green*, one of the latest and most valuable, certainly the most remarkable of the anthracene vat-colours: it was first made in Scotland. Mark its symbol—it is benzene soldered upon benzene, many times over: a *Nonaphene*. The two lone, unsociable, oxygen atoms are the main cause of its colour. Note the wonderful change in colour when these oxygen atoms are wedded each to an atom of hydrogen—now the *Jade green* becomes a salmon-red, with a most remarkable fluorescent sheen, indicating a simplification of the light-absorbing mechanism. The big hank of viscose silk across the green curtain is dyed with the material in which the green has been thus wedded hydrogen: if oxygen be allowed to take away the hydrogen, the dyestuff again becomes green, may we not say, with envy. Note also this intensely blue hank. In *Jade green* the oxygen atoms are related as are my thumbs when I so juxtapose my fingers that the backs of my two hands are in the same plane. Turning one hand round, my thumbs become related diagonally. Making a like change in the molecule of *Jade green*, converting the dibenzanthrone into isodibenzanthrone, the colour passes into blue: wed the oxygen with hydrogen, it passes into red of a blue shade. We can picture what would have been Faraday's and Schönbein's ecstasy of delight at seeing their prophecy verified in such chameleon-like behaviour.

I have referred to Viscose silk. What would Faraday have said, if told that we had not only found " tongues in trees " and gone far to discover " good in everything " but also that, spider-like, we had made the mere timber of trees into a veritable silken web, carrying colours of every hue made from his benzene, a material found worthy of notice even by a Chancellor of the Exchequer and actually worn not by Queens alone but also by most of their female subjects? Could we tell him these things, might he not well ask what is left for poor Nature to do: at the same time, he would be the first to recognise that we had studied " natural things " to some purpose and had he foreseen the power chemists were to wield over Nature, he would perhaps have elected to remain a chemist and have thought little of electricity—as do chemists to-day.

We may go further still in tracing the scientific progress of benzene. It is written that " the last shall be first." Benzene, however, retains its dominance and is everlasting. The discovery of the first Fullerian professor, benzene and its descendants are now the objects of most serious attention by the latest holder of the chair. Racked upon his goniometer, tortured by X-rays, they are being forced to disclose the secrets of their inmost atomic centres: their molecular dimensions are being determined in ultramicroscopic terms. Faraday would not have been surprised: he would have been the first to welcome such achievements but with reverence, as well as delight at our progress.

By some uncanny mental process, the chemist has prophesied what X-rays are justifying; and now a new era is upon us, one for which we must prepare ourselves. Like Faraday, we must have many-compartmented minds. We must learn to think in the solid. The chemistry of the future will be spatial in dimensions and distribution. It will be in no slight degree a science of solid geometry. I have here a model of benzene in terms of units such as X-rays reveal to us in the diamond. Mr. William Barlow and I desire to lay this to-day upon Faraday's table as a solid tribute to his memory: it is something more than a mere symbol: we believe it to be a very close approach to the geometrical structure of the molecule. It is something I have hoped for during the whole of my life. There are other models here, made by Mr. Barlow, of various derivatives of benzene, all in close accordance with crystallographic data.

To return to colour, the colour-chemist to-day is a super-magician. If women could be scientific, they would insist upon being stamped all over, not with a king's cartouche, such as we have seen was used on Tut-ankh-Amen's tomb; no, with the hexagon symbol of benzene, as the emblem of the colours in which they are now arrayed far more gloriously than were ever the lilies which Solomon, we are told, could not rival. To-day, we can paint the lily with its own colour. We make the colours of the lily, indeed those of most flowers, in the laboratory, actually from benzene. Faraday, in Sandemanian moments, would almost have regarded this as sacrilege.

