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Medical Research in Great Britain.[1]

THE Report of the Medical Research Council for the year 1923–24 to the Committee of the Privy Council for Medical Research consists for the most part of a condensed epitome of the results already achieved during the year by research workers wholly or in part financed by the Council. The large number and great variety of the researches undertaken make it impossible to refer to them individually in this article. Mention will, therefore, be made of a few subjects only which, either from the completeness of the issue arrived at or from the interest of the results obtained at the present stage of the inquiry, force themselves upon the attention.

Results of far-reaching importance are being achieved by the committee appointed under the chairmanship of Prof. J. Barcroft to investigate the properties of hæmoglobin; and a paper on the correlation between the spectra of various hæmoglobins and their relative affinities for oxygen and carbon monoxide has recently been published from Prof. Barcroft's laboratory in Cambridge. Using the Hartridge reversion spectroscope, it was found that a relationship existed between variations in the gas-binding affinities of different hæmoglobins and in the character of the α-bands. These variations appear to be conferred on the hæmoglobin by differences in the protein part of the molecule.

That light was a potent means of disturbing the equilibrium between hæmoglobin, carbon monoxide, and oxygen was confirmed by the investigators engaged in this research, and its action on other biological processes is being intensively studied by many workers at the present time. It has been found that the bactericidal power of blood is raised by exposing the skin of the subject to ultra-violet radiation, the exposure causing in some obscure manner a greater avidity of the leucocytes for the organisms with which they come in contact. This result may be related to the now well-known beneficial action of sunlight in tuberculous infection in man, an action which is being demonstrated with such success by Rollier at Leysin and by Gauvain in Great Britain.

It is not alone in its power of increasing the resistance of individuals to microbic infection that light is being exploited in research schemes at the present time. Rapid progress is being made in the elucidation of the relation between irradiation and dietetic deficiency. It had previously been shown that exposure of rats fed on a diet deficient in fat-soluble vitamins to ultra-violet radiation was capable of bringing about normal growth. This effect was found to persist if the containers in which the animals lived were irradiated, and the result was interpreted as pointing to some property

[1] Committee of the Privy Council for Medical Research. Report of the Medical Research Council for the year 1923-1924. Pp. 142. (London: H.M. Stationery Office, 1924.) 3s. 6d. net.

conferred by the ultra-violet light on the air in the immediate environment. Independent experimentation, however, failed to confirm this; and quite recently the original observers of the phenomenon have come to the conclusion that the positive results obtained by them were due to the presence of sawdust in the glass containers during the period of irradiation. When a piece of deal board was substituted for the dust an intermediate rate of growth was found. No precautions were taken to prevent the animals consuming some of the sawdust or gnawing away pieces of the irradiated board; but experiments at present in progress suggest that actual ingestion of the irradiated material is not essential for its beneficial action.

This result, if confirmed, is clearly one of fundamental and far-reaching importance. In the experiments referred to, the values for calcification of the bones were found to follow those of growth very closely. Whatever the nature of the emanations from these materials after exposure to ultra-violet light may happen to be, it is clear that a whole new field for research is rapidly opening up. What substances are capable of "phosphorescing" in this manner? Is vitamin A, the origin of which we know to be absolutely dependent on sunlight, a substance in which the power of absorbing ultra-violet light and converting this energy into a form of emanation having a potent effect in controlling the vital processes of growth and calcification, and is it developed to an extreme degree?

The Standards Department of the National Institute for Medical Research has now practically completed the work involved in the preparation of a stable dry standard of insulin. The Toronto unit will be defined in terms of this standard, which should then serve "as a currency for its transmission to all countries."

Much work is in progress on the nature and location of the action of insulin, when injected into animals, in causing the well-recognised fall in the blood sugar concentration. It had previously been shown by two Canadian physiologists that the isolated mammalian heart perfused with Locke's solution caused a fall in the sugar content of the perfusate, and that this fall was accentuated by the addition of insulin. The destiny of this extra quantity of sugar which disappeared remained, however, obscure. The question has recently been reinvestigated at the National Institute for Medical Research. Determination of the quantity of sugar disappearing in a given time, and the amount of carbon dioxide produced by the heart during the same period, have shown that in the absence of insulin there is a yield of carbon dioxide greater than can be accounted for solely by the combustion of the glucose removed. In the presence of insulin, however, the reverse is the case.

It is certain, therefore, that under the latter conditions part of the sugar is not oxidised, and at the present time the form into which the sugar has been changed remains obscure. It has been possible, however, to exclude certain hypotheses, such as that of the transformation of some of the sugar into fat, from a study of the respiratory quotient of the decapitated and eviscerated animal under constant infusion of dextrose. In such a preparation, insulin causes the characteristic fall in blood sugar, even when the muscles are inactivated by curare, without any change in the respiratory quotient which remains throughout at unity. Immediate transformation of the sugar into fat, or into lactic acid, seems therefore to be definitely excluded. Furthermore, investigations at Cambridge have shown that the heat production of isolated frog's muscle is unaffected by the presence in the surrounding fluid of relatively large concentrations of insulin. Recent work, too, on the sugar consumption of the heart-lung preparation has failed to show an increase in the rate of disappearance of this substance from the circulating blood on the addition of insulin. Insulin apparently is essential at some stage on the anabolic ladder of glycogen formation, though it will be clear from the foregoing account that we are still ignorant of the intimate nature of its action.

Studies of the excess metabolism of muscular exercise in man over and above the resting level have shown that this, provided the exercise is short-lived, has a respiratory quotient of unity. Experimental evidence all tends towards the conclusion that muscle is capable of metabolising directly carbohydrate alone.

It will be apparent from the few foregoing examples of work which is being pursued in the physiological and biochemical laboratories of Great Britain, that these two sciences are extremely virile and rich in productive effort. Turning to experimental medicine and clinical research, we find that here again much progress is recorded and "the Council are of opinion that during the past five years these University clinics have wholly justified their foundation by their success." Where the material for research is human, it is unavoidable that advance should be slower than in the sciences contributing to medicine. Furthermore, we must remember that the staffs of the medical and surgical units of the London hospitals are not in a position officially to exercise their option as to the type of case admitted to their wards any more than their colleagues on the remaining hospital "firms."

For teaching purposes this is no doubt an advantage, but it must inevitably break any attempt at co-ordinated research into the mechanism of the disturbances which culminate in disease. The first effective trial unit made by the Medical Research Committee, namely, the

Cardiac Department of University College Hospital Medical School, has more than justified its existence. This unit is unique in that it is engaged in an intensive study of the physiology, pathology, and nosology of one system only; a fact which is probably not unrelated to the richness of its scientific produce. The conception of "capillary pulsation" as a sign primarily of high pulse pressure, and in consequence a common accompaniment of aortic insufficiency, has been shown to be erroneous, the main causative factor of the phenomenon being a "widening of the arterioles of the skin or mucous membrane in which it occurs." The capillaries of the human skin have been shown to be capable of exerting relatively high pressures (from 50 to 100 mm. of mercury) when they are stimulated to contract by light stroking of the skin. Injury to the skin, on the other hand, leads to a train of vascular changes—dilatation and increased permeability of the minute vessels—which is conditioned by the liberation from the injured cells of a substance akin to histamine. To quote from an original paper,

"from the simple reactions of a healthy skin to the relatively mild stimuli such as are experienced daily by almost all; through the more serious, though trivial, local injuries, the bruise, the blister and the small scald, which find their simple household remedies; to the most grave mechanical injuries and extensive burns which in their late manifestations endanger life, we pass by transition. It begins to be apparent why this transition is throughout a transition of quantity and not of quality; for underlying the whole series of reactions there is seemingly one chief determining cause, the unvarying reply of the affected cell to injury; this response of the cell, protective as it is to the cell itself, when united with that of neighbours, produces a massive action, threatening or terminating the life of the organism as a whole; an example which is not the sole example of conflict between the cell and the community of which it is a member."

In the introductory review by the Council of its second quinquennium, attention is directed to the unsatisfactory position and progress of pathology and bacteriology. It is pointed out that in Great Britain this is in part due to the "accidents of historical circumstances," but that "in all countries bacteriology is halting for more intimate knowledge of the infective organisms and of their biochemistry, while pathology only shows promise of advance in so far as it proceeds as a study of the reactions of the body to disturbance, as a part indeed of physiology, and in so far as it can express its phenomena in terms of biochemistry."

The munificent benefactions which these two sciences have recently received at the Universities of Oxford and Cambridge through the generosity of the Dunn Trustees, the Rockefeller Foundation, and Mr. Ernest Gates, coupled with their full recognition by the universities as being sciences laudable of pursuit, will, however, doubtless raise their position rapidly and effectively to the level and productive capability of those sciences which are less directly concerned with the alleviation of human suffering.

It is impossible to read this Report of the Council without being impressed with the wide range of its activities and the wisdom it displays in allocating the funds entrusted to it by Parliament for the furtherance of medical research. E. B. V.

Geography and World Development.

Geography and World Power. By James Fairgrieve. Fifth impression. Pp. viii+373. (London: University of London Press, Ltd., 1924.) 5*s*. net.

North America: an Historical, Economic, and Regional Geography. By Ll. Rodwell Jones and Dr. P. W. Bryan. Pp. xiii+537. (London: Methuen and Co., Ltd., 1924.) 21*s*. net.

Europe. Vol. 1: *The Peninsula*. Edited by B. C. Wallis. (Stanford's Compendium of Geography and Travel, New Issue.) Pp. xxiii+763+40 maps. (London: Edward Stanford, Ltd., 1924.) 15*s*. net.

The New World: Problems in Political Geography. By Dr. Isaiah Bowman. Revised and enlarged edition. Pp. vi+630+112. (London, Calcutta and Sydney: G. G. Harrap and Co., Ltd., 1924.) 21*s*. net.

Elementary Commercial Geography. By Dr. Hugh Robert Mill and Fawcett Allen. Pp. ix+194. (Cambridge: At the University Press, 1924.) 4*s*.

MODERN science has changed the size and shape of the earth. Time is the measure of its distances and routes the framework of its shape. London is nearer to New York than to Kashgar, and the Pacific Ocean, once the limits of the Orient and Occident, is now becoming the strategic and economic centre of a new world based upon the universal ocean. The latest development is a bi-weekly service of motor cars across the French Sahara. The adjustment of human activities to physiographic conditions has been in progress from before the dawn of history, and human institutions have shown that they are no more permanent than the "everlasting" hills.

The author of "Geography and World Power" defines history in its widest sense on its material side as the story of man's increasing ability to control energy. In a most suggestive book he gives a series of excellent studies, showing how empires and states have developed conformable to certain major phenomena of a physical order, and how a change in geographic values has effected changes in the relative importance of nations. Some, no doubt, will quarrel with the word "control," and especially so when it is urged that

"Men may advance or fall behind because the geographical conditions affecting their bodies react on their minds"; and again: "In the long run the geographical conditions are more powerful than the genius of individuals, more powerful even than racial characters, unless these racial characters are due to geographical controls."

The genius of mankind shows itself in its adaptability to new physical environments and an increasing ability to harness or to modify certain natural phenomena. The modern farmer in Saskatchewan shows an entirely different adjustment to the natural conditions from that of the Indians who preceded him, though no doubt the influence of the prairies is as marked on the social and economic life of the present inhabitants as on the culture of the Plains Indians, their former occupants. But time is on the side of man. The cutting of the Suez and Panama canals, the irrigation works of California and S.E. Australia, are of the same order as the works of Nature which are said to be "controls"; and these are but an earnest of still greater scientific achievements. The hot deserts may not only be made to blossom as the rose, but these areas of excessive insolation may also become the power stations of a new age when man has used up his capital energy of oil and coal. Nevertheless, the main thesis holds true that world power, at present, is closely related to the ability of man to utilise the physiographic conditions of his region. A knowledge of the manner in which man to-day is adjusting himself to the modern complex conditions of world occupancy ranks high in the essential sciences. *Wissen ist Macht—Geographisches Wissen ist Weltmacht!*

The volume on North America furnishes not only innumerable illustrations of these principles, but also shows how these principles operate in the modern world. The first part traces the influence of physiographic conditions on the progress and development of settlement in America by emigrants from Europe. The second indicates the conditions which have arisen in North America from the application of modern science to the utilisation of coal, oil, and iron, and to the cultivation of wheat and cotton, both groups being extractive industries which are essentially localised. The third part reviews these historical and economic considerations from a geographical view-point, and discusses the present-day adjustment of life and labour which makes the geographic region a more powerful entity than the individual state. Both the localisation of industries, as the iron and steel on the Pennsylvania coalfields, and the cultivation, and in these days the manufacture, of cotton on the warm fertile lands of the Atlantic and Gulf plains, give rise to regional interests of a very definite character. Dr. Bowman states in his book, "The New World," in a section devoted to America: "To a much greater degree than an outsider might suppose, and in spite of all the patriotic assurances to the contrary, there is a deep underlying question in the minds of thoughtful men in the United States as to the continued unity of the nation." He reiterates the words of Prof. Turner that to-day the United States is a federation of sections rather than of states, and that even a map of political votes roughly outlines the geographic provinces of the country.

Regional development is not, however, antagonistic to national unity. Indeed, it often furnishes the driving force of political or economic expansion. Most of the world-development problems of our time are questions of political or economic frontiers largely developed by expansive forces generated regionally within the political boundaries. Regional consciousness is expressed within the nation, national consciousness within the world itself. Though there may be, and often is, a physical and historical background, the delimitation of political divisions is often of an arbitrary character. Europe bears on its new political map the evidences of both the constructive and destructive forces let loose by the War. The pre-War tendency towards consolidation into great and powerful states has been followed by disintegration into innumerable new states, as Poland, Czechoslovakia, and Yugoslavia, the uprising of which can be explained, if not also justified, by considerations of a physical, racial, or economic character. As a statement of the new political position within the "peninsula" of Europe, together with a certain amount of useful data about each state, the volume on Europe serves as an excellent reference book. It is what it claims to be, a "compendium" rather than a geographical treatise. Such is the organisation of a modern state that, complex as may be the adjustment of life and labour to the physical conditions of the area, it forms a body politic capable of determining policies affecting not only its internal but also its external affairs. Political lines will sever what Nature has joined, often dividing physiographic or economic regions into two or more geographic entities, as between the United States and Canada or between France and Belgium. On the other hand, political boundaries may bring a number of regional entities into a single political expression, as in the United States or France.

Though the political divisions may be somewhat arbitrary, the regional divisions within the state tend to be based on considerations of an economic character, which in turn may rest largely on physiographic foundations. The region has a distinctive life of its own, and the regional consciousness is more than the whirr of

its machinery or the rattle of its trains and lorries. It springs from an adjustment of life and labour to the area, and it lives, not so much because of the factors which brought one or more of its industries into being, but because of its functions to-day. A British company desirous of erecting additional cotton mills would place them in South Lancashire, not because of those factors which first attracted the industry, but because to-day the region possesses the machinery for dealing with the cotton trade; there are located the necessary subsidiary trades, and there is the great reservoir of labour skilled in the processes of cotton manufacture.

South Lancashire to-day lives, no doubt, on cotton, but fate has not decreed that it must die if cotton be withheld, providing the withdrawal of the raw material is sufficiently gradual to allow a readjustment to new activities. Man's salvation lies in his adaptability. London, like some urban Vicar of Bray, has accommodated itself to and grown with the changing conditions of the British Isles, thereby retaining the premier position in trade and commerce. If geographical science can so study what one may call the anatomy and functions of the region, diagnosing incipient diseases and prescribing cures, it will render invaluable aid not only to the body politic of which the region is a limb, but also to the millions of people whose lives are more or less anchored to the area. Must New England necessarily perish because the Southern States have now entered into competition with it?

"North America" and "The New World" furnish innumerable illustrations of world development, both in the purely geographic region and in the political region, which in these days assumes a geographic form. The former to-day conforms largely to an economic or physiographic foundation, because a region, like an individual, must in general live by work. One example from "North America" must serve. The broad indentation of the east American coast between Capes Cod and Hatteras appears on a relatively small scale map as an unnamed bay sweeping inward to the foothills of the Appalachians, broken in outline by three large inlets, Long Island Sound with the Narrows, and Delaware and Chesapeake Bays. These give access to river valleys which lead across the mountain barrier to the rapidly developing manufacturing and agricultural regions beyond. Population in the narrow belt of broken lowland has gathered round the three port nodals of New York, Philadelphia, and Baltimore. They and the surrounding districts form a region of considerable importance, though it is not easy to state exactly the causes of its growth. The most powerful may well be the very size and adjustment of the present population, compelling the consideration of the factors of its origin to be made in the light of modern demands and opportunities. What is said of New York, London, Berlin, and Paris may be applied to all great ports and their hinterlands. "Every individual quota to provincial population, whether industrial or agricultural, has its counterpart in metropolitan expansion." Every development in the hinterland has a corresponding development in the port. Yet Salem in New England and Chester in old England failed to keep the developing traffic of their hinterlands, and succumbed to Boston and Liverpool respectively. Great and prosperous cities have declined, and often the germ of decay has been secreted in the heyday of prosperity. When geographical science can not only observe accurately the full foundations of regional prosperity, but can also form an estimate of the vitality and capabilities of the region, it will have made a contribution of prime importance to mankind.

The political region or state presents a geographical study of a somewhat different order. The very rigidity of the frontier is incompatible with the economic development within and the expression of the national consciousness without. "The New World" is an exhaustive and masterly study of problems in political geography. They are problems of the frontier, either political, economic, or social. Dr. Bowman asks: "Will the changes in the political and economic geography of the world spell peace or war, strength or weakness, in the years immediately before us?" He then makes the comment that there are about 10,000 miles of boundary round the states of central Europe alone, of which more than 3000 represent newly located boundaries. "Every additional mile of new boundary, each new location, has increased for a time the sources of possible trouble." Indeed, it may not be too much to say that the conflicts of expanding frontiers have probably been far more determinant of historical development than the physical conditions over which these frontiers have passed.

The principal cause of regional growth, accompanied by economic or political expansion, lies in the increasing ability of man to develop and utilise the world's resources. This ability is most evident in the large, well-organised states, and creates not only the desire but also the power to push outwards into the world market. Economic or commercial geography throws considerable light on the character and direction of these movements, affecting not only the Great Powers of the world, but also the many states of Europe and Latin America. The "Elementary Commercial Geography" is a useful introduction to this aspect of geographical study.

The effect of the frontier in American history has long been recognised. But the expanding frontier did not rest on the shores of the Pacific States. In

Alaska and the Aleutians, Central America and the Caribbean Sea, in Hawaii, the Philippines, and other Pacific Ocean islands, the United States has extended its political possessions, and this has been accompanied by a still greater expansion of its commerce and prestige in South America and the Far East. Britain, France, Japan, and other nations differ from the United States not in kind, but merely in degree. The consequence is that world development is being accompanied by conflicting interests over wider areas than the mere frontier zones of individual states. Countries nominally independent, as China, and states under the administration of European powers, as those of Africa, are feeling the effects of world development. Moreover, the change in the regional life is not measured merely by the change in economic values. There is a profound change in the people themselves. The old order changes, giving place to new. A new orientation and a new outlook are rapidly being developed. The population, under the external stimulus from Europe or America, is adjusting its life and labour anew to the physiographic conditions and possibilities of the region. The African, the Egyptian, the Chinese, and a thousand other "questions" arising with world development have a regional basis, and demand the urgent and careful investigation of the new science of geography.

Some Sponges of the Southern Seas.

British Museum (Natural History), British Antarctic ("Terra Nova") Expedition, 1910. Natural History Report. Zoology. Vol. 6, No. 3: *Porifera.* Part 1: Non-Antarctic Sponges. By Prof. Arthur Dendy. Pp. 269 + 392 + 15 plates. (London: British Museum (Natural History), 1924.) 17*s.* 6*d.*

PROF. DENDY has produced a very beautiful and elaborate memoir on the sponges collected by the *Terra Nova* expedition in the southern seas. It is possible that such a highly technical piece of work may appeal only to a few readers at the present moment, but it can nevertheless be recognised as a permanent and important contribution to zoological science.

The modern developments of biology in the directions of embryology, the problems of heredity, experimental zoology, and comparative physiology have proved to be especially attractive to the younger generation of biologists, and no one can deny the value and importance of the scientific results of their work in the new fields of research that are being opened. It must be remembered, however, that the accurate and detailed description of new and old species, especially when it is accompanied by sound judgment in systematics, and careful consideration of the possibilities of natural variation and powers of adaptation to environment, is an important and indeed fundamental branch of the science of zoology. There is indeed a pressing need, at the present time, for more work of this description if we are to keep pace with the receipt of specimens that collectors are sending to Great Britain from all parts of the sea and land. To workers in this line, Prof. Dendy's account of the sponges may well serve as a model of what such monographs should be, and it is a great satisfaction to realise that some of our ablest zoologists are still willing to devote their time and expert knowledge to the production of systematic treatises of a high standard of merit.

All the sponges, except three, described in this memoir were obtained by five hauls of the dredge in water extending from the shallows to a depth of 100 fathoms off the north of New Zealand. The cruise revealed a very remarkable and, at the same time, a very rich fauna of sponges in these seas, such as has not yet been equalled in any region of the world. In these five hauls no less than 90 species were discovered, and of these 62 appear to be new to science. If it were to occur to any one on reading this statement in the introduction that in such a restricted area some of these species must be variations or mutations of relatively a few species, such a criticism would be dispelled by the careful description of the form and particularly of the spicules of the sponges the author describes.

The problems associated with the occurrence of such a remarkable assembly of organisms of the same group competing fiercely with one another for the advantages of the situation are not ready for solution, but the record of this wonderful sponge fauna is of importance in the science of the distribution of animals, and should not be lost sight of or forgotten because it is buried in a systematic treatise.

It is difficult to select from the many detailed descriptions of species the points of special interest for the general zoologist. The extraordinary range in form and structure of sponge spicules and the numerous technical terms that have been invented for them may be bewildering to those who are not well acquainted with the literature of the group, but there seems to be no doubt that in the Porifera the spicules are more constant in character for each species, and therefore more valuable for systematic purposes, than they are in the Alcyonaria. Accurate description and careful illustration of the spicules is an essential feature of a good monograph on sponges.

The discovery of two fine new species of the interesting group of hexactinellid sponges is a welcome and noteworthy point in this work.

The monograph is well illustrated by fifteen quarto plates, and we have to thank Prof. Dendy also for a good index.

The Rat Menace.

Rats and How to Destroy Them; dealing with Rats in a House, Shop, Warehouse, Outbuilding, Yard, Stable, Cow-house, Fowl-house, Pig-sty, Garden, Greenhouse, or Vinery; by a River, Stream, or Ornamental Water; on a Ship, Shooting Estate, or Farm; and in Sewers. By Mark Hovell. Pp. xlii+465. (London: J. Bale, Sons and Danielsson, Ltd., 1924.) 10*s.* 6*d.* net.

IT has been estimated that the damage caused by rats to the food supply and buildings in Great Britain alone represents a loss of something approaching 50 million pounds a year. In addition to this, the rat is a serious menace to society as a carrier of disease; the occurrence of infectious jaundice in epidemic form on the western front during the War and more recently in Scotland, where a mortality of 40 per cent. of cases occurred, has directed attention to a new danger near home, for which the rat is responsible. It is common knowledge that rats are prolific, but few people realise the rapidity with which their numbers increase. The litter in an adult rat varies from 8 to 16. Rats breed throughout the year, the period of gestation is only 21 days, and impregnation may again take place within a few hours of the birth of a litter.

A very moderate estimate of the number of descendants of one pair of rats born during one year is well over a thousand, and these in the course of three years will have increased to a quarter of a million; these calculations are based on litters of 10, and only 6 litters in the course of a year are allowed for. A single pair of rats will eat more than 80 quartern loaves or their equivalent in a year, and their descendants in the same year will eat more than 46,000 loaves or their equivalent in wheat or flour.

After reading the introductory chapter of Dr. Hovell's book in which these and many other interesting facts are lucidly presented, one cannot remain apathetic to this ever-increasing menace to humanity. The remainder of his book deals chiefly with all the known methods of preventing the spread of rats and destroying them in every conceivable situation. Traps of every description are described, with many illustrations, and the relative values of all the better known forms of rat poison are dealt with. A very interesting chapter is devoted to the history of bubonic plague, and the way in which it is carried by the various rat fleas. It is interesting to note that, even in Old Testament times, rats were in some way held responsible for the spread of plague, continual reference being made to "golden mice" which were made "as an offering for the Plague."

There is a short section on rat cancer and the life history of the nematode (*Spiroptera neoplastica*) which causes this disease in the stomach of the rat and passes its larval stages in the muscles of a species of cockroach. In this and in his remarks as to the possible relation of human cancer to cockroaches, the author is perhaps a little misleading, as he does not state that the cockroach in question is the New World cockroach *Periplaneta americana*, and not *Blatta orientalis*, which is the one common in Europe.

There is an appendix dealing with a scheme for the organised destruction of rats throughout the country, but though this would seem to be a highly desirable step, it would require special legislation to enforce.

The book is one which will direct public attention to a very real menace and at the same time be of the greatest assistance to those who are brought into direct conflict with that menace.

Our Bookshelf.

Masters of Science and Invention. By Floyd L. Darrow. Pp. v+350+24 plates. (London: Chapman and Hall, Ltd., n.d.) 10*s.* 6*d.* net.

IN recent years progressive science teachers have been pondering the problem of "humanising" scientific instruction, of introducing the breath of life into the "valley of dry bones" of experiment, observation, and inference, and thus in a measure treading on the ground hitherto monopolised by the humanists. The work under notice represents an attempt in this direction. The author has set himself the difficult task of giving, in simple biographical form, an account of the development of scientific achievement, and he states that "no knowledge of the laws of science and their manifold applications is even approximately complete without acquaintance with the outstanding figures who have made possible the age in which we live." In the twenty-eight chapters, each of which is more or less complete in itself, we are given an excellent bird's-eye view of the march of discovery and invention, which will especially appeal to the young—in years or knowledge.

Although we may question if biography is essential to the understanding of the content and method of science, there can be no doubt that its inclusion is a most valuable stimulus, particularly to that large majority which prefers the study of man to the study of Nature. This book is a very useful addition to popular scientific literature; the arrangement is good, the style is clear and vivid (but why, oh why, does the author never use a colon or a semicolon?), the selection of "masters"—an invidious task—is good, and the statements are generally accurate. Two errors in the chapter devoted to briefer biographies should be corrected: Sir Ernest Rutherford is no longer professor of physics at Montreal, and the late Sir William Crookes was never a professor either in the Royal College of Science, Oxford, or elsewhere.

An analysis of the nationalities of the men who are noted at length in this volume may be of interest. Of the men of science, about one-third are British, one-fifth French, one-sixth German, one-fifteenth each

American (U.S.A.), Swedish, and Swiss; whilst ninety per cent. of the inventors are either American or British. If these figures may be taken as a rough index of the distribution of scientific and inventive genius, it would appear that although science has no fatherland (as Pasteur said), invention can make out a good claim for the English-speaking world.

Complex Salts. By Dr. William Thomas. (Manuals of Pure and Applied Chemistry.) Pp. xi+122. (London, Glasgow and Bombay: Blackie and Son, Ltd., 1924.) 10*s.* net.

DR. THOMAS'S book on "Complex Salts" is a small volume of about 120 pages, intended more especially for students reading for final and honours degrees. It differs from a recent book by Schwarz on "The Chemistry of the Inorganic Complex Compounds" (see NATURE, October 27, 1923, p. 617) in that it deals in a much more general manner with the problems of molecular asymmetry, optical activity, methods of resolution and rotatory dispersion of optically-active complex salts. On these subjects Dr. Thomas has himself done important original work.

A novel and extremely valuable feature of the text is a chapter on the "Preparation and Resolution of Inorganic Complex Salts," including two examples of resolution, one involving the use of an active acid, and the other the use of an active base. This chapter should be of great value in enabling an honours student, or a young research worker, to secure experience in the manipulation of this important group of compounds. The book is presented in an attractive form, but the price appears to the reviewer to be rather high in view of the small size of the volume, although the price per page is appreciably less than that charged for the English translation of Schwarz's book.

The equilibrium-diagram which represents the case in which a racemate is formed when the temperature is raised, instead of (as in the case of sodium ammonium tartrate) when the temperature is lowered, appears to have been omitted, since Fig. 3, p. 60, represents the unsymmetrical diagram for a double salt which decomposes above a transition-point. It is not immediately obvious from the text what has gone wrong, and a student who encountered this error without knowing the correct form of the diagram might be puzzled for a long time before finding the correct interpretation.

The High Grass Trail: being the Difficulties and Diversions of Two; Trekking, and Shooting for Sustenance in dense Bush across British Central Africa. By Frank Savile. Pp. 255+10 plates. (London: H. F. and G. Witherby, 1924.) 15*s.* net.

