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## Vanishing Life of Australia.

THE conditions which made for the evolution of the fauna of Australia along its unique path, the isolation of the continent associated with the early influx of primitive groups of animals, are now hastening that peculiar fauna towards its doom. Uniqueness has its own attractions, and there can be no replenishment of the disappearing forms from the outside world. There can be no doubt on the question of the disappearance of Australian birds and mammals. Sir James Barrett expresses the general opinion in Australia when he says: "The answer is unequivocal. Except in certain places where enlightened citizens have protected them, they are all disappearing. It is difficult for anyone to show a visitor in the State of Victoria the larger marsupials or the lyre bird. It is quite impossible to find the smaller marsupials except in a few favoured places and with great trouble. It is, indeed, feared that some varieties have been exterminated."

The same opinion is held in America. The title of our article is that of a paragraph in the Annual Report for 1921 of the American Museum of Natural History, which goes on to say: "We are approaching the close of the age of mammals all over the world, but in no continent has the devastation been more rapid than that of Australia, owing to three causes: deforestation, an enormous fur trade, and an increasing leather trade. In 1921 it became apparent that the American Museum must secure its representative collection now or never. Accordingly an expedition headed by Curator William K. Gregory was sent to Australia . . . to explain the chief purposes of the Museum, which are to secure an exhibition of the wonderful and unique life of Australia, past and present, as distinguished from a research collection, which belongs properly in the Australian museums and in the great British Museum of Natural History in London."

It is a rule in the decline of a fauna that when agriculture and commercial slaughter have reduced numbers to rarity, new forces step in to complete the destruction. The rare animal becomes desirable, scientifically and commercially, and collectors, animated by one enthusiasm or the other, rush to secure the last of the specimens. In the British Isles with their limited fauna this tendency has been particularly forced upon the notice of naturalists. A few years ago, the once common kite, in spite of strenuous protection, was reduced to some five breeding pairs on the borders of

Wales; the great skua and the St. Kilda wren were brought to the verge of extinction, the osprey was exterminated, all through the activities of collectors.

In Australia the same forces have taken a hand in the threatening final stages. Sir James Barrett, in the work from which we have already quoted ("Save Australia", 1925, p. 3), says: "Australia has lately been inundated with collecting expeditions, and what is still more serious, private commercial collectors are trying to obtain specimens before extermination takes place"; and Dr. J. A. Leach writes (p. 122): "The rumour having gone forth that the Australian mammals, the most primitive in the world, are doomed to early extinction, the museums of the world are making special efforts to obtain specimens of Australian animals before it is too late. Many scientific expeditions have visited Australia in recent years. These must be controlled. Worse still, prices for Australian birds have soared so high that the greed of private traders has been excited, and some big shipments have been sent from Australia for private gain. The mortality has been heavy, and the cruelty involved great, but the high prices obtained for the remainder have yielded a handsome profit."

We had these facts and opinions in mind when in a note (July 11, p. 63) we referred to a new collecting expedition to Australia from the Harvard Museum of Comparative Zoology. Prof. T. Barbour, director of that museum, and himself a distinguished naturalist, takes exception to our comment, which he thinks may be interpreted as expressing jealousy of American scientific activity. We need scarcely assure him that our only jealousy is for the safety of the rare animals of Australia, and we welcome his assurance that no attempt is to be made to secure 'long series', although that was scarcely apparent from the American notice of the expedition, which stated that the collection aimed at being one of the largest and best balanced in the world. The instructions given to the members of the expedition in connexion with their collecting, as stated by Prof. Barbour, are unexceptionable, and we are certain that Harvard will make good scientific use of the specimens collected. Indeed, it becomes clear, when we examine the staff of this expedition and of the Agassiz Museum, from which it emanates, that this is no collecting expedition but one with more serious and desirable scientific aims.

Museums of zoology a century ago were collections of animals similar to and about as informative as other indiscriminate collections. Then in Darwinian times an attempt was made to illustrate the main lines of evolution, and following this to obtain long series of animals to study the variation of the individual species, so as the better to understand this evolution. The mere student or sightseer was relatively little catered for, and the bewildering variety of animals in the museum cases depressed him. To-day the adequate display of properly labelled and well selected animals illustrative of the phyla and their subdivisions is recognised as of peculiar necessity to students, since they have to learn much of this side of zoology, and also of the possible lines of evolution, without the aid of teaching that has to be thrown more and more in the direction of experimentation and the study of the forms of life in relation to their surroundings. It is this last side, which we may term the natural history of animals, that is likely to be increasingly occupying the attention of museums, for it interests the public also. To prepare the requisite displays, even of common animals, requires that each curator must know intimately his forms of life in the field, together with the vegetation and other animals associated with them. We understand that this is so well recognised at the Agassiz Museum that its staff is dispersed into the field during the summer months; the local province here is North America, including the West Indies. Occasional expeditions travel farther afield, following out the practice of Louis Agassiz, but no longer restricting themselves to marine life. The present expedition is under W. M. Wheeler, the distinguished American entomologist, whose studies on social and other insects have materially guided the development of modern research on insect life.

So far as we can see, it appears doubtful whether both the terms 'scientific' and 'collecting' can be applied to any expedition. The collecting expedition requires action and often a personnel not altogether desirable, while it tends to think too much of the value, as instanced by rarity, of the specimens obtained. The scientific expedition is necessarily led by experienced naturalists, whose study is the actions of the various forms of life in their natural habitats, and whose collections are supplementary to the understanding of these. These men personally dislike to kill, and no expedition led by them will ever gauge its success by the 'bag'. Such expeditions should be encouraged, whatever may be their origins, since their sole aim is to add to the common stock of knowledge.

This, however, leaves the question of the preservation of the fauna, which usually means the birds and mammals, of Australia and other regions unconsidered. It is surely useless to obstruct even 'collecting' expeditions, while the local fur and feather merchants and the professional collectors are left to pursue their aims. We suggest that nothing except local legislation, honestly and firmly applied, can really be effective in any country. The birds, mammals, and other animals can be classified by their rarity and by their effects, beneficial or otherwise, in relation to man. The introduction of animals from other countries would be considered as affecting both the local indigenous fauna and man's agriculture. In addition, national parks might be established, as has been done in Africa and other countries, and there are surely large tracts of Australia and Tasmania which might be so declared without seriously affecting the local population. Sporting, collecting, and scientific expeditions would be either licensed or prohibited as might seem desirable. There would be no hardship in this, for science has nothing to fear when it is understood that the progress of the State is inseparably locked with its own.

## Geophysical Prospecting.

*The Principles and Practice of Geophysical Prospecting: being the Report of the Imperial Geophysical Experimental Survey.* Edited by A. B. Broughton Edge and Prof. T. H. Laby. Pp. xiii + 372. (Cambridge: At the University Press, 1931.) 15*s*. net.

TO the Imperial Geophysical Experimental Survey, 1927–29, was entrusted the task of testing, under conditions and on problems available in Australia, the applicability of the principal methods—gravitational, magnetic, seismic, and electrical—which recent developments in apparatus for local geophysical investigations have placed at the disposal of the economic geologist. As explained by the Director in his introduction to this Report, special stress was placed on the electrical methods, in view of the paucity of reliable information regarding these methods which was available at the time when the Survey was initiated.

The volume, however, comprises a good deal more than a mere detailed account of the tests undertaken in Australia, valuable though these are. As the title hints, it is, in addition, a comprehensive review of the principles of applied geophysics, and as such immediately stands out as the best available English exposition of these principles. Moreover, in the wealth of detail and illustration used to describe the apparatus employed, and the invaluable accounts of the procedure used in the field and in interpreting the results, the book fulfils all the functions of a practical manual of the science. Finally, in the comprehensively illustrated reports of the actual surveys undertaken, with the careful analysis and conclusions added both individually and as a whole, the volume permits all interested in the economic application of geophysics to form conclusions regarding its value on problems differing widely in characteristics. Of very particular interest in this connexion is the frequency with which, so far as possible, several methods have been tested on the same problem, in order that a comprehensive estimate of costs and value might be made.

The work is ingeniously divided into two parts. The first part, occupying some two-thirds of the book, may be regarded as the report proper; the second part comprises a very detailed exposition of the theory of each method and the apparatus employed. Thus the first part is more suited to the mining engineer and geologist who wish to assess the value of the method and its characteristic scope, whilst the second part is more adapted to the critical analysis of the physicist. In each chapter of Part 1, a brief introduction to the method is imparted, but much greater detail of the physical principles involved will be found in Part 2.

In Chapter xi will be found the general conclusions as to the applicability of the methods in Australia, and hints and statistics to serve as a basis for judgment as to their value elsewhere, but certain conclusions are also drawn in the various chapters of Part 1. Each section of the volume, whether principles, apparatus, procedure, or actual surveys, aims at a high standard, and attains it within the necessary limitations of the book. It is doubtful whether the whole range of the principles and procedure of geophysical prospecting could be comprehensively surveyed in a single volume of reasonable dimensions. So much of both pure and applied physics is involved in each individual method that a good-sized book could readily be filled in each case, as indeed has been demonstrated by the German publication "Sammlung geophysikalischer Schriften".

In the present volume, the tendency has been to build the 'procedure' round the actual 'practice' in Australia, so that in certain respects the account

is simplified. On the other hand, the particular problems selected for the trial of some of the methods, for example, the gravitational, whilst probably representing the best available in Australia, by no means covered the complete field of applicability of these methods. Consequently the procedure adopted in these instances was rather restricted, and the exposition in these methods may be regarded as somewhat elementary. Similarly, the descriptions of the instruments used, and the conclusions derived as to the scope of these particular methods, are limited by the relatively restricted work carried out in Australia.

The above criticism applies generally to the gravitational, magnetic, and seismic sections, but they are nevertheless excellent outlines of principles, procedure, and apparatus. In the case of the electrical methods, the exposition is in all respects more comprehensive and complete. The whole field of direct current, low and high frequency alternating current supplies, potential, resistivity, and phase measurements, conductive and inductive excitation of the earth—in fact, practically all the known varieties of method used—are surveyed conscientiously and efficiently. It is in this section that the chief value of the volume lies. The accounts of electrical apparatus are very detailed and contain descriptions hitherto unavailable. In addition, in the method known by the name ' Potential-Ratio ', we find a distinct advance in procedure of great importance. Even here, however, certain recognised methods were not actually tested in Australia and are not dealt with. One such method is that associated with the name of Gella, of the Elbof Company. In this method the measurements of the electromagnetic field, due to a current field introduced by two electrodes sited very near each other, are made in the region beyond the electrode interval, and certain advantages are claimed for such a procedure. As the Elbof Company has been operating under a commercial contract in Australia, it is unfortunate that no opportunity arose for the Survey to test the claims of this particular method. Two other methods, one involving the use of very low frequencies—for example, about 50 to 100 cycles—and the other utilising the electromagnetic field in the neighbourhood of a single rectilinear cable—are of comparatively recent development and therefore were not available for test during the Australian survey work.

Whilst the above reflections may serve to indicate how the volume falls somewhat short of the ideal of a really comprehensive account of the principles and practice of geophysical surveying, we would hasten to affirm that it is exceptionally complete. The very numerous diagrams and photographs are of immense value to the student, and to the practising geophysicist.

Turning now to the accounts of the various surveys, unqualified approval may be expressed of the way in which these have been presented. The selection of the tests gave a wide variety of problems, including the location and definition of deposits of sulphide and other ores, brown coal, and graphite, and the determination of regions bearing saline water. The accounts of the surveys are copiously illustrated by admirably clear maps and sketches, and many folding plates are inserted. The descriptions of the procedure, analysis, and interpretation are models of what such accounts should be, and are in striking contrast to the vague, unintelligible travesties which we meet so frequently in the average description of electrical surveys undertaken by commercial concerns. We do not encounter here the usual hieroglyphic indication of a ' good conductor ', which has no apparent connexion with the actual measurements, but contrives to present a specious concordance with the actual mineral deposits known to exist by borings. In this volume, the whole procedure of the trial is made perfectly clear and the method of interpretation rendered intelligible. There is no attempt to gloss over difficulties or to hide perplexities. Finally, so far as was known by the date of publication, the results of confirmatory drillings are given. Unfortunately, the close of the Survey coincided with the advent of intense depression in Australia, so that few of the valuable indications obtained by the Survey have as yet been prosecuted by drilling or mining. This will doubtless be remedied as future opportunity arises. Meanwhile, it is heartening to note that many successes are already confirmed, in some cases where valuable deposits were previously unsuspected.

We cordially recommend this volume to the attention of all interested in economic geology and mineral resources generally, and, above all, to students and exponents of geophysical prospecting. The remarkably low price of the work is a mystery; we hope it will not create in the mind of the would-be purchaser the erroneous impression that it has any relation to the value. Had this book been published in Germany or the United States it would be twice the price.

## Treatise on Physical Chemistry.

*A Treatise on Physical Chemistry: a Co-operative Effort by a Group of Physical Chemists.* Edited by Prof. Hugh S. Taylor. Second edition. In 2 volumes. Vol. 1. Pp. xv + 852 + 48. Vol. 2. Pp. xii + 901-1766 + 48. (London: Macmillan and Co., Ltd., 1931.) 30*s.* net each vol.

THE welcome appearance of a second edition of this two-volume treatise on physical chemistry has clearly demonstrated both the practicability and the usefulness of Prof. Taylor's somewhat novel experiment of attempting to produce a text-book by the co-operative efforts of different individuals; a practice usually reserved for dictionaries and tomes of a more encyclopædic character. Whilst the first edition was a good treatise, this second edition is better. Apart from the inclusion of new matter and the adjustment of stress on importance of what may be termed personal factors in the various chapters, the volumes, on the whole, are much more evenly balanced. We note, for example, the growth of uniformity in the treatment of the theory of solutions and of reactions taking place therein, a more minute analysis of the problems of the kinetic theory of gases, and a very desirable extension of the treatment of colloidal systems. Dr. Dushman's chapter on the quantum theory and atomic structure is really a remarkable production both for clarity and scope.

In the introduction to the first edition, Prof. Taylor states that the first volume represents that portion of the subject which can with advantage be addressed to the first-year student; the second volume presumably to those who are spending the two subsequent years in the study of chemistry. The treatise has swollen unavoidably from 1359 to 1766 pages. To those who were brought up with Ostwald, Nernst, or Sir James Walker's books on physical chemistry as texts during their years at college, these new editions, whilst representing faithfully the growth and, as some of us like to believe, the growing importance of the subject, will be welcomed and give much pleasure; but at the same time it raises in a somewhat pertinent form the important question as to what courses in college chemistry should and what such courses can do. It would be surprising if any student on graduation in chemistry could be really *au fait* with the content of these volumes. At the same time, it is doubtful if even the clear appreciation of what are somewhat vaguely termed general principles will suffice to render a man a competent scientific worker when he leaves college. Some happy combination of general principles, the working out of examples, and development of a logical and critical faculty seem to be desirable in any college course. Such are not obtainable in treatises. For example, the first-year college student in reading the first volume would receive his first introduction to the ionic theory in the heat of hydration of gaseous ions and the Donnan distribution on the two sides of a semi-permeable membrane.

For the research student, however, the two new volumes are really excellent. It is natural that with the rapid growth of particular phases of the subject even in the new volumes certain statements require revision, for example, the sections devoted to consideration of heats of adsorption of gases on active metal surfaces. Whilst a certain amount of duplication of material is unavoidable, the proof readings must have been no light undertaking and the final text is remarkably free from typographical errors. We note a few, such as 'Seminoff' for 'Semenoff' p. 1012, 'rom' for 'from' p. 1092, and 'corresponcence' for 'correspondence' p. 1172. It is to be hoped that when the third edition is called for, Prof. Taylor will continue to adopt the policy of attempting to make the book a representation of the science as it is, and not delimit it for the purpose of providing first-year college students with material for study. I suspect that this material is already too indigestible for their consumption. The printing and binding of the volumes are excellent. ERIC K. RIDEAL.

## The Complete Evolutionist.

*L'Ologénèse: nouvelle théorie de l'évolution et de la distribution géographique des êtres vivants.* Par Prof. Daniel Rosa. Adapté de l'italien par l'auteur. (Bibliothèque de Philosophie contemporaine.) Pp. xii + 368. (Paris: Félix Alcan, 1931.) 35 francs.

SOME time ago there was reviewed in these pages (NATURE, May 11, 1929, p. 709) a book in which Dr. George Montandon of Paris sought to explain the origin of human races by applying a theory of evolution which had been first propounded by Prof. Daniel Rosa of Modena in 1909. Dr. Montandon's advocacy has stimulated an interest in this new theory, with the result that Prof. Rosa has translated his chief work ("Ologenesi: Nuova teoria dell' evoluzione e della distribuzione geografica dei viventi." 1918) into French. The book in its French dress is much more than a translation of the original; the author has taken

the opportunity of amplifying his theory and of introducing new evidence.

Prof. Rosa claims that his theory of hologenesis gives a more complete and satisfying explanation of all the facts known to students of the evolution of living things than any other. By applying it, the naturalist is given, so he believes, an acceptable explanation of how the present flora and fauna have come into existence; the palæontologist obtains from it a clue to the distribution of species in space and time, and it solves all problems of embryology, heredity, anatomy, classification, and of adaptation. The theory of hologenesis succeeds in doing so much because of its blunderbuss charge. Its shot has been culled from Lamarck, Darwin, de Vries, Weismann, Naegeli, etc., whereto Prof. Rosa has added a potent factor of his own. His theory has much in common with that held by the late Dr. William Bateson, namely, that evolution is an unfolding of potentialities inherent in the germ plasm of the originals of living things.