To-day is no common occasion and we desire to deal with it in no common way. This commemoration is held at the instance of a remarkable and unusual conjunction: by the Royal Institution, acting together with the Chemical Society, the Society of Chemical Industry and the Association of British Chemical Manufacturers—a trinity completely representative of English chemical interests. Chemists desire to show that for once they can think together. We together acclaim the memory of Faraday—of Faraday the complete philosophic chemist. Moreover, our committee has decided to take in hand the preparation of a medal, to be awarded at intervals, perhaps sexennially, without regard to nationality, for an outstanding achievement in some clear relation with Faraday's discovery of benzene. We desire not only to keep his influence alive but also to extend it. We propose to follow a well-known practice of the clergy and make the first award, in anticipation, to-day. We ask Mr. James Morton, of Carlisle and Grangemouth, to accept promise of the first Faraday Benzene Centenary Medal, in special recognition of the signal service he has rendered to chemical science and industry in Great Britain, during the past ten years, by developing and extending the manufacture of the anthracene vat-dyestuffs and, more recently, by extending their application to silk and wool.

Faraday and his Contemporaries.[1]

By Prof. Ernst Cohen.

YOU all know Lord Byron's reply to the malignant diatribe on his "Hours of Idleness," published by the *Edinburgh Review*, the slating critique which advised him "that he do forthwith abandon poetry, and turn his talents, which are considerable, and his opportunities, which are great, to better account."

Some years afterwards Byron himself admitted that he had gone too far in his "English Bards and Scotch Reviewers," saying: "The greater part of this satire I most sincerely wish had never been written, not only on account of the injustice of much of the critical and some of the personal part of it, but the tone and temper are such as I cannot approve." Not only did he attack in this most vehement effusion the achievements of English literature, but also he fretted and fumed about those produced by contemporary science:

"Thus saith the Preacher: 'Nought beneath the sun
Is new; yet still from change to change we run;
What varied wonders tempt us as they pass!
The cow-pox, tractors, galvanism, and gas,
In turns appear, to make the vulgar stare,
Till the swoln bubble bursts—and all is air!'"

The word "tractor" wants explanation, as its meaning differs from that which it has to-day.

About the year 1796 an American physician, Dr. Elisha Perkins, invented an instrument, which he named "metallic tractors," for the cure of local pains, inflammations, and rheumatism. The tractors, he claimed, were of peculiar and secret composition, but it is asserted that one was of iron, the other brass. They were three inches long and pointed. In use they were drawn downward over the affected part of the patient for twenty minutes. Dr. Perkins' son published a book in London, introducing the method, and it inspired so much faith that a Perkinsian Institution was opened, of which Lord Rivers was president. Recommendations were signed by many physicians and clergymen and thousands of cures published, so that the inventor pocketed a considerable sum of money. Heated discussions arose, and James Gillray, the celebrated caricaturist, lampooned the matter in his production "Metallic Tractors," where Dr. Perkins is seen trying to restore, by means of his instrument, the normal shape of the nose of a drunkard.

That Byron had been absolutely wrong so far as gas bubbles are concerned is evident from the most interesting addresses we had the good fortune to hear a few moments ago, as gas was the material to which we owe Faraday's wonderful discovery of the foundation-stone of a major section of organic chemistry and of the synthetic dye-stuff industry.

If Byron had been right where he mentions Dr. Jenner's magnificent invention, what would have been to-day the aspect of this assembly?

Allow me to remind you in this place where chemists from all parts of the world are gathered to-day to do homage to the memory of one of the most admirable geniuses, of one of the most noble characters England ever produced, that Byron continued his comedy of errors when he ridiculed the achievements with which Galvani and Volta as well as Humphry Davy had presented natural philosophy. This can scarcely be done in a more striking way than by resuming, be it only in a few words, what the human race owes to Michael Faraday in his capacity of a physical chemist, especially in that branch of our science which was so mercilessly attacked by the author of "English Bards and Scotch Reviewers."

Two years after the discovery of benzene, Faraday published his "Chemical Manipulation." This title is far too narrow, as we have to deal with an almost complete laboratory companion for physico-chemical work. In none of our contemporary books on this subject is so much stress laid upon the necessity of cleanliness in laboratory work, none of them gives so strong evidence as Faraday's manual that Peter Riess was absolutely wrong in his definition of chemistry:

[1] Address delivered at the Royal Institution on June 16, the Duke of Northumberland in the chair, at the celebration of the centenary of the discovery of benzene by Faraday.