THIS is a day-to-day account, written in an easy and pleasant style, of a shooting trip, undertaken in the high grass season, to Nyasaland and Northern Rhodesia. As no map has been provided, and most of the places mentioned are not marked on the ordinary map one has at hand, it is not easy to follow, except in a general way, where the author really did go.

This part of the world seems to be a veritable sportsman's paradise, both as regards small and big game. There was something to shoot almost every day. The natives are extremely friendly and willing to assist in all operations of shikar. Their intense desire for meat makes them very ready helpers where big game is concerned. In a country where supplies are so scarce it is necessary to ply the gun in order to keep the larder replenished, and provide food for an army of carriers. Some game, however, is not exactly up to the white man's standard. Of zebra meat the author remarks: "It is dark, unwholesome red, greasy and revolting. I have tried the brains and tongue, which are passable, but so far, to Allah be praise, have never had to set my cheap German teeth the task of masticating its steaks or cutlets," but "the ordinary nig. loves it."

None of the problems of the country are dealt with. It is purely a book for the sportsman, and any one contemplating a visit to British Central Africa for shikar purposes should certainly read it. It will give him a good idea of what to expect as well as a considerable amount of entertainment. H. L. C.

Chambers's Encyclopædia: a Dictionary of Universal Knowledge. New edition. Edited by Dr. David Patrick and William Geddie. Vol. 4: Dioptrics to Freistadtl. Pp. iv+856. Vol. 5: Fréjus to Humboldtia. Pp. iv+840. (London and Edinburgh: W. and R. Chambers, Ltd.; Philadelphia: J. B. Lippincott Co., 1924.) 20*s.* net each vol.

THE most recent volumes which have appeared of this handy encyclopædia carry the alphabet nearly to the end of the letter H. They are well supplied with finely produced coloured maps, of which the historical maps of Europe and the physical and geological maps of Great Britain are particularly useful. Most of the articles of the last edition have undergone revision, in some cases by the original writers, and references to recent events have been added. Other articles have been re-written. Many of them are models of summarised knowledge, and several on the more important subjects run to considerable length. Thus "electricity" covers twenty-six pages, with another eight pages on cognate subjects. "Eye" runs to twelve and "fishes" to seven pages. Cross-references enhance the value of the work, but do not occur so frequently as to impede quick reference.

Elementary Experimental Statics for Schools. Written by A. P. McMullen. Revised for the Press, with some additional Matter and a Preface, by E. W. E. Kempson. Pp. vii+315. (Cambridge: At the University Press, 1924.) 8*s.* 6*d.*

IF the object in teaching a subject such as statics to schoolboys is not so much to give them anything in the nature of a logical training as to render them appreciative of the fundamental principles and convinced of their truth, no better system can be adopted, we believe, than the experimental method. Especially is this the case in the present age, when boys display a lively interest and knowledge of machines, and appear to have relatively little difficulty in grasping the idea of mechanical work. It is for this reason that the authors of the present book have developed their subject in the order work, moments, triangle of forces, dealing in their appropriate places with friction, centres of gravity, equilibrium and stability. The result is that they have produced a book which must be of real value to all teachers of the subject. The illustrations are copious and instructive.

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.*]

Local Reflection of Wireless Waves from the Upper Atmosphere.

In some recent experiments carried out for the Radio Research Board of the Department of Scientific and Industrial Research, measurements have been made of the diurnal variation of the signals received at Cambridge from the stations of the British Broadcasting Company. During the day-time these signals have been found to be fairly constant, but night-time variations of intensity have been measured at distances from the transmitter so short as 50 miles. For example, the signals from London at Cambridge are found to be constant during the day; but, at about sunset, variations, which are often of a periodic character, begin, and continue through the dark hours. In this case the mean night value is very little different from the day value. For more distant stations (for example, Bournemouth) the phenomena are different. During the day the signal is weak and constant; but after sunset the intensity increases and, though variable, the signal maxima may be several times the day value. In this case the variations in signal intensity are larger, less rapid, and less markedly periodic than in the case of the London signals.

These effects may be explained in a general way if an atmospheric reflecting layer is postulated which is comparatively ineffective for the waves of this frequency during the day-time but bends them down very markedly at night. According to this view two rays arrive at the receiver at night, one nearly along the ground, which may be called the direct ray, and the other returned from the atmosphere, and called the indirect ray. In the case of the London signals the direct ray is considered as being strong and constant compared with the indirect ray; and the night-time variation is considered as being due to interference between the direct and the weak indirect ray. For the longer distance transmission, the stronger night-time signal is to be attributed to the indirect ray.

If the reflecting stratum is imagined to be at a height greater than say 50 kilometres, the above interpretation indicates bending back at relatively small angles of incidence (for example, if London is considered, and the height is assumed to be 100 kilometres, this angle of incidence is about 22°). Such high grazing angle reflection from the Heaviside layer has not usually been considered possible, and we have therefore attempted to examine the phenomena in a more direct manner. The method adopted has been to vary the frequency of the transmitter *continuously* through a small range and attempt to detect the interference phenomena so produced between the two rays. From our measurements it was estimated that at a distance of about 160 kilometres from the transmitter, the effects of the direct ray and the indirect ray at night would be approximately equal.

The British Broadcasting Company, on being approached, very kindly consented to collaborate in the experiments and to use the Bournemouth station as the transmitter. Oxford, being about 140 kilometres from Bournemouth, was chosen as the receiving site, and excellent facilities for the installation of the receiving station were provided for us in the Oxford Electrical Laboratory by Prof. J. S. Townsend and Mr. E. W. B. Gill. Capt. A. G. D. West, of the B.B.C., who was in charge of the Bournemouth end of the experiment, arranged the transmitter so that a known frequency change could be produced uniformly during a given time (for example, 10 to 30 seconds) while the aerial current remained practically constant. The received signal intensity at Oxford was determined with a receiver specially designed to give approximately uniform sensitivity over this band of frequencies. The resulting signal currents were measured by moving coil and small Einthoven galvanometers. Mr. F. G. G. Davey gave us most valuable assistance at the receiving station. Land-line communication was also maintained between the two stations during the period of the experiments for control purposes.

Two sets of experiments were carried out on December 11, 1924, and on February 17, 1925, and in both cases quite definite examples of successions of interference bands were observed as the wave-length was changed, the intensity varying from a maximum value almost to zero as was arranged for by choice of distance. If we assume the simplest interpretation of these interference phenomena and regard them as analogous to those of a Lloyd's mirror fringe system, the effects may be viewed as follows. For a direct ray path of length a, a higher ray path of length a' and a given wave-length λ, the higher ray arrives N wave-lengths behindhand as compared with the lower ray where $N = (a' - a)/\lambda$. If N is an integer the waves steadily reinforce unless a' is changing, while if N is halfway between two integers they are steadily opposite in phase. If the wave-length is gradually increased to λ' at the sending station, alternations of intensity may be expected, the number being $(a' - a)/\lambda - (a' - a)/\lambda'$. The experimental observations according to this simple interpretation indicate a path difference $(a' - a)$ of the order of 80 kilometres, which is consistent with a reflecting layer at a height of about 85 kilometres. Evidence was, however, obtained that the results may be somewhat complicated by the elliptical polarisation of the indirect ray, in which case the above estimate of the height may have to be revised. Further experiments on this point are in progress. But the interference phenomena between two rays depending on the existence of a deflecting layer seem definitely established.

It has been usual to attribute the difference between day and night strengths of wireless signals to a difference in the sharpness of the boundary of the effective atmospheric layer, the lower boundary being assumed sharper by night than by day. We think, however, that the transition cannot be sharp compared with the wave-length, particularly for the short waves we have used, and therefore the term "reflection," used for convenience above, must be taken as meaning "ionic deflection."

We imagine, therefore, that at night the layer is sufficiently high and intense to permit of ionic deviation taking place, the ray being turned through large angles without undue absorption. During the day the ionisation due to solar agencies throws the ray down at lower levels (for example, 40-50 kilometres), and here, although ionic refraction can take place, the collisional "friction" causes heavy absorption at these short wave-lengths and high grazing angles. The difference in the action of the atmospheric ionisation between day and night is therefore to be taken as due to the differences in height (and therefore density) of the effective layer, and not as due to the difference in the sharpness of the boundary of the layer as has been usually assumed.

These and other experiments suggest the inference that, at distances greater than about 100 miles from a wireless transmitter of these wave-lengths (for

example, 300-400 metres), night-time reception is dependent almost entirely on the upper indirect ray; and evidence is not lacking that, due to the more effective reflection by the ionised layer at smaller grazing angles, the signal strength maximum may in some cases increase with increase of distance from the transmitter.

E. V. APPLETON.
M. A. F. BARNETT.

Cambridge,
February 21.

The Propagation of Radio Waves over the Earth.

AMONG the facts to be explained in a satisfactory theory of the propagation of radio waves over the earth's surface are the curvature of the rays in transmission between stations far apart, the absorption during transmission, the peculiar phenomenon of fading, in which the magnitude of the received wave fluctuates more or less rapidly, the differences in transmission in different directions over the earth, and the extraordinary differences in the transmission of long and short waves.

This letter is to outline a new theory of transmission which accounts quantitatively for many previously unexplained facts of radio transmission. A detailed treatment of important cases will appear shortly.

The atmosphere to a considerable height above the earth contains ions which react upon electromagnetic waves and, as shown by Larmor (*Phil. Mag.*, Dec. 1924), may account for the bending of long waves around the earth. His explanation, however, does not show the large and characteristic differences between short and long wave transmission, which become especially marked in passing through the region between 100 and 200 metres. Other theories, also, have the defect of predicting entirely incorrect results for short wave-lengths.

The theory now developed takes into account both the earth's magnetic field and the distribution of ionised particles in the atmosphere. It is found that this field, together with the electrons, produces marked selective effects at wave-lengths between 100 and 200 metres, and that these effects are different for different directions of transmission and for different planes of polarisation of the wave. A summary of the effects follows :

For the case in which the electric force of the wave is parallel to the earth's magnetic field, the only effect is due to a variation in ionic density above the earth. This case is realised practically only over very limited areas of the earth's surface.

For transmission in any other direction or for any other direction of the electric field, four effects are in general produced, namely, the plane of polarisation of the wave is rotated by an amount depending upon the density of free electrons, the magnetic field, and the frequency. This effect reverses at the critical frequency, which, for a field of 0·5 gauss, is 1400 kilocycles (214 metres). The second effect is that of double refraction in the medium, producing two waves of different velocities and polarisations. The third effect is a bending of the rays due to a variation in ionic concentration, as in Larmor's case, but, due to the magnetic field, this bending also, in most cases, reverses at the critical frequency, so that if long waves bend down in a certain region, short waves will be deflected upwards in the same region. The fourth effect is a bending of the rays due to variations in the magnetic field strength, and this effect also reverses at the critical frequency.

The general solution of this problem cannot be given in this note, but some interesting special cases will be described.

For transmission from a vertical antenna along a magnetic meridian the electric vector tends to be rotated, and, when this rotation becomes equal to 90°, the usual methods of reception produce no signals ; hence we should expect, in general, better reception of east-west than of north-south signals at certain points. Also, since the plane polarised ray can be resolved into two circularly polarised rays travelling with different velocities, under certain conditions both components may not be able to travel over the same path between two points.

The rotation of the plane of polarisation for transmission along the magnetic field is rather large ; for example, the electric vector in a wave 2 km. long will turn from vertical to horizontal in about 80 wave-lengths if there are present only 10 free electrons per cubic centimetre in a layer for which the mean free path is sufficiently long for free motion. A wave 100 metres long will rotate through the same angle, but in the opposite direction, in about 5000 wave-lengths or 500 km. For larger ionic densities, appropriate to high levels, the waves may be rotated very rapidly, which is one of the causes of variable transmission along a magnetic meridian.

For transmission at right angles to the magnetic field, we find double refractions with the ordinary ray unaffected by the magnetic field and the other selectively affected.

In all these cases, the variation in the number of ions and in the magnetic field at different heights above the earth produces deflexions of the rays which may be calculated.

The introduction of a resistance term into the equations of motion of the electron leads to an attenuation factor in the equations of wave-motion. Thus, for transmission parallel to the magnetic field, the exponential term involves the reciprocal of the square of the frequency for frequencies sufficiently large compared to the critical value. This means, therefore, that attenuation due to this cause falls off rapidly as the frequency is increased. At the other extreme the same expression is found to apply, except that in place of the transmitted frequency, the critical value is substituted. Hence in this range attenuation due to this cause is constant. There are, of course, other causes of attenuation—for example, the conductivity of the earth.

When the frequency is near the critical value, large anomalous effects occur. For example, the wave may be required to travel over a widely different path by a slight change in either the magnetic field or the ion density. The signal may arrive at the receiver from several directions simultaneously or successively, producing fading or apparent change of direction. The absorption may become extremely high for certain rays.

The detailed theory, with its predictions, will be published soon.

H. W. NICHOLS.
J. C. SCHELLENG.

Bell Telephone Laboratories, Inc.,
New York City,
February 6.

Molecular Symmetry in Crystal Structure.

IT has been pointed out by Clark [1] that there is a great similarity between the structures of the four alkali polyhalides KI_3, CsI_3, $CsIBr_2$, and $CsICl_2$. They have the same arrangement of atoms in unit parallelepipeda, if the unit cells are chosen so as to contain one molecule. The arrangement is with the metal atoms at the corners of the cell and the halogen atoms inside the cell and in a line on the body diagonal.

[1] A. L. Clark, Pro. Nat. Acad. Sci., 9, 4, 1923, p. 112.

The same arrangement is taken up by the complex radicles in the hexammoniates of the nickel halides and the hexahydrate of zinc bromate. This body-centred grouping is a deformation of the arrangement in CsCl.[2]

A study of the chlorates, bromates, and iodates of sodium and potassium shows that similar relations exist between these salts. Some are closely related to cæsium chloride in structure, which we shall call the CsCl set; and the rest to sodium chloride, referred to below as the NaCl set. The distinction between the more complex salts and the simple halides is that in the former the chemical molecule can be identified, in the latter it cannot.

Sodium chlorate and sodium bromate have been studied by several workers.[3] They belong to the NaCl set, with four molecules per unit cell, the edge of the half-molecule parallelepipedon being 3·29 angstroms in the chlorate and 3·35 angstroms in the bromate.

The three potassium salts have been examined by the writer using the ionisation spectrometer, and the following results were obtained:

Potassium chlorate, which is monoclinic, belongs to the NaCl set. The half-molecule parallelepipedon has edges 3·56, 3·69, 3·69 angstroms. Potassium bromate is ditrigonal pyramidal (pseudocubic). Measurements on the spectrometer show it belongs to the CsCl set, the edge of the one molecule pseudocube being 4·46 angstroms. Potassium iodate is monoclinic (pseudocubic). The spectrometer method, and a photograph taken by the powder method, show that it belongs to the CsCl set. The edges of the one molecule parallelepipedon are 4·57, 4·50, and 4·50 angstroms.

No measurements have been made on anhydrous sodium iodate, but, from its form and specific gravity, it probably belongs to the CsCl set.

The great similarity between these more complex salts and the simple halides shows that the complex radicles act as single units and the molecule behaves as an electric doublet. Each radicle is surrounded, but not equidistantly, by six or eight oppositely charged radicles according as the crystal is of the NaCl or CsCl type. The question arises as to the possibility of determining the positions of the constituent atoms of the complex radicles, from symmetry conditions and intensity measurements.

The case of cæsium dichloro-iodide, examined very completely by Wyckoff,[4] indicates that this determination is impossible from symmetry considerations, and he attempts to fix the chlorine atoms from his intensity measurements alone, describing his results as very uncertain on this account. Symmetry considerations, following Shearer's principle,[5] show that the $CsICl_2$ molecule should possess a trigonal axis, which is impossible for any static arrangement of the ICl_2 radicle, since chemical considerations of stability, and the shape of the cell, negative the placing of the atoms in a line along the trigonal axis.

Another relevant case is that of the ammonium radicle in ammonium chloride. The radicle as a whole occupies positions in space which determine the crystal symmetry, and the positions of the hydrogen atoms cannot be determined. This conclusion is verified by the study of the ammonium alums.

There seems to be no valid reason for giving to the hydrogen atom alone the negative privilege of self-effacement in symmetry considerations, so long as it occupies space. The fact that the salts containing complex radicles which are considered above are so closely related to the simple halides leads to the conclusion that, for other radicles as well as ammonium, the symmetry is independent of the position of the constituent atoms in the radicle, the latter behaving as a unit. The crystal-forming forces are probably electrostatic attractions independent of any structural axes the radicles may possess.

The occurrence of what has been called ionisation in the simple halides has led to the conclusion that no deduction as to atomic symmetry can be made from their crystal structure. As I have pointed out elsewhere,[6] this "ionisation" probably indicates the presence of heat motion in the form of rotation. In the simple halides the radicles can rotate separately, since there is no molecular bond. In the more complex salts considered above, in which the chemical molecule exists, the molecule apparently rotates as a whole about the electrostatic axis of the doublet, and the positions of neighbouring molecules are probably determined by the sizes of the radicles and pressure considerations, similar to those described by Bartlett and Langmuir,[7] to explain the transition of ammonium chloride from the CsCl to NaCl type.

J. H. SMITH.
Physical Laboratory, University College,
London, January 29.

[2] R. A. Dickinson, J.A.C.S., 44, 1922, p. 1489.
[3] A. Karssen, Dissertation, Amsterdam, 1923; W. Kiby, *Zeit. f. Physik*, 17, 1923, p. 213.
[4] R. G. W. Wyckoff, J.A.C.S., 42, 1920, p. 1100.
[5] G. Shearer, Pro. Phys. Soc. Lond., 35, 1923, 81.

[6] J. H. Smith, *Science Progress*, Jan. 1924, p. 403.
[7] Bartlett and Langmuir, J.A.C.S., 43, 1921, p. 84.

The Atomic Weights of Zirconium and Hafnium.

IT is just a hundred years ago that the atomic weight of zirconium was determined by Berzelius. The method used, namely the analysis of the sulphate, yielded too low a value for the atomic weight, the same being the case in all the different methods used by his followers. This error was compensated, however, in part by the presence of 0·5 to 2 per cent. of a heavy element (hafnium) in their preparations (see NATURE, March 15, 1924). It was only in 1917 that Venable and Bell, when analysing $ZrCl_4$, used a more trustworthy method originating from T. W. Richards's laboratory. The values found by these investigators were appreciably higher than those found by their predecessors, and showed at the same time fluctuations for the values of the atomic weight, greater than should be expected considering the extreme precautions taken and the reliability of the method used.

These fluctuations could not be accounted for at the time of the measurements. After the discovery of hafnium it suggested itself that the variations found by Venable and Bell were due to a varying hafnium content in the preparations used. Through the courtesy of Prof. Venable we have been able to investigate the samples used by him and by Dr. Bell, and have found a hafnium content varying between 0·7 and somewhat above 1 per cent. Taking into account this presence of an element having the atomic weight of about 180 in their preparations, Venable and Bell calculated the value 91·3 for the atomic weight of zirconium. This value is in an excellent agreement with the value (91·25) arrived at recently by Hönigschmid and Zintl (*Zeit. anorg. Chem.* 139, 293, 1924) using a preparation purified from hafnium in this laboratory and found to contain less than 0·02 per cent. of this element. It is of great interest that the above numbers coincide cosely with the value which can be estimated from experiments with positive rays. Aston found for zirconium the mass lines 90, 92, 94, and a doubtful one at 96, and estimates the atomic weight as 91·4 or 91·2, according to whether the mass number 96 is included as an isotope or not. We may, therefore, be justified in believing that the atomic

weight of zirconium is 91·3 with an accuracy of about 0·1 unit.

While the presence of 1 per cent. HfO_2 in a preparation of ZrO_2 influences the apparent atomic weight by 0·6 unit, the presence of 1 per cent. of ZrO_2 lowers the apparent atomic weight of hafnium by not less than 1·4 units. One must thus obtain a hafnium preparation containing a very small amount of zirconium in order to fix the atomic weight of hafnium with an accuracy similar to that reached for zirconium. It was possible some time ago to supply Prof. Hönigschmid with such preparations from this laboratory. The values found by him, when analysing $HfBr_4$, for the best preparation were 178·32 and 178·35, and for a less pure fraction 177·78 and 177·80. The samples used by Hönigschmid and Zintl were recently very thoroughly investigated by Mr. Thal Jantzen by means of the method of X-ray analysis, which when proper precautions are taken is able to give values of high accuracy and offers a simple method of estimating the zirconium content of hafnium preparations. The values for the zirconium content of these preparations were found to be 0·16 and 0·57 per cent. The values for the atomic weight found by Hönigschmid and Zintl have thus to be raised to 178·57 in the first, to 178·64 in the second case, and we may, therefore, with a probable error of less than 0·1 unit fix the atomic weight of hafnium at 178·6.

G. HEVESY.

Universitetets Institut for teoretisk Fysik,
Copenhagen, February 5.

Late Palæolithic Art in the Cresswell Caves.

I WRITE as chairman of the British Association Committee, now resuming, by permission of the Duke of Portland, the exploration of the Cresswell Caves where it was dropped some forty years ago by the Rev. Magens Mello and myself, to prevent your readers from being misled by the following passage in the third edition of Prof. Sollas's book on "Ancient Hunters," p. 536.

"There is a singular absence of any attempt at art in all the Palæolithic stations of England. The horse figured here [Fig. 299] is, I am assured, a forgery introduced into the cave by a mischievous person."

The Cresswell horse was the first proof of the range into Britain of the wonderful art of the French caves, and the discovery made in the 'seventies by myself was published—after a careful scrutiny by Sir John Evans, Sir Augustus Franks, Lord Avebury, General Pitt-Rivers, and other leaders—in the Quarterly Journal of the Geological Society of London. It has remained unchallenged for more than forty years, and has passed into the literature of anthropology. *Res judicata est.* The charge of forgery is not now to be made without clear evidence. In answer to a letter asking for this evidence Prof. Sollas writes to me that it is based on what he was told "some years ago, I think 1919," by a clergyman since dead, who declined to give names or other particulars. This means that the charge of forgery is founded on gossip without a shred of evidence, and is unworthy of further notice.

The Cresswell horse is engraved in fine lines in a style similar to that of the figures of animals found since in the late palæolithic caves of France and Switzerland. It is not accurately represented by Prof. Sollas in his Fig. 299. This figure is copied from Evans's "Ancient Stone Implements" (2nd edition, p. 524), in which my woodcuts were used. If the copy be compared with the original it will be seen that the details have been omitted, leaving merely an outline useless for the study of the art of the caves.

Prof. Sollas is equally unfortunate in his sweeping statement that there is no attempt at art in the palæolithic caves of England. Our Committee is now at work at Cresswell, and Messrs. Garfitt and Leslie Armstrong have already recorded the discovery of incised figures of bison and reindeer along with other late palæolithic finds. As the work proceeds it will probably result in further proof that the picturesque gorge of Cresswell Crags was a hunting station of the artistic tribes who followed the wild animals in their migrations from the south of France into Britain, then the north-western region of the great Pleistocene Continent.

W. BOYD DAWKINS.

Fallowfield House,
Fallowfield, Manchester,
January 29.

The Ages of Peat Deposits.

THE wide interest now taken in the study of peat will, I think, justify further reference to the subject of Dr. Pearsall's article in NATURE of December 6 and the letters from Mr. Tonks and Mr. Forbes which followed on January 24. It is satisfactory to note that Dr. Pearsall has withdrawn from the obviously fallacious correlation he at first put forward. He now, however, makes a second correlation based on the identification of the birch scrub on the peat-covered 25-foot beaches as Lewis's Upper Forest, making the latter Neolithic in age and therefore climatically in conflict with the evidence in the Pennines. This yields him the same result, namely, that climatic deductions from peat and forest beds are untrustworthy.

This second correlation, however, has no more to recommend it than the first. Mr. Forbes will, I am sure, bear me out when I say that a few isolated occurrences of birch scrub at a low level are no proof of a forest period. On the contrary, the evidence of the submerged forests indicates that the period of greatest tree growth in the British Isles, *i.e.* Lewis's Upper Forest, antedates the 25-foot beach. Dr. Pearsall will, therefore, have to try still another correlation if he wishes to establish his point.

May I add to that of Mr. Tonks my appreciation of the admirable work recently done in the Pennines by Dr. Woodhead, Mr. Buckley, and Mr. Holmes.

W. B. WRIGHT.

Manchester.

IN directing further attention to the question of peat deposits, Mr. Wright seems to add little to the questions raised. He accuses me, however, of basing a hypothesis on the occurrence of isolated patches of birch scrub. I have repeatedly (and publicly) expressed the opinion that the presence of timber in peat can have little significance unless the wood layer is continuous over a very wide area, and I have, indeed, criticised Lewis on the grounds that his "forest layers" did not always fulfil this condition. I may, therefore, be forgiven for finding Mr. Wright's accusation a little amusing. It appears to me, however, that his criticisms can only be seriously urged by disregarding completely the use of the words "may" and "might" in my letter (although one of them is italicised), and by failing to attach any significance to the sentence which expresses the opinion that, on whatever they are based, these hypothetical correlations throw doubt on the climatic hypothesis of peat stratification. This is the gist of the letter, to which Mr. Wright's attention may be redirected.

W. H. PEARSALL.

The University, Leeds.

The Mortality of Plaice.

THE letter of Dr. G. P. Bidder in NATURE for January 31, p. 155, on "Constant Differential Growth-ratios and their Significance," raises the very interesting question: Are plaice potentially immortal? In other words, does senile decay occur? This might be decided directly by cytological investigation of old fish; but there is another indirect aspect of the question which my own work on plaice suggests as worthy of being brought forward in this connexion; namely, the differential death-rate of the sexes. Dealing with large collections from two regions, the North Sea and western part of the English Channel respectively, I showed (International Investigations: Marine Biological Association, Report III. 1906–8 (1911)) that in each region males were more numerous than females up to the age at which the majority of males become mature for the first time; after which, or soon after which, females begin to preponderate, the number of males diminishing somewhat rapidly.

Commenting on this phenomenon I said: "The reason for the *rapid* decline in the relative number of males just after maturity might be somewhat obscure if only natural causes were at work. We know, however, that in the breeding season the catch of ripe males by trawlers greatly exceeds that of females on the spawning grounds; and it is possible, as Hefford suggests, that this factor may be the cause of the rapid decline in the proportionate numbers of this sex after maturity is reached." This artificial factor would, however, scarcely explain the whole result; nor would it account for the same phenomenon in the plaice of the Barents Sea, which was practically a virgin fishing-ground when Atkinson investigated it in 1907 and 1908 (Journal of the Marine Biological Association, vol. 8, Nos. 2 and 5). Then there are many cases of other species of fish and of other groups (cited by S. W. Geiser, *American Midland Naturalist*, vol. 8, No. 7, 1923) in which the same thing occurs, and where there is apparently no suspicion of the unequal incidence in the two sexes of extraneous factors tending to the longer survival of one sex. How then are we to account for the difference except by the lesser viability of males? This apparently implies natural death.

Dr. Bidder also makes the interesting statement that "the ratio of ovary-weight to body-weight has no relation to age, but only to body-weight; in this as in some other respects, the age of a plaice is not measured by years but by the quantity of food which it has succeeded in assimilating." Among the "other respects" with which I am familiar from personal investigation I may mention the advent of maturity, which is apparently determined by size and not by age. Thus the plaice of the Barents Sea (see Atkinson, *ibid.*) are the same average *size* at first-maturity as the plaice of the central North Sea, but the average *age* at first-maturity differs very considerably owing to the much slower growth-rate of the Barents Sea fish (up to 1908 at least), due ostensibly to overcrowding and limited food supply. The same general cause would also account for the fact that while the average *size* at first-maturity of the North Sea plaice soon after the War (during the latter years of which restrictions on fishing produced overcrowding) was the same as in pre-War years, the average *age* at first-maturity was considerably higher.

WILLIAM WALLACE.

Fisheries Laboratory,
Lowestoft,
February 11.

Coal Resources of Alberta.

I SHOULD like to use the medium of your pages to ask that, when scientists and others sit in their offices or studies at home, to write about the resources of the outlying portions of the British Empire, they at least consult up-to-date and official reports on their subject. I hesitate even to suggest that they might restrain their pens either from modesty or from fear of ridicule when their information is only second-hand.

A case in point is a recent volume on "Fuel" in the "Resources of the Empire" series. The description of the coals of Alberta, which have been estimated to constitute more than 60 per cent. of the coal resources of the British Empire, is allowed only one and one-half pages out of the 63 pages in this section of the book. The compiler takes most of his statements from a report published in 1913, and now much out-of-date. But, to make matters worse, in a drastic condensation of the earlier report, he retains all or most of the mistakes and adds others. The result is laughable to any one who knows anything of the subject.

The Canadian Government at Ottawa has published many reports on the natural resources of the country, and the Scientific and Industrial Research Council of Alberta, during the past five years, has published ten reports on the resources of the province. These reports are readily available in England, and requests for information receive attention. There is therefore no excuse for the publication in England of out-of-date and incorrect statements.