To make his theory clear to his readers, Prof. Rosa uses as a simile the development of a chick from the egg. The sequence of developmental processes which give rise to the chick lie dormant in the fertilised egg, and, in the period of incubation, the potentialities unfold themselves to produce a chick. In like manner, he holds that in every species of living thing, just as in every fertilised egg, there is a load of potentialities or determinants, which, when unfolded or spent, the species reaches maturity. Having reached maturation, the germ plasm of the species undergoes a sudden change whereby the mother species suddenly gives rise to two daughter species, which differ from each other and also from the mother. The daughter species then set out to unfold their determinants, and if the environment is favourable —for environment and selection play their part in the theory of hologenesis—then maturation stages are again reached and a further dichotomy with the production of new species takes place. Given living matter laden with an infinite and suitable supply of determinants, the hologenist is armed for all the eventualities with which the living world is likely to present him.

The theory of evolution has now reached a strange stage in its progress—a stage of indifference. Biologists of all shades of opinion are convinced that living things have evolved from simpler and older forms, but for the meantime they have lost interest in how the transformation has been effected; they are careless of theories and hungry for new facts. This mood will militate against the theory of hologenesis receiving the attention it deserves, for Prof. Rosa has cast his net widely and brought up for consideration a great assortment of biological facts. He is right when he declares that no theory of evolution can be finally acceptable unless it explains by natural and observable processes the wonderful adaptations and contrivances which are to be found everywhere in the kingdom of life. He faces the problems of adaptation and seeks for an explanation by postulating that the 'determinants' must be functional in their constitution, that their unfolding must take place as a harmonious specialisation of labour. We may grant that much and yet be no nearer to an understanding of how this specialisation does take place.

Prof. Rosa's book will serve to remind its readers how far we are yet from an exact knowledge of the machinery which underlies evolution. It is the physiologist rather than the morphologist who is most likely to find the clues to the essential problem of evolution. A. K.

## Short Reviews.

*Foundations of Geometry and Induction.* By Jean Nicod. Containing Geometry in the Sensible World, and The Logical Problem of Induction. Translated by Philip Paul Wiener. (International Library of Psychology, Philosophy and Scientific Method.) Pp. iv + 286. (London: Kegan Paul and Co., Ltd.; New York: Harcourt, Brace and Co., 1929.) 16*s*. net.

THOSE who knew the late Jean Nicod will be glad to have this translation of his two main works; yet the book itself will interest a much larger circle of readers, because of the very problems it discusses and because of the original and valuable contributions made by the author towards their solution. In discussing "Geometry in the Sensible World", Nicod starts from data of perception and tries to derive the various geometries that can be built on them, a method which is quite the inverse of Prof. Whitehead's 'extensive abstraction'. For the logical development of this very interesting method, the author shows us an animal which is endowed successively with more and more complex senses, and tries to build up gradually the geometrical world of his sensations. He obtains in this way some remarkable conclusions which strengthen the case against Kantian philosophy, and illustrate to the full the relations between symbolic logic and experience. Indeed, the line of approach suggested by Nicod is one which ought to become classical in the investigation of the problems concerning mathematics and the external world.

In the second part of this volume, "The Logical Problem of Induction" is analysed in itself and in relation to the doctrine of probability. Nicod tries

to show why induction by simple enumeration is a fundamental mode of proof, and that all those who have thought they can do without it have done so only by the aid of sophisms; also, that it can increase the probability of a hypothesis, even when the new facts observed should do nothing but repeat without variation facts already known. The author endeavours, finally, to show that it is not actually demonstrated by any procedure whatsoever how inductive reasoning can raise the probability of a law to the point of indefinite proximity to a certainty. The penetrating analysis of these various theses would have no doubt led the author to a more positive construction, but his premature death has unfortunately terminated a career which would have been a credit to scientific philosophy. T. G.

*School Certificate Magnetism and Electricity.* By Dr. Harold Toms. (Pitman's School Certificate Series.) Pp. viii + 440. (London: Sir Isaac Pitman and Sons, Ltd., 1930.) 5*s*.

THE author justifies the appearance of this new text-book in a preface, where it is stated that the traditional division of the subject into magnetism and voltaic and static electricity has not been adhered to, and that an effort has been made to present the facts as one homogeneous and interrelated set of phenomena rather than as three vaguely connected subjects. Emphasis is laid on mechanics and units since experience has shown that "only those who realise that mechanics can be applied to electrical and magnetic phenomena ever acquire a thorough grasp of the subject". The object has been "to provide a solid groundwork for those who, at a later stage, intend taking an advanced course".

The exposition is clear rather than detailed, and, in spite of the size of the book, is in some respects superficial. A chapter on magnetic theory is entirely devoted to Weber's theory, and gives the impression that magnetism is a simple matter, wholly understood, and presenting no difficulties. One feels that even an elementary book should direct some attention to the great strides made on the theoretical side in recent years. Alternating currents, the dynamo and accumulators, are very briefly dismissed; hysteresis and the nickel cell are not mentioned. N. M. BLIGH.

*The Laboratory Mouse: its Origin, Heredity and Culture.* By Dr. Clyde E. Keeler. Pp. viii + 81. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1931.)

IN this monograph, by the author of a series of papers on inherited abnormalities, especially of the retina, in the mouse, the early chapters deal with the systematic position and history of house and domesticated mice. There is much curious information: we learn, for example, that, according to the London Pharmacopœia of 1667, "A flead mouse dried and beaten to powder, and given at a time, helps such as have Diabetes"; that a special word for the dominant spotted variety of mouse appears in the earliest Chinese lexicon, written 1100 B.C.; and that "The clergy of the Middle Ages never ceased to comment upon the libidinous habits of mice. Indeed, mice were frequently raised by curious churchmen in order to observe their wicked actions".

The origins of the different fancy breeds are traced out so far as possible. A chapter follows, cataloguing and tabulating the various gene-mutations that are known in mice, with full descriptions of their effects; this leads up to an account of heredity, normal and abnormal. A chapter on the technique of breeding and keeping mice, five pages of photographs of different varieties, and a bibliography of 184 titles conclude a very admirable little volume. G. P. W.

*The Bacteriophage and its Clinical Applications.* By Prof. F. d'Herelle. Translated by Prof. George H. Smith. Pp. viii + 254. (London: Baillière, Tindall and Cox, 1930.) 18*s*. net.

THIS book, based upon the Lane Lectures delivered by the author at Stanford University, California, in 1928, is addressed primarily to practitioners of medicine. The subject of bacteriophagy is a complicated one, and still in an imperfectly understood state. The history of its discovery, its nature, and its relationship to bacterial mutations, infectious diseases, and recovery and immunity, are outlined quite clearly and simply. It is not within the scope of a book of this sort to enter exhaustively into the conflicting theories of the nature of the bacteriophage, nor does it do so. The author's views as opposed to those of Bordet and his followers are given in some detail. About sixty-five pages are devoted to the clinical application of the bacteriophage. Records of its use in enteric infections, infections due to pyogenic cocci, streptococcus, and bubonic plague are included.

The book is interesting. But it is unjustifiable to conclude, as its author does, that in bacteriophage lies an explanation of all immunity to the exclusion of generally accepted theories. The clinical application is as yet far from being established.

*Handbuch der biologischen Arbeitsmethoden.* Herausgegeben von Prof. Dr. Emil Abderhalden. Lieferung 346. Abt. 9: *Methoden der Erforschung der Leistungen des tierischen Organismus*, Teil 7, Heft 1. *Methoden der Tierhaltung und Tierzuchtung.* Pp. 226. (Berlin und Wien: Urban und Schwarzenberg, 1931.) 13 gold marks.

THE present section of this work contains four articles on the following subjects: (1) the collection, study, and rearing of tardigrades, by Prof. Marcus, of Berlin; (2) and (3) the collection, rearing, and investigation of ticks and of fleas, by Prof. Pawlowsky, of Leningrad, two valuable articles, stressing, as might be expected, the pathological significance of the parasites; and (4) methods of investigating subterranean faunæ, by Prof. Chappui, of Klausenberg, an article including much useful general information about the ecology of caves and underground streams. G. P. W.

# The Origin of the Solar System.*

By SIR JAMES JEANS, F.R.S.

THE observational astronomer generally feels only an indirect interest in the problem of how our earth and its companion planets came into being; his telescope can give him no direct information on the subject, since such planets as other suns may possess are too small and too distant to be observed. If every star in the sky were suddenly to give birth to planets we should in all probability remain unaware that anything was happening.

Yet the problem is of thrilling interest to science in its widest sense. The old nebular hypothesis of Laplace had pictured the stars as shrinking nebulæ which rotated faster and faster as they shrank, and in so doing threw off their equators rings of matter, each of which was destined in time to condense into a planet. This cosmogony implied that the shedding of planets was a normal event in the life of a star. It led to the concept, so commonly held in the nineteenth century, that every star in the sky was a sun distributing light and heat to a retinue of worlds circling round it. As solar light and heat are the most obvious essentials for terrestrial life, it was natural to take the next step and assume that every star we saw in our telescopes was busily at work radiating energy to maintain life on its surrounding planets. When once this step had been taken, no great violence to the probabilities seemed to be implied in taking the further step of assuming that each star had been created to this special end.

The more modern view supposes that the birth of planets is very far from being a normal event in the life of a star—it is an abnormal and exceedingly rare event. So rare is it that, even if the stars have already lived the longest lives that have ever been suggested for them—lives reaching back many millions of millions of years into the past—only a minute fraction of them can be surrounded by planets. If they are destined to live into the future for the longest period that has ever been suggested—a period measured in hundreds of millions of millions of years—even by the end of this inconceivable length of time only a minute fraction of their total number will be surrounded by planets. This view implies that most stars must live and die without giving birth to planets at all—and even of those that do, the majority must be so cold and shrunken before their planets are born that there can be little or no question of their sustaining life.

In brief, the older theory, with the help of a little kindly imagination, depicted a universe teeming with life. The more modern theory depicts a universe which proceeds steadfastly on its way, while here and there, in insignificant corners and at infrequent intervals, a strange accident results in life stumbling into being. It can scarcely be a matter of indifference to science—and still less to humanity—which picture is correct.

Let us first consider some evidence of a purely physical nature. The activity of radium appears at first glance to be permanent; yet we know that it is no more permanent than anything else in Nature. All radium gradually loses its potency; it deteriorates, so that after about 1600 years it will be only half as potent as it is to-day.

The reason for this loss of potency is now well understood. It is that the radium gradually changes into something which is not radium, and has not the properties of radium—the debris of radium, let us call it. After 1600 years, a mass of pure radium becomes changed into half radium and half debris of radium. The potency is reduced to half because the amount of radium is reduced to half.

It follows that if we are given a mixture of radium and its debris, we can tell how long the radium has been at work to produce this debris. For example, if the amount of debris is equal to the amount of radium, we know that the disintegration of the radium has been in progress for 1600 years; if three-quarters of the mass is debris the process has been in action for 3200 years, and so on.

The time needed for a mass of a radioactive substance to change into half substance and half debris is known as the 'half-period' of the substance; it varies enormously for different substances. It is 1600 years for ordinary radium; for one radioactive substance, radium C′, it is only about a millionth of a second, while at the other end of the scale are substances for which the half-period is measured in thousands of millions of years. For thorium it is about 16,500 million years; for uranium, 4500 million years.

Now in various rocks in the earth's crust geologists come upon imprisoned uranium accompanied by debris of uranium. In no case is the mass of debris ever as great as the surviving mass of the uranium. There is only one possible inference—the uranium has not been imprisoned for as long as 4500 million years. The proportion of debris found in all samples of rock tells much the same story—the uranium has been imprisoned for a time of the order of 1500 million years. The rocks in which thorium is imprisoned have much the same thing to say—the thorium has been imprisoned for a time of the order of 1500 million years. We conclude that something like 1500 million years must have elapsed since the crust of the earth solidified. We can now add something for the time before solidification and we shall obtain the total age of the earth. From a study of the relative abundance of ordinary uranium and its isotope actino-uranium, Rutherford has been able to show that this total age cannot have been more than about 3400 million years.

* Address delivered at the Franklin Institute in Philadelphia on May 20, on the occasion of the presentation of the Franklin Medal to Sir James Jeans.

Shooting-stars or meteors confirm the story told by the earth's rocks. Occasionally one of these objects is too large to be completely vaporised by the resistance of the air, and what is left of it strikes the earth in the form of a large rock or stone known as a meteorite. Many of these bodies are found to contain imprisoned thorium or uranium, along with the debris of their disintegration. The amount of the latter makes it possible to estimate the length of time since the stone solidified. The time cannot be estimated with great accuracy, but no body that has been examined suggested a period of more than 2900 million years since solidification, and the majority appeared to be of about the same age as the earth. In a general way we may say that the length of time which has elapsed since the planets and other members of the solar system solidified cannot have been more than about 3000 million years.

This estimate depends solely on recent advances in physical science. The earlier cosmogonists had no means of forming such an estimate, and it would have been of little use to them if they had. It is important for us of to-day, because we can combine it with recent astronomical knowledge. We can tell how much the sun and stars have changed in 3000 million years. The sun is radiating its substance away at the rate of 360,000 million tons a day. This sounds like a very rapid rate of loss until we compare it with the huge total mass of the sun. We then find that radiation at this rate for 3000 million years scarcely affects the sun's mass at all. The mass of the sun, and indeed of all the stars, must have been very much the same 3000 million years ago as to-day. Furthermore, recent astronomical research has shown that the physical state of a star depends almost entirely on its mass —stars which have approximately the same mass as the sun are found to have also approximately the same physical constitution as the sun. Thus we must suppose that when the planets and meteors were born, the sun not only had the same mass, but also the same physical constitution and size as it has to-day.

This conclusion, based on evidence which can scarcely be challenged, provides a test which we may apply to the various theories of the origin of the solar system in turn. Let us first apply it to the most famous of all, the nebular hypothesis of Laplace. Laplace supposed that the sun started as a huge nebula, extending out as far as the orbit of the farthest known planet—to-day we must say as far as the orbit of Pluto; as it shrank with cooling it left behind it rings of matter which afterwards condensed and formed the separate planets. When the earth was shed, this nebulous sun would have a diameter equal to the present diameter of the earth's orbit. We see at once that this hypothesis cannot survive the test I have just described; and indeed there are many other tests, mainly of a dynamical kind, which it is equally unable to survive.

It would be an impossible task to test all the various theories of the earth's origin which might be propounded one by one. Let us notice that all such theories fall into two distinct classes, according as they suppose that the sun alone was concerned in the process of creating the planets, or that other bodies were concerned in addition to the sun.

If the sun alone was concerned it is difficult to discover by what mechanism the outermost planets could be projected to their present distances from the sun. We seem compelled to postulate some system of internal explosions as the origin of the planets, and this seems inconsistent with the present orderly arrangement of the planetary orbits. It also fails to explain why the systems of Jupiter and Saturn are so exactly like the main system of the sun in every respect except size. Indeed, this likeness is so marked that any theory which fails to explain it may safely be dismissed; we may be sure that the same mechanism must have produced these smaller systems as had already produced the main system. This test seems fatal to any hypothesis of explosions. It is straining probabilities far too much to imagine that a succession of explosions could produce anything so orderly as the main system of planets; it is straining them infinitely more to suppose that the same miracle could be repeated twice again to produce the similar systems of Jupiter and Saturn.

Thus there seems to be no alternative to supposing that at least one other body besides the sun was concerned in the birth of the planets. In 1750, Buffon imagined the planets to have been splashed out of the sun as the result of collision with a passing comet. In 1880, Bickerton propounded a somewhat similar theory, except that he replaced the comet by a star. This collision theory has recently been revived, with further modifications, by Jeffreys. Although his views call for further discussion and critical examination, it is difficult to see at present how they can possibly be reconciled with the similarity of the systems of Jupiter and Saturn to the main system. Grant for the sake of argument that a big splash formed the planets, then it seems quite beyond the bounds of probability that two smaller, but otherwise almost exactly similar, splashes should occur to create the systems of Jupiter and Saturn.

I believe I was the first, in 1901, to consider the possibility of the second body not colliding with the sun, but producing planets by tidal action. In 1904, Profs. Chamberlin and Moulton independently considered the same possibility, and developed it, along lines of their own, much further than I had done. They imagined that a series of solar eruptions, such as normally cause prominences, were so intensified by the tidal action of a neighbouring star that the ejected matter was projected clear of the sun's gravitational field, where it condensed into small solid bodies, which they designated as 'planetesimals'. These in turn underwent further aggregation and in due course formed the planets.

The scheme which they propounded seemed to me to be open to many objections. Not only did it fail to explain why the satellite systems of Saturn and Jupiter should resemble the main planetary system, but also it failed to explain

why satellite systems should exist at all. Indeed, it is doubtful whether it can even explain the existence of the planets. Puffs of gas such as Profs. Chamberlin and Moulton imagined to condense into planetesimals would not condense into solid bodies at all. They could not do so inside the hot atmosphere of the sun, and as soon as they got clear of the sun's atmosphere they would merely scatter into space, like the leak of gas from a gas-burner. Calculation shows that any body of gas will do this unless it is of enormously greater mass than the supposed planetesimals. The mutual gravitational attractions of the molecules of a mass of gas of planetesimal dimensions would be too small by a factor of several millions to result in condensation in opposition to the ordinary gas pressure resulting from the kinetic energy of their motion.

Because the planetesimal theory seemed open to these and other fatal objections, I tried to trace out mathematically the course of events which would actually occur when a second star approached to within a specified distance of the sun and passed on its course without an actual collision taking place. Discarding all physical assumptions as to solar eruptions and the formation of planetesimals, I found that my own old conception of tidal action was able of itself, without any adventitious assumptions, to give a plausible account of the origin of the solar system. In this way I was led to propound a new theory of the origin of the solar system in 1916, which was very different from that of Chamberlin and Moulton.

The researches of Roche (1850) had already shown that every large mass such as the sun is surrounded by what may properly be described as a 'danger-zone'. No body of moderate size can revolve permanently inside this danger zone; it is rapidly broken up into minute pieces. Roche suggested that Saturn's moons and rings provide an example of this; the moons are all outside the danger-zone, but the rings are just inside, whence it is generally believed that the rings are the broken fragments of what was originally an ordinary moon of Saturn. There are good reasons for conjecturing that the system of asteroids which surrounds the sun forms a second illustration of the same effect.