"Die Chemie ist der unreinliche Teil der Physik," which runs in plain English: "Chemistry is the dirty part of physics." Every page of this most valuable book not only shows the author's passion for his subject, but at the same time his extraordinary skill as an experimenter, who tries to perform the operations, when desirable, with the smallest number of requisites. Years afterwards this faculty of Faraday's was symbolised by a most charming cartoon of *Punch* with this legend: "Faraday giving his card to Father Thames; and we hope the Dirty Fellow will consult the learned Professor." The adjoined text runs as follows:

"A Philosopher Afloat.

"A chemical work of small size and great importance has been lately published. The production alluded to is Faraday on the Thames, a title which means even more than it appears to mean; for it not only expresses Professor Faraday's views of the composition of the river, but also describes the sensations experienced by him during a period of brief transit upon its surface. A piece of white card, according to the professor, becomes invisible at a very small degree of submersion in the Thames water, which is of a peculiar colour—'opaque pale brown'-drab-quakerish—and a not very peculiar smell, because it partakes of that of the sink-holes, and may be described as odoriferous, but not fragrant. We have often had great pleasure in hearing Faraday explain the composition of water, pure and simple; but we rejoice much more that he has enabled the public to form a correct idea of the constituents of that of the Thames, which consists of something more than Oxygen and Hydrogen. Because we are losing brave men by war, it is rather the more desirable than otherwise that we should not also lose useful citizens by pestilence, as we certainly shall if the Thames continues much longer to be an open sewer. We hope that Professor Faraday's publication, which takes the shape of a concise letter to the *Times*, will effect a saving of human life still greater than that which has resulted from his predecessor's safety-lamp. Davy's invention prevents carburetted hydrogen from blowing up miners; may Faraday's epistle avert cholera and typhus by stirring up senatorial and municipal persons to prevent sulphuretted hydrogen from being disengaged."

In the year 1830 an event occurred in Great Britain which is to be considered as unique in the history of science. Let me tell you this historical story, as I did some time ago on another occasion.

Charles Babbage, then a professor in the University of Cambridge, published a small pamphlet, "Reflections on the Decline of Science in England and on some of its Causes," in which he tried to prove that England was, with respect to the more difficult and abstract sciences, not only below other nations of equal rank, but even below several of inferior power. It should be mentioned that this opinion did not remain unnoticed abroad. A short time afterwards a reply was published to Babbage's book. Its title was, "On the Alledged Decline of Science in England," by a *Foreigner*. Now I found that this foreigner was Dr. Moll, then a professor of physics in the University of Utrecht. It may interest you also that I found that Faraday, who was an intimate friend of Moll's, paid the publishing expenses, Moll being unable to find a publisher. The Utrecht professor proved that Babbage was wrong. Here you see on the screen a caricature of the time, with the legend: "Dedicated (but not), with permission, to the British Association for the Advancement of Science." I have been able to prove that the men pictured represent Moll and Dalton meeting at the Royal Institution of Edinburgh, Dalton expressing thanks to Moll for having defended British Science. The name of the author of this picture, who hides behind the initials X Y Z, is unknown up to the present.

Even to-day it can scarcely be understood how Babbage could express such an unfavourable opinion at a period when such a brilliant array of British names had become immortal by scientific labours. As if Faraday had cherished the desire to give the lie to Babbage's arguments, a few years later he presented science with the discovery of those wonderful laws which for all times will form the base of the theory of electro-chemistry. Do not suppose that this achievement was immediately unanimously applauded. I find in a letter of Berzelius to his friend Wöhler, written some months after the publication of Faraday's celebrated paper: "I have got Faraday's sixth and seventh paper and read his discovery of definite proportions of electricity, which has been so greatly extolled in England. It covers 4 sheets of printing, and is devilishly hard to read. Besides this the conceptions developed in this purely theoretical paper are so narrow that it declines very strongly my former opinion of Faraday." But some months later Berzelius again changed his mind, and in his review of Faraday's investigations, published in his *Jahresbericht* of the year 1835, he wrote these sentences: "As a matter of fact, Faraday created by his meritorious investigations the possibility of founding our theoretical conceptions on a more reliable base."