EDGAR STANSFIELD,
Honorary Secretary,
Scientific and Industrial
Research Council of Alberta.

Edmonton, January 30.

Pliocene and Pleistocene.

As you quote in NATURE of February 21, p. 278, from a note of mine printed in No. 6 of *Natural History* (American Museum of Natural History), will you allow me to state that the note quoted was not submitted to me in proof by the editor of *Natural History*. The part you quote embodies a serious misprint. The words "distinguished by the marine 'Pliocene'" should read "distinguished by the name 'Pliocene.'" As I am writing further on the application of the terms "Pliocene" and "Pleistocene" to various deposits in East Anglia, I should like to remove at once this unfortunate misrepresentation of my views.

E. RAY LANKESTER.

Mercury Helide.

IN a recent note (NATURE, December 13, 1924, p. 861), dealing with the formation of mercury helide, mention was made of a plan which was being perfected for a quantitative analysis of the compound. The analysis has now been completed, with the result that 210·79 parts by weight of mercury were found in combination with 4·18 parts by weight of helium. Hence 200·6 parts by weight of mercury combine with 3·98 parts by weight of helium. The simplest formula for the helide is therefore HgHe.

A detailed account of the work upon which this conclusion is based, will, I hope, be published shortly.

J. J. MANLEY.

Daubeny Laboratory,
Magdalen College, Oxford,
February 13.

The Control of the Tsetse Fly Menace.

By C. F. M. SWYNNERTON
(in charge of Tsetse work in Tanganyika Territory).

TSETSE-FLY problems may be divided into three —the problem of *G. palpalis* and the rain-forest tsetses, that of *G. tachinoides* and that of the savannah or "bush" tsetses belonging to the *morsitans* and *fusca* groups. These, as Major Church showed well in his recent article in NATURE, January 31, inhibit the development of vast areas in Africa, and members of the *morsitans* group are the carriers of Rhodesian sleeping sickness. It is to the control of the bush tsetses that I shall refer in this article (though the broader principles laid down would refer to all), and I shall describe in particular the methods and ideas that we are employing in our fight against them in Tanganyika. These may be understood best if I say that I have from the first felt that if we are to attack the tsetse-fly economically as well as effectively, we must do so in the main by the mere diversion and regulation of agencies already in existence—always, of course, with the fullest knowledge of and regard to the habits of the particular species we are fighting.

This implies that the natives would be taught to understand and take part in the solution of their own problems, and that natural agencies, such as grass-fires, flooding and exceptional seasons, would be harnessed. In a report to the Portuguese Government (*Bull. Ent. Res.*, vol. xi. pt. iv. pp. 315-385) I laid special stress on the fact that "settlement properly planned will protect itself," on the utility of offering inducements to natives to settle in places, perhaps quite limited, where previous ecological investigation should have indicated that their presence will lead to control of the fly, on the part that European settlement on a sound agricultural basis might be made to play if clearing of the crucial spots were made a condition of occupation and the farms were small enough, and on the probable great value of postponing the annual grass-burning, usually worse than useless, to the end of the dry season (October), and then carrying it out under chosen conditions and in a thoroughly organised fashion.[1] I also emphasised the necessity for studying means of consolidating clearing or, in the absence of consolidation, the need, in a great fly-belt, for providing fly-proof barriers up to which to work; and, in a later report (*Bull. Ent. Res.*, vol. xiii., pt. iii. pp. 317-370), I sketched the scheme which has since been put into operation in Tanganyika Territory, and will be described briefly here.[2]

It should be noted, first, as regards "settlement properly planned," that the bushless cattle-areas of that Territory are, in very large part, "culture steppe," to borrow, provisionally, a German term. That is, they are kept free of bush and, thereby, of tsetse-fly, almost solely through the presence of sufficiently (not excessively) closely-dotted villages with their chopping for firewood, building and cultivation and the browsing of their numerous stock. On the whole, settlement and bush, man and fly, are sharply segregated. It is hoped that by encouraging this form of settlement in the far greater areas in which the natives *all* live dotted through the bush, pestered with tsetse and subject to other serious disabilities, we shall extend segregation and obtain what will be, for practical purposes, a control of the fly. This form of settlement—implying concentration of organisable labour, a safe base from which to extend, and a breeding centre for population which, being accessible, is capable of receiving assistance from us—is in any case a necessary preliminary to all measures of a large nature against the tsetse in the bush—that is to say, to *reclamation*. The production of it throughout the Territory will be gradual, and in certain parts it may prove to be impracticable, but appreciable success is already in places attending our initial propaganda.

Concentration accomplished and the natives in our new culture steppes assisted to become the possessors of cattle (for these are necessary in order to "anchor" them), it will remain for them to protect themselves against encroachment of the bush and the fly and to expand their fly-free grazing *pari passu* with the increase in their cattle. This, with tact and propaganda, will be done as we have already begun to do it in Shinyanga—through sheer clearing (as last year), for this appeals to the native, or better, through more discriminating measures which will be carried out by the people themselves under our guidance during a few days each year. Here I would say that our victory in Shinyanga lay not in our large clearing of ground—many people have cleared ground (and then let it go back to bush and tsetse)—but in the successful teaching of a native population to tackle its own problems. Stiebel, McMahon, Scupham are my administrative collaborators to whom the credit for this is chiefly due.

Thereafter, as population increases (and we would help it to increase by means of propaganda in hygiene), the scheme is that we should so guide the directions of expanding settlement as to bring into being coalescence, and thereby complete our fly-proof barriers and break off our blocks—the latter corresponding, let us say, in width with so small a fly-belt as that of Zululand. These, being of more manageable dimensions than our entire belt, would next be attacked individually in order to obtain final security and room for the freest development.

What methods are we to apply to the blocks? Lamborn's fine work in the breeding and release of parasites has been mentioned by Major Church. This, in places, might prove a useful contributory measure. Shircore, in an admirable little paper published in 1914, suggested, first, the concentration of attack on the dry-season centres of *G. morsitans* (which would first, he suggested, have been isolated by clearing from the rest of the bush and finally be cut down themselves); and, secondly, for the further controlling of the movements of the fly (which can be done, he considers,

[1] I based this recommendation primarily on more than fifteen years of experiment and observation as to the results on woody vegetation of grass-fires lighted year after year in different months, but suggested that deferred fires would also have the other effects—on the pupæ and as to the driving of the fly on the wing into unburning thickets, which would themselves gradually be destroyed—which I shall describe below. Shircore, in 1914, included grass-burning postponed to late July or August, for the clearing up and driving of any flies still scattered, amongst his measures of attack on the dry season centres of *G. morsitans*. Lloyd and Johnson have suggested that, long grass being inimical to breeding, the postponement of burning may be useful also for the prolongation of this unfavourable condition.

My experiments in Shinyanga will be described in detail in the *Bulletin of Entomological Research*.

even by narrow barriers), "the splitting up of fly-belts near villages and along main routes by forest destruction and burning." This, with the extension of agriculture, the clearing of villages and the attacking of the fly-centres, would ultimately, he thought, limit fly to areas which need not be entered by the natives. I doubt whether, short of such concentration of population as would produce "culture steppe," these measures could maintain safe segregation in any considerable belt; but they are thoroughly sound in principle and probably roughly represent a part of the means by which the relatively small belts of South Africa were unintentionally cleared of fly by the early settlers. Under such conditions I propose to use them freely.

Jack has experimented on a large scale in the destruction of game—but while, here and there, the checking of particular movements, large or small, of game animals may, if it is also feasible, be very necessary, no one wishes to exterminate our wonderful African fauna, a heritage of the Empire, of posterity, and of the scientific world, if we can control the tsetse otherwise. Our first results in Tanganyika lead to the very strong hope that we can, at least in the type of belt in which I have worked chiefly of late (Acacia-bush with *thickets* as the keynote to the fly's control, much like the fly-bush seen by me in Zululand); and suggest that we should wait a little longer before we commit ourselves finally anywhere to counsels of despair in the form of war against the game.[3]

I have mentioned my own views already on the utilisation of man-power and the grass-fires and on discriminative clearing, and I think that the diversion of native energy and settlement—or European energy and cultivation where that is present—to the destruction and breaking up merely of the locally-important types of thickets, is likely to be a most valuable measure, because thickets are the chief breeding place of most species of tsetse and a refuge for all during fires. I am employing this already in conjunction with late grass-burning.

As regards the latter, I demonstrated last year (and, concerning certain points, many years previously) the correctness of the view stated in my Portuguese report, that postponed and organised grass-burning is capable, where the grass and the dry season are long enough, of destroying small woody growth and numbers of the smaller thickets, logs and (to judge from a comparative count obtained at Shinyanga) pupæ, and of driving the flies before the fire in great numbers into previously burned patches and such unburning thickets as are as yet uncleared. Our work suggested that in these places they can be exterminated (given the labour) by sheer catching on a great scale by hand and otherwise before they disperse. There can be little doubt also that by means of October grass-burning Father Cirvegna, a missionary in the Iringa district, has cleared of fly (*G. morsitans*), progressively but completely, an area a dozen miles in diameter in three burnings. The measure is not applicable everywhere.

[3] I may here correct an error that has slipped into a quotation of Major Church's from a conversation with myself—undoubtedly through my not making myself clear. It is by no means the whole of the Dar-es-Salaam district that is "gameless," and bush-pigs are present in any case. The point is that bush-pigs, by any methods now known to us, are, I believe, inexterminable in certain tsetse-infected types of woodland that cover great areas of Africa; and that, from observations made, I consider that these animals can alone support populations of fly sufficient to preclude the keeping of cattle.

An exceptional season appears to have been responsible for the disappearance of the fly in 1921 from some of the out-jutting portions of the Shinyanga belt. Had there existed fly-proof barriers between these and the main belt, they would not have been re-stocked. It is thus, and for the accentuation of the effect of late grass-burning, once this is installed as an annual custom, that I suggest that we shall "harness the exceptional season" for the clearing of some of our blocks.

Finally, the verification by Harris of views held by him (for example as to the possibility of isolating tsetses in particular pieces of bush until, as I understand it, they starve) is likely, when it comes, to help greatly.

I am experimenting also in Shinyanga as to consolidation of ground gained. We are offering inducements to natives to settle where their activities will be of use, introducing a rule that villagers should keep down young shoots from cleared growth round their villages, experimenting in the encouragement of the keeping of goats for their browsing, trying to induce people in culture steppe to dig up stumps for firewood rather than make journeys to the bush for it, and experimenting in cheap methods of killing woody growth. The encouragement given by our Department of Agriculture to the use of ploughs by the natives is helping me, for ploughing entails the removal of stumps, and we are diverting so far as possible large-scale cotton culture by means of ploughing to the actual ground I am clearing. The replacement of great thicket-areas by high forest (in this form, an idea of Fiske's), the safeguarding of roads, the means of reducing the carrying of fly into contact with cattle by man, and the testing of three important questions in connexion with the game, including its possible utilisation as an ally in our fight with the tsetse, are amongst the further experiments which are already in progress or contemplated.

In short, with the very hearty co-operation of the other Departments and of the District Administration, I have put into effect and, I think, begun to justify the view, that we can now best advance our knowledge of how to fight the tsetse by taking a definite large area or entire Territory and applying to it, without stint of necessary funds and labour, all ideas and knowledge that have been gained hitherto, and all further knowledge we yet shall gain, in a large-scale experiment in control by means (preferably) of reclamation officers working hand in hand with research officers. The latter are still needed for expert "survey," for the many points which will come up for investigation as we go along, and because, for economical and effective work, our knowledge of our flies' habits and habitats must be absolute; and, should funds become available, they will be needed in some numbers, in order that, as they master thoroughly the details of the problem and the work in the field (which it would take new men, unattached, some years to do), many may pass on from the earlier centres to other parts of Africa and assist in making the campaign general. Especially is needed a large fund to meet the various expenses of a scheme which shall provide for this gradual development of large-scale experimentation in actual control under all African conditions; that is, at the stage we have now reached, the right method of research.

The Phylogenetic Classification of Flowering Plants.

By JOHN PARKIN.

THE epithet, phylogenetic, in the above title might be considered superfluous, as all biologists are agreed that a taxonomic arrangement of any group of plants or animals should, so far as possible, follow evolutionary lines; after that, its convenience should be considered. Strange to say, up to the present, no arrangement of the Flowering Plants (Angiosperms), which has been generally adopted in text-books or used for floras, merits the term phylogenetic—hence the insertion of the word in the heading to this article.

Of the two chief classifications in use at the present time, that of Bentham & Hooker never outwardly professed to be a phylogenetic arrangement; while that of Engler, though apparently launched as such, has proved unworkable from the evolutionary point of view, and bears the impress of being artificial in its main contention, namely, the primitiveness of the apetalous unisexual flower of few parts. Surely, then, the time is ripe—some would say long overdue—for the introduction of a new system embodying up-to-date views respecting the evolution and possible origin of the flower. A strong movement in this direction is being taken by Mr. J. Hutchinson of the Kew Herbarium, and a series of papers by him, entitled "Contributions towards a Phylogenetic Classification of Flowering Plants," are appearing in the *Kew Bulletin*.[1] It is the purpose of this article to invite the attention of botanists to these papers, and at the same time to review briefly the general position and trend of this department of botany.

Kew has never adopted Engler's system. It has hitherto remained faithful to that of Bentham & Hooker as expressed in their classical work the "Genera Plantarum." But at last it shows unmistakable signs of breaking away and of inaugurating a new arrangement on logical lines. As it controls largely the systematic botany of the Empire, such a system is bound to make headway; so it is incumbent on those botanists who are interested and sympathetic to give it their attention and helpful criticism, in order that it may benefit thereby before it becomes too stereotyped. A new system cannot be fully worked out all at once. Hutchinson's method of publication by a series of preliminary papers gives ample opportunity for this kind of criticism, and we are sure that such comments will be much welcomed. He has already enunciated his principles and dealt in detail with some of the important families[2] composing the Ranales upon which his system is based; and last year he published his proposed rearrangement of the orders (cohorts) and families constituting the Archichlamydeæ of Engler (the equivalent of the Polypetalæ and Apetalæ combined of older classifications). These papers are not only worthy of the attention of the taxonomist, but also of the general botanist. They infuse new life into a department of botany which at times is apt to savour too much of the kind of material with which the systematist usually deals.

It is well to remember that, prior to the publication of "The Origin of Species," systematic botany was under the influence of the dogma of the constancy of species. Since systematists then adhered to the belief that the different forms of plants were special creations, the idea of primitiveness was not involved—it had no meaning. Consequently it was largely optional as to which group was given the initial place in a system. Two chief tendencies, however, are noticeable with respect to the Dicotyledons—one the placing of plants with incomplete flowers lacking petals (the Apetalæ) first, and the other, the putting of the Ranalean families (Ranunculaceæ, Magnoliaceæ, etc.) into this prominent position. One may be said to have culminated in the classification of Engler and the other in that of Bentham & Hooker. The former system in a measure owed its initiation to Brongniart, who in 1843 suggested that the apetalous division of Jussieu ought to be abandoned on the ground that these flowers are an imperfect state of polypetaly. This was a remarkable step forward on the part of this French botanist, considering it was ventured at a time when the principle of evolution was not generally accepted. The German school later, while putting into practice to some extent Brongniart's suggestion, *e.g.* in uniting the apetalous Chenopods with the petalous Caryophylls—the stock example—made no attempt to interpolate the whole of the apetalous families among the Polypetalæ; but instead diverged on novel lines by postulating, or at least inferring, the primitiveness of unisexual flowers of few parts, such as we find in the catkin-bearing trees and Casuarina.

Bentham & Hooker made no attempt to apply Brongniart's principle. They adopted the Candollean classification, modifying it in certain respects. De Candolle was the first to commence a dicotyledonous sequence with the Ranalean families, and Bentham & Hooker followed suit. They both treat the apetalous families as a sort of miscellaneous appendage, after dealing with the whole of the Polypetalæ and Sympetalæ. It is interesting to note that no phylogenetic significance was attached to the position assigned to the Ranalean families.[3] Intuitively they appear to have alighted upon the primitive group.

Hutchinson's aim is to reconcile, as it were, the two opposing systems at present in use, on one hand, by taking the Ranalean families as his base and, on the other hand, by making full use of Brongniart's principle. He considers such a system, broadly speaking, phylogenetically sound, and with this the present writer is in agreement.

Among British systematists Engler's system has met with tardy acceptance. The conservatism of Kew has probably been the restraining influence—a conservatism which now appears justified. In universities, however, it has by now been generally adopted, apparently without criticism. Doubtless Engler's great name, coupled with the publication in association with Prantl of that colossal, finely conceived and beautifully illustrated work "Die Natürlichen Pflanzenfamilien," which marks an epoch in botanical literature, prevailed upon botanists to accept the

[1] *Kew Bulletin*, pp. 65 and 241, 1923; pp. 49 and 114, 1924.

[2] Ranunculaceæ, Winteraceæ (detached from the Magnoliaceæ) and Anonaceæ.

[3] See, in this connexion, a letter dated May 13, 1907, from Sir J. D. Hooker to Dr. Newell Arber, reproduced in "Life and Letters of Sir J. D. Hooker" (Leonard Huxley, London, 1918, vol. II, p. 22).

system. It appears to me to be a most difficult one upon which to frame a course of instruction in what is known, for want of a better term, as systematic botany. Perhaps, though accepted in the abstract, it is largely ignored in the class and lecture-room! But there is the self-taught botanist to consider, and he has only text-books on Englerian lines for his guidance.

Let us glance at the difficulties in the way of regarding Engler's system as even remotely phylogenetic. It is based essentially on the character of the perianth: the mere fact of relying on one organ for his sequence arouses suspicion as to its naturalness. He commences with families possessing flowers without a perianth or with sepals only, passes to those with a petaloid perianth, and then to those with a definite calyx and corolla. There is no evidence of the perianth arising in this *de novo* fashion, as outgrowths from the floral axis, as presumably is the supposition. Besides this, we are committed to the difficulty of deriving the hermaphrodite from the unisexual flower. In both cases the evidence—and there is an abundance—points the other way, namely, that the absence of the perianth or of one set of sexual members is due to reduction. In regard to the catkin families (Amentiferæ) and the like, with naked or apetalous flowers, where obvious links with petalous hermaphrodite forms are not to the fore, surely it is simpler on circumstantial evidence to look upon these flowers as very reduced, than to view them as being primitive in character. Further, it is to be noticed that such flowers are grouped in dense and often complicated inflorescences—an arrangement which cannot be taken as primitive.

A considerable controversy has centred around the supposed primitiveness of the Amentiferæ on other grounds than the character of the flower. This has arisen in part through Treub's classical researches on Casuarina published in 1891, and in part through the hope of deriving the Angiosperms from the Gnetales through this group. The Amentiferæ consequently received a considerable amount of attention, especially as regards the internal structure of the ovule. All attempts, however, to connect the catkin-trees with the Gnetales have proved abortive, or at any rate far from convincing. Treub's discovery of the peculiar way (chalazogamy) in which the pollen-tube penetrates the ovule in Casuarina, though hailed at first as a primitive character of prime importance, can now only be regarded as secondary and of little or no phylogenetic significance. The Amentiferæ may possess some primitive features in the ovule and in the structure of the wood, but they do not appear to have a monopoly of these. In one point the Magnolian group surpasses them, for certain of its genera lack vessels in the wood, and so are gymnospermous in this respect. It would thus appear quite feasible to regard the Amentiferæ as having come as an early offshoot from Ranalean stock along reduction lines. There is some evidence for their affinity with the Rosales generally, and with the witch-hazels (Hamamelidaceae) in particular. Hutchinson favours this view.

In certain quarters in which the Amentiferous flower has been accepted as primitive, the Ranalean flower has also been admitted as a primitive type. The logical outcome of such an expression of opinion would surely be to infer a polyphyletic, or at least a diphyletic, origin for Angiosperms. But there are grave difficulties in such an inference. At the present time I venture to think that the vast majority of botanists regard the Angiosperms as monophyletic; that is to say, an interrelated assemblage of plants which have arisen from one source. Apart from other considerations, one has only to dwell upon the unique type of embryo-sac and the same kind of stamen (microsporophyll) prevailing throughout the group to be convinced of this. Ruling out, then, the possibility of a mixed origin for Flowering Plants, the derivation of all forms of flowers from the Ranalean pattern,[4] especially as exhibited in Magnolia and its allies, would appear to be the only feasible one; thus affording a basis upon which to erect a phylogenetic, or at any rate a logical, system of classification.

The Monocotyledons have so far not been mentioned. Though various views have been held in the past regarding their relationship to the Dicotyledons, there is now a consensus of opinion that they have had a dicotyledonous origin. In other words, their ancestors possessed seedlings with two seed-leaves (cotyledons). How the monocotyledonous seedling with its single seed-leaf arose from the dicotyledonous one is still a matter of dispute. The Monocotyledons must perforce have branched off at a very early period, as the two groups are traceable back to rocks of about an equal antiquity.

It is then on morphological rather than geological evidence that the dicotyledonous derivation of the Monocotyledons is favoured. It is difficult to interpret otherwise their peculiarities, such as the single cotyledon, lack of cambium and style of leaf. Consequently, in a new system of classification which professes to be phylogenetic, they should follow, and not precede, as Engler has them, the Dicotyledons. Hutchinson, I believe, intends to place them so. Two points now arise which affect their arrangement. Have they had a single or plural origin from the Dicotyledons? Though no precise answer can yet be given to this query, the present writer sees no cogent reason for regarding them as other than a natural self-contained group. Then it may be asked from what dicotyledonous assemblage of plants can they be derived? The floral features in common between some of the water-lily family (Nymphæaceæ) and the Helobieæ (water-plantain, flowering-rush, etc.) suggest something deeper than mere parallelism. It may not therefore be unduly straining affinities to derive the Monocotyledons from the Ranalean plexus. The Helobieæ can then be treated as the primitive group, at any rate so far as floral features are concerned. The question of the origin of the Monocotyledons is largely bound up with that of the habit of their immediate ancestors. Henslow, years ago, suggested an aquatic origin, and though this was seriously challenged by the late Miss Ethel Sargant in favour of a geophilous origin, it cannot yet be dismissed. The truth may lie somewhere between. Just as in the Dicotyledons, lines of both advancement and reduction with respect to the corolla (petals) can be traced. One of the former has ended in the Orchids, with their

[4] A hermaphrodite flower, in short, with its members indefinite in number, free from one another, borne spirally on a conical axis and arranged in a definite sequence on this axis, namely, proceeding from below upwards, first perianth members with no clear separation into sepals and petals, then stamens, and finally carpels.

extreme specialisation for insect-pollination, and one of the latter in the Grasses, well adapted for pollination by the wind. Disregarding the teleology, we believe there is a substratum of truth in the following lines :

They tell us that the homely corn that grows,
From russet stem and leaf, our daily bread,
Was once a lily ; which by various steps
Of menial work, became degraded thus;
It left its high-born sisters in their robes
Of gorgeous idleness to clothe itself
In this plain dress for common household use.
Its bright-hued petals, nectar cup, and store
Of fragrance sweet, that insect lovers wooed,
It sacrificed ; and only wandering winds,
That have no sense of beauty or delight,
Now woo its sober blooms with heedless sighs.
But for this noble humbling of itself
God has more highly honoured it, to be
The chief support of human beings, made
In His own image—rulers of the world.

(*To be continued.*)

Biographical Byways.[1]

By Sir ARTHUR SCHUSTER, F.R.S.

10. HERMANN HELMHOLTZ (1821–1894), HEINRICH HERTZ (1858–1894), AND RÖNTGEN (1845–1923).

THE names of Helmholtz and Hertz remain connected together in my mind probably because, when I met them towards the end of their lives, the conversation with both mainly turned on the nature of cathode rays. Hertz adhered to the idea that they consisted of vibrations, while Helmholtz from the beginning stood up for the corpuscular theory, and was rather sore that the idea did not originate in his own laboratory. During the few months I was working there, at the end of 1874, Goldstein was engaged in the important researches which the Royal Society has recognised by the award of the Hughes Medal. His experiments, which showed that the rays emanating from a cathode were strongly repelled by an adjacent parallel electrode, were sufficient to convince Helmholtz that the rays consisted of a projection of negatively electrified matter, but Goldstein did not fall in with this view. "Of course," said Helmholtz to me a few years later, "as soon as Stokes became acquainted with Crookes's experiment he guided him into the right path."

In his early years Helmholtz seems to have been very sensitive to criticism. Roscoe used to relate how he found him once in great distress, complaining that his whole scientific career was endangered because some one had thrown doubt on one of his conclusions.

The Physical Laboratory of Berlin in 1874 contained only three or four rooms, with about a dozen students engaged in researches on a number of subjects mostly suggested by Helmholtz. In his daily rounds he used to discuss scientific problems freely with each in turn. He was as quick as Kelvin in being able to shift his mind quickly from one subject to another, but, in contrast with Kelvin, there was always a good deal of the *Grand Seigneur* in his attitude, and the title of *Excellency* bestowed upon him was borne with great dignity. He relaxed to some extent in his annual visits to Pontresina, where I received much encouragement from him in my early attempt to form some consistent theory of the passage of electricity through gases.

Her Excellency—his second wife, and a member of the South German aristocracy—was fond of society and gave weekly musical parties at their home in Berlin. She was of a highly strung and nervous temperament. During one of their visits to England they were staying with Roscoe at Manchester, and one morning she came down to breakfast complaining that she had been very ill during the night. She woke her husband, saying : "Hermann, I am going to die." "That is easier said than done," replied Helmholtz, turning round to sleep again. At one of his visits to Roscoe, he was accompanied by his daughter. The conversation turned on the possibility of flying. "It would be beautiful," said Miss Helmholtz ; "one could escape so easily from one's chaperon ; but then perhaps girls would be put into cages."

The intimate relations which Helmholtz maintained with Kelvin are referred to in the biography published by Königsberger. I may quote here the passage from a letter written by Helmholtz to his wife while on a visit to Lord Kelvin :

> "The former (James Thomson) has a good brain with clever ideas, but he will not listen to anything except about engineering and talks about it at all hours, day or night, so that no other subject of conversation has a chance in his presence. It is amusing to watch each of the brothers (William and James) insisting on explaining something to one another, and neither of them listening to what the other says. But the engineer is more persevering, and generally gets his own way.
>
> "In the meantime I have seen a number of new and ingenious appliances of William Thomson's, and had two interesting days here in consequence. But Thomson's thoughts follow each other so rapidly, that one can only obtain the necessary explanations about the working of his instruments, etc., by a series of questions to which it is difficult to get an answer. How his students can understand him is beyond me, as they cannot permit themselves to make the efforts to keep him to the point, which I could venture upon. All the same, a number of students were working in the laboratory and seemed to know what they were doing. . . . Thomson's experiments did for my new hat. He set a heavy metallic disc, balanced on a point, into rapid rotation, and in order to show me how the disc became immovable by the spin—he struck it with a hammer. The disc revolted against this treatment and flew off to one side, projecting the iron stand in the opposite direction. The stand split my hat and carried it away. The disc happily did no damage beyond breaking some glasses."

As is well known, the original suggestion that Hertz should undertake the experimental demonstration of the propagation of electrodynamic waves according to Maxwell's theory came from Helmholtz. The research could be undertaken only by one who possessed exceptional abilities both on the theoretical and experimental

[1] Continued from p. 306.

side. The merit of the execution belongs to Hertz alone. Towards the end of 1888, he communicated his first decisive success in obtaining waves of comparatively short length so that he could, by means of a parabolic mirror having an aperture of two metres, form a parallel beam and confirm previous results. Helmholtz wrote in answer: "I was much pleased with your latest feat. It concerns things at the possibilities of which I have nibbled for years in the hope of finding a hole by which to enter. I am therefore familiar with your line of thought, and its great importance is quite clear to me." In the same year Hertz had the choice of accepting a professorship at Berlin or Bonn, the vacancies occurring through the deaths of Clausius and Kirchhoff. Hertz decided for Bonn, and Helmholtz, approving the choice, writes: "Whoever is still able to carry out extensive scientific work is well advised to keep away from large towns." The great appreciation of Hertz's work by Helmholtz is shown by the unusual course he took in proposing the posthumous award of a certain prize to Hertz. He justified the proposal on the ground that it may "discharge a debt of the nation, inasmuch as Hertz during his lifetime had been much less honoured by his countrymen than by other nations."

In my own intercourse, I found Hertz to be a man of extreme modesty. During one of my visits to him, he received the news of some distinction the Academy of Sciences of Vienna had bestowed upon him. He seemed worried by it. "Too many honours," he said, "are as bad as too few. They do not add to the pleasure and only create jealousies." With regard to the fundamental question of cathode rays, he attached great importance to an experiment he had made, which showed that they could pass through gold leaf, and looked upon this as telling in favour of waves; to which I could not agree.

I am told that in early youth Hertz gave expression to weird ideas with regard to possible happenings if some of the ordinary circumstances of life were changed.