Mathematical investigation of the tidal action between two stars showed that this concept of a danger-zone is equally applicable when two bodies merely approach one another temporarily and then pass on their respective courses. Two bodies which remain always at more than a certain distance from one another merely raise tides like those which the moon raises on the earth. As their distance lessens the height of tide increases; as it increases again the tides fall, until finally both bodies are left in their original undisturbed state. But if the two bodies approach to within a certain critical distance of one another, the whole character of these tides changes. Instead of a small elevation travelling over the surface of the disturbed body, as ocean tides travel over the surface of the earth, we have a huge mountain of gaseous matter which continually increases in height as the bodies approach, and finally shoots out to form a long arm which may finally, if conditions are favourable, establish contact with the second body. The two bodies will then be joined by a filament of gas, much as the two ends of a dumb-bell are joined by the handle of the dumb-bell. Under other conditions contact may fail to be established, and a long filament of gas will be left projecting from the primary body in the direction of the secondary body. It can be shown that this filament must inevitably, as the result of the mutual gravitational attractions of its own molecules, condense into detached masses. We can even calculate how massive these condensations will be. No great accuracy is possible, but we find that such condensations would at least be of the same general order of magnitude as the actual planets.

Before condensation commenced, the filament would be shaped like a cigar or a torpedo; one of the two pointed ends is the peak of the tidal mountain, the other is the last thin dribble of matter which came off just as the gravitational pull of the receding star was failing. After condensation we should expect to find the largest condensations near the centre, where the matter was originally richest, with the size of condensations tailing off at either end.

This exactly represents the present arrangement of the planets. It explains why the central planet Jupiter is the largest, and why the sizes and the weights of the planets both show a general tendency to fall off as we recede from Jupiter in either direction. The discovery of Pluto, which is, I suppose, quite certainly less than Neptune both in size and weight, has recently provided welcome confirmation of this prediction of the theory. It is perhaps also significant that, on the whole, the densest planets are not the most massive planets, in which we might reasonably have expected to find the matter most tightly packed, but those which lie nearest to the sun, although these are of comparatively small weight. These came from the root of the tidal mountain, and it seems possible that the heavier elements were more abundant here than at the peak of the mountain. The puzzlingly low density of Saturn, only one-eighth of that of the earth, is at once explained if we suppose that Saturn was formed mainly out of the higher strata of the sun's atmosphere.

We can, however, elaborate the theory in much greater detail than this. The planets at present move in orbits which are almost circular, but this must inevitably result from their having ploughed their way, for thousands of millions of years, through the dust and debris of space. When the planets first condensed they would be describing quite erratic, and indeed almost random, orbits about the sun. Their orbits could scarcely be expected to show any regularity beyond that of all lying in the plane of motion of the passing star which had brought them into being. Those planets which passed near enough to the sun would enter

its danger-zone and be broken up in turn, just as the sun had previously been broken up by entering the danger-zone of the other star; the plane of their motion would be that containing the orbit of the planet round the sun. In this way we get a conjectural explanation of the satellite systems of the planets, of their general resemblance to the main system, and of the fact that their orbital planes lie mainly in the plane of the solar system.

In time the planets would cool, then liquefy, and then solidify; the largest would remain gaseous for longest. Now a theoretical investigation of the question shows that planets which remained gaseous until after the birth of their satellites would be likely to give birth to a large number of small satellites, whereas planets which had already liquefied or solidified would be likely to give birth to a smaller number of large satellites—or possibly to no satellites at all. This at once explains a further regularity in the arrangement of the solar system. The planets which have the greatest number of satellites are the two big central planets, Jupiter and Saturn. These have nine satellites each, and all are very small in comparison with the planets round which they revolve. Like the main solar system, the satellite systems of Jupiter and Saturn show the characteristics to be expected in systems born out of a gaseous body. As we proceed away from these giant planets in either direction we come to planets whose satellites are fewer in number, but larger in size relative to the sizes of their primaries—the characteristics to be expected in systems born out of a liquid, or liquefying, body. This is at once explained if we suppose that the great size of Jupiter and Saturn caused them to remain gaseous for a long time, while the smaller planets such as Mercury and Venus liquefied or solidified almost at once. The cases of transition appear to be provided by our own earth in the one direction and by Neptune in the other; each of these planets possesses a single satellite which is abnormally large in comparison with the size of its primary.

We can perhaps find confirmation of this in the fact that Mars and Uranus, the two planets which come next to these as we pass inwards towards Jupiter, are both abnormally small; we might have expected Mars to be intermediate in size between the earth and Jupiter, and Uranus to be intermediate in size between Neptune and Saturn. Now if we suppose that these two planets were the smallest of all the planets which retained their gaseous condition for long, they would suffer more than the others from the continued dissipation of their atmospheric layers into space. On this view Mars and Uranus must be regarded as mere relics of far larger masses, and we see at once why they are abnormally small for their positions in the planetary sequence.

There are so many conjectural elements in this theory that it would be rash to claim, or even to hope, that it can in any way prove final. The highest claim I would make for it is that it accounts for many of the observed facts, and has not yet been found to suffer from insuperable objections—and this can be said of few, if any, other hypotheses as to the origin of the solar system.

If we accept it we must accept also the consequences I stated at the outset. Stars are very rare objects in space, and so are spaced very far apart, so far apart that it is very hard to imagine the sparseness of stars in space. If we take three particles of dust and place them in a large cathedral, this would be incomparably more crowded with dust than space is with stars. As a consequence stars approach one another very rarely, and it is an almost inconceivably rare event for two stars to come so close that planets are born. Planets, and so presumably life also, must be exceedingly rare in the universe.

We can regard this with satisfaction or the reverse, as we choose. Some will feel overwhelmed with a great loneliness; they will feel that it adds to the terror which overcame Pascal when he contemplated the immense voids of space. Others will view it with satisfaction, because it adds to the relative importance of human and terrestrial life. When we thought of each star as the centre of a system which teemed with life, human life appeared as a very small thing; it formed an inconceivably small fraction of the total life of the universe. The new view compels us to think of life on earth as forming a comparatively large fraction of all life of the universe.

## George Graham, F.R.S., 1673–1751.

ON Nov. 24, 1751, at night, a funeral procession left a shop bearing the sign of the Dial and One Crown, in Fleet Street, for Westminster Abbey. The hearse was preceded by three coaches containing the pall-bearers Dr. Knight, Mr. Watson, Mr. Canton, Mr. Short, Mr. Catlyn, and Mr. Bird, and was followed by nine other coaches. Thus was borne to his last resting-place George Graham, widely known both at home and abroad as the finest mechanician of his day. Arrived at the Abbey, the coffin was carried into the nave and was then laid beside that of Thomas Tompion, who had died in 1713, recognised as "the father of English watchmaking". The grave is not far from that of Newton. It is covered by a stone with an inscription, a part of which refers to Graham, "whose curious inventions do honor to ye British genius whose accurate performances are ye standard of mechanical skill". In the middle of the eighteenth century burials in the Abbey were more frequent than they are to-day, and it was a fortunate decision which led to the interment within its walls of these two famous masters of horology.

Graham, who was a Quaker both by upbringing and by conviction, was cast in much the same mould as that other Quaker and man of science of a later day, John Dalton. Born in Cumberland in 1673, at the age of fifteen he came on foot to London and there began an apprenticeship of seven years with Henry Aske, a clockmaker. His

apprenticeship ended, he entered the employ of Tompion, afterwards marrying his niece and succeeding to his business at the Dial and Three Crowns, Fleet Street. In 1720 Graham moved across the street to the Dial and One Crown to a shop which was destined to become famous, and it was there he died, Nov. 20, 1751. The friend of Newton, Halley, Molyneux, Hadley, Bradley, and many others, Graham lived for the advancement of science and the benefit of mankind, and though his business brought him ample means, so little account did he take of wealth that on principle he refused to accept interest on loans and never invested in Government securities. To his more intimate contemporaries he was known as honest George Graham.

Of the life of such a man we cannot know too much, and both horologists and astronomers will read with interest the pamphlet issued by the *Vassar Journal of Undergraduate Studies*, giving Miss C. D. Hellman's sketch of George Graham, maker of horological and astronomical instruments. Miss Hellman has taken the trouble to consult most of the original works which give information of Graham's scientific inventions and observations and her account is the fullest we have hitherto seen. Graham's position among his fellows can be judged from the facts that in 1720, when he took up his residence at the Dial and One Crown, he was elected a fellow of the Royal Society, and that two years later he was made Master of the Clockmakers' Company. He had already invented the 'dead beat' form of the anchor escapement for clocks and watches, and in 1721 had brought out his mercurial pendulum, an improvement which became of great importance.

With these inventions to his credit, Graham then proceeded to add to his reputation by observations on the magnetic needle, during which he discovered the diurnal variation and measured the magnetic intensity. In 1725 he made his well-known 8 ft. quadrant for Greenwich Observatory and at the same time constructed sectors for both Molyneux and Bradley. Much of Bradley's work at Kew was done with his assistance. Other instruments he made were those supplied to the French Academicians who in 1736 visited Lapland to measure an arc of the meridian. At his house in Fleet Street he observed comets, solar and lunar eclipses, sometimes by himself, sometimes with a fellow-observer. He also served on a committee connected with Greenwich Observatory, and carried out work in connexion with the standards of measurements. On all these matters Miss Hellman gives an account, and her pamphlet contains extracts from Graham's paper published in the *Philosophical Transactions*. Without an equal in his own line, Graham lived to see the rise of Mudge, Harrison, Dollond, Bird, Short, and others, in whose hands scientific instrument making reached a pitch of excellence surpassing even that of Graham. Most of these, however, owed something to Graham, and Bradley once wrote: "If my own Endeavours have, in any respect, been effectual to the advancement of astronomy, it has principally been owing to the advice and assistance given me by our worthy member, Mr. George Graham, whose great skill and judgment in mechanics, joined with a complete and practical knowledge of the uses of astronomical instruments, enable him to contrive and execute them in the most perfect manner". "No greater tribute than this", says Miss Hellman, "could be paid to George Graham."

## Obituary.

### Dr. Richard Wettstein.

THE death on Aug. 10, at the age of sixty-eight years, of Dr. Richard Wettstein, Ritter von Westersheim, Hofrat, professor of systematic botany and director of the Botanic Garden and Institute of the University of Vienna, removes a notable figure from the botanical world. His commanding presence, courteous demeanour, and powers of oratory give credence to the statement by the correspondent of the *Times* that on more than one occasion he was seriously considered as a possible president of the Republic.

Among botanists, Wettstein was known as a careful and painstaking investigator, a capable teacher, and an efficient organiser. He studied at Vienna under Anton Kerner von Marilaun, author of the well-known volumes on the natural history of plants, and, after a short period as a *privatdocent*, went in 1892 to Prague, where he followed Heinrich Willkomm as professor of botany in the German University. Seven years later he returned to Vienna to succeed Kerner, whose daughter he had married, as University professor and director of the Gardens. Shortly after his return, a commodious botanical institute was erected to replace the historic but meagre old buildings at the Gardens, and here Wettstein played the part of host to the delegates who met to formulate the Rules of Botanical Nomenclature at the International Botanical Congress in 1905, of which he and Prof. Julius Wiesner were joint presidents. More recently, as senior president of the International Horticultural Congress, in September 1927, Wettstein again welcomed botanists and horticulturists from all parts of the world at the University.

In 1889, while still *privatdocent* at Vienna, Wettstein succeeded Alexander Skofitz as editor of the *Oesterreiche Botanische Zeitung*, which he continued to edit, with some assistance in later years, until his death. The volumes of this journal contain numerous contributions from him relating to the Austrian flora, of which he was a careful student, to systematic botany, and to nomenclature. The journal took a leading part in preparation for the discussions on nomenclature at the Congress in 1905. In 1901, Wettstein led a botanical expedition to South Brazil under the auspices of the Austrian Academy of Sciences, the results

of which he published in the *Denkschrift* of the Academy.

Wettstein's chief contributions to botanical knowledge lay in the application of principles of phylogeny and morphology to taxonomy. His monograph of *Euphrasia* (1896) was an intensive study of the species, and their origin and affinities, especially in relation to their geographical distribution. He also developed the idea of *Saisondimorphismus*—the evolution of early and late flowering forms of one stock—as a source of new species. A similar study of a group of European gentians appeared in the following year. He had previously (1891) contributed accounts of the families Solanaceæ and Scrophulariaceæ to the "Pflanzenfamilien", and a "Beitrag zu Flora Albaniens" was published in 1892 as a volume of the "Bibliotheca Botanica". He was a good draughtsman and his botanical contributions are illustrated largely by himself. To botanical students, Wettstein is familiar as the author of a widely used "Handbook of Systematic Botany" (1901–8); he attempted to derive the Angiospermous flowering plant from the Gymnosperms through the Gnetales, regarding *Casuarina* as the most primitive existing Angiosperm. The theory was an ingenious one, but has not been generally accepted.

Wettstein was honoured by his fellow-countrymen and also received many marks of recognition from European and overseas societies and institutions. He was elected foreign member of the Linnean Society of London in May 1914.

A. B. RENDLE.

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WE regret to announce the following deaths:

Mr. M. M. Pattison Muir, senior fellow of Gonville and Caius College, and formerly prælector in chemistry in the University of Cambridge, on Sept. 1, aged eighty-two years.

Prof. A. S. Pringle-Pattison, emeritus professor of logic and metaphysics in the University of Edinburgh, on Sept. 1.

Dr. Droop Richmond, chief analyst to Boots Pure Drug Co., Nottingham, for sixteen years, on Aug. 26, aged sixty-four years.

Dr. Per Axel Rydberg, for the last thirty-two years curator of the New York Botanical Garden in the Bronx, on July 25, aged seventy-one years.

Dr. Louis W. Sambon, a pioneer worker in tropical medicine, on Aug. 31.

Col. the Hon. Milo G. Talbot, C.B., who was awarded a Royal Medal of the Royal Geographical Society in 1909, known for his surveys of the north-west frontier of India and Anglo-Egyptian Sudan, on Sept. 3, aged seventy-six years.

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## News and Views.

THE very personal appeal of the problems of the internal secretions is sufficient guarantee that the valuable résumé by the master in this subject which appears as a Supplement to this week's issue of NATURE will be widely read. Both author and subject came into being at about the same time and both have grown and developed side by side. During the eighty odd years of a fruitful scientific life, Sir E. Sharpey-Schafer has not only witnessed the change of view regarding the basis of animal behaviour but also he has played a prominent part in bringing about this broader basis. It is being realised more and more that racial and individual characteristics are not solely the expressions of an inherited nervous system but are also dependent, though to a lesser degree, on the development and efficiency of the organs of internal secretion. Many unwarrantable assertions appear from time to time regarding the part played by these special glands in the determination of personality, and until further information concerning their variations with age, climate, and habitat are available, such statements must continue to remain of a highly speculative nature. As in all subjects, during the constructive period, some confusion creeps into the nomenclature, but up to the present no better term has been introduced to connote an internal secretion than the word 'autacoid' proposed by Schafer to express the drug-like action of such a chemical regulator; it is more accurate though less euphonic than the term 'hormone' introduced by Starling, which was originally intended to suggest excitation only and would thus exclude depressing autacoids.

THE methods of studying these autacoid substances are based largely, first of all, on the loss or removal of the particular gland, with observation of the resulting deficiency disease set up, and secondly, with the cure of the disease by grafting or feeding with the gland from a healthy animal, or alternatively by injection of an extract of the gland, and lastly by administration of the active chemical principle when this is known. The method which has been most extensively used and has proved the most fertile in ascertaining important facts is the injection of extracts into animals and into man. This technique was not used much until Schafer, working in conjunction with Oliver, discovered that extracts made from the adrenal bodies give rise—when injected into the veins of an animal—to a very great increase in blood pressure. It is worthy of mention that all the fundamental facts were noted by Schafer in his early papers. In his work with Oliver he observed that one other gland extract besides that of the adrenal, namely, the pituitary, also contained a pressor principle, and an extract of this gland is now widely employed by obstetricians for the arrest of hæmorrhage after childbirth. The account of the interrelationships of the organs of internal secretion given by Schafer does not warrant the present-day wholesale dissemination of poly-glandular preparations coming from foreign drug manufacturers.

Progress in the elucidation of the mode of action and therapeutic action of a specific autacoid can be established only by careful dosage and observation of a physiologically standardised unit.

CONSIDERABLE interest has been aroused recently by the claim of Dr. Bendien, of Zeist, to have developed a method of diagnosis of cancer which is infallible even in the early stages of the disease. The method has been briefly described by Dr. A. A. Miller in a recent letter to the *Lancet* (Aug. 22, 1931; p. 427) and is given in more detail in a paper by F. C. Smith, E. R. Holiday, and J. Marrack (*ibid.*, Aug. 29, p. 507). It consists of two parts: in the first the serum is mixed with a series of mixtures containing varying proportions of sodium vanadate and acetic acid: normal human serum produces a precipitate in tube No. 6: if flocculation occurs below this, that is, in the more acid mixtures, carcinoma, tuberculosis, or some other disease is indicated. In the second part of the test, the precipitate obtained is heated to 56° C., filtered off, weighed, and dissolved in two per cent sodium bicarbonate solution. The ultra-violet absorption curve of this solution is then obtained by means of the spectrophotometer. Bendien claims that there is a curve typical of cancer and another of tuberculosis.