To-day we know that there scarcely exists any natural law which holds good within such wide intervals of concentration, temperature, and pressure as those discovered by this hero of science. From the chemical point of view it is to be emphasised that his investigations, which culminated in the demonstration that equivalent quantities of substances have equal quantities of electricity associated with them, disproved, once and for all, the Berzelian hypothesis that a greater quantity of electricity is needed to separate a compound of a very positive with a very negative element, or radical, than is required to separate a compound of a less positive with a less negative element, or radical. But, at the same time, Faraday's researches strengthened that part of the Berzelian doctrine which asserted the existence of a close connexion between electrical and chemical forces.

Looking to-day at Faraday's words: "The electricity of the voltaic pile . . . is entirely due to chemical action, and is proportionate in its intensity to the intensities of the affinities concerned in its production, and in its quantity to the quantity of matter which has been chemically active during its evolution," we immediately recognise in them the roots of the magnificent development which the doctrine of chemical affinity has shown since those times by the labours of Willard Gibbs, von Helmholtz, and van 't Hoff. While the whole of the present electric industry is based on Faraday's discoveries in the fields of converting electric energy into mechanical power or, reciprocally, of obtaining electric energy by an expenditure of mechanical work, electro-chemical industry owes its existence to his far-reaching researches in the field of chemistry.

It would be carrying coals to Newcastle to give here an account of the influence of these achievements upon our purely theoretical conceptions and upon the conveniences of modern life, which could never have been dreamed of by our ancestors. Recalling this to mind, we cannot but repeat Shakespeare's words:

> "He was a man, take him for all in all,
> I shall not look upon his like again."

The Royal Institution.

New Honorary Members.

THE proceedings at the centenary celebrations at the Royal Institution were marked by the presentation of diplomas of honorary membership to six distinguished foreign chemical workers. The presentations were made by the president of the Institution, His Grace the Duke of Northumberland, and the recipients, two of whom were represented by fellow-countrymen who were able to be present, were introduced by the secretary of the Institution, Sir Arthur Keith, in the following words:

Gabriel Émile Bertrand, professor of biological chemistry at the Sorbonne, Paris, and Director of the Laboratory of Biological Chemistry at the Institut Pasteur. Prof. Bertrand is distinguished as an inquirer into bacterial activity, particularly in connexion with oxidation phenomena, of which he has made a special study. He has also paid great attention to the influence of minute quantities of metals not usually regarded as acting upon the course of vital change.

Ernst Julius Cohen, professor of general chemistry and inorganic chemistry, University of Utrecht, Holland. Prof. Cohen is an acknowledged leader in physical chemistry, the biographer in England of his master, Van 't Hoff, and like him, a devoted student of Byron.

Piero Ginori-Conti, Senatore, president Associazione Italiana de Chimica, Generale ed Applicata, Rome, Italy. Prince Ginori-Conti has acquired distinction by capturing natural steam and using it as a source of energy, at the same time extracting from it large quantities of boric acid. He manufactures perborates from this latter by Faraday's method of electrolytic oxidation.

James Flack Norris, professor of organic chemistry, Massachusetts Institute of Technology, and secretary of the American National Research Council. Prof. Norris is president of the American Chemical Society, a constituency of 15,000 chemists. He is professor in the most noted of American Technical Schools, the Massachusetts Institute of Technology, and himself a well-known original worker.

Joji Sakurai, president of the Japanese National Research Council, emeritus professor, Imperial University of Tokyo, Japan, and member of the Japanese House of Peers. Prof. Sakurai was a student under the late Prof. A. Williamson at University College, London, one of the first small band of Japanese students who came to Europe to acquire a knowledge of western science. Working upon foundations laid by the late Prof. Divers, he has long been noted as the inspiring mind in Japanese chemistry. A founder of the National Research Council of Japan, he is now actively engaged in promoting the application of science generally in his country.

Frederic Swarts, professor of chemistry, University of Ghent, Belgium, and member of the Royal Academy of Belgium. Prof. Swarts is the son and successor of the successor of Kekulé in Gand. His father was Kekulé's assistant at the time (1868) Sir James Dewar worked in Gand, together with Körner, celebrated as the first to disclose the value of Kekulé's benzene symbol. Prof. Swarts is distinguished as a student of the organic compounds of fluorine.

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