It is sad to think that the illness which led to his death was probably aggravated, if not caused, by the unsanitary state of his laboratory, which, as I am told, had been built and used as a hospital for certain contagious diseases.

The succession of experimental discoveries leading, through Hertz, to the important researches first of Lenard and then of Röntgen is well known. I never spoke to Röntgen, and hearing of his presence in another hotel during one of my visits to Pontresina, I called on him. He was not at home, but I saw his wife, who received me in a friendly manner. The call was never returned, though amends for this want of courtesy were made a few months later. Returning to Manchester from a short Christmas holiday at the end of the same year, I called at the laboratory on my way home from the station. On looking at the accumulated correspondence, I opened a flat envelope containing photographs which, without explanation, were unintelligible. Among them was one showing the outlines of a hand, with its bones clearly marked inside. I looked for a letter which might give the name of the sender and explain the photograph. There was none: but inside an insignificant wrapper I found a thin pamphlet bearing the title "Über eine neue Art von Strahlen," by W. C. Röntgen. This was the first authentic news that reached England of the discovery of the so-called X-rays. I sent a translation of the paper to NATURE, where it appeared on January 23, 1896.

Obituary.

SIR EDWARD THORPE, C.B., F.R.S.

ALTHOUGH Sir Edward Thorpe had been unwell for some considerable time, yet his well-known energy and virility were so remarkable that it came as a shock to his many friends to learn that he had passed away on Monday, February 23, at his beautiful Devonshire home by the sea, Whinfield, Salcombe. It was an ideal residence in his retirement, for he could there enjoy his favourite relaxation of yachting, and take any one of his three yachts out to sea for a sail just as readily as taking a walk, which the hilly roads and paths of South Devon had latterly rendered a matter of difficulty for him.

Carrying my mind back to the year 1885, when I had already been two years as a Royal Exhibitioner at the Royal College of Science, South Kensington, I remember the gratification with which we students learnt that our retiring professor of chemistry, Sir Edward Frankland, was to be succeeded by Prof. Thorpe, whose reputation at the Yorkshire College, Leeds, had gone before him. I had previously studied under Sir Henry Roscoe at the Owens College, Manchester, where Dr. Thorpe had held his first appointment as demonstrator on Sir Henry's staff, and this fact, together with a personal introduction to the new professor from the latter's father-in-law, Dr. John Watts, proved a bond of attachment, which, after my third year as student, but working in the research laboratory, led to collaboration with Prof. Thorpe in several years of research on the oxides and other compounds of phosphorus, and to a demonstratorship and lectureship which lasted eight years, indeed, until Sir Edward, in 1894, left South Kensington to become Principal of the Government Laboratories.

Sir Edward was born in the Harpurhey suburb of Manchester on December 8, 1845, his father, Mr. George Thorpe, having been a merchant of that city. At the close of his student days at the Owens College he went to study under Bunsen at Heidelberg, carrying with him a letter of introduction from Prof. Roscoe, who had himself been a pupil of Bunsen. Moreover, young Thorpe was entrusted with a present from Roscoe to Bunsen, namely, some well-formed crystals of potassium and sodium, which Roscoe had placed in separate bottles under rock-oil, as usual with the alkali metals. In the throes of packing, the young student economised space by placing both metals in one of the two bottles, the crystals being sufficiently different to be distinguishable. After presenting his letter, he duly brought forth the bottle, removed its paper covering, and ceremoniously presented it to Bunsen as containing unique specimens of potassium and sodium crystals. The great chemist looked hard at the bottle and then at his visitor, who then first realised that something was wrong. For, instead of metallic crystals beneath the rock-oil, there

was nothing but a shining liquid resembling mercury. He was beginning to fear that the great master would suspect a practical joke, of doubtful taste, when suddenly Bunsen's face lighted up with a great smile, and he told the would-be new disciple that his first research should be the investigation of this new liquid; he then welcomed him heartily to Heidelberg. The sequel revealed no joke, but the important new fact that sodium and potassium unite to form an alloy, which is liquid at the ordinary temperature, and closely resembles mercury in appearance.

While at Heidelberg, Thorpe had Victor Meyer for both laboratory companion and lodgings partner, so that the well-known great friendship between them dates from that time. After taking his Ph.D. degree, Thorpe spent a short time in the laboratories of Bonn, after which he returned to Manchester and took up his duties as demonstrator under Roscoe.

In the year 1870 two important events occurred in Thorpe's career, namely, his first professorship in chemistry, at the Andersonian College, Glasgow, and his marriage to Caroline Emma, the daughter of Dr. Watts, chairman of the Lancashire and Cheshire Institutes and of the Manchester School Board, and one of the ablest of the pioneers of higher education. In 1874 came the call to the newly established Yorkshire College, Leeds, where he made the chemical department renowned for its efficiency and its output of original research. His painstaking and highly accurate determinations of the specific volumes of liquids of definitely related chemical composition, involving new and refined modes of determining their densities and thermal expansions, led to very important conclusions concerning chemical constitution, and he was elected a fellow of the Royal Society in 1876.

On taking up his appointment to the chair of chemistry at South Kensington in 1885, Thorpe suggested to me a research on the oxides of phosphorus, especially with the view of identifying, or if necessary of discovering, the lower oxide, supposed to be P_2O_3. This oxide had really not hitherto been isolated, for the supposed descriptions of it turned out eventually to be quite absurdly erroneous. The professor's first instruction, however, was one which greatly impressed itself at the time, and one which might with great advantage be more generally followed in commencing a research: it was to spend several days in studying and abstracting all the known literature on the subject, from both books and original memoirs.

This research extended over six years, and resulted in the publication of four joint papers. The first paper, published in the Journal of the Chemical Society in 1886, concerned an altogether new oxide of phosphorus, the tetroxide P_2O_4, which we obtained in excellent crystals instead of the expected P_2O_3 for which we were searching. The second paper was published in the same journal in 1890, and described the isolation and eventual successful determination of the constitution and properties of the so-called trioxide. It proved to be a white waxy solid, melting to a colourless liquid at summer temperature (22° C.), and boiling, in an inert atmosphere, undecomposed at 173°, and affording a vapour density which indicated precisely the double formula P_4O_6 and not P_2O_3. The third paper, also in the same journal, was published in 1891, and described a number of interesting reactions and additive compounds of the new phosphorous oxide. The fourth paper gave further details of one of these addition compounds, phosphorus sulphoxide, $P_4O_6S_4$, in preparing which on several occasions very lively and dangerous explosions occurred, one of which left the nearest of us on the floor. This fourth paper was contributed to the newly projected *Zeitschrift für anorganische Chemie*, being the first paper in the first number published (February 27, 1892) of that journal.

One of the most satisfactory things about the results of this research was the establishment of the fact, by the kind collaboration of the late Sir Lauder Brunton, that the oxide P_4O_6 was the cause of the necrosis of the jaw from which workers in match factories so frequently suffered. The knowledge gained in the research was eventually the means of entirely avoiding the production of the oxide during the manufacture of matches, and consequently brought about the total disappearance of this terrible disease.

During his tenure of the chair at South Kensington, Sir Edward Thorpe carried out the determinations of the atomic weights of gold and silicon, in collaboration with Dr. A. P. Laurie and Mr. Young respectively; and also a prolonged research on viscosity with Mr. J. W. Rodger, which formed the subject of the Bakerian Lecture to the Royal Society in 1894. The wonderful delicacy and dexterity of manipulation manifested in these researches was even more fully exemplified in the research on the atomic weight of radium, which was carried out by Sir Edward at the Government Laboratory, and formed the subject of his second Bakerian Lecture in 1907. He also carried out at South Kensington researches on some volatile fluorine compounds in collaboration with Mr. Rodger and with Mr. Walter Kirman.

A further important research of a totally different kind was the magnetic survey of the British Isles, which Sir Edward commenced while at Leeds and continued when at South Kensington, in collaboration with Sir Arthur Rücker, who was similarly transferred from Leeds to South Kensington as professor of physics. The writer has some special knowledge of the immensity of this work, as he made the computations and maps for the first survey, that of Scotland. Sir Edward Thorpe's yacht was of great assistance in this part of the work, especially as regards the stations on the west coast, and among the isles. His love of the sea was also the cause of his taking part in four solar eclipse expeditions, those of 1870, 1878, 1886, and 1893. The first proved unduly exciting, for H.M.S. *Psyche*, carrying the members of the expedition from Naples to Sicily, was totally wrecked.

After sixteen years at the Government Laboratory, Sir Edward returned to South Kensington as professor of general chemistry at the Imperial College of Science and Technology. He finally retired at the close of the War with the title of emeritus professor. He had been knighted in 1909, after receiving the C.B. in 1900. He was the recipient of a Royal Medal from the Royal Society, of which he was foreign secretary from 1899 to 1903, and was the first Longstaff medallist of the Chemical Society, of which he was president (after being for a number of years treasurer) from 1899 to 1901. He received honorary degrees from several

universities at home and abroad, and was an honorary member of a great number of learned societies throughout the world. He was president of the Society of Chemical Industry in 1895, and in 1921 of the British Association at its meeting in Edinburgh. This last occasion saw the beginning of his illness, for he was taken ill on arrival in Edinburgh, and was unable to deliver his presidential address on atomic structure, which was read for him by Sir Alfred Ewing.

It is only possible in the space left at my disposal to mention briefly Sir Edward's brilliant lecturing and literary ability. His early books, "Chemical Problems," "Inorganic Chemistry," "Quantitative Analysis," and "Qualitative Analysis," were used by thousands of students, while his great "Dictionary of Applied Chemistry," now appearing in a new edition, is a monumental work of the utmost importance to industrial chemistry. His biographies of Dr. Priestley and Sir Humphry Davy, the "Essays in Historical Chemistry," and his "History of Chemistry," are most readable and entertaining, as well as of scientific value, giving the personal touch which is so charming to the wonderful events in the evolution of modern chemistry. Finally, his "Yachtsman's Guide to Dutch Waterways" and "The Seine from Havre to Paris" are permanent records of a master yachtsman and valuable guides to later comers in the yachting world, whether their vessels be propelled by wind, steam, or petrol.

Sir Edward Thorpe thus passes from our ken in his eightieth year, full of honours as of years, and with a published record of scientific work which it is given to few scientists to achieve. He leaves no children, so that our sympathy will therefore go out in all the greater measure to his lifelong companion, Lady Thorpe, who has so devotedly watched over and cared for him, and made his home a paradise.

A. E. H. TUTTON.

Miss L. S. Gibbs.

MISS LILIAN SUZETTE GIBBS, the news of whose death at Santa Cruz, Teneriffe, on January 30, came as a shock to her botanical friends at home, had done good work both as an investigator in the laboratory and as an explorer in many parts of the world. After a two years' course at the Swanley Horticultural College, she entered the Royal College of Science as a student in the Department of Botany under Prof. J. B. Farmer. From that time onwards her life, which might have been one of leisure, was devoted to the pursuit of science. She became a research student at the College, and the value of her work was attested by the award of the Huxley medal and the prize for research in natural science.

Miss Gibbs became early interested in the floristic side of botany, and collected in the Alps of Switzerland and Austria. In 1905 she visited South Africa with the British Association and collected in Southern Rhodesia and at the Victoria Falls. But her great contribution to floristic botany was her work on the mountain flora of various parts of the world. Between 1907 and 1915 she visited successively the mountains of Fiji, Mt. Kinabulu in British North Borneo, the Arfak Range in Dutch North-west New Guinea, the Bellenden-Ker Range in Queensland, and the mountain plateaux of Tasmania. Each of these expeditions formed the subject of a memoir—published in the Journal of the Linnean Society, the *Journal of Botany*, or the *Journal of Ecology*—in which she described her observations on the plant-formations, discussed questions of distribution of plant-life, and gave a systematic account (with the assistance of experts in some of the groups) of the very considerable collections which she brought back. A complete set of these collections is in the Department of Botany of the British Museum, where her floristic work was elaborated. She retained, however, her interest in structure and development, and her papers in the *Annals of Botany*, especially one on the development of the female strobilus in Podocarpus, based on her own collected material, are valuable contributions to this aspect of botany.

Miss Gibbs was a woman of strong personality, and keenly interested in the question of equal rights for her sex. She was one of the earliest women fellows of the Linnean Society and the Royal Microscopical Society, and was also a fellow of the Royal Geographical Society. She had many friends, who deeply regret that her work is finished, and to whom her death comes with a sense of personal loss.

THE world of geography has sustained a serious loss by the death of Mr. John Bolton, which occurred after half an hour's illness on February 22. Mr. Bolton was in his eighty-third year, having been born in 1842. In 1857 he entered the service of Mr. Edward Stanford, the grandfather of the present head of the firm of Edward Stanford, Limited, and although of recent years he had only acted in a consulting capacity, his connexion with the firm was continuous until his death. Many leading cartographical works were produced under his direction, including the London Atlas series of maps, Stanford's 6-inch and 4-inch scale maps of London, and their series of library maps. In 1884 Mr. Bolton was appointed geographical expert to the Congo conference at Berlin, and in 1897 served on the Venezuela Boundary Arbitration, being loaned by the firm to the government for such service. He was a life member of the Royal Geographical Society, and attended regularly the meetings of the Geographical Section of the British Association, including the visit of the Association to South Africa in 1905. He was also a fellow of the Royal Colonial Institute. In the course of his career Mr. Bolton had been associated with many famous men, including General Gordon, H. M. Stanley, Cecil Rhodes, Lord Kitchener, Capt. Scott, and Sir Ernest Shackleton. He possessed a personality that inspired confidence, and a geniality that endeared him to all with whom he came in contact.

WE regret to announce the following deaths:

Dr. Adolph Kemna, corresponding member of the Zoological Society of London and formerly president of the Royal Zoological and Malacological Society of Belgium and of the Belgian Society for Geology, Palæontology and Hydrology.

Dr. C. Symes, president in 1897 and 1898 of the British Pharmaceutical Conference, on February 13, aged eighty-five.

Dr. A. de Watteville, for many years editor of *Brain* and distinguished for his work on the nervous system, on February 24, aged seventy-eight.

Current Topics and Events.

Two subjects of philosophical and physical investigation have excited deep interest during recent years, the theory of relativity and the theory of quanta. These were discussed by Dr. J. H. Jeans in his Kelvin Lecture on "Electric Forces and Quanta," delivered on February 5 at the Institution of Electrical Engineers, and published as a special supplement to this week's issue of NATURE. The first part of the lecture deals with electric forces in the light of the theory of relativity, and it is claimed that, as all the phenomena go on as though there were no ether, the conception of an ether is superfluous. If an ether does exist, it must probably be thought of as a four-dimensional structure and must be largely subjective. The generalised geometry of Einstein and Weyl can predict and explain all the systems of forces of the universe, both gravitational and electrodynamical. But geometry does not explain the atomicity of electric charges or the essential difference between positive and negative electricity. Again, quantum theory indicates the existence of discontinuities in Nature of a kind not contemplated in the older mechanics. No one is better qualified to deal with the implications of this theory than Dr. Jeans, whose report on radiation and the quantum theory published by the Physical Society of London has long been a mine of information for those interested in the subject. Some of the ideas adumbrated in the final chapter of that report have now been developed further. It may well be that the atomicity of the quantum theory is only another aspect of the atomicity of electric charges. The quantum theory represents, perhaps, a quality of the four-dimensional continuum, which is somehow analogous to the scaliness of a crocodile skin. This is equivalent to the suggestion that the "calamoids" or four-dimensional tubes of force of Prof. Whittaker should be regarded as quanta. Our conception of the action of an electric field on an electron seems to require revision in the light of a recent hypothesis due to Einstein. The electric forces in Maxwell's equations serve in some way to measure the *probabilities* of jumps in the velocity and perhaps also in the position of an electron in an atom.

THE numerous statements that have been made recently by politicians and others about the great economies that could be effected by erecting very large electric generating stations are sometimes very misleading to the public. It is pointed out that, by the use of these super power stations, the cost of the coal used per unit of power generated would be halved. It is generally concluded, therefore, that the cost of power to the consumer would be reduced by a half. When we remember, however, that only from 20 to 25 per cent. of the total cost of generating a unit is due to the coal used, it will be seen that the reduction of price to the ultimate consumer would only be about 12 per cent., and not the 50 per cent. which the public have been led to expect. Similar conclusions apply to water power. We have received from the Smithsonian Institution of Washington an excellent report, by S. S. Wyer, on the power possibilities and preservation of Niagara Falls. It is pointed out that the erection of the requisite hydro-electric plant is less than half that of the total scheme. Few realise that about 80 per cent. of the cost of delivering the energy to the resident consumer is incurred after the power has left the generating station. The money used for carrying out an enterprise, whether state-owned or not, must ultimately come from individual owners, and they have an obvious right to receive a hire or rental for it. An interesting comparison is made between the systems adopted on the Canadian and on the American side of the Falls. In Canada the Government owns about 79 per cent. of the hydro-electric system. The service in Ontario is not taxed, so that the lowering of the cost to the consumer is done at the expense of the tax-payers of the districts in which the property is located. On the American side, about 10 per cent. of the price of the service has to be paid for taxes. The rate of recession of the crestline of the Canadian Falls, which carry 94 per cent. of the water, is about 5 feet per annum. On the American side it is only about 2 inches per annum. Methods of preserving the scenic beauty of the Canadian Falls and preventing them from "gradually committing suicide" are discussed.

A STEP, which may eventually be one of far-reaching importance, has recently been taken by the authorities of the London School of Hygiene and Tropical Medicine. They have appointed a Rhodesian Research Fellow in the person of Dr. G. R. Ross, at present lecturer in the University of Leeds and a former graduate of the University of St. Andrews. This development is the direct outcome of the co-operation which existed between the Government of Southern Rhodesia and the old London School of Tropical Medicine whereby, on two occasions, Dr. J. G. Thomson, Director of Protozoology at the School, visited Southern Rhodesia and carried out research work in connexion with blackwater fever. The results of Dr. Thomson's useful inquiries have appeared in the form of a well-illustrated monograph, a pioneer publication. Dr. Andrew Fleming, the Medical Director, Southern Rhodesia, felt, however, that this was merely a beginning and that the question of blackwater fever, and indeed of other tropical maladies, was so important from the point of view of the white settlers and of the general development, not only of Southern Rhodesia but also of the whole chain of Central African tablelands, that measures should be taken to ensure a continuance of such research work. He found his Government in a sympathetic mood and, together with Sir Francis Newton, the High Commissioner of Southern Rhodesia, he approached the Board of Management of the London School of Hygiene and Tropical Medicine after some preliminary discussions with the Director of the School. Eventually it was arranged that, for a period of three years, the Southern Rhodesian Government, in addition to making an annual grant

towards the expenses of the Field Station, would undertake to provide laboratory accommodation and equipment together with travelling expenses in Rhodesia for one or more research workers to be appointed and sent out by the London School. In accordance with this arrangement, Dr. Ross, accompanied by a trained laboratory assistant, will leave England in March.

SIR OLIVER LODGE'S fifth broadcast talk from the London Broadcasting Station 2 LO on "Ether and Reality" was delivered on Tuesday, March 3. His subject was "Electromagnetism: How Radiation is Generated." An electron at rest has nothing magnetic about it; but the path of a moving electron is surrounded by magnetic lines of force, as an umbrella might be surrounded by indiarubber rings. When the electron is suddenly stopped, these rings are "shocked" off, spreading out as a pulse or shell of radiation with the speed of light, carrying away the energy and momentum. A moving electron has additional mass: when stopped, this mass disappears as a quantum of radiation; the size of the quantum depending on the previous speed. There are strange unexplained facts looming ahead of us. Sometimes, Sir Oliver said, we feel as if radiation were a half-way stage between ether and matter. Matter is discontinuous. Is light discontinuous? Is light a kind of matter which is bound to travel at a fixed speed, unless perchance it be modified into an electron? The difficulty and the interest of the problems before us are only equalled by the ingenuity with which they are being attacked. The eternity of the cosmos seemed at one time in doubt by reason of the dissipation of energy: now there is some glimpse of a way out. Matter tends to fall together gravitationally, but radiation tends to spread to the confines of the universe; and however diluted it retains its vigour. What becomes of the quanta? Why is no speed greater than that of light possible? Some revelation is dawning upon us, and confronted with a majestic vision of reality, we—like those other explorers on their first view of the Pacific Ocean—have

"Look'd at each other with a wild surmise—
Silent, upon a peak in Darien."

SIR JAMES C. IRVINE in his discourse on Friday evening, February 27, at the Royal Institution, dealt with sugars from the point of view of the organic chemist. Within the last fifty years many new sugars have been isolated from natural sources; others, unknown in Nature, have been prepared synthetically; formulæ have been ascribed to them, and in many cases the structure has been determined. In order to make further progress, a new phase must be entered upon when only such reactions of the sugars will be studied as proceed under conditions approaching closely to those which obtain in the living tissues; conditions which will not admit of the use of solvents or reagents inimical to life, and in which the optical, electrical and thermal factors will be rigidly controlled. Above all, new types of synthesis are required, and only when the chemist resolves to regard it as a crime to conduct a sugar-reaction at the boiling point is there any real hope for sugar chemistry. Eighty years ago Faraday was investigating the electrical properties of cane-sugar, and the recollection inspires the hope that the research now associated with the Royal Institution may again be applied to the whole series of carbohydrates. What a prospect is opened up when a well-founded conception of constitutions based on both physical and chemical evidence shall have been acquired.

AT the forty-seventh annual general meeting of the Institute of Chemistry held on March 2, the president, Prof. G. G. Henderson, after referring to the loss sustained by British chemistry by the death of Sir George Beilby, one of the past presidents, announced that the Council had invited the co-operation of the Society of Chemical Industry and the Institute of Metals, of which Sir George had also been president, in establishing some fitting memorial in his honour. The Institute was frequently invited to appoint delegates to participate in public inquiries. Such invitations were welcomed, but the Council had felt obliged to give expression to a mild protest that provision could not be made to lighten the sacrifice of time and expense which the duties of such representatives entail. The Council was diffident about asking fellows who were resident in the country to attend Government committees at their own cost and without emolument. The attitude of authorities towards scientific men had been reflected in the speeches of Ministers of the late Government, who apparently regarded the professional scientific man in the civil service as a very useful person in an ancillary or subordinate position, but it should be insisted upon that scientific departments should be controlled by competent scientific men. Chemists who were also capable men of affairs were available; many such held high positions in industry, and they were coming more and more into positions of control. It was the business of the Institute to ensure the supply of such chemists for the benefit of the country. The following officers for the year ending March 1926 were elected: *President*, Prof. G. G. Henderson; *Vice-Presidents*, Prof. E. C. C. Baly, Mr. E. R. Bolton, Mr. A. Chaston Chapman, Dr. T. Slater Price, Prof. A. Smithells, Mr. E. W. Voelcker; *Hon. Treasurer*, Mr. P. H. Kirkaldy. At the conclusion of the formal business, the president, supported by Prof. Thomson, made a presentation, on behalf of the fellows and associates, to Mr. Richard B. Pilcher on completing thirty years as secretary and twenty-five years as registrar and secretary of the Institute. In the evening the Council entertained Mr. and Mrs. Pilcher and their family to dinner at the Hotel Russell, followed by a reception.

ON February 28, at 9.23 P.M., a strong earthquake was felt in the eastern United States and Canada. The first accounts do not suggest a shock of unusual or destructive intensity, but it is possible that its importance was not fully realised at the time the messages were sent. Two facts in the brief reports seem to indicate the severity of the earthquake. One is its great duration, even supposing that the estimate

of four minutes at New York was much exaggerated. The other is the magnitude of the disturbed area. An earthquake that was noticeably felt in New York, Richmond (Virginia), Louisville (Kentucky), Chicago, and Montreal must have disturbed a district at least 750 miles in diameter and containing not less than 450,000 square miles, that is to say, an area greater than that affected by the San Francisco earthquake of 1906. At New York the movement was strong enough to break the writing pointer of the seismograph at Fordham University. It was recorded at West Bromwich and, no doubt, at many other places in Europe.

AN important conference upon applied microscopy is to be held in Sheffield on April 20 next and following days under the auspices of the Royal Microscopical Society at the invitation of the University of Sheffield, the civic authorities, the Master Cutler, and the local technical colleges and research associations. A local committee has been appointed representative of the academic and industrial research interests, and the programme includes a large number of communications and discussions dealing with technical problems connected with iron and steel, wood, coal, paper, textiles, industrial diseases, and microscopical optics. Visits to works and laboratories are being arranged, and an imposing exhibition of instruments and apparatus will be open throughout the meeting. It is also hoped to arrange with the railway companies to grant cheap travelling facilities to those attending the conference. The conference is open to all interested in technical microscopy, and full particulars can be obtained from the Secretary, Royal Microscopical Society, 20 Hanover Square, London, W.1, or from the Local Secretary, Mr. E. J. Thackeray, Dept. of Applied Science, University of Sheffield.

THE fifth International Congress of the History of Medicine will be held at Geneva on July 20-25, with Dr. Charles Greene Cumston as president and Sir D'Arcy Power as president of honour. The following papers among others will be read: medical operations in the stone age, by M. Eugène Pittard of the University of Geneva; Albert von Haller and the "Disputationes chirurgicae selectae," by Sir D'Arcy Power; Robert Whytt, an eighteenth-century neurologist, by Dr. John D. Comrie; the history of typhoid fever in the child, by Prof. P. Gautier; a letter of Tronchin and the Suttonian method of inoculation, by Dr. J. G. de Lint; Voltaire and medicine, by Dr. J. D. Rolleston; goitre at Geneva in the Middle Ages, by Dr. E. Wickersheimer; Lavater and his successors, by M. Fosseyeux; a note on the history of diagnosis in medicine, by Dr. F. G. Crookshank; a letter of Girolamo Fracastoro on poetry, by Dr. J. W. S. Johnsson of Copenhagen; historical researches on the history of anatomy in the Ateneo Romano, by Dr. P. Capparoni; medical literature of the seventeenth century as exemplified in the Elzevir Press, by Dr. E. B. Krumbhaar; hygiene and public health in the early civilisations, by Mr. C. J. S. Thompson; the origin of veterinary art, by Sir Frederick Smith; the history of magic in the cure of disease, by Prof. Jeanselme; Martin Luther and his noises in the ear, by Prof. G. Bilancioni; a medical congress at Rome in 1681–82, by Dr. C. G. Cumston; and Benjamin Waterhouse, an American pioneer, by Dr. J. W. Courtney. Further information can be obtained from the general secretary of the Congress, Dr. A. de Peyer, 20 Rue Général Dufour, Geneva.

THE new journal entitled *The Industrial Chemist and Chemical Manufacturer* constitutes a somewhat novel departure in the sphere of chemical journalism, because it will be the only monthly publication of its kind in Great Britain, and because it is very attractively got up. The general style resembles that of some American journals which contain articles profusely illustrated and advertisements very effectively displayed. It is interesting to note that in the new publication the advertisements of many old-established firms that have, apparently, never been radically changed within living memory, appear in an entirely new dress—the designs and the letterpress being entirely novel. In the journal proper the main feature is the large number of articles, many of which are written by well-known authorities. Among the subjects treated are vanadium, saccharin, power alcohol, petroleum refining, glass, disintegrating mills, lime, vegetable adhesives, disinfectants, and adhesives. The manner of treatment may be described as not severely technical, the object being to attract and interest not only the chemist, but also those employed in or associated with chemical undertakings, including the works' manager and the directorate, who may have no expert knowledge of chemistry. This is a field which has hitherto been neglected or inadequately cultivated, and in extending a welcome to the new publication we express the hope that it will be particularly successful in fulfilling this part of its programme.

ON Tuesday, March 10, at a quarter past five, Prof. E. N. da C. Andrade will begin a course of two lectures at the Royal Institution on the evolution of the scientific instrument, and on Thursday, March 12, Dr. Leonard Hill will deliver the first of two lectures on the biological action of light. The Friday evening discourse on March 13 will be delivered by Prof. Gilbert Murray, on the beginnings of the science of language, and on March 20 by Prof. J. W. McBain, on soaps and the theory of colloids.

APPLICATIONS are invited by the Board of Management of the Christie Hospital, Manchester, for the post of cancer research worker, whose duties will be to carry out research work on the blood in cancer. Candidates should have a medical qualification and experience in clinical, pathological, and biochemical methods. The latest date for the receipt of applications, which should be sent to Dr. C. Powell White, Christie Hospital, Manchester, is March 13.

AT the annual general meeting of the Physical Society held on February 13, the following officers were elected: *President*, Mr. F. E. Smith; *Vice-Presidents* (*who have filled the office of President*), Sir Oliver J. Lodge, Sir Richard Glazebrook, Dr. C

Chree, Prof. H. L. Callendar, Sir Arthur Schuster, Sir J. J. Thomson, Prof. C. Vernon Boys, Prof. C. H. Lees, Sir W. H. Bragg, Dr. Alexander Russell; *Vice-Presidents*, Dr. E. H. Rayner, Dr. J. H. Vincent, Dr. D. Owen, Mr. C. R. Darling; *Secretaries*, Prof. A. O. Rankine, Imperial College of Science and Technology; Mr. J. Guild, National Physical Laboratory, Teddington, Middlesex; *Foreign Secretary*, Sir Arthur Schuster; *Treasurer*, Mr. R. S. Whipple; *Librarian*, Mr. J. H. Brinkworth.