MARRACK and his co-workers (loc. cit.) in their investigation of the test, point out that the concentration of the precipitate in the bicarbonate solution is very variable owing to the fact that it is only dried by suction on the filter, so that it contains water up to 90 per cent of its total weight. No attention can be paid, therefore, to the actual height of the absorption curve obtained; only the shape and slope are significant. They obtained curves of the same general character as those of Bendien, but they found that the actual slope depended on a time factor. When the spectrophotometric examination is carried out as soon as the precipitate has been dissolved, both cancerous and non-cancerous cases show a typical 'tuberculosis' curve with absorption extending into the visible region of the spectrum, as indeed might be expected from the yellow colour of the solutions. On standing, however, the solutions fade slowly, and no longer absorb the longer wave-lengths: curves 'typical of carcinoma' are then obtained. The authors conclude that the method is of no value in the diagnosis of cancer. It is clear that further work is required before Bendien's claim can be accepted without question: it is possible that the different opinions expressed as to the value of the test may be due to differences in technique, but in any case, Marrack's work indicates that to be of value the details of the test must be very rigidly standardised.

INVESTIGATORS have long sought to discover the cause of the common cold. The condition is unquestionably contagious, and has therefore been considered to be a microbial infection. Many micro-organisms have at different times been assigned a causative rôle, and the evidence adduced in favour of one or another agent has frequently seemed to be impressive. Several well-recognised pathogenic micro-organisms, such as the pneumococcus, streptococcus, influenza bacillus, and *Micrococcus catarrhalis*, have been thought to play a part in the production of this catarrhal condition, the severer form of which was formerly often spoken of as an 'influenza cold', but none can be said to have established a position other than as a possible occasional cause. With the recognition of the existence of the ultra-microscopic or filtrable forms of disease-producing viruses, evidence accumulated that the causative agent of the common cold might belong to this class of infecting agents. This hypothesis receives confirmation by the studies of A. R. Dochez, K. C. Mills, and Y. Kneeland, jun. (*Lancet*, Sept. 5, p. 547), who found that the chimpanzee in addition to man is susceptible to an acute infection of the upper respiratory tract, resembling in every respect the similar infection in man.

MESSRS. Dochez, Mills, and Kneeland have filtered nasopharyngeal washings from individuals with acute colds through Seitz filters, which do not permit the passage of bacteria, and the filtrates were inoculated intranasally into chimpanzees, with the result that a typical acute attack of 'cold' developed. Human volunteers similarly inoculated also manifested the signs of the common cold, and such experimental colds both in apes and in man are contagious by contact to others, and may be passed in series from individual to individual. The virus in the filtrates preserved anaerobically in the ice-box maintained its activity for from four to thirteen days. A method of culture was also devised in a chick-embryo cystein broth medium. This was inoculated with the filtered nasal washings and the culture was carried on for twelve generations, when an inoculation with it induced a mild cold in one out of three human volunteers. The fifteenth culture, representing a dilution of approximately one to two quadrillion of the original material, also produced colds in two out of three inoculated volunteers. In addition to initiating symptoms of infection, the virus also appears to provoke increased activity of any potential pathogenic agents that may happen to be present in the respiratory tract, such as the pneumococcus and others.

ON July 7–20, representatives of the Geological Surveys of Southern Equatorial Africa met at Kigoma to discuss the compilation of a geological map of that part of the continent. The conference constituted the first meeting of the Sub-Commission of African Geological Surveys formed at the Fifteenth International Geological Congress, at Pretoria in 1929, and the countries represented at Kigoma were: French Equatorial Africa, Northern Rhodesia, Belgian Congo, Ruanda Urundi, Uganda, Tanganyika Territory, and Nyasaland. In these countries, provisional geological maps already exist, but great difficulty has hitherto been found in establishing the relation between the geological formations of any one country with those of neighbouring or more distant countries, and this difficulty has been greatest in the case of the ancient unfossiliferous formations. In the course of the recent discussions, however, assisted by a comparison of rock specimens and maps from the different countries, considerable progress has been made, and as a result of this the Sub-Commission has drafted a geological

map of Southern Equatorial Africa, which it is proposed to publish at an early date. A great advance has been made in the mapping of the Katanga System, within which lie the great copper deposits of Northern Rhodesia and the Belgian Congo, and the tin-bearing formations of Uganda can be followed through Tanganyika and Ruanda Urundi to the Belgian Congo. Moreover, the Karroo System, bearing many coal deposits in this part of Africa, was discussed in some detail.

SINCE the only sound basis for the development of mineral resources is a thorough knowledge of the geological formations and of their relation to one another, the discussions at the conference and the conclusions arrived at, as summarised in the new geological map, should prove to be of considerable economical value, as well as of scientific interest. The conference recognised the following three important systems of pre-Karroo age: (*a*) The Basement Complex, comprising sedimentary and igneous groups showing wide variations in degree of metamorphism; this system is roughly comparable with the Swaziland System of South Africa. (*b*) The Muva-Ankole System, consisting principally of quartzite and shales, with acid volcanic rocks locally, and, more rarely, basic rocks. In some areas the shales are represented by phyllites or schists, and the quartzites show a similar range of metamorphism. The system can be traced from Northern Rhodesia to Uganda, and includes, for example, the Muva, Mafingi, Ukinga, and Karagwe-Ankolean groups. It is separated from the systems below and above by vast uncomformities, and it is considered as probably equivalent in part to the Witwatersrand and the Ventersdorp Systems. (*c*) The Katanga System, ranging from the Série des Mines to the Upper Kundelungu, and equivalent to the Transvaal-Nama and Waterberg Systems. At the base of the Lower Kundelungu is the great tillite of the Katanga, so that in this area at least one important glacial epoch of pre-Karroo age is recognised. It may be added that over a wide area in this part of Africa glacial deposits are believed to exist at the base of the Karroo, although their correlation with the Dwyka has not yet been established.

THE special displays of the flood-lighting of buildings in London which began on Sept. 1 and are being given in connexion with the International Illumination Congress have proved a great success and have attracted huge crowds of sightseers. The flood-lighting has brought out the beauty of many architectural features of the buildings which are seldom noticed. For example, the upper façade of Somerset House fronting the river is bathed in a clear rose-coloured light which makes a striking contrast with the dark terrace beneath. Buckingham Palace is perhaps the most brilliantly illuminated building, and makes a very attractive spectacle. The lamps required for it consume 200 electric units per hour. The principal area illuminated is from the Tower Bridge to Westminster. The clock tower of Parliament is flooded with light the colour of old ivory, and can be seen from great distances. The spire of St. Bride's Church, shown up in brilliant white light, also frequently catches the eye when driving through the City. The Institution of Electrical Engineers, on the Embankment, with its six bright pylons, is admired by many. We understand that this illumination is permanent. The illuminations include monuments and parks. From Northumberland Avenue the silhouette of Nelson on his column is a wonderful sight. The column itself is in darkness, and the statue, gently illuminated, stands out in detailed relief. Some well-known buildings in the neighbourhood of London have also been flood-lighted. The George Inn at Slough and the Dysart Arms at Petersham show up the merits of this system of lighting. In a few cases the display is a little garish, but the brighter the spectacle, the better pleased are the sightseers.

THE limitations produced by atmospherics on long-distance working between radio stations are very annoying to radio operators. The commercial operation of a long-wave receiving station may remain completely disorganised for long periods when intense atmospheric disturbances take place near the aerial. A flash of lightning acts as a long-wave spark transmitter, and as the voltage is in millions and the current in thousands of amperes, the effects produced may be very serious. Lightning flashes are not the only cause of atmospherics. The distribution of potential throughout the atmosphere is very irregular and it is probable that sudden equalisations of potential may occur without visual flash, causing all kinds of atmospherics. In *Television* for August, T. Bray points out that television is much less affected by atmospherics than radio communication. It might usefully be employed, therefore, in sending printed messages during heavy tropical atmospherics when ordinary radio cannot be used. Atmospherics manifest themselves as a rapid series of 'splashes' on the television screen, affecting it continuously and sometimes resembling flames passing over it. Bray shows by diagrams that even when aural and automatic reception of the morse code are impossible, the printed letters on the television screen are easily read. This special aspect of television may open out new commercial applications where it can be usefully employed.

NEWS from the *Nautilus*, the submarine in which Sir Hubert Wilkins is making his Arctic expedition, was received by radio by the *News Chronicle* from 350 miles from the north pole, where the ship was on Aug. 25. The actual position was then about lat. 84° N., long 10° E. Echo soundings had shown an irregular ocean floor varying between 1000 fathoms and 300 fathoms within a few miles. This was probably at the place where the *Nautilus* crossed a submarine ridge between northern Spitsbergen and Greenland. Farther east, at a position not stated, a depth of 1205 fathoms was recorded. At the time of the message the ship was in open water with much scattered pack-ice, but closer pack, involving the need to submerge, was expected to the northward. Progress was slow, and spray was freezing on the deck and conning tower. A message sent the previous day

recorded a serious accident. The *Nautilus* was then 500 miles from the pole, when it was discovered that the diving rudder was lost. A diver discovered, however, that the ordinary steering gear was intact. The loss of the diving rudder made submergence difficult and restricted movements below the surface, but later in the week a message recorded progress. During last week no messages were received from the *Nautilus*, and a certain amount of anxiety was felt. The Norwegian Government decided to send a search expedition and two aeroplanes, under the command of Capt. Riiser-Larsen. A long dispatch from Sir Hubert Wilkins appears in the *News Chronicle* of Sept. 7, from which it appears that the *Nautilus* has been holed and emerged from the pack ice on Sept. 4 in about lat. 81° N., long. 11° E.; she was making her way slowly to Spitsbergen. It is stated that the scientific staff of the expedition are well satisfied with the results obtained.

A MEETING was recently held of the Sub-Committee on Symbols, Units, and Nomenclature used in Physics, appointed by the International Union of Physics. Sir Richard Glazebrook was appointed chairman of the Committee. Prof. Kennelly, as chairman of the Section of the Advisory Committee of the International Electro-Technical Commission dealing with electrical and magnetic magnitudes and units, wrote directing attention to the meeting of his Committee in London on Sept. 18, and inviting members of the Committee of the International Union of Physics to attend. This invitation has been accepted, and it has been arranged to hold a meeting of the Sub-Committee on Symbols, Units, and Nomenclature shortly afterwards to continue the discussion commenced at Brussels. Communications with regard to this meeting should be addressed to Dr. Ezer Griffiths, at the National Physical Laboratory, Teddington.

THE claim by Sir Colin Mackenzie, of Canberra, that the female aboriginal skull discovered in the Jervois Ranges is one of the most important of the prehistoric documents in the world to-day has been received with some scepticism in Australia. The skull is 173 mm. in length, the forehead breadth is 86 mm., and the volume between 956 c.c. and 980 c.c. It is contended that this cubic capacity is the smallest known in any complete human skull; hence that the skull belonged to an individual on the confines of the lowest humanoid stock. On the other hand, Prof. F. Wood Jones, of the University of Melbourne, is convinced, from the study of a cast, that the skull falls well within the limits of the normal modern Australian aboriginal female, and that Sir Colin Mackenzie's conclusions are unwarranted.

THE *Spectator* for Aug. 15 contains an article (p. 210) by D. Yorke on bird migrants at Rossitten, in which are some noteworthy observations on the relation of peregrines to their prey. The first one seen made five attempts to capture wood-pigeons from the migrating flocks, but always failed, even when it got into a flock and flew amongst them; ultimately it caught a greater spotted woodpecker and descended to eat it. Later, three peregrines were in sight at once, also attacking pigeons unsuccessfully; and again a woodpecker of the above species fell a victim. This would seem to indicate that the wood-pigeon, though greatly desired, is too much for many peregrines, and that the greater spotted woodpecker occupies to them the same relation as a warningly-coloured moth or butterfly does to insect-hunters—a sort of emergency quarry to be taken in default of anything better. It was proved a generation ago that the Danaid butterflies will be eaten by caged insectivorous birds in default of other live food, and the coloration of most woodpeckers would be classed as 'warning' if worn by an insect.

WE have received a letter from Mr. F. Gilbert Carruthers, 10 Addison Road, London, W.4, relative to the question whether earwigs use their forceps for purposes of offence or defence. He mentions that he inadvertently drank some soda water from a mug which contained one of these insects, and that the first intimation he received of the creature's presence was when he experienced a distinct nip on the lip. The nip, he adds, was more surprising than painful. In this connexion it may be mentioned that, when alarmed or disturbed, earwigs regularly open their forceps in a threatening manner. If a finger, or other object, be placed between the forceps, the latter will often close with a slight nip. The main function of these weapons is still obscure: on rare occasions earwigs have been recorded to use their callipers for seizing their prey, and also for fighting against one another.

SIR WILLIAM R. MORRIS has given £25,000 to the British Empire Cancer Campaign for the establishment of a research fellowship in radiology at the Mount Vernon Hospital, Northwood, Middlesex. This hospital was opened in 1929 as the Empire centre for the treatment of patients suffering from cancer, and for the investigation of the causes and cures.

THE twelve major topics announced for discussion at the third International Conference on Bituminous Coal to be held under the auspices of the Carnegie Institute of Technology, Pittsburgh, on Nov. 16–21 (see NATURE, Feb. 14), are as follows: cleaning and preparation; hydrogenation; by-products; fertilisers; low and high temperature carbonisation; gasification; combustion; railway and steamship fuel; smoke abatement, dust removal, and flue gas purification; origin, classification, and properties; competition between coal and other fuels; storage of coal. The following countries are among those to be represented: United States, Austria, Great Britain, Czechoslovakia, France, Germany, the Netherlands, Poland, U.S.S.R., Spain, and Switzerland.

J. A. A. KETELAAR has asked us to correct an error made by him in his letter in NATURE of Aug. 22, p. 303, entitled "Structure of the Trifluorides of Aluminium, Iron, Cobalt, Rhodium, and Palladium". The value of the $z$-parameter of the fluorine ions (2) is not $\frac{1}{6}$ but $\frac{5}{6}$, in accordance with the description of the structure at the end of the letter.

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# The Physiology of Internal Secretion.

By Sir E. SHARPEY-SCHAFER, F.R.S.*

PHYSIOLOGY must be looked upon as having begun with Harvey. As a science, therefore, it dates back merely three hundred years. It is only during the last one hundred and fifty that it has made real progress, and much of that progress has taken place during the last hundred.

During the period immediately succeeding Harvey's discovery of the circulation of the blood, the attention of physiologists was mainly devoted to the mechanical functions of the body. After Harvey, Stephen Hales was the first to study the mechanics of the circulation. Hales determined the amount of pressure which the blood exerts in the arteries; like a true student of Nature, he did not restrict himself to studying the flow of blood in animals but also investigated the conditions of the flow of sap in plants. In the meantime, it had been found by Malpighi, using the newly invented microscope, that the blood is not homogeneous but a suspension of coloured corpuscles in an otherwise colourless fluid. Nothing, however, was as yet known as to the real nature of blood or as to its functions. Nor was it until the foundations of chemistry had been established by Lavoisier that light was thrown upon the supreme importance of those functions. It has been reserved for the time in which we live to determine the constancy of composition of the circulating fluid and the necessity to health and even to life itself of maintaining that constancy within a very circumscribed limit.

The recognition of the regulation of bodily functions by the nervous system constituted the next step in advance in physiology. This recognition occurred about a hundred years ago. Since then it has been justly regarded as the dominating factor in the physiology of the Metazoa. The definite founding of this doctrine was due to Carl Ludwig in Germany and Claude Bernard in France. Side by side with these researches, others by various workers (Magendie, Bell, Flourens) were revealing the manner in which the central nervous system co-ordinates the functions of the various organs of the body. In our own times, the doctrine of the dominance of the nervous system and the manner in which all reflex and voluntary actions are regulated by it has been firmly established by the researches of Pavlov and Sherrington.

Thus the predominant feature of the development of physiology up to this time has been the evolution of knowledge of the regulation of bodily functions through the nervous system.

A 'new physiology', which does not supersede the old but assimilates and is incorporated with it, has sprung up within the last fifty years. The old physiology was based, as we have seen, on *nervous regulation*; the new physiology is based on *chemical regulation*. We have learned to recognise that the functions of organs are not governed solely by nerves but are largely influenced by chemical substances in the blood; the nerves and nerve-centres being themselves subject to chemical influences. On the other hand, chemical regulation may itself be influenced by the nervous system, so that the reaction is mutual.

Since the chemical substances which react with the tissues are normally produced elsewhere than in the tissues they act upon—many of them in special organs of internal secretion—their action is often spoken of as *humoral*, because they are conveyed in the blood or lymph (humours). But this term is too restrictive, for they may be actually produced in situ within the tissues upon which they act: in such a case, their action, although still chemical, would be incorrectly described as humoral.

Regulation by chemical substances appears to be a more simple process than regulation through

* From the John Mallet Purser Lecture delivered in Trinity College, Dublin, on June 26.

nerves: it might therefore be supposed that chemical regulation would have been the first to be evolved. But this can scarcely be the case, for chemical regulation assumes the existence of a circulating fluid to convey the chemical materials for such regulation to the tissues on which they act, whereas nervous regulation is already developed in the lowest of the Metazoa, such as the medusæ, before the evolution of any circulatory system. The nervous system of these low forms of animal organisation, although much less complex, is already constituted of discontinuous units in no respect essentially different from the neurones of the higher animals, and serves to regulate their activities without, so far as we can tell, the aid of chemical or humoral stimuli.

### Origin of the Doctrine of Internal Secretion.

The history of the development of our knowledge regarding chemical as distinguished from nervous regulation, or, in other words, of the doctrine of internal secretion, is of considerable interest. The first indication that the regulation of function might be effected by chemical rather than nervous agencies was pointed out by Berthold in 1849. Berthold found that the implantation of testicular grafts into castrated cocks (capons) would restore the appearance of the birds to that of normal cocks, and concluded that the testicles must pass some substance into the blood which reacts on the organism in general. He was thus the first to introduce the idea of 'internal secretion'. But for many years his observation remained unnoticed. The idea was almost grasped by Claude Bernard, who in 1852, as the result of his work on glycogenesis, described the passage of sugar from the liver cells into the blood as an 'internal secretion', and recognised that every tissue in the body must be continually passing products of metabolism into the blood, either for nutrition or excretion, and must therefore be yielding similar 'internal secretions'. But this was a long way from the modern interpretation of the term, which implies material of a special nature capable of exerting a specific action. One cannot, therefore, claim Bernard as a founder of the new physiology.