THE series of Early Chellean hand-axes found during 1924 by Mr. Reid Moir upon the foreshore, and in a deposit representing the base of the Cromer Forest Bed, at East Runton and elsewhere on the Norfolk coast, is now being exhibited in the Museum at Ipswich, and the specimens can be examined by any one desirous of doing so. The early flint implements of East Anglia are now arranged in the following sequence, which illustrates the succession of human cultures in Late Pliocene and Early Pleistocene times, namely, (*a*) specimens of Harrisonian eolithic type, (*b*) pre-Chellean forms from beneath the Red Crag, (*c*) Early Chellean hand-axes from the base of the Cromer Forest Bed, and (*d*) Chellean, Acheulean, and Mousterian implements from various deposits in Suffolk and Norfolk.

THE Soviet Government of Russia has taken steps to protect the *zubr* or European bison, and incidentally other rare forms of life, in the Western Caucasus, by declaring an area of about 250,000 dessiatins, or approximately 625,000 acres, a reserved area under the control of a special official with the title of *zubrovni zapoviednik*. Within this area "all activities damaging the natural relief of the surface, such as the felling of timber, pasturing of cattle, opening of quarries, etc.," are forbidden.

THE Cambridge Instrument Co., Ltd., have issued a new list, No. 194B, dealing with thermoelectric pyrometers. The catalogue deals in succession with general principles, indicators, recorders, thermocouples, cold junction control, and pyrometer tester. The latter is a compact form of potentiometer suitable for checking the accuracy of any type of thermoelectric potentiometer. An interesting item is the new thread recorder, which is enclosed within a robust moisture and fume-proof metal case instead of the customary teak cabinet. Recorders of this type are supplied making up to six records on one chart. These may include records of temperature, carbon dioxide percentage, and carbon monoxide percentage. It might be remarked that the carbon monoxide indicating apparatus is a development of the carbon dioxide type. The amount of carbon monoxide is obtained by a differential measurement of the carbon dioxide present before and after the flue gases are passed through a small electric furnace containing copper oxide which converts any carbon monoxide present into carbon dioxide.

ERRATUM.—The words "on the Use of Preservatives and Colouring Matters in Food" appearing on p. 222, col. 2, of the issue of February 14, in the concluding sentence of the review entitled "The Chemistry of Flour Milling," were inserted in error after the author had passed his proof. The Report of the Departmental Committee already published makes no reference to the bleaching and improving of flour, but a further report will appear in due course.

Our Astronomical Column.

THE DISTANCE OF THE ANDROMEDA NEBULA.—There have been several very discordant estimates of the distance of this object. A new one has now been made by Prof. Hubble, and is briefly described in *Popular Astronomy* for February. He has found several Cepheid variables in the nebula, determined their periods, and deduced their absolute magnitudes in accordance with Prof. Shapley's formula. The resulting distance of the nebula is 950,000 light years, a distance which would make it of the same general order of size as our galaxy.

This is probably a more trustworthy estimate than those previously made; a possible correction might arise from absorption of some of the stars' light in traversing the nebulous matter.

A note in *Popular Astronomy* points out that the 7th magnitude Nova that appeared in the nebula in 1885 would at this distance have been 140 million times as bright as the sun.

ANNUAIRE DU BUREAU DES LONGITUDES, 1925.—This little handbook is now very well known, and contains as usual, a large amount of useful information—astronomical, meteorological, physical, geographical, political, etc.

The special essays this year are by M. E. Fichot on the effect of the earth's rotation on the tides, and by M. G. Ferrié on the use of lamp valves in wireless telegraphy and telephony, with applications to astronomy. A little more care would seem to be called for in editing the astronomical tables: p. 289 gives the revolution of Mercury 2 days too great, a very serious mistake; p. 302 in giving the elements of Neptune's satellite omits to notice the very interesting variation in its orbit plane.

The information about the comets of 1923 is not up-to-date; much better elements of comet 1923 *a* were available months ago. The object described here as comet 1923 *b* was found to be a minor planet more than a year ago: there are, moreover, three misprints of proper names in the account of it, "Harward," "Seegrave," "Crowford"; p. 310 gives the erroneous period 12·1 years (more than a year too short) to Tuttle's comet. This mistake has been repeated for several years and has misled many people. This period was deduced from a short arc, and was not intended to be taken as accurate.

UNION OBSERVATORY, CIRCULAR 62.—This circular, dated last June, contains a number of important observations, which include the transit of Mercury (third contact 24 seconds before Nautical Almanac, fourth contact 35 seconds before), also long series of observations of Reid's Comet 1924*a* and Eros, which were too far south for European observers; also 114 occultations of stars by the moon, observed in 1923, which are fully discussed. There are reproductions of the spectra of Nova Aquilæ on 21 days, June 11–August 10, 1918, which are conveniently arranged for studying changes. The identity of the Nova with a 10th magnitude star in the Algiers astrographic catalogue was independently detected by the blink microscope at Johannesburg.

Research Items.

PREHISTORIC POTTERY IN PERU.—Messrs. A. L. Kroeber and D. D. Strong, in a study of the pottery from Ica collected by Dr. Max Uhle for the University of California some years ago, pay a well-deserved tribute to the valuable but too little recognised work of this archæologist in South American, and especially Peruvian, archæology. In the case of the pottery from Ica now described in University of California Publications in American Archæology and Ethnology, vol. 21, No. 3, and in the case of the pottery from Chincha, of which an account by the same authors appeared in a previous issue, they find that their independent study completely corroborates Dr. Uhle's suggested classification and sequence in all important respects. The pottery from graves in the Ica Valley, which lies on the coast of southern Peru, is classified into seven periods, as against the three at Chincha, representing more or less successive culture phases—Inca, late Ica II. and I. (corresponding closely with the three phases at Chincha), Middle Ica II. and I., Early Ica or Epigonal, and Nazca or Proto Nazca. The last named is unique and distinctive in colour, design, and shape. The stylistic development from Middle Ica I. to Inca is so continuous that when once Inca is accepted as latest, any other sequence is impossible. The Ica Epigonal and Middle Ica are undoubtedly related to Tiahuanaco style, but it is difficult to see that Epigonal represents a decadence of Tiahuanaco styles as Uhle supposes.

THE THEORY OF SENSE DATA.—In a lecture published in the Journal of the Royal Astronomical Society of Canada, Dr. H. H. Plaskett expounds what he calls the descriptive view of science. This is the view that the objective content of science consists exclusively of the data of sense; that these sense data are not subjective aspects of reality but the actual non-mental content of the scientific object itself which is a construct of them; that the metaphysical concepts of substance and cause have no place in science, which can quite well dispense with them; that the atoms and molecules of physics and chemistry are not real existents but concepts. Dr. Plaskett seems to have taken this view from the chapter on sense data in Hobson's Gifford Lectures and to find support for it in Pearson's "Grammar of Science." The first of these does not profess to be original, but gives an excellent account of the recent controversy aroused in philosophical circles by the new realism of Mr. Bertrand Russell and Dr. Broad. If Dr. Plaskett had gone directly to the origin of this theory in modern times, Mach's "Theory of Sensations," he would probably have been aware of some difficulties of his descriptive view of science which are unnoticed in his lecture. Mach found, in fact, that, try as he would, he could not get scientific objects out of sense data; they are not implicit in them, and yet only as sense data do scientific objects exist for us at all. Mach spurned metaphysics, and he put forward as the only alternative to a scepticism like Hume's a theory of psycho-physical parallelism. This for him was the only possible way of objectifying scientific knowledge. The ideal of a science of pure description, renouncing all explanation, is no new thing. It goes back at least to Bacon, but it has never proved satisfying to the restless spirit of scientific inquiry. Since Berkeley, the problem of perception has made it still more disconcerting. It is well, however, that we should be continually reminded of the initial difficulties, even the paradoxes, which surround the problem of the true method of scientific procedure.

CUTTING SEED POTATOES.—Potato growers frequently hesitate to cut their seed potatoes on account of the uncertainty as to the yield per plant and to the growth and healthy development of the cut sets. This second point has been investigated by J. H. Priestley and G. C. Johnson (Journ. Min. Agric. 31, No. 11), who indicate the precautions needed to eliminate this uncertainty. The healing of the cut surface of a tuber is brought about by the deposition of a suberin deposit, which forms a barrier to the entry of moulds and bacteria capable of attacking and rotting the tuber. If the potato is cut in moist air this suberin layer is continuous over the whole surface, but if the air be dry the suberin is patchy and organisms are able to penetrate through the cracks between the patches, thus damaging the tuber. Field trials have proved the importance of this fact. Similar tubers of Great Scott were cut and exposed to sun and air for 24 to 48 hours, or kept in a damp, warm place for the same time. Much heavier crops were obtained with the latter treatment, 15½ tons against 6½ tons, 23½ tons against 14½ tons, etc., similar results being obtained with other varieties in other districts. Apart from the question of yield, it appears that the certainty of growth from cut sets is much greater if precautions are taken to protect the sets from sun and wind after cutting before they are planted.

OBSERVATIONS ON HOOKWORM LARVÆ.—Dr. L. Fabian Hirst describes (*Ceylon Journ. Sci.*, Section D, Medical Science, vol. i. pp. 1-26, 1924) investigations on the epidemiology of hookworm disease in Colombo. His attention was directed to the problem in consequence of a severe outbreak of hookworm dermatitis and disease amongst coolies handling soil from certain trenches in a field used for the disposal of septic tank sludge. The larvæ of Ancylostoma, Necator, and Strongyloides exhibit aerotropism, *i.e.* they attach themselves by one end to some fragment of fibre or similar substance on the surface of the soil and extend the rest of their bodies into the air, constantly moving as if in search of some additional support. The movement of Strongyloides larvæ is more jerky and gyratory; the hookworm larvæ exhibit a slow undulating motion. The author figures an apparatus in which buckskin leather is employed as a means of bringing about a separation between penetrative larvæ (which pass through the buckskin into a warm solution on the other side) and others present in the soil. The species of the penetrative larvæ (Ancylostoma and Necator) can be definitely determined only after development to the sexually mature form in the intestine of a suitable host. In laboratory experiments the author found that larvæ of *Necator americanus* could be recovered from the surface of infected soil for at least 108 and up to 124 days. Larvæ lived about three months in water and fluid extracts of trench soil; they died much more rapidly in soils and fluids kept at blood heat than in the same media at room temperature.

GROWTH IN INDIAN MOLLUSCS.—In an account (Records, Indian Mus., vol. xxvi. pp. 529-548, Nov. 1924) of his observations on growth in Indian molluscs, Major R. B. Seymour Sewell deals with five freshwater species and four marine brackish-water species—all gastropods except one (*Mytilus variabilis*). He examined 212 examples of *Pyrazus palustris*, which occurs in abundance in Nankauri Harbour, Nicobar Islands, in a swamp which is submerged at high water, and found that correlated with the gradual increase

in size is a remarkable change in the character of the radula. So marked is the difference between the radulæ of the smallest and the largest specimens that one might reasonably doubt whether they belong to the same species. In the smallest individuals, having a height of about 12 mm., the radula consists of rows of teeth—seven in a row (dental formula 2.1.1.1.2), each tooth possessing several cusps. As growth proceeds the cusps on the teeth become gradually reduced in number until finally the central tooth presents only a single median cusp, the lateral tooth has a single cusp and a trace of a second one, and the two marginal teeth have a single cusp with traces of one or two small ones. The reduction seems to be brought about by a process of fusion rather than by suppression, and, so far as can be ascertained, is not correlated with any change in the habits of the mollusc. No corresponding change occurs in the other gastropods examined.

BLACK SHEEP.—Wensleydale sheep have white wool, but the skin of the face and ears is deep blue, and this colour may extend to other parts of the skin. Breeders select for a maximum amount of pigment. The breed produces about 15 per cent. of black lambs, together with a number which are "pale blue" and very occasionally one which is pure white. Mr. F. W. Dry, from breeding experiments (*Journ. Genet.*, vol. 14, No. 2), concludes that the black is a simple recessive, since blacks bred together give only black offspring. The same is true of blacks in certain other breeds of sheep. The blue-faced sheep are found to be heterozygotes analogous to the Blue Andalusian fowl; in other words, a black sheep with a (dominant) white coat. On the other hand, the Karakul sheep is a dominant black. When crossed with white breeds, the lambs are pure black. Such F_1 hybrids are now widely bred and their fleeces used as fur, but in the adult the colour becomes grey or dirty white. In black Welsh mountain sheep the colour of the coat and horns is also apparently dominant in crosses. Mr. J. A. Fraser Roberts (*Journ. Genet.*, vol. 14, No. 3) describes experiments with this breed. A pattern known as "badger-face" also occurs, which is white with black markings on the face, belly, and legs. This appears to be recessive to both black and white. In crosses between black and badger-face a white lamb has been known to appear. Such cases of "reversed dominance" have been recorded in other breeds. Their further investigation is a matter of much genetical interest. The badger-face marking has also been studied by Wriedt in a Norwegian breed of sheep. Individuals with reversed badger-face markings, *i.e.* black where white should appear and vice versa, are also known to occur.

NEW PLANT ILLUSTRATIONS.—Two numbers of *Curtis's Botanical Magazine* have recently appeared under the energetic editorship of Dr. Stapf, being parts i. and ii. of vol. 150, each containing plates of eleven plants, and each including one rhododendron and one primula, *R. bracteatum* and *P. Bulleyana*, in part i., *R. glischrum* and *P. melanops* in part ii. Other interesting plants in part i. include *Stellera Chamæiasme*, an example of a small genus of Thymelaceæ that has not previously figured in the *Botanical Magazine*; *Lindmania penduliflora*, a Peruvian example of this genus of Bromeliaceæ which may be in Nature an epiphyte like so many of the family, although the immediate allies of this plant grow on the ground on the edge of the forest; and a species of the cactus-like genus of the Senecioneæ, *Kleinia stapeliiformis*. Part ii. includes some very striking plants, notably an epiphytic member of the Vacciniaceæ *Agapetes speciosa*, with brilliant scarlet flowers; a species of an Orobanchaceous genus, *Æginetia indica*, successfully raised at Kew as a parasite upon the roots of the sugar cane, which will apparently only grow upon the roots of monocotyledons; and a shrub from Natal, *Ochna serrulata*, with yellow flowers and very striking fruits, in which the blue-black drupelets stand out against a vivid background of vermilion-coloured, enlarged sepals.

FOSSIL CRANE FLIES FROM SOUTH AMERICA.—Two species of crane flies have been discovered by G. R. Wieland (*Amer. Journ. Sci.*, 9, Jan. 1925, p. 21) in the Rhætic beds of Minas de Petroleo, south-west of Mendoza, Argentina. The larger (*Tipuloidea rhætica*) had a wing spread of 2·6 inches, so that it rivalled in size the Australian "robber fly." The smaller form (*Tipulidites affinis*) had a wing spread of half an inch. This discovery emphasises the great antiquity of the Diptera.

UINTACRINUS IN THE CHALK OF WESTERN AUSTRALIA.—Remains of the free-swimming crinoid, Uintacrinus, have been found in the chalk of Gingin, Western Australia (T. H. Withers, Journ. Roy. Soc. W. Australia, 11, 1924, p. 15). This discovery gives important evidence of the age of the Gingin Chalk, since Uintacrinus is characteristic of the lower part of the Marsupites zone of the Upper Chalk; it also shows that this crinoid, hitherto known from Utah, Kansas, England, and Westphalia, had a very wide geographical distribution.

THE DOLDRUMS OF THE NORTH ATLANTIC.—The *Marine Observer* for February contains an article on "The Doldrums of the North Atlantic" by Mr. C. S. Durst. The author gives credit to Maury and Toynbee for their full discussion of this interesting region. Toynbee's discussion was carried out with the perfection of minuteness, comprised by elaborate charts and voluminous letterpress. It has the advantage of being based chiefly on the results from sailing ships, the observations being gathered by the Meteorological Office. An attempt has been made at a further discussion which may be of scientific value, but with the present-day steam vessels the region for the sailor has lost much of its "torment." Fig. 3 (p. 21), to which the author attaches considerable importance, is at least for the first ten days open to considerable doubt so far as the northern and southern boundaries of doldrum in March 1923 are concerned, and the resulting width of doldrum certainly is not 600 miles as given in the text.

ICE IN THE BALTIC SEA.—Among a number of interesting publications on various aspects of Baltic meteorology and oceanography published by the Havsforsknings Institutet of Helsingfors a particularly detailed paper deals with the occurrence and distribution of sea-ice during the winter of 1920–21 (No. 22, Isarna Vintern, 1920–21). The observations, which were gathered at coast stations and Finnish lightships, are given in full and entered on a series of coloured maps for the Gulf of Bothnia, the Gulf of Finland, and the Finnish water of Lake Ladoga. These charts show the beginning of the ice in the north of the Gulf of Bothnia in early December and its gradual extension southward. In the year under review the waters of the Aland Archipelago were not blocked until late January, but soon after that date fast ice extended across to the Abo Archipelago and the coast of Finland and remained until early March. The period of greatest extension of ice in the Gulf of Finland was the middle to the end of February, when, as usual, the Gulf was more or less entirely blocked. In early April the southern coasts of Finland were clear, while the western coasts cleared between the beginning of April and the middle of May. These dates appear to have been earlier than usual. This

and other publications of the Institute are in Swedish, with very brief German summaries.

SPARK IGNITION.—A knowledge of the conditions under which an electric spark in an explosive mixture of gases will initiate an explosion is of great importance in the mining, motor, and other industries, but the results of experiments made hitherto have been inconclusive. In a communication to the *Philosophical Magazine*, which appears in the February issue, Mr. J. D. Morgan gives an account of his experiments on the igniting powers of inductance sparks in direct and alternating current circuits, and comes to the conclusion that the thermal theory of ignition is sufficient to cover all the known facts. According to this theory, it is necessary to raise a sufficient volume of the gas in the immediate neighbourhood of the spark to a sufficiently high temperature before ignition results, and if both conditions are not satisfied the flame produced in the gas immediately in contact with the spark will not spread. To satisfy them a certain minimum energy must be imparted to the gas in a fixed short time, and this is in general more easily done by a capacitance than by an inductance spark, but there is no difference between the effects of the latter when in direct or in alternating circuits. The cooling effect of the electrodes is very marked and must be taken into account.

TESTING PHOTOGRAPHIC PLATES.—The February number of the Journal of the Royal Photographic Society is devoted to the first session of the Conference on the Standardisation of Plate-testing Methods which was held at the Society's house on December 9. The papers read and the discussions on them are given in full. The subjects treated of at this meeting were (1) the light source, primary and secondary; (2) the exposure mechanism; (3) the development. The first paper is from the National Physical Laboratory and deals with standards of light. Of the standards at present available for sensitometry either the crater of the carbon arc or a gas-filled tungsten lamp, operating at a colour temperature of 2950° absolute, is recommended, but in either case definite specifications of details would have to be prepared. Dr. Helmuth Naumann gives a formula for a colour filter in gelatine which contains six different dyes, and changes the light from a vacuum tungsten filament lamp into "daylight" from about 3000 Å.U. to about 7000 Å.U. with sufficient accuracy for most photographic purposes. It seems generally acknowledged that the intermittency error caused by rapidly revolving sector wheels placed in the path of the light should be eliminated. With regard to development, it is argued on one hand that this should be uniform, and, on the other hand, that uniformity would not be fair, because different plates need different treatments to get the best results of which they are capable. In all, ten papers were read and discussed.

THE γ-RAY SPECTRA BY THE CRYSTAL METHOD.—M. J. Thibaud has recently described experiments, in which the frequencies of monochromatic γ-rays are arrived at by converting the radiations into β-spectra, by means of the photoelectric effect on different elements, and measuring the energies of the electronic streams emitted. In the *Comptes rendus, Acad. Sci. Paris*, of January 12, he describes how, using de Broglie's method, with a rotating crystal of rocksalt and photographic registration, he has been able to make measurements with angles α of reflection scarcely more than a fraction of a degree. The velocity of rotation was less than 1° in twenty-four hours. Glass tubes containing 40 mgm. of radium bromide in equilibrium with its products were employed, and also a preparation of mesothorium. The spectra consist of clear sharp lines, with no continuous bands, and the following values have been found for radiothorium or mesothorium:

No.	Int.	λ in Å.	Energy in volts.	Origin.
1	strong	0·168	73,500	—
2	,,	0·145	85,000	Rd Th
3	weak	0·062	198,000	,,
4	medium	0·052	236,000	Th B

The indirect method gives 233,000 for the energy in volts of a γ-ray from thorium-B, which agrees with No. 4 above within the limits of probable error; this line has been found by Meitner and by Ellis. Fräulein Meitner assumes a γ-ray 0·146 Å to explain the β-radiation of radiothorium, which agrees with No. 2. The origin of No. 1 is not explained. Rays with energies of 273 and 298 kilovolts found by the indirect method, but weaker than the 233 kilovolt ray, have not as yet been observed directly. The spectrum obtained with radium confirms the two lines found by Rutherford with α about 1° 30′.

TYPOGRAPHIC INKS.—The technology of printing inks is described by Dr. N. F. Budgen in the *Chemical Trade Journal* for January 23. Typographic inks (used for book-printing, labels, etc.) are softer and thinner than lithographic inks, which must be unaffected by water. The essential constituents of printing inks, apart from the pigment, are the oil (usually linseed, though soya-bean, perilla, and other oils are often used), and the varnish (largely made from rosin oil). Cheap inks contain varnish made from mineral oils. The pigments used for obtaining different coloured inks and the incorporation of the ingredients are described in detail. Cheap black inks contain carbon black. More expensive inks use a black made from rosin oil.

SUGAR INDUSTRY IN GREAT BRITAIN.—The English beet-sugar industry is described in an article in the *Chemical Trade Journal* for January 23. The first factory to be erected in England was put up near Maldon (Essex) about 1832. It did not continue long, and the next factory, erected at Mount Mellick, Queen's County, Ireland, in 1851, also closed down at an early date. A works put up at Lavenham, Suffolk, in 1868, closed down ten years later; it was recommenced in 1885, but only worked for a few weeks. The primary cause of these initial failures seems to have been lack of beet, which the farmers would not produce in sufficient quantities. The more recent schemes are mentioned. The Cantley factory (near Norwich) was opened in 1912; it was closed during the years 1914–1920, but since the latter date it has operated each season. The old and modern methods of refining beet-sugar are described; the modern bone charcoal filtration method does not appear to be used in England. Some possible developments in the sugar industry are described in *Chemistry and Industry* for January 23. The article is mainly concerned with the use of vegetable charcoal for refining purposes; it is more economical than bone charcoal. One such charcoal is "suchar"; whereas a factory turning out 200 tons of raw sugar daily requires about 600 tons of bone black for refining purposes, the same factory would require only about 30 tons of "suchar." It is claimed that this reduces the cost of refining by one half. The "suchar," after it has been used twice, is washed and revivified by passing an electric current through it. This burns off the impurities without impairing the activity of the carbon itself. Glucose can now be obtained in a colourless crystalline form on a large scale; it is marketed as "ceralose." Crystalline fructose has also been obtained on a laboratory scale under conditions which make the transference of the method to the manufacturing scale almost certain of success.

Physiological Standardisation.

THE use of substances in the treatment of disease has, probably in a majority of cases, been empirical for some time after their discovery and adoption; in fact, in spite of recent advances in chemistry, through which the actual structure of many drugs has been elucidated, pharmacology is in many instances only able to describe the actions of drugs on living tissues without at present finding it possible to give the actual reasons for these actions. The problem is part of the wider one of the relation between chemical structure and physiological action. In those cases where the chemical structure is known, it is easy to investigate the action of known quantities of the drug upon a number of organisms of the same or different species and thus arrive at the minimum dose which is effective, and at the maximum dose which is safe, for no drug is absolutely harmless when the dose has exceeded a certain specific limit. But when a substance cannot be isolated in a pure state and its chemical structure is unknown, as is the case for example with the active principles obtained by extracting certain glandular organs, the sole indication of their presence being the effects they produce upon living tissues, it is essential, to get comparable results with different samples and to protect the patient against a possible overdose, to have an approximate idea of the strength of the sample in terms of its physiological action. It is a common experience to find that extracts prepared in the same manner and containing a known amount by weight of the original organ, may yet differ enormously in physiological activity. This variability is due to variations in the condition of the gland before extraction and to varying loss of the active principle during this process.

To illustrate the methods used in physiological standardisation, those employed in assaying the active principle or hormone of the posterior lobe of the pituitary gland, commonly known as pituitrin, and that obtained from the pancreas, called insulin, may be described briefly, with special reference to recent work on the subject.

Pituitrin acts as a stimulant to smooth muscle, affecting the muscle fibres directly; its main effect on intravenous injection is to raise the blood-pressure, but after administration per os, or intramuscularly, its absorption is too slow to produce this effect, and yet it will cause contraction of the uterus, an organ the contractile power of which is due to the smooth muscle in its wall. In clinical medicine it is used chiefly for the latter purpose in the later stages of labour. Methods of assay have been based on its effects on the blood-pressure and on the uterus. Dale and Burn (Medical Research Council Report, No. 69) have given a detailed account of the latter: the uterus of the virgin guinea-pig is used as the test object, and an extract of the posterior lobe of the pituitary, prepared in a certain manner, as the standard. It would be convenient to use as standard a substance of known composition which could be obtained in a pure condition, having the same stimulant action on smooth muscle as pituitrin. Unfortunately, tests with histamine and potassium chloride showed that uteri varied in sensitivity to these substances and to pituitrin independently.

Hogben, Schlapp, and Macdonald (*Quart. J. Exp. Physiol.*, 1924, vol. 14, p. 301) have recently described a method of assay based on the rise of blood-pressure produced by intravenous injection. It is not yet certain that the principles producing rise of blood-pressure and uterine contraction are the same, but a trustworthy method of assay of the former should be useful. Hitherto, the difficulty has been that successive doses of pituitrin produce a diminishing rise, or even a fall, of blood-pressure, and therefore samples cannot be compared with certainty. In part this is due to the presence in the extract of a substance causing a fall of pressure; this can be removed by alcoholic extraction of the gland extract, or its formation prevented by placing the gland in cold acetone, as soon as it is removed from the body. Apart from this, however, frequent injections of a depressor-free extract produce diminishing effects until a complete immunity is obtained. This can be obviated by spacing the injections at wider intervals. The test object recommended is the spinal cat, and the extract must be depressor-free, since it is possible that the substance which causes a fall of pressure in the anæsthetised animal causes a small rise in the spinal preparation. If a dose which is about half the maximum, and produces a rise of pressure of 55 mm. Hg., is injected every hour, a 10 per cent. discrimination between two samples is perfectly possible, since the effect of the previous injection has worn off in this time. The chief objection to the method appears to be in the time taken, since injections are only possible every hour; the guinea-pig's uterus, on the other hand, can receive five or six separate doses in this time. A further difficulty is that the preparation may vary slightly in sensitiveness during the course of an experiment, but this may be overcome by comparing the unknown only against adjacent injections of the standard.

The standardisation of insulin is an even more complicated problem. Its effect is to enable the tissues to utilise more carbohydrate both in health and in diabetes, when the pancreas is diseased; the simplest observation to make which shows this increased utilisation is an examination of the sugar of the blood, which falls after a dose of insulin. But if it falls too much, unpleasant symptoms, including convulsions, are produced.

Macleod and Orr (*J. Lab. Clin. Med.*, 1924, vol. 9, p. 591) have described in detail a method for assaying insulin based on the fall in blood sugar in rabbits. Owing to the variability in the response of different animals, a number must be used in any single test; the conditions must also be standardised so far as possible since the level of the blood sugar is influenced by many factors; thus the animals must be starved for the preceding 24 hours, must not have a blood sugar much above 0·1 per cent., and must not be used for more than two or three months, when they become refractory and put on weight. At least four estimations of the blood sugar are necessary in each animal, and the time occupied is considerable; hence a simpler method, if as accurate, would be preferable, and Margaret Cheadle (*Austral. J. Exp. Biol. and Med. Sci.*, 1924, vol. 1, p. 121) has utilised the incidence of convulsions as a method of assay. In this case mice are used as test animals, and minute doses of insulin injected, and the incidence of convulsions in each group injected with the same dose noted. After injection the animals must be kept at body temperature, otherwise they do not regularly develop convulsions. If a mouse unit of insulin be defined as the amount necessary to give convulsions in 60 per cent. of animals after subcutaneous injection, it must be correlated with the present standard, which is based on the fall of blood sugar in a rabbit, one unit being defined as the amount necessary to lower the blood sugar of a 2-kilo. rabbit to 0·045 per cent. in 5 hours. The unit used clinically is $\frac{1}{8}$ of the rabbit unit. The author finds 167 mouse units equivalent to 1 rabbit unit.