The next distinct move in the establishment of the doctrine of internal secretion came from the clinicians. The Swiss surgeons, J. L. and A. Reverdin and Th. Kocher, described, in 1883, as the result of extirpation of the thyroid gland, a peculiar cachexia which was termed by Kocher 'cachexia strumipriva' and by the Reverdins 'operative myxœdema'. They compared it with the conditions which accompany atrophy of the gland in children or its degeneration in the adult. These conditions had already been described by Gull in 1874 and later by Ord in 1878, and the resulting affection had been termed 'myxœdema' from the peculiar œdematous condition which characterises the skin, which was supposed to be due to the presence of mucin.

That myxœdema is due to the absence of an internal secretion of the thyroid is shown by the fact that, if not too advanced, all the symptoms are removed by administration hypodermically (or even orally) of thyroid juice or extract of thyroid. The chief ingredient of the secretion is thyroxine, the chemical constitution of which has been exactly ascertained, thus enabling it to be produced synthetically. Thyroxine can be substituted for thyroid juice or gland extract and will remove the consequence of removal or atrophy of the gland.

Apart from the isolated observation of Berthold, the thyroid was thus the first of the endocrine organs to furnish definite evidence not only of the existence but also of the importance of an internal secretion. In the absence of its secretion, nutrition and growth are impaired and the functions of the brain, especially those of the cerebral cortex, can no longer be carried on normally; while administration of the gland substance or of its chief ingredient will restore the cretin to a normal condition both bodily and mentally. As Gley has remarked, we are faced with the remarkable fact that the highest functions of the brain cannot be carried out in the absence from the blood of a relatively simple chemical substance. And this substance is formed by a gland which is not connected either anatomically or developmentally with the central nervous system but is related primitively to the alimentary canal. Moreover, the internally secreting function of the thyroid is, so far as our present knowledge goes, independent of the nervous system. It can be carried on if the thyroid is entirely cut off from connexion with that system as by severance of all nerves passing to the gland or by transplanting it from the neck to some other position in the body.

The internal secretion of the thyroid was, as we have seen, discovered about fifty years ago from the results of surgical removal of the organ in man. These results were confirmed and amplified by experiments on animals, and form the actual beginning of our knowledge of the internal secretions, the existence of which had not previously been recognised. All the various internally secreting organs, now recognised as fulfilling functions of the highest

importance, were until then regarded as mere rudimentary structures devoid of function: which may at some early period of evolution have had a meaning but had long ceased to exercise any influence in the animal economy.

In 1855, Thomas Addison described the disease which bears his name, and associated the symptoms of the affection with destruction of the suprarenal capsules. 'Addison's disease' is characterised by extreme debility and is invariably fatal. The publication of Addison's memoir led to the performance of experiments by Brown-Séquard and others with the view of determining whether surgical extirpation of the capsules would produce effects in animals similar to those accompanying their destruction by disease in man. Although the pigmentation effects seen in Addison's disease were never observed in animals, these experiments showed that complete removal of both capsules was invariably fatal. Attempts made by implantation of capsules from other individuals to antagonise the effects of removal always proved abortive, and the cause of the fatal result of extirpation could not at the time be ascertained. Nearly forty years more elapsed before the suprarenal capsules were recognised as organs of internal secretion, owing to the discovery that a powerful, physiologically active material is produced in the medulla of the organ.

The discovery was made in 1893. On testing the effects of intravenous injection of extracts of a number of organs, including the chief ductless glands, it was found by Oliver and Schafer that while extracts of most organs produce a distinct fall of blood pressure, extracts of suprarenal and of pituitary cause an immediate and extraordinary rise. While this active substance of the pituitary has never been isolated in a pure state, so that its chemical constitution remains unknown, that of the suprarenal is obtainable in a crystalline form. It can also be prepared synthetically, and constitutes the now well-known drug 'adrenaline'. Adrenaline was the first of the active principles of the internal secretions to be isolated and synthesised and for long remained the only one, but it has now been joined by thyroxine.

Adrenaline and thyroxine may be taken as yielding examples of two entirely different kinds of action of the internal secretions. Adrenaline produces its effects immediately—upon heart, blood vessels, liver, salivary glands, intestine, pupil, spleen—but the effects soon pass off, owing to destruction of the adrenaline either in the tissues or within the vessels. Thyroxine, on the other hand, acts slowly and gradually, influencing the nutrition of the tissues, stimulating the multiplication of cells, and producing characteristic effects upon general metabolism. These results do not appear immediately and do not readily subside, but are continued long after the administration of the thyroxine has ceased; they may even be cumulative, so that a dose which seems insufficient at first may, if continued, produce an exaggerated effect.

Adrenaline and thyroxine also furnish examples of a striking difference between the mode of secretion which occurs in different endocrine organs. Thus, adrenaline is passed from the cells of the suprarenal medulla, in which it is formed, directly into the blood; whereas the internal secretion of the thyroid does not pass directly into the blood, but passes from the vesicles, in which it is secreted by their lining cells, into the lymph in the interstitial spaces of the connective tissue of the gland, and from these into efferent lymphatics, and eventually into the blood by the great lymphatic trunks.

On consideration of all the organs and parts of organs which are credited with the production of an internal secretion, it will be found that those which contain sinusoids, into the blood of which the secretion is passed directly by the cells of the organ, are—besides the suprarenal medulla—the liver, the islets of Langerhans of the pancreas, the pars anterior of the pituitary body (perhaps also the pars tuberalis), the parathyroids, and the placenta; whilst the internally secreting organs which resemble the thyroid in possessing ordinary capillaries and pass their secretion into the lymph of the organ are the cortex of the suprarenal capsules, the pars intermedia and pars nervosa of the pituitary, and the gonads. Naturally, it does not follow that the efferent lymphatics are the only vessels which absorb the material of the internal secretion from the interstitial lymph of such organs; it may also be absorbed in part from the lymph by the blood capillaries. The distinction is that in one case it is passed directly into the blood and produces its effects immediately, whereas in the other case its passage into the blood is slower and its effects are produced more gradually.

There can be no doubt that a real physiological distinction underlies this difference of the mode of secretion: and we may probably draw the inference that in the case of secretion directly into the blood, it is momentarily varying—increasing or diminishing—according to the immediate calls of the organism; and that when

reaching the blood through the lymph, its purpose is to cause such gradual changes as those affecting growth and nutrition.

### Relations of Internal Secretions to Nervous System.

The internal secretion of some endocrine organs is independent of the nervous system, their activity or inactivity being directly influenced by constituents of the blood. Thus an increase of blood sugar will provoke an increased secretion of insulin from the islets of Langerhans. With other endocrine organs the case is different; their internal secretion is dependent on the nervous system. Of these, the medulla of the suprarenals furnishes an example. It can be shown that the adrenaline it forms is dependent for its secretion into the blood upon the integrity of the nerves passing to the organ. If the splanchnic is cut, the secretion of the corresponding suprarenal capsule is arrested; if now the peripheral end of the cut nerve is stimulated, the secretion is poured into the blood. Normally this influence is exerted through a nerve centre in the bulb, in the same way that the secretion of the salivary glands is poured out as the result of afferent stimuli affecting the reflex centre for salivation. This salivary centre can be influenced not only to increase but also to diminish or arrest the secretion, and, *ceteris paribus*, this is also true for the secretion of the suprarenal medulla, which can be influenced to secrete more or less adrenaline according to the nature of the stimulus reaching the bulb. This influence is the falling or rising of arterial pressure. Anything which tends to lower blood pressure produces an increase of the secretion, anything which tends to raise blood pressure produces a decrease of the secretion: and as a larger amount of adrenaline in the blood has the effect of raising arterial pressure and a diminished amount tends automatically to lower it, an average arterial pressure is thus maintained by a system of self-regulation exercised reflexly.

The chief afferent nerves for the reflex are those distributed to the carotid sinus—the bulbous extremity of the common carotid artery where it bifurcates into the internal and external carotids. This part of the vessel is richly supplied with nerves, as is also the small carotid gland which lies at the bifurcation. The researches of H. E. Hering and of J. F. and C. Heymans have demonstrated conclusively the fact that most of the vascular reflexes which are brought about by variations in arterial pressure are effected through the nerves of the carotid sinus and carotid gland. Whenever the sinus becomes more distended by an increase of arterial pressure, the vasomotor centre becomes inhibited and dilatation of the arteries of the body generally is produced. Similar effects produced through the agency of the depressor nerve have been longer recognised, the effect of its stimulation in lowering blood pressure by causing dilation of arteries through the vasomotor centre having been discovered by Cyon (working under Ludwig) so long ago as 1866.

As Tournade has shown, however, the raising and lowering of the blood pressure in the aorta and carotid sinus affects not only the vasomotor centre in the bulb but also an adrenaline-secreting centre, and this, by causing a variation in the amount of adrenaline poured into the blood, assists the regulating action of the vasomotor centre.

### Detection of Adrenaline in Blood.

When first the presence of so powerful a stimulant of the vascular musculature was shown to be yielded by the suprarenal medulla, it was conjectured that the physiological purpose of the secretion must be to aid the nervous system in maintaining the tone of the arteries and in keeping up their blood pressure. But attempts to demonstrate that there is a normal or physiological secretion of adrenaline into the blood were made in vain by many experimenters. It was admitted that such a secretion could be produced by stimulation of the splanchnic nerves and by stimulation of the bulb either directly or through drugs; and also that an increase of secretion would be evoked by violent emotions and would show itself by producing the usual effects of adrenaline—the 'emotional secretion' of Cannon. But as it proved impossible, using even the most delicate physiological tests, to determine that adrenaline is present in the blood under resting conditions, the idea that it is being constantly secreted as a normal physiological act was given up. The question has, however, been answered in the affirmative by Tournade (working for the most part in collaboration with Chabrol) by the use of a new method of experimentation.

Two animals—generally dogs—are used for each experiment. Both are fully anæsthetised with chloralose. From one (*A*), both suprarenals are removed; from the other (*B*), preferably the larger, only one, usually the right. The whole of the blood coming from the remaining (or left) suprarenal of *B* is allowed to pass into *A* by making connexion between the suprarenal-lumbar vein of *B* and the external jugular vein of *A*. *A* therefore receives all

the adrenaline secreted by *B*. *A* may be termed the 'receiver', *B* being the 'donor'.

The blood pressure of each animal is recorded from the femoral artery by mercury manometers. If anything is done to *B* which affects its secretion of adrenaline, the increase or diminution will show itself in the blood pressure of *A*; *B*, of course, will remain unaffected, the whole of its suprarenal blood being passed into *A*. Hence, if the secretion of adrenaline by *B* is increased, the blood pressure in *A* will rise: if diminished, it will fall. Further, it is known that the intravenous injection of extract of suprarenal medulla, that is of adrenaline, produces in dogs not only a rise of blood pressure due to arterial constriction, but also what is known as a 'vagal pulse'—that is a slow and irregular action of the heart, caused by stimulation of the vagus centre in the bulb by the drug. This irregularity may therefore also be expected to occur in *A* if it is receiving an increased amount of adrenaline from *B*. Other tests of increased or diminished amount of adrenaline passing into *A* may be applied in addition, some of which are more delicate than the blood pressure test.

The following results have been obtained by Tournade by the above method:

1. If the venous connexion between the two dogs is interrupted by pinching, no change occurs in *B*, but in *A* the blood pressure falls, the intestinal movements increase in amplitude, the kidney and the spleen expand. On releasing the vessel, adrenaline effects are immediately again apparent, the blood pressure rises, a vagal pulse becomes apparent, the intestine is inhibited, the kidney and spleen shrink, and so on.

2. If the left splanchnic of *B*—in which, of course, the nerve supply of the remaining suprarenal is contained—is cut, the blood pressure falls in both dogs: in *B*, owing to paralysis of vasomotor nerves to the abdominal viscera; in *A*, in consequence of the failure of the suprarenal of *B* to secrete adrenaline. On now stimulating the peripheral cut end of the splanchnic of *B*, the blood pressure in that animal immediately rises, owing to contraction of its abdominal vessels; and after a short delay, due to the time taken by the secreted adrenaline of *B* to pass through the venous anastomosis and to reach the circulation of *A*, the blood pressure rises also in this animal and displays the vagal character of the pulse; besides which, all the other effects of addition of adrenaline to the circulating blood can be observed.

3. If the vasomotor centre in the bulb of *B* is directly stimulated by faradic shocks, there is an immediate rise in the blood pressure of *B* caused by general vascular contraction, and a delayed rise in the blood pressure of *A* due to increase of adrenaline: this is caused by stimulation of the adrenaline-secreting centre in the bulb of *B*. On the other hand, if the fourth ventricle of *B* is painted with dilute solution of cocaine, the activity of the adrenaline centre becomes depressed and less adrenaline is secreted by *B* and passed into *A*, the blood pressure of *A* falls, and the other effects of diminution of adrenaline in the blood of *A* can be observed.

4. If the blood pressure in *B* is lowered by any means, *B*'s adrenaline centre becomes reflexly stimulated, more adrenaline is passed into *A*, and all the effects of the increase become apparent in *A*. On the other hand, any agency which raises the blood pressure in *B*, such as stimulation of a sensory nerve, intravenous injection of a blood pressure-raising drug, re-injection of blood which has been withdrawn, is followed by a diminution of secretion of adrenaline by *B*, and all the effects which such diminution produces are observable in *A*.

5. Even comparatively slight changes in the blood pressure of *B* will cause quite appreciable differences in the amount of adrenaline secreted, so that such fluctuations in blood pressure as are shown by the Traube-Hering waves, or even by respiratory fluctuations when pronounced, are reproduced in *A* in the reverse sense; every fall of blood pressure in *B* being followed by a rise in blood pressure in *A*, and vice versa.

The experiments of Tournade prove conclusively that this internal secretion is intimately dependent upon the nervous system.

### Excitation and Inhibition.

Returning to the history of the new physiology, the next most striking fact regarding internal secretion, after the discoveries relating to the thyroid and suprarenal medulla, was the observation of Bayliss and Starling (1902) that an extract of duodenal mucous membrane contains a substance which when injected into the blood stimulates the secretion of pancreatic juice. To this substance they gave the name 'secretin', and supposed it to be formed when the acid chyme from the stomach comes into contact with the lining membrane of the duodenum. They spoke of it as a 'chemical messenger' absorbed by the blood from the intestine and carried to the pancreas in order to stimulate that gland to secretion; and, somewhat later, assuming that all such chemical messengers possess a stimulating function, Starling

suggested for them the general term 'hormone' (stimulant).

Starling included in the term 'hormone' such products of metabolism as carbonic acid and urea which pass into the blood from the tissues and act as chemical messengers stimulating the respiratory centre and the kidney respectively. More recent writers, in disregard of the original meaning of the term and the definition of it given by its author, have extended it to apply not only to substances which excite to activity but also to substances which have an exactly opposite effect—which, in fact, instead of exciting activity, depress it. We should, however, recognise in our nomenclature that the internally secreting organs yield materials which produce specific effects of two opposite kinds, namely, excitation and inhibition. These two kinds of effect are comparable with those obtained from stimulation of nerves, which we are in the habit of speaking of as 'excitatory' and 'inhibitory' and recognising as antagonistic. Antagonistic effects are also caused by drugs—some stimulating to activity, others restraining activity. Now, the active substances of the internal secretions act like drugs and several are used in medicine. Such are adrenaline, thyroxine, parathormone, insulin, as well as the active substances of liver and stomach, of the pituitary body, of the ovaries, placenta, and testes. As with nerves and as with drugs, some of these active substances are excitatory, others are inhibitory. They assist the excitatory and inhibitory nerves to maintain that constancy of physical and chemical condition which seems to be essential to life. They act as 'balancers', throwing their weight first on one side, then on the other, so as to preserve a normal equilibrium.

The resemblance between the action of the internal secretions and that of drugs is very close: the active substances they contain are, in fact, drugs. This close resemblance should be incorporated in the nomenclature; it is unfortunate that this was not originally done. Starling, who was a pioneer in their investigation and was particular to point out their drug-like character, was not aware that they may be either excitatory or inhibitory: he supposed that their action is always to produce excitation. It was for this reason that he invented the term 'hormone', having selected that name because it expresses 'excitation' (ὁρμάω, I excite). The example which led to the adoption of the name was 'secretin', which excites the pancreas to secrete pancreatic juice; as we have seen, Starling compared this action with that of carbon dioxide, which excites the respiratory centre to activity. He accordingly proposed the name 'hormone' for all substances, whether organic or inorganic, carried by the blood for the purpose of exciting the cells of any organ to activity. At the time that he wrote (1906) our knowledge of the constituents of the internal secretions was comparatively limited, and it was supposed that they must all act like secretin and possess an excitatory action. The term 'hormone' seemed, therefore, suitable.

Presently, however, when the knowledge of the action of internal secretions became extended, it was apparent that they not only stimulate to increased activity but that they also serve the antagonistic rôle of diminishing or restraining action. To express the latter the term 'hormone' is inappropriate, since it involves an express contradiction in terms. I accordingly suggested in 1913 that such inhibitory substances might be distinguished as 'chalones' (χαλάω, I restrain), as expressing both correctly and conveniently the opposite of 'hormones'; the term is gradually coming into use, although many authors, especially in the United States and Germany, still confuse chalones with hormones and use the latter term for both. Hormones have been longer known and are supposed to occur more frequently, but it is not improbable that as our knowledge extends it will be found that chalones are just as numerous, and not unlikely that for every hormone there is an antagonistic chalone: the 'law of balance' of the living organism almost demands this. To denote all such specific principles of the internal secretions, whether excitatory (hormones) or inhibitory (chalones), I suggested the term 'autacoid' (Greek αὐτός, self, ἄκος, a drug).