This somewhat cumbrous method of expressing the strength of insulin is necessary if comparable results are to be obtained in different tests with animals of varying weight. A further complication has been found, in that some samples of insulin seem to contain a substance which may be described as an anti-insulin. de Jongh (*Biochem. Jour.*, 1924, vol. 18, p. 833) gives an account of its properties: its presence is only revealed when small doses of insulin are injected, as in rabbits, but in man its influence appears to be small. It is apparently of a protein nature, and as the purification of insulin in the process of manufacture has been made more complete, the samples on the market at present appear to be free from it. In any case it is an illustration of the difficulties encountered by those who have to measure the strength of substances of unknown composition and isolated only in an impure condition.

Heterogeneous Equilibria.

THREE papers by Mr. J. A. V. Butler, in the Transactions of the Faraday Society, February 1924, and two in the *Phil. Mag.*, October and November, deal with problems of equilibrium at the boundaries between solids and liquids, and between two solids. The methods of statistical mechanics are applied in each case, and the first paper, "Conditions at the Boundary Surface of Crystalline Solids and Liquids," well illustrates the way in which other problems are dealt with.

A diagram shows how the attractions of the solid and of the liquid on a molecule of the solute and their resultant are assumed to vary with distance from the surface, with a balance point at which the two opposing forces are equal. A molecule from the surface will escape if, owing to thermal agitation, it has sufficient kinetic energy to carry it past the balance point. Molecules which reach the balance point from the interior of the liquid are attracted to the surface. An equation is deduced, similar to that of Langmuir, for the number of molecules reaching the boundary surface of a gas with kinetic energy greater than a certain quantity λ. This equation, which contains the mean collision frequency, applies to the molecules moving in the liquid towards the surface, but not directly to the molecules in the surface, the only motion of which is a vibration about an equilibrium position. The mean collision frequency is replaced in the equation for these molecules by a vibration frequency ν.

An expression for the solubility is thus obtained which leads to the le Chatelier-van 't Hoff equation for change of solubility with temperature, one of the terms of which is the heat of saturated solution. Assuming that ν is the characteristic vibration frequency of the solid, as determined by *rest strahlen*, and that the work done by the molecules from the surface layer, per gram molecule, in reaching the balance point is equal to the total heat absorbed in solution, unless this is less than the latent heat of fusion, when the latter is used, the author applies his equation to the alkaline chlorides. In this way he obtains results which are of the right order of magnitude.

Similar methods are employed in a discussion of the E.M.F. produced when a metal is dipped into a solution containing its ions. The process is regarded as essentially a solubility phenomenon. In the solution of a salt crystal, made up of positive and negative ions, both kinds are dissolved; but it is assumed that in the case of a metal, only the positive ions pass into solution, while the electrons which go to build up the crystal lattice are left behind. Equilibrium is attained when equal numbers of positive ions are dissolved from and deposited at the surface in unit time. The negative charge due to the free electrons left on the metal retards the solution and assists the deposition, and to this extent the phenomena of salt solution are modified. This is taken into account in the mathematical treatment of this case, with the result that a formula is obtained for the potential which, in form, resembles that of Nernst. Instead of being based on osmotic pressure, however, it depends on the heat absorbed in the passage of the metal ions into solution, and on quantities defining the statistical conditions. The values calculated from the formula are again of the right order of magnitude.

In a third paper Mr. Butler proposes a kinetic theory of reversible oxidation potentials at inert electrodes dipped into a solution containing two substances related by a simple oxidation reduction process. An expression is obtained for the numbers of each of the two ions, M′ and M″, contained in the solution adsorbed by each square centimetre of the electrode, using a mathematical method similar to that applied above. The reaction between each of these ions and the electrode is considered, one of them tending to gain an electron and the other to lose one, and an expression for the oxidation potential is obtained. This is determined by the ionisation potential corresponding to the loss of an electron by the reduced molecule, the difference in the energies of hydration of the two substances, the thermionic work function of the metal and two statistical constants.

Mr. Butler deals with metal contact potentials in a paper in the *Philosophical Magazine* for October. He obtains an expression for the potential difference at the surface of a single metal in a closed space containing an electron atmosphere, the loss of electrons from the surface of the metal being balanced by the gain of electrons from the atmosphere. He then considers the case of two metals in the electron atmosphere, but not in contact, and finds that though the surface P.D. of each metal depends on the electron atmosphere *concentration*, the difference for any two metals is characteristic of them. If the metals are brought into contact, the conditions at the surfaces not in contact are unaltered, and if there is to be no continuous flow across the junction, there must be a P.D. at the junction equal to the intrinsic P.D. of the metals. The Peltier heat effect at the junction is explained, and the various equations of the thermionic effect are co-ordinated. On certain assumptions they lead to the conclusion that the Thomson P.D. is the same for the same difference of temperature in all conductors.

Finally, in a paper on the seat of the electromotive force of the galvanic cell (*Phil. Mag.*, Nov.) Mr. Butler co-ordinates the results of his previous papers, and derives a statistical theory of the galvanic cell. The existence of large metal contact P.D.'s is not inconsistent with the correspondence between the E.M.F. of the cell and the energy of the chemical reaction. The metal contact P.D. theory, the chemical theory, the Nernst theory of metal electrode potential differences and the relation between E.M.F. and total energy change expressed by the Gibbs-Helmholtz equation are included in the new theory as different aspects of the whole truth.

University and Educational Intelligence.

BIRMINGHAM.—The annual meeting of the Court of Governors was held on February 26. The report of the Principal (Mr. C. Grant Robertson), which was presented to the meeting, shows that during the last session the number of students diminished slightly as compared with the number for the preceding session. The total, however, is still 50 per cent. higher than in the year before the War. An encouraging fact is the increase in the proportion both of full-time degree students and of post-graduate students.

New buildings are to be erected at Edgbaston for the Petroleum Mining Department, and it is hoped that they will be ready for occupation by October next. The transfer of this department will give room for the expansion of the Department of Coal Mining. An effort is being made to provide further buildings, which are urgently needed, for an extension of the Department of Chemistry and for the removal of the Biological Departments to Edgbaston; but the great increase in the cost of building is a very serious obstacle to be overcome.

Two important events of the year have been the creation of a chair of law (of which Mr. C. E. Smalley-Baker is the first occupant) and the establishment of a readership in geography.

CAMBRIDGE.—Dr. J. H. Jeans has been appointed Rouse Ball lecturer in mathematics for the present academic year.

LONDON.—Mr. J. H. Dible has been appointed to the University chair of pathology tenable at the London School of Medicine for Women. Prof. Dible studied at the University of Glasgow. In 1919 he was appointed lecturer in pathology in the University of Manchester and assistant pathologist to the Manchester Royal Infirmary, and in 1921 lecturer in bacteriology and senior assistant in the Department, carrying out work both for the Ministry of Health and for public bodies and hospitals in Manchester and adjacent towns.

The title of reader in economics in the University has been conferred on Dr. Hugh Dalton, in respect of the part-time appointment which he will hold at the London School of Economics from August 1, on his resignation of the Sir Ernest Cassel readership in commerce. The title of emeritus professor of hygiene in the University has been conferred on Prof. H. R. Kenwood, who held the Chadwick chair of hygiene at University College from 1904 to 1924, and the title of emeritus professor of medicine at University College on Sir John Rose Bradford, who occupied at that College the chair of materia medica, pharmacology, and therapeutics from 1895 to 1903, and the chair of medicine and clinical medicine from 1899 to 1907.

The School of Pharmacy of the Pharmaceutical Society of Great Britain has been admitted as a School of the University in the Faculty of Medicine (in pharmacy only) for a period of five years as from January 1 last.

The following Doctorates have been awarded:—*D.Sc.* (*Biochemistry*): Mr. Robert Robison (Lister Institute of Preventive Medicine), for a thesis entitled "Hexosephosphoric Esters and their Physiological Functions"; *D.Sc.* (*Chemistry*): Mr. G. R. Clemo, for a thesis entitled "Strychnine and Brucine," and other papers; *D.Sc.* (*Physics*): Mr. Frederick Simeon, for a thesis entitled "1. The Carbon Arc Spectrum in the Extreme Ultra-Violet; 2. Note on the Striking Potential necessary to produce a Persistent Arc in Vacuum," and other papers; *Ph.D.* (*Science*)—Mr. L. Horton (Imperial College—Royal College of Science) for a thesis entitled "The Effect of the Alteration of the Carbon Tetrahedral Angle upon the Ease of Formation of Heterocyclic Rings"; Mr. A. B. Manning (Imperial College—Royal College of Science) for a thesis entitled "Researches on Gelatin"; Mr. E. G. Richardson (East London College) for a thesis entitled "Aeolian Tones, Vibrations excited by Fluid Motion"; Mr. J. W. Baker (Imperial College—Royal College of Science) for a thesis entitled "The Formation and Stability of Compounds containing Associated Alicyclic Rings (highly strained Rings)"; Mr. I. Cohen (Middlesex Hospital) for a thesis entitled "Observations on Variations in Blood and Urinary Diastase, with special reference to Meals and Starvation"; Mr. E. C. Dodds (Middlesex Hospital) for a thesis entitled "Observations on the Body Diastase," and other papers; Mr. W. Russ (University College) for a thesis entitled "1. The Phosphate Deposits of Abeokuta Province. 2. The Riebeckite Rocks of Northern Nigeria"; Mr. E. R. Trotman (University College, Nottingham) for a thesis entitled "The Preparation of Quaternary Hydrocarbons."

Prof. E. Barclay-Smith, professor of anatomy since 1915, and Prof. O. W. Richardson, appointed Wheatstone professor of physics in 1913 and relinquishing that appointment in 1924 on appointment as one of the Yarrow research professors of the Royal Society, have been appointed fellows of King's College.

A CONVERSAZIONE will be held at the Chelsea Polytechnic, Manresa Road, London, S.W.3, on March 13. The laboratories and workshops will be open for inspection, 6.30-10.30 P.M.

APPLICATIONS are invited for a research studentship in tropical medicine in connexion with the government of the Federated Malay States. The annual value of the studentship is 700*l*. Particulars of the post, and forms of application, are obtainable from the Private Secretary (Appointments), Colonial Office, Downing Street, S.W.1.

APPLICATIONS are invited by the Glamorgan Agricultural Committee for the position of instructor in dairy and poultry husbandry. Special knowledge of poultry keeping on the farm, and dairy farming (including clean milk production), and good technical qualifications are expected from candidates. Application forms (returnable by March 16 at latest) can be obtained from the Director of Agriculture, 5 Pembroke Terrace, Cardiff.

THE work of research has received a noteworthy and welcome stimulus at Armstrong College, Newcastle-on-Tyne. An anonymous gift of 12,000*l*. enabled the Council to establish a Research Endowment Fund in 1923, and the Committee which was appointed to administer the fund has published its first annual report. The Committee records its intention to utilise the proceeds to help members of the College and others with their researches by providing temporary or partial relief from teaching or by arranging for assistance, and by defraying the cost of books, apparatus, travelling and other expenses: thus to supplement the resources already in operation and not to supersede the provision available for the training of post-graduates. These considerations have guided the Committee in allocating grants during the first year. The Committee has also been able to arrange for a grant being given by the Newcastle and Gateshead Water Co. for a special research; and intimates a desire to advise or to co-operate with industrial firms and corporations desiring investigations in any particular direction. The opportunity has been taken to give a list of papers which have been published by members of the College staff during the year, and from this, although it is not exhaustive,

it is evident that all departments are actively engaged in research.

LORD EMMOTT presided at an important meeting held in the Regent Street Polytechnic, London, on Friday, February 27, when the question of an inquiry into the relationship of technical education to other forms of education and to industry and commerce was discussed. The case for the inquiry was presented by Lord Emmott and Mr. J. Wickham Murray (Joint Committee of the Three Technical and Art Associations). Their speeches indicated that, although technical education forms the contact-point between education and industry, its place in the national system of education is undefined. Since, in any area, the technical institute draws its pupils from all other types of school, it is essential—if waste and overlapping are to be prevented—that its relationship to those other schools should be clearly understood. Further, since technical education (including applied art) is the contact-point with industry, it is very necessary that more definite relationships be established if education is successfully to be linked to the world's work. Educationists and industrialists seem more than ever to be sharply critical of each other's aims and methods, but no comprehensive attempt has been made towards sane and tolerant discussion of mutual problems. It is now proposed to bring together not only primary, secondary, technical, and university teachers, but also employers, representative industrial and commercial bodies, and learned institutions. Among the bodies represented at the meeting were the British Association, the Federation of British Industries, professional engineering bodies, teachers' associations, Institutes of Chemistry and Physics, and the British Science Guild. The meeting finally resolved that the inquiry was desirable, and that the bodies represented be asked to appoint representatives to a committee whose work will be the preparation of the ground which the inquiry will cover.

THE Parliamentary Grant (ordinary) for universities and university colleges in the British Isles, which was increased in 1921 from 1,000,000*l.* to 1,500,000*l.* (including 110,000*l.* for Irish universities), did not escape the attention of the Geddes Economy Committee. For each of the two succeeding years it was (for Great Britain only) 1,169,000*l.*, and for 1924–25 it is 1,122,570*l.*, excluding the new grants (amounting now to 120,000*l.*) for Oxford and Cambridge. Last November a deputation from all the universities of Great Britain, except Oxford and Cambridge, headed by Sir Donald MacAlister, waited upon the Chancellor of the Exchequer to urge the raising of the grant to 1,500,000*l.* A letter on this subject from Mr. Churchill to Lord Balfour, who introduced the deputation, was published in the *Times* of March 2. After reciting the salient points of the case presented by the deputation, which was very sympathetically received, the letter announces the stabilisation of the grant for five years at 1,380,000*l.* (excluding provision for Oxford and Cambridge). For this relief the universities will, undoubtedly, echo the expression of thanks conveyed in Lord Balfour's reply, and if their gratification is tempered by regret that Mr. Churchill has so firmly required them to forgo the expectation of any further increase for at least five years, they cannot fail to recognise that even this condition carries with it compensations, among which may be reckoned the greater precision and therefore effectiveness with which they will be able to define their needs when appealing for aid to local authorities, to alumni, and to the public. The amount at which the grant has now been fixed (1,380,000*l.*) is approximately 39 per cent. of the aggregate annual expenditure of the universities concerned in 1922–23.

Early Science at Oxford.

March 7, 1683/4.—After ye reading of ye Minutes, Dr. Plot was pleasd to acquaint ye Society that he had lately calcined clay-ochre, and stone-ochre (both which were yellow, from Shotover) about thirty-six hours, but neither of them applyed to ye Magnet; which gave ye Doctor grounds to question, whether yellow ochres will be affected by ye Magnet after any calcination, how long soever. Tobacco-pipe clay, Marl, Bole armeniac and Terra Lemnia were calcined ye same space of time, but none of them applyed to ye Magnet.

Then Dr. Pit was pleased to inform ye Society that Oyl Olive is uncapable of any ebullition after it has spent its aqueous parts, which rise in bubbles; for, being pressed with a stronger fire, than what made water boyl over a large vessell, it could not be sensibly raised, although ye heat of ye oyl was so intense, that, being removed from ye fire, it broke out into a flame, and continued to do so after six or seven suffocations of ye flame. Butter boyls over till its serous parts are evaporated, but afterwards, though pressed with a very great heat, is no more capable of ebullition, than so much melted lead.

A Report of ye consultation, held for ye drawing up Articles, for ye better Regulation of ye Society, was offered; but ye examination of it was deferred, till ye next meeting: which was ordered to be on ye Tuesday following, at 2 after dinner.

March 8, 1686/7.—Dr. Plot reported on the prices of commodities in the time of King John, which he had extracted from a Dugdale manuscript in the Ashmolean Library.—Mr. President wrote to Mr. Halley several arguments against Mr. Hooke's late hypothesis of the change of the surface of ye Earth.

March 9, 1685/6.—Dr. Lister of London communicated a paper of Georgics concerning ye improvement of Sandy land by ye *Vicia multiflora nemorensis perennis sive Dumetorum* I.B. which is practised both in Yorkshire and Staffordshire.

March 10, 1684/5.—Mr. Maunders speaking of ye dismall weather on ye 23rd of December last, says, that above eighty Persons were found killed by it, in Wiltshire and Dorsetshire. Some died suddenly, others by degrees: some, that escaped, were so tormented in their hands, and face (parts exposed to ye cold) that, as they recovered, and ye swellings abated, the skin peeled off, and they were some days without ye use of their limbes, and sometimes of their senses.—Part of Mr. King's ingenious discourse of Bogs was read; and also Mr. Aston's letter relating that ye Savages of Canada get from Maple juice a sugar as sweet as that of ye Canes.

March 11, 1683/4.—Salamander's wool was observed, by Mr. Ballard, to be separated from ye earthy parts, to which it is joynd, by heating the Amianthus and bruising it into peices. It was ordered, that some attempts should be made, towards ye working this wool into a thread; that so we may [if it be possible] either trace out ye methods of ye Antients, or equall their inventions with new ones in this kind; for ye effecting of which, Dr. Beeston was pleased to take on him, ye trouble of employing some curious hand, suitable to so ingenious a design.

March 13, 1687/8.—Mr. Cole of Bristoll discoursed concerning the Descent of Spiders with their webs, taken in the County of Wilts in September and October 1686, with an occasionall discourse about Spontaneous Generation wherein is given allso an account of people that have been witnesses of the raining of frogs and crabs.

Societies and Academies.

LONDON.

Royal Society, February 26.—E. H. **Starling** and E. B. **Verney**: The secretion of urine, as studied on the isolated kidney. The mechanism of urinary secretion in mammals has been studied by perfusing the dog's kidney with the heart-lung preparation. The glomeruli filter from the blood plasma its non-protein constituents. Hydrocyanic acid suspends tubular activity, while the action of hydrocyanic acid is reversible. Urea, sulphate, and, when present in the serum, phenosulphonephthalein, are secreted by the tubule cells into the glomerular filtrate. Water, chloride, bicarbonate, and glucose are re-absorbed by the tubule cells from the glomerular filtrate. Water appears to be re-absorbed lower down the tubule than chloride. Pituitrin causes a marked increase in the percentage and absolute amounts of chloride and a decrease in the amount of water eliminated. Substances of this type normally regulate the output of water and chloride in the intact animal, and the characters of the urine secreted by the isolated organ are due in large part to their absence.—F. **Eicholtz** and E. H. **Starling**: The action of inorganic salts on the secretion of the isolated kidney. Calcium working on a background of potassium leads to an increase of chloride excretion and water output, due to decreased re-absorption in the tubules. These salts, if given separately, have no definite effects. Inorganic phosphates decrease the output of water and chlorides by turning the calcium ion into a colloidal form. To this colloidal form the glomerulus membrane is impermeable. Cyanide increases the permeability of the glomerulus membrane and allows the colloidal phosphates to appear in the urine.—G. V. **Anrep**: A new method of crossed circulation. The method consists in an arterial anastomosis between a heart-lung preparation and the descending aorta or the brachio-cephalic artery of another animal. Thus the part of the animal connected with the heart-lung preparation receives its blood supply from the latter, while the remaining part of the animal continues to be fed by its own heart. The blood flow and the blood pressure of the perfused part of the animal is therefore under complete control.—G. V. **Anrep** and I de B. **Daly**: The output of adrenaline in cerebral anæmia, as studied by means of crossed circulation. In this condition there is an increased liberation of adrenaline from the suprarenal glands, which is due to a true secretion and not to redistribution of blood, and the increased secretion disappears after denervation of the suprarenal glands.—G. V. **Anrep** and E. H. **Starling**: Central and reflex regulation of the circulation. Mechanical rise in blood pressure in the brain inhibits the vasomotor centre and stimulates the cardio-inhibitory, the two centres acting synergetically to produce lowered pressure. Asphyxia by cerebral anæmia stimulates both vasomotor and cardio-inhibitory centres, the centres acting antagonistically, not synergetically. Andrenaline (small doses) introduced into head circulation causes slowing of heart and fall of pressure in lower half of animal. Measurement of pressure in Circle of Willis shows these effects are due to increased circulation through medullary centres, and cannot be ascribed to direct excitation of centres by adrenaline itself. The effects are analogous to, and produced in the same way as, those obtained on increasing pressure in head circulation.—K. **Furusawa**: Muscular exercise, lactic acid, and the supply and utilisation of oxygen. Part IX. Muscular activity and carbohydrate metabolism in the normal individual. Results obtained are: On normal diet, carbohydrate only is responsible for the process of contraction and recovery from it. As duration of exercise is prolonged respiratory quotient of excess metabolism falls slowly, indicating that some substance other than carbohydrate is being called upon. On fatty diet, short-lived muscular exercise is performed at expense only of carbohydrate, as on normal diet. In long-continued exercise, fat takes part more quickly than on normal diet. In exercise of short duration, in which no change in general metabolism of body as a whole might be expected, the human body acts as though it were an isolated muscle, in which carbohydrate is the only substance oxidised, as shown by Meyerhof. The primary fuel of contraction, therefore, in human muscle is carbohydrate, and fat or protein is presumably used to replenish carbohydrate store disappeared.—A. **Hunter** and J. A. **Dauphinee**: (1) Quantitative studies concerning the distribution of arginase in fishes and other animals. (2) An approximative colorimetric method for the determination of urea with an application to the detection and quantitative estimation of arginase.—J. J. R. **Macleod** and N. A. **McCormick**: The effect on the blood-sugar of fish of various conditions, including removal of the principal islets (isletectomy).

Royal Microscopical Society, January 21.—A. Chaston **Chapman**: The yeasts: a chapter in microscopical science (presidential address). Some new technique, such as the use of ultra-violet light, applied to the investigation of the cytology of the yeast cell, might, in the hands of expert cytologists, yield results equally valuable to industry and to general biology. The views of Cramer and others as to the dependence of intra-cellular enzymic activity on surface tension was referred to, and reasons were given for supposing these surface tension effects to be operative in connexion with some industrial fermentation processes. The yeast cell is, in fact, a chemical laboratory of the highest efficiency, and of the most remarkable character, and if the processes of building up and breaking down, which are so quietly and so regularly occurring in a single cell of yeast, could be understood and artificially imitated, we should be not only within measurable distance of a new organic chemistry, but also appreciably nearer to an understanding of that greatest of all problems, the nature of life.

Linnean Society, January 22.—Miss M. S. **Johnston**: Calcareous deposits (rhizocretions, Kindle) round roots of Canadian birches in Pleistocene sands. The concretion is considered to be due to the action of humic acid from the roots segregating the lime constituents in the sand.—R. D'O. **Good**: The flora of Canada. As in Britain, the largest plant families are the Compositæ, Gramineæ, Cyperaceæ, Leguminosæ, Rosaceæ, and Labiatæ, and the first named is very much larger than any of the others. In traversing the country from east to west, four main vegetational types are encountered: the Eastern forest, the prairie, the mountain, and the Pacific littoral. The southern limit of the Pleistocene ice was well down in the United States, and the present flora of Canada is therefore an immigrant flora developed in the geologically short time since the retreat of the ice.—J. **Munro**: Canadian forests and forestry. There are four climatic belts between the east coast and British Columbia.

CAMBRIDGE.

Philosophical Society, January 19.—H. F. **Baker**: A transformation of Segre's figure in space of four dimensions; the equation of Kummer's surface. There is a figure, first studied by Stéphanos in the

theory of circles, but studied particularly by Segre as a figure in four dimensions; consisting of fifteen lines meeting by threes in fifteen points. The figure is of great interest, as being the centre of a discussion of many well-known surfaces; the cubic surface, the cyclide, Kummer's surface, and so on. In this figure there are also six sets of fives of the lines, each being taken twice over, called sets of *associated* lines. The present paper finds a transformation from the lines of the figure to the joins of six points in space of *five* dimensions—a set of associated lines becoming the joins of one of the six points to the other five. Intimately related therewith is the expression of the equation of a Kummer surface by a sum of five squares. The coefficients of these squares are invariants of the discriminantal equation of the primary quadratic complex.—R. **Vaidyanathaswamy**: On simplexes doubly incident with a quadric. The generalisation of the figure representing a double six of lines in five dimensions, wherein a hexad is both inscribed to and circumscribed about a quadric.—H. G. **Green**: The classification of conicoids by their generators. An actual method of reduction of the equation of a conicoid to a form showing the character of the surface.—R. **Whiddington**: On the positive flash in vacuum discharge tubes. Moving striations previously observed in the rare gases were reinvestigated in the case of pure argon. The bright flashes travelling from the anode with velocities depending on the pressure show no Doppler effect. The luminous radiation seems to be excited by invisible radiation given out by positive ions as they travel along the tube.—E. C. **Stoner**: The structure of radiation. On the assumption of conservation of energy and linear momentum, the evidence in favour of radiation being constructed of linearly directed, spatially localised quanta is held to be conclusive. Further properties, which are not physically unreasonable, must be postulated of these quanta in order that interference phenomena may be possible.—Major P. A. **MacMahon**: The symmetric functions of which the general determinant is a particular case.

MANCHESTER.

Literary and Philosophical Society, January 20.—W. **Robinson**: On proliferation and doubling in the flowers of *Cardamine pratensis* L. Specimens of *C. pratensis* showing two main types of abnormality were found in meadows near Cheadle Hulme, Cheshire, in June 1923, one of which was similar to the double-flowered form, arising by proliferation of the ovary, described most frequently by previous observers, and the other, a less completely double-flowered specimen. Microscopic investigation showed that, in both types, proliferation took place by the meristematic activity of a growing-point at the base of the ovary, of a flower which was otherwise normal. In one case, however, the ovary itself was carried up on a stalk produced by the growth activity of tissues immediately below the base of the ovary, but outside this; in the other specimen all the growth took place within the ovary from the base of this, and the meristematic growing-point was carried up to about the middle of the pod-like structure. The doubling seen in *C. pratensis* has recently been spoken of as a mutation from the more normal single form, but Goebel has stated that by cultivating plants of the double form in sandy soil they completely lost the character. By vegetative multiplication from the original specimens collected wild at Cheadle Hulme, it has been possible to cultivate plants showing variations, both in the character and degree of the doubling. Further work will show whether the plasticity of *C. pratensis* is such that doubling can be produced under experimental conditions in a single-flowered form by nutritional changes as Goebel has suggested, or whether, as seems more likely, the double-flowered and single-flowered forms are two different races with distinct hereditary complexes.

PARIS.