In nearly every instance an autacoid is either exclusively hormonic or exclusively chalonic. Adrenaline, which is hormonic in its action on the circulatory system but chalonic in its action on the muscular coat of the alimentary canal, appears to furnish an exception. Occasionally, however, it excites intestinal muscle instead of inhibiting it. All its excitatory activities are paralysed by ergotoxine, its effects being then purely chalonic.

### Regulation of Gland-function by Nerves and by Autacoids.

It was already known that the pancreas can be excited to secrete through the nervous system. There is therefore in the case of this gland a dual control, namely, through the nervous system and through an internal secretion. In regard to some externally secreting glands—for example, the sali-

vary glands—we only know of one kind of control, that exercised through nerves. On the other hand, some externally secreting glands are not controlled by nerves at all, but only by substances circulating in the blood; the control being in such cases purely chemical (humoral). This applies to the mammary gland and to the kidney, the secretions of neither of which are directly influenced by nerves, but are freely provoked by substances circulating in the blood. Externally secreting glands may therefore be classed under three heads, namely: (1) those that are exclusively under the influence of nerves, such as the salivary glands; (2) those that are entirely under the influence of chemical substances in the blood, such as the mammary glands and kidneys; (3) those that are influenced both by chemical substances and by nerves, such as the pancreas and gastric glands. The same distinctions appear also to obtain with the endocrine glands; although (except in the case of the suprarenal capsules) less is known about their regulation by nerves.

The doctrine of the regulation of bodily functions by chemical agents may be regarded as having been definitely established with the discovery of secretin. Since then facts have been accumulating at an ever-increasing rate in support of this doctrine, so that a complete change has come about in our conceptions of the working of the body.

Many organs are known to possess the double function of producing materials which are discharged externally and of secreting autacoids internally. The gonads were the first organs to be recognised as having this double function, since besides producing the gametes they also yield an internal secretion to the blood which affects the formation of the secondary sex characters. The discovery of secretin furnished another example. To this was added the pancreas, which not only produces pancreatic juice but also by its islet tissue furnishes insulin. To these still more recently has been added the liver, which besides secreting bile and assisting in metabolism, produces an autacoid which stimulates the hæmapoietic organs. A similar duality of function is furnished by the stomach and kidneys.

In the case of the gonads, their complete removal (castration) has been employed from time immemorial, both in animals and man, and the effects are well known. These effects were formerly thought to be produced through the nervous system, and assumed to be due to the lack of afferent stimuli from the organs in question to the nerve centres. But when it was made clear by implantation experiments and by the administration of extracts that many of the effects of castration can be removed, it was evident that the nervous system is not responsible for the phenomena but that they must result from the action of an agent produced by the gland and carried by the blood to the organ affected. This was indeed the explanation to which Berthold was forced in 1849. The explanation does not exclude the nervous system from influencing the results, but they are obtained without its co-operation.

### Influence of Endocrine Organs on One Another.

Not the least interesting feature of the study of the internal secretions is the influence exerted by one set of internally secreting organs upon others; the influence is frequently mutual. This is illustrated by the mutual influence of the thyroid and pituitary. Removal of the thyroid causes enlargement of the pituitary, with increase of its secretion. Destruction of the pituitary in the young animal arrests the development of the thyroid. Its secretion stimulates the thyroid. The thyroid in its turn stimulates the suprarenal medulla. The increase of adrenaline thereby caused provokes the liver cells to discharge their glycogen into the blood as glucose, and the hyperglycæmia stimulates the islet tissue of the pancreas to an increased secretion of insulin. This in its turn stimulates and facilitates carbohydrate metabolism and thus affects the activities of many tissues and organs of the body. In this way we can trace a chain of phenomena starting from excitation of the pituitary and linking together organs topographically distant and to all appearance functionally distinct.

Another striking illustration of mutual reaction is the influence of the pituitary upon the sex organs. The size and secretion of the pituitary is affected by the condition of the gonads: removal of the gonads is followed by an increase in size of the pituitary, while destruction of the pituitary is followed by diminution in size of the gonads and ultimately by loss of sexual functions.

It is the pars anterior of the pituitary which is concerned with the sex organs. For it can be shown that the cyclic changes in the ovary and uterus which characterise the period of sexual activity are initiated and conditioned by autacoid substances produced in the pars anterior, so that in the absence of these substances (as after removal of the pituitary) maturation of the ovum and its fixation in the uterus is no longer possible. Its activity can, however, be restored or, in immature female animals, can be aroused by implantation of anterior pituitary or by hypodermic injection

of its extracts. To influence the ovary the anterior pituitary produces two distinct hormones. One stimulates the ovaries, even in immature animals, and produces maturation of the Graafian follicles. The enlarging Graafian follicles produce in their turn an internal secretion containing an autacoid (folliculin) which causes ovulation and starts changes in the uterus, preparing it for the reception of the discharged ovum if fertilised. A second hormone of the anterior pituitary causes the corpora lutea which are formed from the discharged follicles to produce another autacoid (lutin) which promotes further alterations in the uterus, preparing it for the fixation of the ovum. The corpora lutea also yield a chalone which prevents the further action of folliculin and the further discharge of ova.

All these autacoids of the pituitary and ovary can be detected in the blood. They are found in it in greater amount during pregnancy than at other times, and pass out from the blood into the urine, so that if a few drops of the urine of a pregnant woman are injected under the skin of an immature mouse, the growth of the ovaries of the latter is stimulated, the Graafian follicles enlarge and discharge their ova, corpora lutea are precociously formed, and changes characteristic of œstrus occur in the uterus and vagina. The effects thus produced on the ovaries of immature mice constitute the Zondek-Aschheim test for pregnancy now in general use. It furnishes a striking example of the application of the new physiology to clinical medicine, others being the curative effect of thyroxine in myxœdema, that of insulin in diabetes, and that of liver or stomach extract in pernicious anæmia.

### Functions of the Pituitary.

The pituitary gland consists of several parts, and each of those parts yields its own specific autacoids. That the anterior lobe is concerned with growth is evidenced by the fact that it is greatly enlarged in acromegaly and gigantism—affections characterised by hypertrophy of the body in general and of the skeleton in particular—while its administration to growing animals both increases their rate of growth and causes them to become of more than ordinary size. On the other hand, if the anterior lobe is atrophied or by any means diminished in size, growth is slowed and dwarfism results; while its removal in growing animals is followed by arrest of growth. There is also reason to believe that it produces a chalone which acts antagonistically to the growth hormone. Metabolism in general and the metabolism of carbohydrates in particular is influenced by it: one result being the production of obesity, which is observed in cases of disturbance of its endocrine function, and interference with the action of the autacoids which regulate the metabolism of fat. Also, as we have seen, it exerts an enormous influence upon the gonads.

The other parts of the pituitary are also connected with many and varied functions. The pars intermedia and pars nervosa are closely interlocked and difficult to separate. The pars intermedia is formed of epithelial cells; the pars nervosa is developed from brain substance and consists mainly of neuroglia cells and ependyma fibres. In the spaces between these fibres are peculiar colloidal masses which are formed from the cells of the pars intermedia and can be traced through the pars nervosa to be discharged into the cerebro-spinal fluid of the third ventricle. They are known from their discoverer as 'Herring's bodies'. If extracts are made of the pars nervosa and injected into the blood vessels, powerful effects are obtained upon the arteries, the heart, the intestinal muscle, the muscular tissue of the uterus —all of which are stimulated—and the mammary glands, which, if lactating, are caused to secrete. The kidneys are also stimulated so that the amount of urine is increased; but if the extracts are administered hypodermically instead of intravenously, the effect is antidiuretic. Such extracts act therefore in two directions upon the secretion of urine, either stimulating or inhibiting; they therefore contain two antagonistic autacoids affecting its secretion, a hormone and a chalone.

The action of extracts of posterior lobe on the uterus is powerful and specific; contraction of the organ is caused by an infinitesimal amount of the so-called 'oxytocic' hormone. Since the secretion of this lobe is discharged into the cerebro-spinal fluid, this fluid also acquires the properties of the extracts. The uterine action is most marked during gestation and the action is strongest near parturition, which it assists and perhaps initiates. An extract of the posterior lobe of the pituitary constitutes one of the most useful medicaments of the accoucheur.

Another action of extracts of the posterior lobe, probably due to a chalone produced in the pars intermedia, is that of causing expansion of the melanophores of Amphibia so that the animals become dark: this is a specific effect, no other natural substance being known to produce the same result. On the other hand, removal of this part of the pituitary body in Amphibia results in contraction of

the cutaneous melanophores, so that the animals become pale and offer a great contrast to the effect of injection.

Thus the pituitary body influences by its internal secretions a large number of diverse functions. It is extremely probable that each function is influenced by a different autacoid; some by two antagonistic autacoids: this is the case with the diuretic and antidiuretic effects. Nevertheless, up to the present, it has proved impossible to isolate any one of the active substances. By the employment of different solvents extracts have been obtained which contain more of one autacoid than of others, but no one autacoid has been got in a pure condition.

### Autacoids of the Gonads.

Although the pituitary body is the endocrine organ the secretion of which influences more numerous functions of the body and produces more diverse effect than any other, several have multiple effects. This is the case, for example, with the gonads, for besides the internal secretions of the Graafian follicles and corpora lutea which have already been considered, these organs produce other autacoids on which the secondary sex characters depend. The autacoids to which these characters are due are not formed by the reproductive cells themselves but by special cells in the connective tissue between them, known in the testis as 'interstitial cells'. That the secondary sex characters are not dependent on the true reproductive elements is evidenced by the fact that these characters are developed after destruction of the true reproductive elements. Extracts of gonads in which the reproductive cells have been eliminated contain all the substances which promote the appearance of secondary sex characters; their administration will cause the production of these characters even in castrated animals. Thus a castrated animal, which, whatever was its original sex, may be regarded as neuter, can be made to assume the secondary characters of either the male or female sex by administration of extract of testicle or ovary as the case may be, or by implantation of portions of one of those glands. Extracts of the gonads also contain antagonistic substances which prevent the appearance of the secondary characters of the opposite sex.

### Tissue Autacoids.

There is another class of autacoids, not produced in internally secreting organs and not passing into the blood, but produced in situ in the tissue they are to influence. We may term them 'local' or 'tissue autacoids', as distinguished from those we have hitherto considered and which may be termed in contradistinction 'blood' or 'circulating autacoids'. The 'tissue autacoids' have only been discovered recently, and we have very little accurate information regarding either their nature or their mode of activity. Such knowledge as we possess has been mostly derived from experiments upon the heart.

Whilst investigating the possible chemical changes produced by stimulation of the vagus nerve upon the frog's heart, Loewi (1921) found that Ringer's solution which had been used for perfusing a heart inhibited by the vagus, would, if introduced by perfusion into another frog's heart, itself produce an inhibitory effect upon the second heart. Evidently the impulses descending by the vagus have caused the formation of an autacoid which, by chemical action, reproduces the effect of the nerve itself. An electrocardiogram obtained during its action resembles that obtained during stimulation of the vagus. The autacoid produced by the vagus may possibly be the actual cause of the inhibitory effect of that nerve rather than its consequence. This substance is termed the 'vagal substance' or the 'vago-mimetic autacoid': obviously it is an inhibitory substance or chalone. It can also be obtained from the mammalian heart (Rijlant). Atropine, which prevents the production of inhibition of the heart through the vagus, does not prevent the formation of the 'vagal substance': it does, however, prevent this substance from slowing or inhibiting another heart on which it is allowed to act. The vagal substance resembles acetyl choline in many respects and may be identical with this.

Similarly it is found that after stimulation of the sympathetic fibres to the heart an autacoid is produced which stimulates a second heart to increased rate and force—in fact, reproduces the action of the sympathetic: this may be termed the 'sympathetic substance' or 'sympatho-mimetic autacoid'. Its action is nullified by ergotoxine, as is the action of the sympathetic. It is obviously a chemical substance produced under the influence of the sympathetic and seems to be identical with adrenaline. Being a stimulating autacoid, it is, of course, a hormone and is antagonistic to the vagal chalone. It is possible that it is owing to the local production of these autacoids in the part of the heart which is supplied by the vagus and sympathetic nerves that the inhibitory action of the one and the accelerator and augmentor action of the other is actually due.

The formation of these vagal and sympathetic substances is probably the explanation of the

continuance of vagal and sympathetic action which is always observed for an appreciable time after stimulation of the respective nerves has been discontinued—a phenomenon which has hitherto received no adequate explanation. Their formation may also account for the relatively long latency period between stimulation and commencement of response, with which all who have observed the effects on the heart of nerve-stimulation are familiar, and for which a reasonable explanation has hitherto been lacking.

These observations upon the autacoids produced in the heart as the effect of stimulation of its antagonistic nerves are comparatively recent, but they serve to recall an observation made by Demoor in 1913. Demoor found in the dog that extracts of a submaxillary gland which had been caused to secrete actively for some time by stimulation of its branch from the chorda tympani would, if injected into another dog, also produce in the second animal active secretion from its submaxillary gland. He inferred therefrom that an active chemical substance is produced locally in the gland of the first animal, which has the same action on its cells as the chorda tympani and may be the actual cause of the secretion. This again may furnish an explanation of the fact that the secretion takes an appreciable time to start after the stimulation of the nerve is commenced, and a still longer time to cease after the stimulation of the nerve is discontinued; also of the observation that after stimulation of the chorda tympani, stimulation of the sympathetic supply is usually followed by considerably greater secretion than in other circumstances, this being due perhaps to the fact that there is still a remainder of active substance in the gland cells. The active substance in the case of the salivary glands may be saliva itself. Guimaris (1930) found that if saliva from any source, or an alcohol-extract of saliva, is injected into the artery supplying the submaxillary gland of the dog, free secretion is provoked, and that this will happen even if the chorda tympani has been cut and its fibres allowed to degenerate.

Cannon (1930) has brought forward evidence that a substance resembling adrenaline in its action is formed in plain muscular tissue as the result of stimulation of its sympathetic supply. He terms the substance 'sympathin', but suggests that it may be identical with adrenaline. Finkleman had previously found that stimulation of the sympathetic fibres to the intestine results in the production of a substance which when brought in contact with a second preparation of intestinal muscle will cause its inhibition: this obviously suggests the formation of adrenaline. Finally, Ch. Richet *fils* has found that extracts of kidney produce diuresis if injected into the blood.

Observations of this kind suggest that an autacoidal action of gland extracts may be of more general occurrence than has been thought, and that functional changes in cells may be correlated with the formation of autacoids specific for each kind of cell. Probably in the near future there will be discovered many more illustrations of this form of chemical control of the bodily functions. Various experiments indicate the influence upon these functions of such products of metabolic activity as acetyl choline and histamine—both of which have been found by Dale and Dudley in notable amount in various tissues and organs.

Such 'metabolic autacoids' or 'metabolites' may have a local action affecting either the tissues themselves or their blood vessels, causing the vessels to contract or dilate according to the nature of the autacoid set free (T. Lewis). Whether the metabolites are formed as the result of stimulation of nerves or by direct irritation of the tissue is difficult to decide. In any case, the facts indicate that chemical substances are formed, under the influence of nerves or as the result of direct excitation, which act directly on the tissue in which they are produced.

### Inherent Autacoids.

There is yet another class of autacoids which are not produced as the result of excitation by nerves or otherwise, but appear spontaneously or are inherent in the tissue and impart to it active properties. They are chiefly known in the heart, where they have been investigated by Demoor, Rijlant, Zwaardemaker, Haberlandt, and others.

Although it has been known from time immemorial that the heart will continue to beat after removal from the body and therefore possesses in itself a natural tendency to automatic rhythm, it was long thought that this was actually due to nerves and ganglia within its substance. But the researches of Gaskell (1883) on the hearts of fishes, amphibians, and reptiles—confirmed by Engelmann and by many subsequent workers—showed conclusively that the nervous system of the heart has nothing to do with its automatism, which is inherent in cardiac muscle and is most pronounced near the entrance of the great veins and least near the exit of the great arteries. Therefore in a simple heart such as that of a fish the

contractions start at the sinus venosus and traverse successively the auricle, the ventricle, and the bulbus aortæ. Gaskell observed that, if such a heart is cut across transversely into segments, the segments will beat spontaneously, but not all at the same rate: the rhythm of the sinus will be the fastest, that of the auricle next; that of the ventricle will be slower than that of the auricle, and that of the aortic bulb the slowest. In the intact heart the rate is always that of the sinus, which is accordingly termed the 'pace-maker'. Gaskell further showed that the dominance of the sinus is due to the fact that its tissue possesses greater excitability than the rest; for if the excitability of any other part is increased locally above that of the sinus—as by the application of warmth—the contractions will now start from the part which has been thus rendered more excitable. In the embryonic heart of the bird and mammal much the same conditions are found as in lower vertebrates, but as development proceeds the distinction of the several parts becomes confused, the venous sinus being merged into the right auricle and the aortic bulb into the ventricle. The only sequence to be clearly seen with the unassisted eye is that described by Harvey, namely: auricular systole, ventricular systole, pause.

It is, however, still possible to show by electrographic methods (T. Lewis) that the contractions actually start from a point in the auricle close to the entrance into it of the superior and inferior venæ cavæ. At this point the thin contractile tissue of the right auricle is marked by a slight swelling—the 'node of Keith and Flack' or the 'sinus node': here the muscular fibres are somewhat peculiar in structure and arrangement, and receive many nerve fibres derived from the vagus and sympathetic. In the same auricle—the right—there is another node of similar structure placed near the base and close to the entrance of the coronary sinus. This is the 'node of Tawara'. From the node of Tawara a circumscribed bundle of muscular fibres—the 'bundle of His'—passes through the connective tissue of the auriculo-ventricular system to the ventricles; the bundle divides into two branches, one for the right, the other for the left ventricle. Each branch ends in a network of peculiarly constructed muscular fibres, the 'network of Purkinje', which covers the interior of each ventricle underneath the endocardium and is connected everywhere with the adjacent fibres of the myocardium. The muscular tissue of the nodes, as well as that of the auriculo-ventricular bundle and that of the network of Purkinje, is different from ordinary cardiac muscle, from which it also differs somewhat in function: it is termed the 'nodal tissue' to distinguish it from the ordinary cardiac muscle.