Academy of Sciences, January 26.—G. **Bigourdan**: The propagation of Hertzian waves to great distances. The order of magnitude of the perturbations of this propagation. A table is given showing the results of the reception of the Bordeaux time signals for 1923, by Helwân (near Cairo), Washington, Ottawa, Greenwich, Paris and Uccle.—H. **Vincent**: The urinary elimination of the *Bacillus coli communis* and its hæmatogen origin.—P. **Bazy**: Remarks on the preceding communication.—Maurice **Lugeon**: The presence of fossilised organic bodies in the marbles of Uruguay. Fragments of echinoderms and molluscs have been recognised in marble from Nueva Carrara; this is of interest, as being the first occasion of the discovery of fossil remains in this crystalline deposit.—Bertrand **Gambier**: The continuous deformation of surfaces, isometry and applicability.—Mlle. Thérèse **Leroy**: A new method for the determination of the working costs and a tariff for railway transport. A new tariff scheme has been developed as the result of a mathematical study of data from eighty years' actual railway experience.—**Andrieau**: The Andrieau motor. A detailed description of the mode of working, construction, and experimental results of a new design of internal combustion motor.—Carl A. **Garabedian**: Solution of the problem of the heavy rectangular plate, framed or open, carrying a charge uniformly distributed or concentrated at its centre.—A. **Alayrac**: The theoretical study of motorless flight in a variable horizontal wind.—Ernest **Esclangon**: The eclipse of the sun of January 24, 1925, observed at the Strasbourg Observatory. The time of first contact, deduced from two series of independent measurements of the chord of contacts, was $15^h\ 3^m\ 37^s$.—L. **d'Azambuja**: Observation of remarkable protuberances, made at the Meudon Observatory, January 24, 1925, before the eclipse of the sun. On January 24 a series of spectroheliograms of the lines K_3 (calcium) and H_2 (hydrogen) was taken continuously. A photograph taken at 11.10 A.M. with the calcium line showed the existence in the N.W. quadrant, of a fan-shaped group of protuberances in the form of jets, the largest of which attained a height of one-fifth of the solar radius. Its development was very rapid, since photographs at 10.40 A.M. and 12.20 P.M. did not show it.—J. **Guillaume** and Mlle. M. **Bloch**: Observation of the partial eclipse of the sun of January 24, 1925, made at the Lyons Observatory. Clouds interfered with observations. First contact was noted at $15^h\ 4^m\ 36^s{\cdot}2$.—P. **Chofardet**: Observation of the eclipse of the sun of January 24, 1925, at the Besançon Observatory. Time of first contact at $15^h\ 3^m\ 48^s{\cdot}8$.—F. **Holweck**: Determination of the critical potential L_{III} of argon. Discussion of the precision of this measurement and of analogous measurements.—Ed. **Friedel**: Smectic bodies and X-rays. The existence of a stage (smectic state) intermediate between the solid crystal and the true liquid has been indicated in an earlier communication for certain oleates. These conclusions have been questioned, and additional experiments on the radiograms furnished by ethyl *p*-azoxy-benzoate, and ethyl azoxy-cinnamate have been made. The results confirm the conclusions previously given.—F. **Baldet**: The spectrum of carbon monoxide at very low pressure; the so-called comet-tail spectrum.—Ernest **Bengtsson** and Erik **Svensson**: The conditions

of the appearance and structure of the silver bands, λ3330 and λ3358.—F. **Croze**: The structure of the line spectra of ionised nitrogen and oxygen.—Jean Jacques **Trillat**: The molecular orientation of the fatty acids.—Herbert **Brennen**: Chemical studies on the isotopes of lead. A partial separation of the isotopes of lead by the action of the Grignard reagent on lead chloride has been recently described by Dillon, Clarke, and Hinchy. This work has been repeated, and no evidence of separation of isotopes was obtained. —Georges **Fournier**: The absorption of the β-rays by matter. If μ is the coefficient of absorption and ρ the density of the material, then experiments with six materials show that the relation $\mu/\rho = a + bN$ (where N is the atomic number) is valid.—A. **Bigot**: Clays, kaolins, etc.—L. **Blanc** and G. **Chaudron**: The magnetic study of the stable form of the sesquioxides of iron and chromium. The magnetic susceptibility of Fe_2O_3 and Cr_2O_3 as a function of the temperature is given in graphical form: the results are difficult to interpret. André **Graire**: The reduction of the oxides of nitrogen in the presence of sulphuric and sulphurous acids.—Marcel **Godchot** and Pierre **Bedos**. The chlorination of para-methyl-cyclohexanone.—Ch. **Courtot** and P. **Petitcolas**: Syntheses of 9-fluorenylamines. —J. **Barthoux**: Description of a new mineral, dussertite. This mineral, found at Djebel Debar, is an arsenate of the composition $(FeAl)_3(CaMg)_3(OH)_9(AsO_4)_2$. The full chemical analysis, physical and mineralogical description are given.—Pierre **Bonnet**: The problem of the Trias of the Avallonnais and Auxois.—Pierre **Dangeard**: Limits of the submerged plant growth of Lake Annecy at varying depths.—P. **Mazé**: The plurality of the products of photosynthesis, deduced from the study of the gaseous exchanges between the atmosphere and the whole plant.—Mlle. Sara **Bache-Wüg**: The vacuome of *Erysiphe graminis*.—P. E. **Pinoy**: Concerning the cancer of plants or crown gall. L. **Ravaz** and G. **Verge**: A disease of the vine, excoriosis.—Mme. Jean **Francois-Perey**: The influence of the culture medium on protozoa counts in soil. The influence of the culture medium is marked; an extract of the earth with gelose is recommended as giving the most trustworthy results.—C. F. **Muttelet**: Study of the development of the pea; from the point of view of conservation for food.—Vittorio **Pettinari**: The toxic action of *Amanita phalloides*.—Georges **Bourguignon** and J. B. S. **Haldane**: The evolution of chronaxy in the course of the crisis of experimental tetany by voluntary hyperpnea in man.—A. **Malaquin**: The segregation, in the course of ontogenesis, of two primordial sexual cells; origin of the germinal descent in *Salmacina Dysteri*.—Robert **Weill**: Foci of formation and ways of migration of the nematocysts of *Halyclistus octoradiatus*. The existence, along their path, of selective reservoirs.—J. **Chaine**: Remarks on the penian bone.—Armand **Dehorne**: The petaloid expansions of the leucocytes of the Chetopoda. The case of *Leydenia Gemmipara*.—Ph. **Joyet-Lavergne**: The lipoids and fats of the Sporozoa.—Edouard **Chatton** and André **Lwoff**: The physiological determinism of the phases of the cycle of the infusorian *Spirophrya subparasitica*.—A. **Berthelot** and G. **Ramon**: The agents of transformation of the toxins into anatoxins. Toxins can be converted in various ways into substances deprived of toxic power, but retaining the power of flocculation (*in vitro*) and immunising power (*in vivo*). These products are described as anatoxins, and the action of a large number of chemical compounds on the diphtheria toxin has been studied from this point of view. The most effective reagents for the production of the diphtheria anatoxine proved to be acrolein, crotonaldehyde, acetaldehyde and hexamethylenetetramine.

Official Publications Received.

Department of the Interior: United States Geological Survey. Bulletin 751-E: The Scobey Lignite Field Valley, Daniels, and Sheridan Counties, Montana. By Arthur J. Collier. Pp. v + 157-230 + plates 21-29. (Washington: Government Printing Office.)

Department of the Interior: United States Geological Survey. Professional Paper 132-F: Relations of the Wasatch and Green River Formations in North-Western Colorado and Southern Wyoming, with Notes on Oil Shale in the Green River Formation. By J. D. Sears and W. H. Bradley. Pp. ii+93-107+2 plates. Professional Paper 132-G: Discovery of a Balkan Fresh-water Fauna in the Idaho Formation of Snake River Valley, Idaho. By W. H. Dall. Pp. ii+109-115+1 plate. Professional Paper 132-H: The Resuscitation of the Term Bryn Mawr Gravel. By F. Bascom. Pp. 117-119. (Washington: Government Printing Office.)

"The First Five Thousand": being the First Report of the First Birth Control Clinic in the British Empire, "The Mothers' Clinic" for Constructive Birth Control at 61 Marlborough Road, Holloway, London, N. 19. By Dr. Marie Carmichael Stopes. Pp. 67. (London: J. Bale, Sons and Danielsson, Ltd.) 2s. 6d. net.

Department of Commerce: U.S. Coast and Geodetic Survey. Serial No. 260: Precise Triangulation, Traverse and Leveling in North Carolina. By Walter D. Sutcliffe and Henry G. Avers. (Special Publication No. 101.) Pp. iv+184. (Washington: Government Printing Office.) 25 cents.

Annuaire de l'Observatoire Royal de Belgique. Par P. Stroobant. 93me année, 1926. Pp. iii+154. (Bruxelles.)

The Physical Society of London. Proceedings, Vol. 37, Part 2. February 15. Pp. 75-100+50 D. (London: Fleetway Press, Ltd.) 6s. net.

Thirty-eighth Annual Report of the Bureau of American Ethnology to the Secretary of the Smithsonian Institution, 1916–17; with accompanying Paper, An Introductory Study of the Arts, Crafts and Customs of the Guiana Indians, by Walter Edmund Roth. Pp. vii+745+183 plates. (Washington: Government Printing Office.) 3 dollars.

State of Illinois Department of Registration and Education: Division of the Natural History Survey. Bulletin, Vol. 15, Art. 3: Second Report on a Forest Survey of Illinois; The Economics of Forestry in the State. By Herman H. Chapman and Robert B. Miller. Pp. vii+46-172. (Urbana, Ill.)

Iowa Geological Survey. Vol. 29: Annual Reports, 1919 and 1920, with Accompanying Papers. Pp. xlviii+568+54 plates. (Des Moines.)

University of Iowa Studies in Natural History. Vol. 10, No. 5: Fiji-New Zealand Expedition. Narrative and Preliminary Report of a Scientific Expedition from the University of Iowa to the South Seas. By C. C. Nutting; with Chapters on Ornithology and Entomology by Dayton Stoner, on Botany by R. B. Wylie, and on Geology by A. O. Thomas. Pp. 369+58 plates. (Iowa City.) 3 dollars.

Royal Botanic Gardens, Kew. Bulletin of Miscellaneous Information, 1924. Pp. iv+400+50. (London: H.M. Stationery Office.) 10s. 6d. net.

Ministry of Agriculture, Egypt: Technical and Scientific Service. Bulletin No. 50: A Third Bioclimatic Study in the Egyptian Desert. By C. B. Williams. Pp. ii+32+7 plates. (Cairo: Government Publications Office.) 5 P.T.

Memoirs of the Department of Agriculture in India. Chemical Series, Vol. 7, No. 6: Studies in the Chemistry of Sugarcane. 2: Some Factors that determine the Ripeness of Sugarcane. By D. Viswanath and S. Kasinatha Ayyar. Pp. 123-144. (Calcutta: Thacker, Spink and Co.; London: W. Thacker and Co.) 8 annas; 9d.

Western Australia. Annual Progress Report of the Geological Survey for the Year 1923. Pp. 38+3 plates. (Perth: Fred. Wm. Simpson.)

Department of the Interior: Bureau of Education. Bulletin, 1924, No. 19: Schools for Adults in Prisons, 1923. By A. C. Hill. Pp. iii+33. (Washington: Government Printing Office.) 5 cents.

Diary of Societies.

SATURDAY, MARCH 7.

ROYAL SOCIETY OF MEDICINE (Otology Section), at 10.30.

ASSOCIATION OF TECHNICAL INSTITUTIONS (Annual Meeting) (at Institution of Mechanical Engineers), at 11 A.M.—Lord Emmott and Ppl. W. M. Varley: The Local College and its Relation to Surrounding Education Authorities.—G. Mavor: Training and Education for Apprenticeship.—J. E. Montgomery: The Working of the Schemes for National Certificates and Diplomas in Engineering.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS (Eastern and South Midland Districts) (at Town Hall, Ealing), at 2.35.—The Question of Regional Town Planning.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Sir Ernest Rutherford: The Counting of the Atoms (II.).

IPSWICH AND DISTRICT NATURAL HISTORY SOCIETY (at Ipswich).—Dr. F. W. Crossley-Holland: Science and the Criminal.

MONDAY, MARCH 9.

ROYAL SOCIETY OF EDINBURGH, at 4.30.—A. H. R. Goldie: Discontinuities in the Atmosphere.—Dr. A. P. Laurie: Stone Decay and the Preservation of Buildings (Address).—W. H. Watson: An Investigation of the Absorption of Superposed X-Radiations.—H. W. Turnbull and J. Williamson: The Minimum System of Two Quadratic Forms.—Prof. H. S. Allen: Note on Whittaker's Quantum Mechanism. —Marion C. Gray: The Equation of Conduction of Heat.

VICTORIA INSTITUTE (at Central Buildings, Westminster), at 4.30.—Rev. C. Gardner: Nature and Supernature.

BIOCHEMICAL SOCIETY (at Lister Institute), at 5.—F. W. Fox: The Cholesterol Content of Bile and its Bearing upon the Metabolism of Cholesterol and the Bile Acids.—J. R. Marrack: The Total Base Content of Plasma.—D. Hoffert and I. S. MacLean: The Action of Yeast on Lactic Acid.—E. H. Lepper and C. J. Martin: (a) The Influence

of Salt Concentrations on the C_H of Buffer Solutions as indicated by the Electrometric and Colorimetric Methods respectively; (*b*) Can the C_H of Mixtures of $NaHCO_3$ and CO_2 in High Dilutions be determined by the Hydrogen Electrode?

ROYAL SOCIETY OF MEDICINE (War Section), at 5.—Presentation, by Sir St. Clair Thomson, of the North Persian Forces Memorial Medal for 1923 to Wing-Commdr. H. E. Whittingham, for his Paper, Observations on the Life-History and Bionomics of *Phlebotomus papatasii*, written in conjunction with Flight-Lieut. A. F. Rook.—Wing-Commdr. H. E. Whittingham: The Treatment of Malaria by Novarsenobillon.

INSTITUTION OF ELECTRICAL ENGINEERS (North-Eastern Centre) (at Armstrong College, Newcastle-on-Tyne), at 7.15.—Major E. I. David: Electricity in Mines.

INSTITUTE OF CHEMISTRY (Birmingham Section) (at White Horse Hotel, Birmingham), at 7.30.—G. W. Marlow: Chemists' Agreements.

INSTITUTE OF METALS (Scottish Local Section) (at 39 Elmbank Crescent, Glasgow), at 7.30.—A. G. Lobley: Electric Furnaces.

SOCIETY OF CHEMICAL INDUSTRY (London Section) and INSTITUTE OF CHEMISTRY (London and South-Eastern Counties Section) (at Institution of Mechanical Engineers), at 8.—Sir Max Muspratt, Bart.: Chemistry and Civilisation.

SURVEYORS' INSTITUTION, at 8.

ROYAL GEOGRAPHICAL SOCIETY (at Æolian Hall), at 8.30.—A. F. R. Wollaston: The Sierra Nevada of Santa Marta, Colombia.

MEDICAL SOCIETY OF LONDON, at 8.30.—E. Clarke, A. F. Moore, Dr. J. Collier, and others: Discussion on The Fundus Oculi in General Medicine.

IPSWICH AND DISTRICT NATURAL HISTORY SOCIETY (at Ipswich).—Dr. F. W. Crossley-Holland: Science and the Criminal.

TUESDAY, MARCH 10.

ROYAL COLLEGE OF PHYSICIANS OF LONDON, at 5.—Dr. S. MacNalty: Epidemic Diseases of the Central Nervous System (Milroy Lectures) (II.).

ROYAL INSTITUTION OF GREAT BRITAIN, at 5.15.—Prof. E. N. da C. Andrade: The Evolution of the Scientific Instrument (I.).

INSTITUTION OF PETROLEUM TECHNOLOGISTS (Annual General Meeting) (at Royal Society of Arts), at 5.30.—H. Barringer: Address.

INSTITUTION OF CIVIL ENGINEERS, at 6.—Prof. S. M. Dixon and F. W. Macaulay: Measurements of Discharge over a Rock-faced Dam.

INSTITUTION OF AUTOMOBILE ENGINEERS (at Royal Society of Arts), at 7.

INSTITUTION OF ELECTRICAL ENGINEERS (Informal Meeting), at 7.—C. W. Sully and others: Discussion on Illumination.

INSTITUTION OF ELECTRICAL ENGINEERS (North Midland Centre) (at Bradford Technical College), at 7.—H. W. Taylor: Three-wire Direct-current Distribution Networks: Some Comparisons in Cost and Operation.

INSTITUTION OF ELECTRICAL ENGINEERS (Scottish Section) (at North British Station Hotel, Edinburgh), at 7.—E. Hughes: Iron Losses in D.C. Machines.

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN, at 7.—Annual General Meeting.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND (at 39 Elmbank Crescent, Glasgow), at 7.30.—G. A. Whiteman and A. Spittle: The Manufacture of Brass Condenser Tubes, with some Notes on an Alternative Alloy.

INSTITUTION OF AUTOMOBILE ENGINEERS (Coventry Graduates' Meeting) (at Broadgate Café, Coventry).

WEDNESDAY, MARCH 11.

INSTITUTE OF METALS (Annual General Meeting) (at Institution of Mechanical Engineers), at 10 A.M.—H. T. Angus and P. F. Summers: The Effect of Grain-size upon Hardness and Annealing Temperature.—S. L. Archbutt: A Method of Improving the Properties of Aluminium Alloy Castings.—U. R. Evans: Surface Abrasion as a Potential Cause of Localised Corrosion.—Dr. J. Newton Friend and J. S. Tidmus: The Influence of Emulsoids upon the Rate of Dissolution of Zinc in Solutions of Lead, Nickel, and Copper Salts.—At 2.—T. G. Bamford: Comparative Tests on some Varieties of Commercial Copper Rod.—R. Genders and G. L. Bailey: The Alpha Phase Boundary in the Copper-Zinc System.—Dr. D. Bunting: The Influence of Lead and Tin on the Brittle Ranges of Brass.—E. A. Bolton: The Removal of Red Stains from Brass.

GEOLOGICAL SOCIETY OF LONDON, at 5.30.—Prof. O. T. Jones: The Geology of the Llandovery District (Carmarthenshire).—G. Andrew: The Llandovery and Associated Rocks of Garth (Breconshire).—G. Andrew and Prof. O. T. Jones: The Relations between the Llandovery Rocks of Llandovery and those of Garth.

INSTITUTION OF CIVIL ENGINEERS (Informal Meeting), at 7.—J. S. Wilson: The Relative Importance and Nature of Secondary Stresses in Steel Structures.

INSTITUTION OF ELECTRICAL ENGINEERS (South Midland Centre) (at Birmingham University), at 7.—Major E. I. David: Electricity in Mines.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (Graduate Section) (at Bolbec Hall, Newcastle-on-Tyne), at 7.—G. R. Hutchinson: Some Problems of the Motor Ship.

ROYAL SOCIETY OF ARTS, at 8.—E. Cammaerts: The Restoration of Public Buildings in Belgium.

INSTITUTION OF CHEMICAL ENGINEERS (at Institution of Mechanical Engineers), at 8.—Prof. A. L. Mellanby: Expansion and Compression Phenomena in Steam Jets.

INSTITUTION OF AUTOMOBILE ENGINEERS (North of England Centre) (at Leeds).

THURSDAY, MARCH 12.

INSTITUTE OF METALS (Annual General Meeting) (at Institution of Mechanical Engineers), at 10 A.M.—G. L. Bailey and R. Genders: The Density and Constitution of the Industrial Brasses.—A. L. Norbury: The Effects of certain Elements on the Electrical Resistivity of Copper.—Sir Thomas Kirke Rose: The Density of Rhodium.—Prof. T. Honda and Prof. R. Yamada: Some Experiments on the Abrasion of Metals.—Prof. T. Isihara: The Equilibrium Diagram of the Aluminium-Zinc System.

ROYAL SOCIETY, at 4.30.—Sir Charles Sherrington: Remarks on some Aspects of Reflex Inhibition.—E. G. T. Liddell and Sir Charles Sherrington: Recruitment and some other Features of Reflex Inhibition.—D. T. Harris: Studies on the Biological Action of Light.—Dr. H. Hartridge and F. J. W. Roughton: The Kinetics of Hæmoglobin. III.—*To be read in title only*:—S. B. Schryver, H. W. Buston, and D. H. Mukherjee: The Isolation of a Product of Hydrolysis of the Proteins hitherto undescribed.

ROYAL COLLEGE OF PHYSICIANS OF LONDON, at 5.—Dr. S. MacNalty: Epidemic Diseases of the Central Nervous System (Milroy Lectures) (III.).

ROYAL INSTITUTION OF GREAT BRITAIN, at 5.15.—Dr. L. Hill: The Biological Action of Light (I.).

ROYAL SOCIETY OF MEDICINE (Comparative Medicine, Tropical Diseases, and Obstetrics Sections), at 5.30.—Special Discussion: Infective Abortion in Cattle and its Relation to Mediterranean Fever.

INSTITUTION OF ELECTRICAL ENGINEERS (Tees-Side Sub-Centre) (at Cleveland Technical Institute, Middlesbrough), at 7.15.—H. W. Taylor: Three-wire Direct-current Distribution Networks: Some Comparisons in Cost and Operation.

INSTITUTION OF ELECTRICAL ENGINEERS (Irish Centre (Dublin)) (at Trinity College, Dublin), at 7.45.—Dr. J. F. Crowley: The Use of Electricity in the Chemical Industries, with particular reference to the Irish Free State.

INSTITUTE OF CHEMISTRY (Liverpool and North-Western Section) (at Liverpool University), at 8.—Prof. E. C. C. Baly: A Lecture Tour in America.

FRIDAY, MARCH 13.

ROYAL ASTRONOMICAL SOCIETY, at 5.—G. Prasad: The Progression of Stellar Velocity with Absolute Magnitude.—Dr. J. W. Nicholson: The Secondary Spectrum of Hydrogen.—Dr. H. Jeffreys: The Origin of the Solar System, in relation to Prof. Eddington's Theory of Stellar Luminosity.—E. A. Kreiken: The Density Function in the Milky Way.—Dr. J. K. Fotheringham: Visibility of Stars in Great Britain during the Solar Eclipse of 1925, Jan. 24.—T. Royds: Note on Spectroheliograms taken with Different Parts of the Hα line.—S. D. Tscherny: (*a*) Results of Micrometer Measures of the Position of Mars relative to the Star B.D. $-4°$ 5913 on 1924, Dec. 5; (*b*) Occultations of Stars by the Moon, 1924.

PHYSICAL SOCIETY OF LONDON (at Imperial College of Science and Technology), at 5.—J. P. Andrews: The Variation of Young's Modulus at High Temperatures.—Dr. E. G. Richardson: The Critical Velocity of Flow past Objects of Aerofoil Section.—Dr. J. Brebtano: A Focussing Method of Crystal Powder Analysis by X-rays.

INSTITUTION OF MECHANICAL ENGINEERS, at 6.—Reports to the Cutting Tools Research Committee:—Prof. E. G. Coker: The Action of Cutting Tools.—D. Smith and A. Leigh: Experiments with Lathe Tools on Fine Cuts, and some Physical Properties of the Tool Steels and Metal operated upon.

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN, at 7.—F. Judge: Many Slides and a few Remarks.

INSTITUTE OF METALS (Swansea Local Section) (at Swansea University College), at 7.15.—General Discussion.

JUNIOR INSTITUTION OF ENGINEERS, at 7.30.—A. P. Bale: Notes on Methods of Producing Modern High Grade Machine Tools.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (at Literary and Philosophical Society, Newcastle-on-Tyne), at 7.30.

ROYAL INSTITUTION OF GREAT BRITAIN, at 9.—Prof. Gilbert Murray: The Beginnings of the Science of Language.

SATURDAY, MARCH 14.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Sir Ernest Rutherford: The Counting of the Atoms (III.).

PUBLIC LECTURES.

SATURDAY, MARCH 7.

HORNIMAN MUSEUM (Forest Hill), at 3.30.—Miss M. A. Murray: Modern Excavations in Egypt.

MONDAY, MARCH 9.

BEDFORD COLLEGE FOR WOMEN, at 5.15.—Prof. L. Lévy-Bruhl: Trois Philosophes français contemporains: Ribot, Espinas, Durkheim (in French). (Succeeding Lectures on March 10, 13.)

UNIVERSITY COLLEGE, at 5.30.—Prof. H. Westergaard: Vital Statistics. (Succeeding Lecture on March 11.)—Miss E. Jeffries Davis: Some Famous London Bridges (I.). (Succeeding Lectures, by Prof. A. E. Richardson, on March 16, 23.)

INNER TEMPLE HALL, at 8.—Lord Newton: The Necessity for Legislation with regard to Smoke Abatement (Chadwick Lecture).

TUESDAY, MARCH 10.

UNIVERSITY COLLEGE, at 5.30.—R. A. Smith: The Old Stone Age.

UNIVERSITY OF LEEDS, at 8.—E. Percival: The Freshwater Zoology of Yorkshire (I.).

WEDNESDAY, MARCH 11.

SCHOOL OF ORIENTAL STUDIES, at 5.15.—E. Richmond: Early Moslem Architecture: The Early Madrassas in Syria, Bagdad, Egypt up to end of Ayyubi Dynasty. Developments during the Mamluke Period up to the Turkish Conquest.

KING'S COLLEGE, at 5.30.—Prof. E. Prestage: Travel and Travellers of the Middle Ages (IX.). The Opening of the Ocean Routes, A.D. 1415-60.

UNIVERSITY COLLEGE, at 5.30.—Miss Ethel S. Fegan: Library Resources outside London.

THURSDAY, MARCH 12.

UNIVERSITY COLLEGE, at 5.—Prof. E. A. Gardner: History of Ancient Sculpture (Introductory Lecture).

SATURDAY, MARCH 14.

HORNIMAN MUSEUM (Forest Hill), at 3.30.—Dr. R. L. Sherlock: Man as a Geological Agent.

Supplement to NATURE

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Electric Forces and Quanta.[1]

By J. H. JEANS, Sec. R.S.

IT is just about twenty-five years since Lord Kelvin spoke of "two clouds" obscuring "the beauty and clearness of the dynamical theory which asserts light and heat to be two modes of motion." The clouds which Lord Kelvin saw as clouds no bigger than a man's hand have grown until they have almost filled the firmament: little can now be seen of the beauty and clearness of the dynamical theory of which Lord Kelvin spoke. The old dynamical theory has given place to the new theories of relativity and of quanta; what Lord Kelvin thought were transient clouds shortly to melt away have proved to be new theories in process of growth; the "beauty and clearness" he saw under these clouds was mostly a mirage.

I have chosen as my title "Electric Forces and Quanta," the two halves of this title corresponding roughly to the two new theories, and I propose to try to sketch out the changes these theories have introduced into our conception of fundamental electrical processes. Let us consider electric forces first. Lord Kelvin, following Maxwell and Faraday, regarded an electric force as evidence of a stress in the ether. An ether can transmit two kinds of stress, one arising from a state of static strain and the other from a transfer of momentum; these were supposed to be electric and magnetic forces respectively. Or, to put the matter in another way, an ether can possess two kinds of energy, potential and kinetic; these were identified with electrostatic and electromagnetic energy respectively. This mechanism of stresses in the ether was devised in order to escape the necessity of "action at a distance." The ether itself had no doubt originally been brought into existence for quite other reasons—to provide a nominative to the verb "to undulate," according to the late Lord Salisbury—but these other reasons were no longer of much cogency. Light, whether an undulation of a medium or not, was admittedly an electromagnetic phenomenon, and the electromagnetic theory of light had already made it clear that any mechanism which could account satisfactorily for electric and magnetic forces could carry the whole of the undulatory theory as well. It was because Maxwell and Faraday had disliked "action at a distance" that the ether continued in existence at the end of the nineteenth century.

A Medium or Action at a Distance.

Nevertheless, the conception involved a difficulty which seems to have troubled the nineteenth-century physicists not a little. The energy of the ether could represent all kinds of electromagnetic energy, but could represent nothing else. Gravitational energy, for example, could not be interpreted as ethereal energy, for the only two types of energy which the ether could hold were already allotted to electric and magnetic energy respectively. It is true that attempts were made to interpret gravitation as normal waves of compression or as pulsations of very high frequency in the luminiferous ether, but such explanations never survived comparison with facts, and those who tried to explain gravitation had to fall back either on a new and entirely separate ether or else on action at a distance. If action at a distance had to be called in to explain gravitation, it might just as well be allowed to explain electromagnetism as well; there seemed to be no logical resting-place between two ethers and none. But the need for multiple ethers simultaneously filling space aroused suspicions in those who were conversant with the history of science. In an earlier century, according to Sir Joseph Larmor, "aethers were invented for the planets to swim in, to constitute electric atmospheres and magnetic effluvia, to convey sensations from one part of our bodies to another, and so on, till all space had been filled three or four times over with aethers. It is only when we remember the extensive and mischievous influence on science which hypotheses about aethers used formerly to exercise, that we can appreciate the horror of aethers which sober-minded men had during the eighteenth century."

In time it became clear that the only thoroughly satisfactory possibility was no ether at all. First the development of the theory of relativity gave its death-blow to the old luminiferous ether of Lord Kelvin, Maxwell, and Faraday. The main result of this theory can be stated in the form that all the phenomena of Nature go on precisely as though there were no ether.

[1] The Sixteenth Kelvin Lecture, delivered on February 5 at the Institution of Electrical Engineers.

This does not of course abolish the ether; it shows the conception of an ether to be superfluous and perhaps even a little bit ridiculous—for it is ridiculous to fill the whole of space with a medium and then agree that everything goes on just as if the medium were not there—but it does not show it to be illogical.

The Existence of an Ether.

To the question, "Does an ether exist?" science is still unable to give a definite answer. The question, "Does the ether exist?" if the ether is taken to mean the luminiferous ether of Maxwell and Faraday, ought almost certainly to be answered in the negative. Speaking for a moment in the language of technical mathematics, the reason is that all the phenomena of Nature are invariant to the Lorentzian transformation (the transformation to axes moving with a uniform velocity), whereas the physical properties allotted to the ether by Maxwell and Faraday are not invariant. Let E and H denote the electric and magnetic force at a point in the supposed ether, then E^2-H^2 (the integrand in the action integral) is invariant, so that all properties which follow from the principle of least action are independent of the motion of the observer. These are of course the dynamical properties of the system. But E^2+H^2 is not invariant, so that the phenomena which follow from attributing energy to the ether at a rate $(1/8\pi)(E^2+H^2)$ per unit volume are not the same for a moving observer as for a stationary one.

Of the six components of stress attributed by Maxwell to the ether, only three are invariant, so that electromagnetic phenomena, if explained in terms of ether stresses, call for stresses which are not the same for a moving observer as for one at rest even though the observed phenomena are absolutely identical. For example, if magnetic forces are of ethereal origin, then the forces observed by a moving observer must be of quite different nature and origin physically from those observed by an observer at rest. If the latter observer's forces are produced by Maxwell's mechanism, the former's cannot be. To take the simplest example: an observer moving through a stationary electrostatic field will in actual fact observe magnetic forces just as much as if the field moved past him, yet the ether at every point of his path possesses no kinetic energy and so, according to the Maxwell-Faraday conception, could show no magnetic forces. The old Maxwell-Faraday ether had in some way to provide a duplicate mechanism for a single phenomenon, the magnetic force arising from an electric charge—and similarly for most other phenomena. No one has ever shown that it is capable of doing this; but even if they had, the duplication of mechanism to produce a single phenomenon is so contrary to the usual workings of Nature that there is not much risk in dismissing the old ether to the lumber-room.