The contractions of the heart start at the sinus node: from that point they spread rapidly over both auricles, which have their muscular tissue in complete continuity. Reaching the node of Tawara, the contractions then traverse the auriculo-ventricular bundle, and are conducted by it and its branches to the network of Purkinje; from this they spread in the muscular wall of both ventricles. The sinus node is the pace-maker in the heart of the mammal. If it is excised, the contractions assume a slower rate, and the electrocardiogram is altered in type; the rate now being that of the part of the auricle near the entrance of the coronary sinus—'coronary' rhythm. If the bundle of His is severed, the auricles continue to contract spontaneously with the 'sinus node' rhythm. The ventricles, which now have no muscular connexion with the auricles, also continue contracting spontaneously, but with a much slower rhythm. The spontaneous contractions, whether of auricles or ventricles, are dependent on the presence of nodal tissue. Separated portions of right auricle or of either ventricle, both of which contain that tissue, will continue to beat spontaneously and rhythmically: but if the left auricle, which contains no nodal tissue, is completely severed from the right, it soon ceases to beat spontaneously, although it will respond to artificial stimulation; it can also be made to resume its spontaneous contractions by addition of an extract of nodal tissue from the heart of another animal.

The inference is that an excitatory autacoid or hormone is produced in the nodal tissue which is necessary to start the spontaneous contractions, and that this hormone is formed in greatest amount in the node of Keith and Flack. This causes the rhythm of the cardiac tissue to start from that node, whence it is propagated over the whole heart in the manner above described. Demoor found that not only is the left auricle caused to contract rhythmically by adding extract of nodal tissue to the Ringer's solution bathing it, but that it and cardiac tissue generally are also rendered by such addition more sensitive to sympathetic stimulation—this effect being due to a second hormone in the extract, different from that which causes the spontaneous contractions.

As already stated, excision of the sinus node causes the right auricle to assume a slower rhythm. If it is now re-implanted in the situation from which it was removed, the original rate of contraction of the

heart is restored (Rijlant), although the continuity of the fibres of the node with the rest of the heart remains, of course, severed. The explanation of this experiment favoured by Demoor is that the tissue of the node continues to produce the active substance or hormone, and that this now diffuses from it and causes increased excitability in the cardiac tissue immediately surrounding it; and thus as long as it survives the graft continues to officiate as the pace-maker. The explanation favoured by Rijlant is that the re-implanted node sets up an electric change with each contraction, and this starts the contractions of the adjacent cardiac muscle at the same rate as those of the node. Should the graft not take, it will before long cease to contract and will presently die. In that event, the heart resumes the rhythm of the coronary part of the auricle. During the activity of such a graft the electrocardiogram is normal; after degeneration it takes on the 'coronary' type.

### Inactivation of Autacoids.

The existence in the blood of most of the autacoids of the body, although long doubted, must now be conceded. It is by their variability in amount in that fluid that their effects are shown. This variability implies that there must be some means of eliminating them; otherwise the continuance of their secretion would lead to an accumulation which would before long produce toxic effects even if the normal rate of secretion were small. If the secretion is rapid, then elimination must be equally rapid. That this is the case is illustrated by adrenaline. Unless this were rapidly eliminated or de-activated, the balancing action upon the blood pressure which Tournade has shown to occur would not be possible. We know very little in most cases as to how the elimination or de-activation is produced. In some it may be that the autacoid forms a stable chemical compound with a product of the cell on which it acts and thus becomes inactivated. This is probably the case with adrenaline, which is de-activated by aldehydes (Cramer), and aldehydes constantly occur amongst the intermediate products of tissue metabolism. Some autacoids are not de-activated, but are eliminated by the urine. This is the case with those secreted by the anterior pituitary, the ovary, and the placenta. Or, finally, the action of an autacoid may be arrested by the secretion of another one which is antagonistic to it: the reaction being assumed to be of a chemical nature.

The large number of autacoids which have now been recognised manifests their importance in physiology. A generation or two ago none of these substances was even dreamed of. Our knowledge of them is wholly the result of the observations and experiments of the last fifty years. The changes in physiology which have resulted from this knowledge constitute not merely an advance in degree but also an alteration in character. The doctrine of internal secretion forms a new departure. We must in future explain physiological changes in terms of chemical regulation as well as of nervous regulation. It is therefore justifiable to speak of the doctrine as the 'New Physiology', seeing that it has completely altered our outlook on many of the problems with which physiology deals and consequently on those met with in medicine and surgery.

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## Letters to the Editor.

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### Quantum-Mechanical Models of a Nucleus.

IN their recent paper,[1] Lord Rutherford and Dr Ellis have shown how the numerous $\gamma$-rays of radium C′ can be arranged in a simple and orderly manner, which suggests, as they point out, that the multiplicity of the $\gamma$-rays is largely due to the excitation of several $\alpha$-particles into the same excited level rather than to the excitation of one $\alpha$-particle into several excited levels. Their arrangement of the lines of radium C′ is probably not a unique scheme of this sort, but any reasonable scheme appears likely (they show) to present the same general features.

It seems desirable therefore to investigate theoretically in detail any simple model or models of a nucleus consisting of some fifty $\alpha$-particles, which might show such general features. The main feature brought out by Rutherford and Ellis is that the $\gamma$-rays can be expressed in the form

$$h\nu = pE_0 - qE_1,$$

where $p$ is an integer running from 1 to 4 and $q$ an integer running from 0 up to perhaps 10; the value of $E_1$ is about $\frac{1}{15}E_0$ for radium C′ and has much the same value for radium B. For radium C′ more than one value of $E_0$ may be required.

There are two models which might be investigated with some chance of success; the first is a model in which each $\alpha$-particle is considered to move independently in a central field (which is ultimately to be referred to the combined interactions with the other $\alpha$-particles), but the whole family is affected by perturbing interactions of the form $V(r_{ij})$, between each pair $i, j$ of all the $\alpha$-particles, where $r_{ij}$ is the distance between the $\alpha$-particles $i$ and $j$. Such a model is very like an atom of electrons, except that wave functions have to be symmetrical in the $\alpha$-particles instead of antisymmetrical in the electrons, and this is the essential difference which allows of the states of reduplicated excitation, which do not occur at all in atoms. This model can be still further simplified from a three-dimensional to a one-dimensional form for a first discussion.

The second model is one in which each pair $i, j$ of $\alpha$-particles act on one another with a potential energy $\frac{1}{2}\lambda r_{ij}^2$. This model is obviously a rather poor physical approximation to the type of force, but it has the advantage that it can be studied exactly and not merely by the approximations of a perturbation method. A discussion of both these models has been begun, but has as yet only been carried through for the first model simplified to one dimension.

Confining attention only to the most general features, likely to be true of any suitable similar model, the following results have been obtained, which are to a large extent in excellent accord with the scheme of Rutherford and Ellis, but also seem to indicate clearly that a rather more elaborate scheme should be adopted. The energy levels of the model which arise from excitation of more than one $\alpha$-particle into a single excited state are of such a configuration that the corresponding $\gamma$-rays (if they could all be emitted) would be approximately of the frequencies

$$h\nu = p(E_0 - qE_1).$$

These frequencies agree with those of the proposed scheme of Rutherford and Ellis if the scheme is only very slightly modified, so that in place of the proposed single set of $\gamma$-rays of frequencies $2E_0 - qE_1$, we have the double set of frequencies $2(E_0 - qE_1)$ and $2(E_0' - qE_1)$ with $E_0$ and $E_0'$ nearly equal, and in place of the single set $3E_0 - qE_1$, the triple set $3(E_0 - qE_1)$, $3(E_0' - qE_1)$, $3(E_0'' - qE_1)$ and so on. It is, moreover, clear that the reduplication of the upper levels is to be expected when we consider the three-dimensional version of the model. Further, the theory suggests that the ratio $E_0/E_1$ should be numerically somewhat less than $\frac{1}{2}n(=26)$ in not too bad conformity with the observed value 16 for radium C′. The theory even suggests further that both $E_0$ and $E_1$, or perhaps rather $E_1$, will not vary very much between one radioactive nucleus and another. It is true that the observed values of $E_1$ (but not those of $E_0$) are much the same for radium C′ and radium B. The $\gamma$-rays of other atoms have not yet been analysed in this way.

All these features are general and the conformity very reassuring. One can, however, further estimate the relative frequency of the emission of the various $\gamma$-rays corresponding to the transitions from a state of $q$-excited $\alpha$-particles to states of $q-1, q-2, q-3\ldots$ excited $\alpha$-particles. With an interaction energy of the proposed form, the transitions $q \longrightarrow q-3$ should be absent, or at most very rare, and the transitions $q \longrightarrow q-4, q \longrightarrow q-5$, etc., entirely absent. The theory gives as a first approximation to $R$, the ratio of the frequency of occurrence of the transitions $q \longrightarrow q-2$ and $q \longrightarrow q-1$, the value

$$R\left(\frac{q \longrightarrow q-2}{q \longrightarrow q-1}\right) = \frac{q-1}{6{\cdot}5}f,$$

where $f$ is a factor certainly less than unity and probably not so small as $\frac{1}{10}$. The absolute value of the ratio $R$ may be heavily affected by higher order terms, and we need not be concerned if the proposed scheme does not conform closely. The feature of $R$ that is almost certainly of general importance is that $R$ increases with $q$. This feature ought to be carefully borne in mind in the construction of any amended scheme. It is not yet possible to say whether these features can be incorporated in an otherwise satisfactory scheme, and a detailed re-examination must be undertaken.

The proposed scheme for radium C′ is arranged to include values of $p$ up to 4 and therefore transitions of the type $q \longrightarrow q-4$. These certainly do not, and the transitions $q \longrightarrow q-3$ probably do not, fit into the allowed transitions of the proposed model with the simple interactions proposed. But such transitions can be present if there are terms in the interactions depending essentially on the co-ordinates of three or more particles, not reducible to sums of terms depending on the co-ordinates of only two. Such terms are to be expected in such a close configuration, though one would scarcely expect their effect to be so large. If the proposed scheme proves ultimately to be correct, one may hope to work back from the $\gamma$-ray intensities to some knowledge of the magnitude of these triple and higher interactions.

To sum up, one may say that the scheme proposed by Rutherford and Ellis, so far as it has yet been closely analysed, *that is for frequencies only*, seems likely with trivial modifications to conform completely to the requirements of a simple quantum mechanical model so far as these requirements can yet be foreseen. Such a model, however, will make fairly stringent demands on intensity ratios, and as yet no scheme has been proposed and tested with these in mind. One may hope that further work on these lines will prove fruitful.

While these models may well be able to explain the

complicated spectrum of radium C′, it is well to remember that the corresponding spectrum of thorium C′ is very much simpler and contains no families of γ-rays—except perhaps very faint ones—corresponding to those of radium C′, which have been interpreted in the scheme as transitions $q \rightarrow q-2$, $q \rightarrow q-3$, and $q \rightarrow q-4$. It has of course, in addition, a very strong isolated γ-ray of very high frequency. If therefore in attempting to proceed with this analysis, which in any event I believe to be important, one is forced finally to conclude that such models will *not* explain the facts for radium C′, there is no call for surprise or disappointment. It may still be that the proposed scheme of $q \rightarrow q-1$ transitions will account properly for the important *common* features of the γ-ray spectra of radium B, radium C′, thorium C′, and probably other nuclei. It is more than likely that the striking *differences* between the spectra of radium C′ and thorium C′ should be associated with the two extra free protons in radium C′, the atomic weight of which is of the form $4n+2$, while that of thorium C′ is $4n$.

In the models suggested above, the effect of the protons has been ignored primarily because there seems at present no simple way of incorporating them. But it is clear that the general effect of free protons present in normal and excited states will be to cause the set of low frequency transitions $q \rightarrow q-1$ to be repeated again at higher frequencies but with the same dependence on $q$, the constant shift between the two sets representing an excitation energy for a proton. R. H. FOWLER.

Cromwell House,
Trumpington, Cambridge, Aug. 14.

[1] *Proc. Roy. Soc.*, A, vol. 132, p. 667: 1931.

### Polarisation of a Beam of Electrons by Scattering.

IN view of the recent experimental work of Dymond[1] on the polarisation of electrons by double scattering, it is of interest to make calculations of the effect to be expected, without assuming, as in the author's previous paper,[2] that the number $2\pi Ze^2/hv$ is small compared to unity, a condition which is not satisfied in practice.

One finds, as before, that the asymmetry in the scattering is very small, unless:

(1) The velocity of the electrons is comparable with $c$. (2) Both angles of scattering are comparable with 90°. (3) The atomic number of the scattering nucleus is comparable with 137.

With both angles of scattering equal to 90°, and gold for the scattering element, the calculated percentage asymmetry (200 δ of the author's paper) is in the direction found by Dymond, and of the following magnitude, for various velocities, $v$, of the electrons:

| $v/c$ . . . . | 0·2 | 0·3 | 0·4 | 0·5 | 0·6 | 0·7 | 0·8 | 0·9 | 1·0 |
|---|---|---|---|---|---|---|---|---|---|
| Energy in kv. | 10·5 | 25 | 45 | 79 | 127 | 204 | 340 | 662 | ∞ |
| 200 δ . . . | 0·5 | 0·2 | 3·0 | 11·5 | 15·5 | 14 | 10 | 5 | 0 |

The asymmetry at 70 kv. is thus about five times as much as that found by Dymond. It is difficult to explain why this should be so. Multiple scattering would reduce the polarisation observed, but there should not be much multiple scattering with the foils used. It is improbable also that the Dirac theory of the electron should give a wrong result when applied to the scattering by a Coulomb field, since the results for the energy levels of an electron in the same field are known to be correct. N. F. MOTT.

Gonville and Caius College,
Cambridge, Aug. 10.

[1] NATURE, vol. 128, p. 149, July 25, 1931.
[2] *Proc. Roy. Soc.*, A, vol. 124, p. 425; 1929.

### The Spermatogenesis of Ticks.

THE spermatozoa of ticks are provided with a peculiar 'plasmal-rod' or spermatophore which has long been a puzzle to cytologists, but the careful work of Nordenskiöld (1920) on *Ixodes ricinus* Linn. threw considerable light on the subject.

Certain recent observations I have made on the red tick (*Rhipicephalus evertsi*) indicate that the spermatogenesis in this species differs considerably from that given in Nordenskiöld's account, and it exhibits certain peculiar features which are of general theoretical interest.

In sections of an impregnated non-engorged female there was found in the seminal receptacle a tangle of long, thick cords, the spermatophore-cords (Fig. 1, *g*).

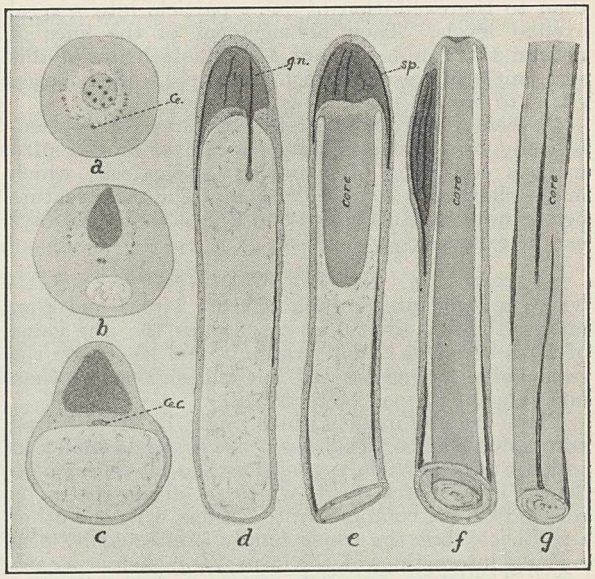


Fig. 1

These are singularly brittle and appear to snap like spun-glass under the microtome-knife, although, doubtless, they are sufficiently flexible in the fresh condition. Each cord carries on its surface a large number of longitudinally arranged filiform spermatozoa, all of which seem to point in one direction. Probably when the eggs are ripe a special secretion is poured into the receptacle, which releases the spermatozoa from the cords.

In sections of a series of male ticks of various ages it was found that each cord and its spermatozoa are formed through the activity of a *single* spermatid. The spermatids, which appear to arise in a typical manner, are unusually large, and it was at once obvious that they are too few to account for the numerous spermatozoa on the spermatophore-cords.

The nucleus of the spermatid bears about eight very small rounded chromosomes. A centrosome (*Ce*) and possibly mitochondria are present (Fig. 1, *a*). Nordenskiöld's "centrosomal corpuscle" (*CeC*) can also be seen; but the structure apparently vanishes and takes no part in the subsequent development. The spermatid expands and a vacuole with semi-fluid contents arises. At the same time the nucleus enlarges, and it assumes a very finely granular or homogeneous structure with diffuse chromatin which stains only weakly with Delafield hæmatoxylin but intensely with iron-hæmatoxylin (*b*, *c*). One or more strongly basophil chromatin-cords are now formed in the nucleus and they pass to its surface. The spermatid

becomes tubular, with the nucleus at the top, and as the tube gradually elongates the chromatin-threads are drawn out of the nucleus and lie on the inner surface of the wall of the tube (*d*, *e*). The chromatin-threads (*sp.*) give rise to the filiform spermatozoa, and the generating nucleus (*gn*) continues to produce them *pari passu* as the tube elongates. The nucleus may remain at the top, or it may slip to one side (*f*), but ultimately it becomes used up and disappears.