Thus we may be confident that if an ether exists, it must be something very different from the Maxwell-Faraday ether. It must probably be thought of as a four-dimensional structure and must be more subjective than the Maxwell-Faraday ether. Each of us must carry his own ether about with him, extending through all space and all time, much as in a shower of rain each observer carries his own rainbow about with him. Whether such a structure, if it exists, ought to be called an ether, others must decide.

We may remark in passing that the conception of an ether has always made a special appeal to the practical, one might almost say engineering, type of mind which we associate with the leaders of British science. While our own physicists have asked for Nature to be reduced to a machine transmitting tensions and stresses, the more metaphysical minds of the Continent have usually been content to accept action at a distance as an ultimate explanation of natural phenomena, or at least to regard such an explanation as being in every way as final and as satisfying as an explanation in terms of a medium. It was something more than a coincidence that Newton, Kelvin, Clerk Maxwell, and Faraday were all British, while Boscovitch, Einstein, and Weyl are not.

Four-dimensional Geometry.

The paper which practically abolished the ether as a serious scientific hypothesis was published by Einstein in 1905. Ten years later he published a second paper which may be said to have shown us how to get on without either an ether or action at a distance. His first paper, as afterwards interpreted by Minkowski, had shown that all the phenomena of electromagnetism might be thought of as occurring in a continuum of four dimensions—three dimensions of space and one of time—*in which it is impossible to separate the space from the time in any absolute manner*. You may separate them in one way, but you will find that I separate them differently, and in the end we shall both agree that no objective separation is possible.

Einstein's second paper showed that the phenomena of gravitation could be explained on the supposition that the geometry of this four-dimensional continuum was not of the ordinary Euclidean type. The continuum was supposed to be affected by kinks and twists in the neighbourhood of gravitating masses, and it was these, and not a "gravitational force," that threw a particle out of a straight course. It became just as inaccurate to say that the sun attracts the earth as to say that a bowl on an uneven bowling green is attracted or repelled by the other bowls. In this curved space

the path of a particle is always a geodesic—the most direct distance between two points—and this may have very different properties from a Euclidean straight line.

We must, of course, remember that the paths we are discussing are in a four-dimensional space—if we were speaking of ordinary paths in three-dimensional space, it would clearly be ridiculous to say that the curved orbit of a planet provided the most direct path from perihelion to aphelion; it is only when we allow for the motion in time as well as in space that the statement becomes reasonable. We can get rid of most of the motion in time by supposing our planet, or other body, to move with enormously high velocity, and then the path described actually approximates to a straight line, which is now the most direct path even in three-dimensional space.

We can gain some conception of the main features of Einstein's geometry from the analogy of spherical geometry; the curved surface of our earth provides a fair two-dimensional analogy to Einstein's curved four-dimensional space. To one who thinks in terms of "parallels" of latitude and longitude, or who studies geography on a Mercator chart, the most direct course on our earth's surface looks oddly curved: it is always a surprise to the unsophisticated traveller that the ship taking him from Southampton to New York (say from A to B in Fig. 1) turns a bit to the north on rounding the Lizard, while the great circle course on the ship's chart (AECB in Fig. 1) looks very much as if the ship were describing an orbit about a centre of attraction in the middle of the Sahara.

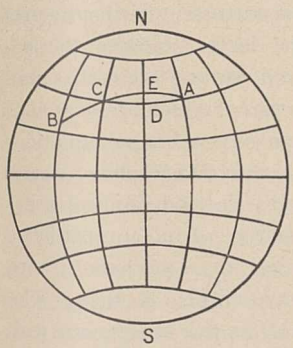

FIG. 1.

If Einstein was able to avoid the evils both of action at a distance and of an ether in the gravitational problem, there would seem to be no reason why they should not be similarly avoided in the electromagnetic problem which specially interests us to-night. Not only is there no reason why this should not be done; it actually has been done. In 1918 Weyl pointed out that the geometry of Einstein was not the most general geometry which conformed to the relativity condition. Space could be distorted still further in ways unimagined by Einstein, these further distortions of the four-dimensional space being specified by the six components of a vector. Now the significant thing is this. On calculating the relations which must hold between the six components of the vector in order that the relativity condition may be satisfied, Weyl finds equations which are precisely identical with the electromagnetic equations of Maxwell, the six components in question now appearing as the three components of electric force and the three components of magnetic force.

Weyl's Electromagnetic Theory.

It is not easy to explain in non-mathematical language what is the essential difference between Weyl's space and the old Euclidean space. We can best attempt it by treating Einstein's space as a half-way house. Returning for a moment to the two-dimensional analogy provided by the earth's curved surface, we know that the length of a degree of longitude decreases as we recede from the equator; the ship turns north on its voyage from the Lizard to New York in order to take advantage of the shorter degrees of longitude up north. The planet going round the sun describes a curved path for a similar reason. According to Einstein's theory, a measuring rod changes in length as it moves about in a gravitational field—a two-foot rule is no longer two feet in length if taken from the earth to the sun; it is because of this that the wave-length of the light represented by a definite spectral line when emitted at the sun's surface is different from that of the same light emitted on earth. The length of the rod depends only on its distance from the sun, being, in fact, proportional to

$$\left(1-\frac{2\gamma m}{rc^2}\right)^{-\frac{1}{2}},$$

where γ is the gravitation constant, m the mass of the sun, c the velocity of light, and r the distance from the sun. But in Weyl's space the length of such a rod does not depend solely on its position: it depends also on the path by which this position has been attained. A rod of length l displaced parallel to itself through a distance dx, dy, dz, dt in the four-dimensional continuum may be supposed to experience a change of length dl defined by

$$dl = l(Fdx + Gdy + Hdz - \Psi dt),$$

where F, G, H, Ψ are quantities which need not at present be specified. If the rod is taken a journey from P to Q its whole change of length will be given by

$$\log \frac{l_q}{l_p} = \int_P^Q (Fdx + Gdy + Hdz - \Psi dt).$$

In Einstein's geometry the integrand is necessarily a perfect differential, so that the value of l_q/l_p depends only on the position of Q and P and not on the particular path selected from P to Q; the condition that this integrand shall be a perfect differential is expressed by the six equations

$$\frac{\partial H}{\partial y}-\frac{\partial G}{\partial z}=0, \qquad -\frac{\partial \Psi}{\partial x}-\frac{\partial F}{\partial t}=0,$$
$$\frac{\partial F}{\partial z}-\frac{\partial H}{\partial x}=0, \qquad -\frac{\partial \Psi}{\partial y}-\frac{\partial G}{\partial t}=0,$$
$$\frac{\partial G}{\partial x}-\frac{\partial F}{\partial y}=0, \qquad -\frac{\partial \Psi}{\partial x}-\frac{\partial H}{\partial t}=0.$$

In Weyl's geometry, on the other hand, the integrand $Fdx+Gdy+Hdz-\Psi dt$ is not a perfect differential, so that the quantities on the left hand of the equations just written down do not vanish; they have values a, b, c, X, Y, Z different from zero, so that

$$\frac{\partial H}{\partial y}-\frac{\partial G}{\partial z}=a, \qquad -\frac{\partial \Psi}{\partial x}-\frac{\partial F}{\partial t}=X,$$
$$\frac{\partial F}{\partial z}-\frac{\partial H}{\partial x}=b, \qquad -\frac{\partial \Psi}{\partial y}-\frac{\partial G}{\partial t}=Y,$$
$$\frac{\partial G}{\partial x}-\frac{\partial F}{\partial y}=c, \qquad -\frac{\partial \Psi}{\partial z}-\frac{\partial H}{\partial t}=Z.$$

These are precisely Maxwell's electromagnetic equations, F, G, H being the components of the magnetic vector potential, and Ψ the electrostatic potential. Turning back, we see that F, G, H, and Ψ are determined at any point by the rate at which a measuring rod of unit length changes its length as it passes through that point.

When Einstein explained gravitation in terms of curvatures and special metric properties of space, the equations of his theory were found to be different from those of the old Newtonian theory. It was accordingly possible to make an observational test between the two theories, and this decided immediately and conclusively in favour of the theory of Einstein. There is no hope of establishing the truth of Weyl's theory in a similar way, for, as we have just seen, the equations to which it leads are precisely identical with the already universally accepted equations of Maxwell. Weyl's theory can only be judged by its inherent plausibility or the reverse.

Judged by this standard, everything seems to be in its favour. The luminiferous ether failed, partly because it left no room for gravitation, partly because its mechanism had to be supposed to be too elaborate for the facts to be explained. The hypothesis of an ether led us to anticipate a whole series of different phenomena corresponding to different velocities through the ether, so that when these were not forthcoming, its advocates were compelled to elaborate a complicated theory by which all the forces of Nature were in collusion to make these different occurrences appear the same to us. The Einstein-Weyl geometrical theory escapes both these reproaches. Both gravitation and electromagnetism fit perfectly naturally into their places. These two systems of forces correspond exactly and completely to the ways in which a four-dimensional geometry can differ from the simple geometry of Euclid. The observed forces of gravitation and electromagnetism correspond exactly to the most general forces which are possible, if "force" is interpreted simply as an illusion arising from a crumpling up of space. Consequently the observed phenomena of Nature are precisely those which ought to be observed—not one is missing and neither is there room for a single one more. There is now no collusion among the forces of Nature to conceal a whole series of unobserved phenomena: indeed, there could be no concealment because there is nothing to conceal. By its simplicity, its completeness, and its perfect agreement with the observed phenomena of Nature, the theory seems likely to take its place as our final interpretation of the "forces" of Nature.

We now see that the universe of Euclid, in which parallel lines never meet and in which two sides of a triangle are always greater than the third, was a simplified ideal universe. In the same way the universe of Aristotle and Plato, in which space and time are permanently distinct and essentially different in their natures, was a simplified ideal universe. Both universes were too simple to fit the facts; remove the unwarranted simplifications and we are left with a universe the geometrical properties of which are expressed by such equations as Einstein's gravitational equations (to which Newton's inverse square law gives a good approximation) and Maxwell's electrodynamical equations. Thus geometry, cleared of *all* unjustifiable assumptions, transforms itself into mechanics, both gravitational and electrodynamical. A being who was born without any one of his five senses, but with unlimited geometrical reasoning powers, could deduce the general nature of the actual world without any experience of reality: he would anticipate that landslides, earthquakes, thunderstorms, and auroræ would occur; but he would know nothing about "forces," and would regard these phenomena merely as geometrical necessities.

Atomicity.

Although generalised geometry can predict and explain all the systems of forces of the universe, it has its limitations; there are features of the actual universe before which it stands powerless. Nothing in geometry can explain the essential differences between positive and negative electricity, or the atomicity of electric charges, so that the whole inner structure of matter, including the whole of chemistry, would be outside the scope of the intuitions of our supposed geometer.

Electric charges are a consequence of, or at least are associated with, a curving or crumpling of space, but so far as pure geometry goes there is no restriction on the extent of this crumpling, so that our geometer, reasoning from geometry alone, might expect to find charges of all possible amounts, whereas in actual fact

electric charges occur only in multiples of a definite unit, the charge of an electron. It is clear, then, that there is something more than geometry underlying the phenomena of Nature; the whole phenomenal universe may be geometry with restrictions if we like, but not merely the geometry which is obtained by generalising the geometry of Euclid until we can generalise no further. Space can be crumpled up qualitatively in all the ways known to geometry but not quantitatively; the uniformity of the electronic charge must in some way represent an absolute restriction on the measure of the crumpling.

Each particle of matter—each electron, let us say—occupies one point of space at any one instant of time, and the succession of these points will form a line in the four-dimensional space-time continuum—the "world-line" of the electron. In the neighbourhood of this world-line there is a deformation of the continuum due to the existence of the electron.

The near approach of two electrons or of any two charged particles is represented by a near approach of their world-lines in the four-dimensional continuum. Each world-line is surrounded by its associated deformation, and in regions in which the world-lines are near to one another the adjacent regions of the continuum will be doubly deformed.

A priori there are two possibilities open. The first is that the two deformations are merely additive, just as, when two ships approach, each making its own wash (or deformation of the surface of the sea), the height of wash at any point is the sum of the heights of the washes made by the two ships independently. The second possibility is that, as there have been found to be restrictions on the amount of deformation associated with the two separate world-lines, there may be a further restriction on the deformation arising from their combination.

In actual fact the former alternative appears to prevail when one or both of the charged particles are "free" electrons, but the latter alternative when they are "bound" together; that is, when they are permanently describing orbits about one another. It is these latter restrictions that have given rise to the theory of quanta. Just as the restrictions associated with single world-lines give rise to an atomic constant e, the charge on an electron, so the restrictions associated with pairs of world-lines give rise to a second atomic constant. This is generally taken to be h, Planck's constant, but in many respects it is more appropriate to regard the product hC as the second constant, where C is the velocity of light. It is significant that hC is of the same physical dimensions as e^2 and so may be regarded as being the same thing as e^2 except for a numerical multiplier. Thus while the restrictions connected with one world-line introduce e, those connected with two world-lines, depending only on e^2, introduce no essentially new constant, whence it may reasonably be suspected that the two sets of restrictions are merely different aspects of one and the same set. It looks as though the atomicity of the quantum theory is only another aspect of the atomicity of electric charges.

Quantum Restrictions.

We can perhaps best visualise the inner nature of the quantum-restrictions by going back to the analogy of the two ships making a combined wash which is in some way restricted to being of a certain height. We have supposed each wash individually to be restricted; if the velocity of the ships is fixed, this requires that each ship shall be of a definite size (corresponding to each electron having a definite charge). How can we now put a further restriction on the total wash of the two ships at points where their washes overlap? Only, I think, by keeping the ships at a specified distance apart. At any rate this is the way in which the quantum-restrictions work. The normal hydrogen atom consists of a negative electron describing a circular orbit about a positively charged nucleus; the quantum-restrictions compel this orbit to keep an unvarying radius of $0{\cdot}53 \times 10^{-8}$ cm. When the atom is in an abnormal state, as, for example, when excited in a vacuum tube, the orbit, if circular, may have radii equal to 4, 9, 16, 25 . . . times the radius of the normal atom. Elliptic orbits also are possible, but only of quite definitely restricted major and minor axes. In actual fact the semi-major axis must be equal to one of the radii permissible for a circular orbit, while the ratio of the two axes must be one of a range of commensurable ratios. The orbits which are possible for the electron of the hydrogen atom are shown in Fig. 2. If it were not for the quantum restrictions, it would be impossible to exhibit these orbits in a diagram at all; orbits of every radius and of every eccentricity would be possible, just as they are for a planet or comet describing an orbit about the sun.

It will be understood that I have not approached the quantum theory by the road of its historical development. Planck originally discovered the existence of the quantum-constant h from a study of black-body radiation. The famous theorem of equipartition of energy showed that if the classical laws of dynamics were of universal validity, the whole energy of the material universe would at once degrade itself into radiant energy of infinitesimal wave-length. Planck showed that this conclusion could be avoided by supposing that the energy of radiating mechanisms changed only by complete quanta, the change of energy $W_2 - W_1$

being connected with the frequency ν of the radiator by the relation

$$W_2 - W_1 = h\nu.$$

He further showed that this supposition led to a law of spectral distribution of black-body radiation, the now famous Planck's law, which was found to agree excellently with the observed distribution. In this way the quantum theory came into being at the very beginning of the quarter-century we have under review.

Some years elapsed before Einstein showed that the same constant was of fundamental importance in the photo-electric effect, and it then began to be suspected that it might conceivably be fundamental to the whole of physics. But it was not until 1913 that Bohr published the epoch-making paper which first suggested, and at the same time finally established, that this

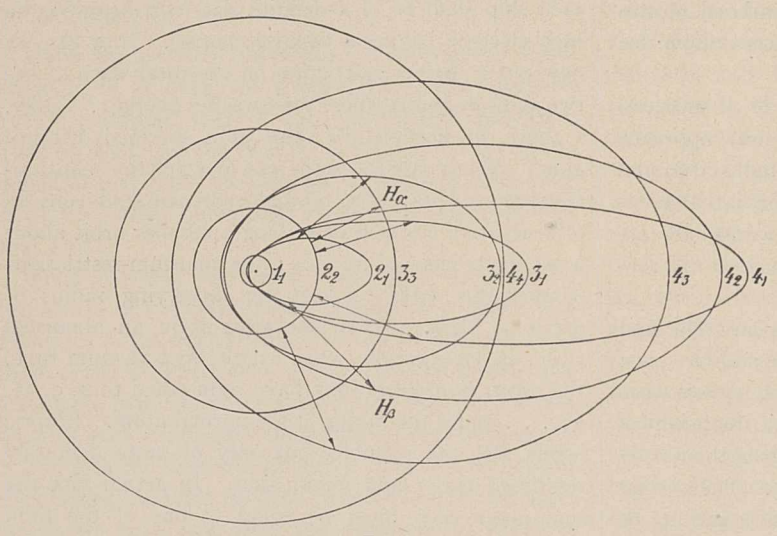

FIG. 2.

constant held the clue to the structure of the atom and determined the scale on which the universe is built. To-night I have disregarded historical development altogether, and have tried to approach the theory in the simplest manner; I am trying to make it look natural. There can be no reasonable doubt that the quantum theory is essentially true, and so would appear perfectly natural to us if we could approach it with entirely fresh minds not already obsessed by erroneous ideas. But with our minds such as they are, the quantum theory as frequently presented does, it must be admitted, raise recollections of plausible conjuring performances. If I were to state the argument by which Planck first arrived at the existence of the quantum, the inclination might well be to dismiss it as mere mathematical sleight-of-hand. I agree it is still a bit surprising that the rabbit came out of the hat, but I have tried to show at least that there was so much room in the hat that almost anything might have emerged.

According to the Maxwellian electrodynamics an electron describing an orbit of any kind must necessarily radiate energy. We can calculate the rate at which energy ought to be radiated by the electron in the normal hydrogen atom; it is 0·46 erg a second. The resulting loss of energy would be compensated by a decrease in the radius of the orbit; we find that the rate of this decrease would be about 112 cm. a second, so that the atom ought to disappear altogether within a small fraction of a millionth of a second. Thus it is the quantum-restrictions which give a permanent existence to matter.

In conformity with the quantum-restrictions, the electron in the hydrogen atom describes an orbit of unvarying radius and so of constant energy. Maxwell's equations, as we have seen, would demand that radiation should be emitted and that the energy of the orbit should decrease accordingly. Here, then, we have a case where the requirements of Maxwell's theory and those of the quantum theory are in irreconcilable conflict. It is the quantum theory which carries the day. Somewhere before we reach the most minute of all structures, Maxwell's theory fails and the quantum theory takes its place. For large scale phenomena the two theories coincide—a thunderstorm is the same thing for Maxwell's theory as for the quantum theory, just as it was the same thing for the old "one-fluid" theory as for the modern electron theory—atomicity is of no consequence when the number of atoms involved approximates to infinity.

In terms of space curvatures we may say that Maxwell's theory is represented by a continuous curvature or crumpling such as might be applied to a rubber membrane, while possibly the quantum theory may be represented by a so-to-speak "jerky" deformation which is the best that can be done with a scaly surface such as a crocodile skin. If we wish to cover the earth's surface with a membrane, it makes little difference, from the point of view of closeness of fit, whether we select rubber membrane or crocodile skin, but it makes all the difference if we are manufacturing a pair of gloves. The quantum theory represents, perhaps, a quality of space, or rather of the four-dimensional continuum, which is somehow analogous to scaliness in a skin.

As the normal hydrogen atom is already in its configuration of minimum energy it can emit no radiation. But under electric bombardment or in the presence of intense radiation, the electron may move to other orbits of energy higher than the minimum. Even now there can be no gradual change of energy, but there can

be spasmodic jumps from one orbit to another orbit of lower energy. According to Bohr's theory of atomic mechanism, the energy lost to the orbit at each one of these jumps is emitted in the form of monochromatic radiation. A jump from energy W_2 to energy W_1 results in the emission of radiation of uniform frequency ν where

$$W_2 - W_1 = h\nu,$$

h being the absolute constant of Nature already referred to. If λ is the wave-length of the radiation, $\lambda = C/\nu$, so that

$$W_2 - W_1 = \frac{hC}{\lambda}.$$

We have already seen that hC is equal to Ke^2 where K is a numerical constant. The energy in an orbit of radius r (or, if elliptical, of semi-major-axis r) is $-\frac{1}{2}e^2/r$, so that if the jump is from an orbit of radius r_1 to one of radius r_2,

$$\tfrac{1}{2}e^2\left(\frac{1}{r_2} - \frac{1}{r_1}\right) = \frac{Ke^2}{\lambda},$$

and the wave-length of the radiation is given by

$$\frac{2K}{\lambda} = \frac{1}{r_2} - \frac{1}{r_1}.$$

Now if a is the radius of the normal hydrogen atom, the possible values for r_2 and r_1 are 1^2, 2^2, 3^2, 4^2 . . . times a, so that our formula becomes

$$\frac{2Ka}{\lambda} = \frac{1}{n_2^2} - \frac{1}{n_1^2}.$$

In actual fact a formula of this type, in which n_1 and n_2 are given all possible integral values, is found to give with the utmost exactness the wave-lengths of the light emitted in the complicated spectrum of the hydrogen atom. On putting $n_2 = 2$ we obtain the Balmer series of lines, of which the principal lines H_α, H_β, H_γ . . . form the most conspicuous feature in the ordinary hydrogen spectrum. The lines obtained by putting $n_2 = 1, 3, 4, 5$ . . . are mostly in the infra-red or the ultra-violet. Many of these have been observed, and there is no reason to doubt that the remainder are there, although at present beyond the range of observation.

So far we have considered only the circular orbits; there must, of course, be other spectral lines arising out of the possibility of the electron describing elliptic orbits. Exact analysis shows, however, that these latter lines coincide almost exactly with those already discussed. They would coincide perfectly if it were not that the mass of a moving electron depends on the velocity of its motion. As a consequence of this dependence of mass on velocity, the two sets of lines do not exactly coincide. Each line of the simple series previously discussed is replaced by a "fine-structure"—a bunch of lines quite distinct in fact, although so close together as to look like a single line in all save the most powerful spectroscopes. Sommerfeld has worked out the structure to be expected theoretically for these bundles of lines and obtains a most gratifying agreement with observation. This and other experimental tests give the most convincing proof of the accuracy of Bohr's theories of atomic mechanism.

We can gain a knowledge of the arrangements of the electron orbits in even the most complicated atoms by using the equation

$$W_2 - W_1 = h\nu,$$

which appears to be of universal validity. The frequencies ν of radiation can be measured, so that the energy-levels W_1, W_2 . . . of the various possible orbits can be calculated. The method has been applied not only to discovering the arrangements of electrons in the atom, but also to discovering the energy-levels of the protons in the nucleus. At present the hydrogen atom and the positively-charged helium atom are the only structures which are completely understood, but there can be little doubt that in time the method will unravel for us the secrets of even the most complicated of atomic and molecular structures.

Already Bohr has constructed a table, of which the first part is shown in Table I., in which he attempts to assign the different electrons in the atoms to the

TABLE I.—ELECTRON ORBITS.

	1_1	$2_1 2_2$	$3_1 3_2 3_3$	$4_1 4_2 4_3 4_4$	$5_1 5_2 5_3 5_4 5_5$
1 H	1				
2 He	2				
3 Li	2	1			
4 Be	2	2			
5 B	2	2 (1)			
– –	–	– –			
10 Ne	2	4 4			
11 Na	2	4 4	1		
12 Mg	2	4 4	2		
13 Al	2	4 4	2 1		
– –	–	– –	– –		
18 A	2	4 4	4 4		
19 K	2	4 4	4 4	1	
20 Ca	2	4 4	4 4	2	
21 Sc	2	4 4	4 4 1	(2)	
22 Ti	2	4 4	4 4 2	(2)	
– –	–	– –	– – –	–	
29 Cu	2	4 4	6 6 6	1	
30 Zn	2	4 4	6 6 6	2	
31 Ga	2	4 4	6 6 6	2 1	
– –	–	– –	– – –	– –	
36 Kr	2	4 4	6 6 6	4 4	
37 Rb	2	4 4	6 6 6	4 4	1
38 Sr	2	4 4	6 6 6	4 4	2
39 Y	2	4 4	6 6 6	4 4 1	(2)
40 Zr	2	4 4	6 6 6	4 4 2	(2)
– –	–	– –	– – –	– – –	–
47 Ag	2	4 4	6 6 6	6 6 6	1
48 Cd	2	4 4	6 6 6	6 6 6	2
49 In	2	4 4	6 6 6	6 6 6	2 1
– –	–	– –	– – –	– – –	– –
54 X	2	4 4	6 6 6	6 6 6	4 4

various orbits permitted to them by the quantum theory. The numbers in the top line specify the orbits in terms of their principal and subsidiary quantum numbers. The numbers below are the numbers of electrons which follow one another round in these different orbits. It will be noticed that in the simpler elements there are never more than four electrons in the same orbit, although in the heavier elements six and afterwards eight electrons may inhabit the same orbit. The table is largely conjectural, but recent spectroscopic research has gone far towards establishing its essential accuracy. When we remember that it is less than twelve years since Bohr first suggested that the quantum theory might provide the clue to the structure of matter, we must agree that the progress of the theory in these years has been remarkable.

The Nature of Radiation.

The quantum theory has been less successful in discovering the nature of radiation, although even here it has been beyond comparison more successful than any previous theory. To illustrate the difficulties of the problem, let us consider one single phenomenon—the X-ray photo-electric effect. A thin stream of electrons each moving with the same high velocity is allowed to impinge on a material target, and X-rays are emitted which carry off the energy destroyed by the collision. These X-rays pass through a gas, and it is found that as soon as the process starts, atoms are ionised and shoot off electrons with a velocity equal to that of the original stream of electrons. Even if the density of X-radiation is so slight that, according to the old view of radiation, an atom would take years to absorb the energy necessary for ionisation, nevertheless ionisation is found to begin at once, energy being absorbed which is not only sufficient for mere ionisation, but also suffices in addition to endow the ejected electron with high velocity.

Such a phenomenon is of course totally inexplicable in terms of the luminiferous ether, or even in terms of Maxwell's equations. The quantum theory gives only a partial explanation. Since the frequency ν of the X-rays does not change with their passage through space, the equation $W_2 - W_1 = h\nu$ shows that the change of energy at the one end of the chain must be equal to that at the other. Thus as much energy is necessarily yielded up to one electron as is destroyed in another, but this does not touch the problem of the mechanism by which this energy is transferred.

Einstein at one time suggested that radiant energy was hurled through space tied up in indivisible packets like bullets from a rifle, but it has proved quite impossible to reconcile this suggestion with the optical phenomena of interference. A more recent hypothesis, also due to Einstein, calls for a revision of our conception of the action of an electric field on an electron.

According to the usual electrical theory, an electric force X acting on an electron of charge e and mass m for a time t produces a change of velocity equal to

$$\frac{Xet}{m}.$$

According to Einstein's recent theory of radiation, this is only true if X arises from a steady field or from a field which changes infinitely slowly. A force X which results from the incidence of radiation will in general produce no change of velocity at all in an electron. Indeed a bound electron is compelled to describe a fixed orbit with a prescribed velocity which cannot change, while a quite simple argument shows that it would be contrary to the fundamental equation of the quantum theory for a free electron to have its velocity changed by radiation. Einstein, following Bohr, supposes that under certain conditions a bound electron can have its velocity changed by a definite amount Q. This amount is not equal to Xet/m, but is determined by the position and motion of the electron in the atom to which it belongs; Q must be such as to move the electron into a new orbit which is also one of the permitted few. The chance of such a jump of velocity occurring is supposed to be

$$\frac{(Xet/m)}{Q}.$$

This conception immediately explains the otherwise incomprehensible photo-electric effect as well as other puzzles in the behaviour of radiation. The difference between a strong and a weak electric field acting on an electron is no longer that the strong field produces a big change of velocity and the weak field a small one; it is that the strong field has a big chance of producing a change, and the weak field only a small chance of producing the same change. When radiation acts on a body containing a great number of electrons, the final result is the same on the new theory as on the old. But there is a difference of method which is similar to the difference in propulsion between a motor-car and a steam-engine; on the new theory the charged body is propelled by a succession of little kicks, whereas on the old theory it was propelled by a steady pressure.

I have tried to sketch the outlines of the changes which the past quarter-century has introduced into our conception of the nature of electric forces and of the electromagnetic field. You will agree with me that there have been giants at work in the field of pure electrical theory. When the history of present-day science comes to be finally written, the quarter-century we have just lived through will, so far as we can now judge, stand out as the period in which man first began to understand the true nature of electricity.

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