During this process a core of homogeneous, compact plasma grows down into the lumen from the top of the tube, immediately under the generating nucleus. The core elongates rapidly and forms a cylindrical rod which is surrounded rather loosely by the original protoplasmic tube carrying the spermatozoa (*e*, *f*). Afterwards the spermatozoa leave the sheath and become attached to the surface of the core. The sheath disappears, and the core (*g*) with its attached spermatozoa remains as the spermatophore-cord which is transferred from the male to the female.

There is no evidence whatever that fragments of the 'centrosomal corpuscle' become associated with each developing spermatozoon.

It may be added that the nature of the spermatogenesis varies to some extent in different species of ticks of the same genus, since some preliminary observations on the brown tick (*Rhipicephalus appendiculatis*) would appear to indicate that in this species a spermatid produces a cluster of very thin spermatophore-cords in place of one relatively stout one.

The theoretical interest of this remarkable behaviour of the spermatid lies in the fact that in the red tick, just as in certain spiders, a single spermatid gives rise to more than one spermatozoon.

In this connexion it must be specially stressed that there is not the least indication of any approach to a mathematically correct division of chromatin-substance in the production of the chromatin-threads in the generating nucleus, and the size of the resulting spermatozoa is extremely variable, in that the largest may be some three times longer than the smallest. In fact, the chromatin of the nucleus behaves as if it is entirely homogeneous in quality, and any sufficiently large portion of it is capable of producing a spermatozoon.

The upholders of the chromosome hypothesis of heredity will have to explain how it is conceivable, in such cases, for an intricate system of material 'genes' to be passed on from one generation to another.

It is hoped that a detailed account of the observations will be published shortly.

ERNEST WARREN.

Natal Museum, Pietermaritzburg.

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### Diamagnetism of Liquid Mixtures.

MISS TREW et Dr. Spencer [1] ont mesuré les susceptibilités magnétiques des mélanges liquides suivants : benzène-dichlorure d'éthylène, tétrachlorure de carbone-acétate d'éthyle, benzène-acétate d'éthyle, benzène-tétrachlorure de carbone, eau-pyridine, acétone-chloroforme, acétone-bromoforme, diéthyléther-chloroforme, acétone-trichloréthylène, diéthyléther-acétone. Ils ont conclu de leurs résultats que, en général, la susceptibilité magnétique des mélanges de deux liquides organiques ne suit pas la simple règle des mélanges. Cependant les mélanges de benzène et de dichlorure d'éthylène obéissent à cette règle.

Si l'on porte en abscisse la composition moléculaire du mélange et en ordonnée la susceptibilité magnétique ou la densité de ces derniers mélanges, on obtient une droite. Ce sont des mélanges idéaux. Pour les mélanges de tétrachlorure de carbone et d'acétate d'éthyle, on trouve aussi sensiblement une droite pour la densité et la susceptibilité magnétique. Pour tous les autres mélanges on obtient des courbes qui présentent un maximum dans le cas de benzène-acétate d'éthyle, pyridine-eau, acétone-chloroforme, diéthyléther-chloroforme, diéthyléther-acétone.

Selon les mêmes physiciens la mesure des susceptibilités magnétiques permet d'affirmer si des changements physiques ou chimiques se forment en mélangeant des liquides organiques et cette méthode est très sensible.

Ranganadham [2] a fait remarquer que ses mesures personnelles ne confirment pas celles de Miss Trew et Dr. Spencer. Ainsi, pour les mélanges de benzène et tétrachlorure de carbone, Ranganadham obtient une droite parfaite pour exprimer la relation entre la susceptibilité magnétique et la composition. Pour les mélanges acétone-chloroforme il trouve, entre les valeurs mesurées et celles qui sont calculées par la règle des mélanges, des écarts beaucoup plus petits que ceux qui ont été trouvés par Miss Trew et Dr. Spencer. En outre, Ranganadham s'étonne que pour les mélanges d'acétone-chloroforme la courbe donnée par Miss Trew et Dr. Spencer passe de la région diamagnétique à la région paramagnétique.

Les deux physiciens anglais ont répondu à ces observations [3] et annoncent la publication prochaine de leurs mesures sur les mélanges acétone-trichloréthylène et bromoforme-acétone.

Je voudrais qu'il me fut permis de rappeler ici deux autres mémoires sur les susceptibilités magnétiques des mélanges liquides. Déjà, en 1918, Alpheus W. Smith et Alva W. Smith [4] ont mesuré les susceptibilités magnétiques des mélanges suivants : acétone-eau, acide acétique-eau, acide acétique-benzène, acétone-alcool éthylique, et pour ces quatre couples de mélanges les courbes qui donnent la susceptibilité magnétique en fonction de la composition sont des droites. Cependant pour les mélanges d'acétone et d'eau, qui se forment avec une contraction très grande du volume, il se produit un maximum d'indice de réfraction ainsi qu'on le lira dans mon mémoire.[5] On verra aussi dans ce mémoire que l'on sait depuis longtemps que les solutions dans l'eau de l'acide acétique donnent lieu à des maxima de densité et d'indice de réfraction.

Enfin, en consultant le volume VII, années 1925–1926, des "Tables annuelles de constantes et données numériques" (Marie), partie concernant l'électricité et le magnétisme, p. 1014, nous voyons que Trifonov, en 1924, s'est occupé de la même question et a étudié les mélanges suivants : benzène-métaxylène, benzène-sulfure de carbone, acétone-chloroforme, benzène-nitrobenzène, benzène-tétrachlorure d'étain, acétate d'éthyle-tétrachlorure d'étain.

Pour aucun de ces couples de liquides on ne trouve un maximum de la susceptibilité magnétique et aucun des mélanges d'acétone et de chloroforme n'a été trouvé paramagnétique.

Ce rappel de travaux antérieurs montre avec quel intérêt les physiciens prendront connaissance du mémoire annoncé par Miss Trew et Dr. Spencer. Cependant, vu la discordance entre les résultats obtenus, on peut déjà affirmer que la mesure des susceptibilités magnétiques ne doit pas être recommandée comme une méthode d'investigation sûre de la constitution des mélanges liquides.

EDM. VAN AUBEL.

Laboratoire de physique de
l'Université de Gand,
8 août.

[1] *Proc. Roy. Soc.*, A, **131**, p. 209 ; 1931.
[2] NATURE, **127**, p. 975, June 27, 1931.
[3] NATURE, **128**, p. 152, July 25, 1931.
[4] *Jour. Amer. Chem. Soc.*, vol. 40, p. 1218 ; 1918.
[5] *Jour. Phys.*, 3e série, vol. 4, p. 478 ; 1895.

### Measurements of the Height of a Large Drop of Mercury.

In determining the surface tension of mercury and other liquid metals, many workers have used the method of measuring the height from the maximum section to the summit of a large drop. Most agree as to the method of setting on the maximum section, but a variety of ways are used to define the top of the drop. Two recent papers [1] describing measurements made after using every care to obtain pure mercury and high vacuum, and with no essential difference in technique except in the method of defining the summit of the drop, give respectively $515 \pm 6{\cdot}8$ dynes and $432{\cdot}2 \pm 0{\cdot}3$ dynes for the maximum surface tension of mercury at 31° C. In view of this discrepancy and the fact that it corresponds to a difference of only about 0·2 mm. in height of the drop, the following notes on methods tried out in this laboratory may be pertinent.

(1) A collimated beam of light from a small distant source set carefully at the height of the drop shines over the summit, and the top of the drop is seen in the horizontal microscope, accompanied by diffraction lines. The definition is good, and the very small correction for diffraction can be determined by setting on to a similarly disposed mercury drop in the open laboratory, when the exact surface may be located by bringing a spherometer point almost into the surface and taking readings on both point and reflection.

(2) A card ruled with slanting lines is placed behind the drop and the setting is made on the intersection of the lines and their reflection.[2] The definition is sharp, but, of course, the telescope must be focused on the card and not on the drop, and there is thus a considerable horizontal distance between the points, the vertical separation of which must be measured. This increases any error due to inaccurate levelling, and, if the aperture is small, it is not easy to see reflections from a horizontal surface using a truly horizontal telescope.

(3) If the drop is enclosed in a box and light admitted through a ground-glass window on one side while observing through a window on the opposite side of the box, the drop appears as a sharply defined black body. What appears to be the upper surface of the drop, however, is really the lowest curve on the drop which will reflect rays coming from the top of the ground-glass window so that they pass into the telescope. The position of this curve depends on the size of the drop and its position relative to the top of the window. Using a window 4 cm. from the centre of a drop 6 cm. in diameter, the following readings were taken as the window was blackened out strip by strip from the top downward:

| Height from top of drop to top of window. | Reading of microscope set on apparent top of drop. |
|---|---|
| 1·0 mm. | 3·343 mm. |
| 2·2 ,, | 3·328 ,, |
| 5·1 ,, | 3·274 ,, |
| 8·3 ,, | 3·222 ,, |

The setting on the top of the drop, using method (1), was 3·367 mm., and the correction for diffraction about +0·01 mm. M. Kernaghan uses an enclosed drop and a ground-glass window, but the method of defining the summit is not very clearly stated. It is remarkable that the difference of 83 dynes quoted above is in the direction to be expected if the workers had used methods (2) and (3) respectively without completely eliminating the sources of error mentioned.

In spite of individual workers obtaining consistent values, the question of the value of the surface tension of mercury in vacuum remains unsettled, and it is obviously desirable that workers should check their readings for the top of the drop by using two distinctly different methods of illumination and finding if the setting is unaltered. It may be said that measurements made here, both with glass and using an apparatus entirely of fused silica made by the Thermal Syndicate, indicate a greater height for the drop than those recorded by M. Kernaghan.

R. S. Burdon.

Department of Physics,
University of Adelaide,
July 10.

[1] Cook, *Phys. Rev.*, August 1929, and Kernaghan, *Phys. Rev.*, April 1931.
[2] Cook, l.c.

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### Polarity and Vapour Pressure.

In considering the effect of polarity on the vapour pressure and association of a liquid, a simple case is its influence on the partial vapour pressures of a polar liquid in its binary mixtures with a non-polar liquid, which, except for lack of polarity, should preferably be closely related in chemical structure to the polar liquid.

It is convenient to consider as 'perfect' a solution in which the restraining force on a polar molecule about to be vaporised is the same as in an infinitely dilute solution of the polar in the non-polar liquid. Perfect solutions are then represented by the tangent to the partial vapour pressure curve of the polar liquid at the limit of zero concentration. It is proposed to consider the effect of polarity in producing deviations from this tangent. To take deviations from Raoult's law as measures of imperfection is unsatisfactory, since to do so implies that all pure liquids are perfect, whilst admitting that mixtures of liquids may be imperfect.

Let the activity of the polar liquid be equal to $b$ times its vapour pressure. Then in a perfect solution the free energy ($F_i$) of the polar liquid per molecule is $kT \log_e bp_i$, where $p_i$ is the partial vapour pressure of the polar liquid, and $k$ is Boltzmann's constant. Let the partial vapour pressure of the polar liquid in a solution of the same concentration in reality be $p$: the corresponding free energy ($F$) being $kT \log_e bp$. The free energy of transference of a molecule from a perfect to a real solution of the same concentration is $F - F_i = kT (\log_e bp - \log_e bp_i)$, that is

$$\frac{p}{p_i} = e^{(F - F_i)/kT}.$$

For such a dipolar molecule as is under consideration, $F$ may be identified with the energy due to the field of the dipole in a medium of dielectric constant equal to that of the real solution of the concentration involved. Similarly $F_i$ is the energy in a medium of dielectric constant equal to that of the pure non-polar liquid (since under perfect conditions the environment of a polar molecule remains the same as in an infinitely dilute solution in the non-polar liquid). If the polar molecule be treated as two charged spheres in contact with each other, for simplicity assuming that each sphere is completely immersed in the dielectric and integrating up to a sphere, the radius of which may be called the molecular radius, it has been shown [1] that this energy is given by $\mu^2/3a^3D$, where $\mu$ is the dipole moment, $D$ is the dielectric constant, $a$ is the molecular radius. Therefore

$$\frac{p}{p_i} = e^{-\frac{\mu^2}{3a^3kT}\left(\frac{1}{D_i} - \frac{1}{D}\right)}.$$

Unfortunately the data required to test this relation are very scanty. The values of $a$ necessary to

give the observed values of $p/p_i$ for heptane-ethyl iodide mixtures at 50° are given below (data by Smyth and Engel [2] and Smyth and Stoops [3]):

| Mol. Fraction $C_2H_5I$. | Observed Partial Vapour Pressure $C_2H_5I$ (mm.). | Ideal Partial Vapour Pressure $C_2H_5I$ (mm.). | $\frac{1}{D_i} - \frac{1}{D}$ | $a$ (Angstrom Units). |
|---|---|---|---|---|
| 0·1 | 57·3 | 58·8 | 0·0574 | 1·06 |
| 0·2 | 107·5 | 118·5 | 0·1089 | 1·28 |
| 0·3 | 151·7 | 178·5 | 0·1557 | 1·41 |
| 0·4 | 188·3 | 238·3 | 0·1982 | 1·50 |
| 0·5 | 218·0 | 297·8 | 0·2384 | 1·56 |
| 0·6 | 243·8 | 357·5 | 0·2749 | 1·61 |
| 0·7 | 268·0 | 417·5 | 0·3080 | 1·65 |
| 0·8 | 292·8 | 477·5 | 0·3379 | 1·68 |
| 0·9 | 321·0 | 537·5 | 0·3643 | 1·72 |
| 1·0 | 354·5 | 598·0 | 0·3866 | 1·75 |

These results are promising, and experimental work is now in progress with the object of testing this point of view further. A. R. MARTIN.

Chemistry Department,
University of Aberdeen,
Aug. 7.

[1] Martin, *Phil. Mag.*, **8**, 550; 1929: **9**, 422; 1930.
[2] Smyth and Engel, *J. Amer. Chem. Soc.*, **51**, 2646; 1929.
[3] Smyth and Stoops, ibid., **51**, 3312; 1929.

## Atomic Hydrogen Occluded in Iron Nitride.

ATOMIC hydrogen in iron has so far been known to be occluded when iron is quenched from a high temperature in water or when iron is electrolytically deposited. I have observed the existence of atomic hydrogen in iron nitride prepared by heating iron in the current of ammonia gas. I confirmed it by measuring the single potential of the iron nitride in normal ferrous sulphate solution. The time voltage curve of the iron nitride showed a minimum due to atomic hydrogen at the beginning, similar to that which appeared in the curve of iron quenched and loaded with atomic hydrogen, obtained by T. W. Richards.[1]

I also confirmed the existence of atomic hydrogen by immersing the iron nitride in a solution of potassium ferricyanide and observing the formation of Prussian blue on adding the ferric chloride solution. This reduction, $K_3Fe(CN)_6$ + atomic hydrogen $\rightarrow K_4Fe(CN)_6$, also takes place with the iron quenched in water, and thus loaded with atomic hydrogen, but never with ordinary iron. SHUN-ICHI SATOH.

Mitsubishi Research Laboratory,
Tokyo, Japan.

[1] *Zeit. physikal. Chem.*, **58**, 310; 1907.

## Audibility of the Aurora Polaris.

IT cannot be doubted that many persons have heard a distinct sound when watching a brilliant display of aurora. Naturally they have connected the two phenomena and have assumed that the sound was emitted by the aurora. Communications regarding the auroral sound appear now and then, and recently Mr. J. H. Johnsen has collected a great number of reports on the auroral sound in his pamphlet, "Concerning the Aurora Borealis", which has been reviewed in NATURE by Prof. S. Chapman.[1] Examining these reports, one finds that the auroral sound, with few exceptions, is described as a weak but distinct swishing or hissing sound which is heard during auroral displays on calm nights and at low air temperatures. I wish to emphasise the fact that the air temperature, in the cases in which it is stated, ranges between −35° F. and −50° F.

Very few investigators of the aurora admit that the sounds which have been heard can be ascribed to the aurora, but a satisfactory explanation of the observations is not yet commonly known, in spite of the fact that such an explanation has been given by Roald Amundsen in his book "The South Pole". Amundsen says (in translation from the original Norwegian edition, p. 417): "The swishing aurora does not exist. What one hears is one's own breath which freezes in the cold air".

The 'swishing breath' is a phenomenon which is well known to many arctic travellers and to natives, but it has not often been mentioned in the scientific literature. J. v. Hann [2] quotes observations of the 'swishing breath' from Siberia, and A. Wegener [3] has discussed the phenomenon, which he has observed in Greenland at temperatures below −44° F.

From my own experience, I can confirm that when the air temperature is below −40° F. and calm prevails, one hears a swishing or hissing sound when exhaling, possibly because the water vapour of the breath immediately condenses to ice crystals which collide when falling to the ground. The sound of the freezing breath is very distinct but weak, and is, therefore, heard only when the observer is standing still and listening intently. The phenomenon is very puzzling to an unexperienced observer, and if several persons are standing together it is impossible to become aware of the real cause of the sound. In that case the sound naturally is connected with any conspicuous phenomenon which occurs simultaneously, for example, an aurora. In the arctic the sky is generally clear when the temperature is low and the air is calm, and in the zone of maximum auroral frequency an auroral display is seen on nearly every clear night. An observer standing still and watching a brilliant display then hears a weak swishing sound, rising rhythmically, and naturally he assumes that this sound is emitted by the aurora.

I do not claim that the sound which has been ascribed to the aurora was always the sound of the freezing breath, but I am convinced that such has been the case in by far the greater number of instances in which persons report having 'heard the aurora'. It would be of interest to study more closely the conditions at which the sound of the freezing breath is heard, and also to direct the attention of auroral observers to the phenomenon in order that in the future the swishing breath is not interpreted as 'auroral sounds'.

H. U. SVERDRUP.

Chr. Michelsens Inst., Bergen,
July 27.

[1] "The Audibility and Lowermost Altitude of the Aurora Polaris" NATURE, March 7, 1931, p. 341.
[2] *Handb. d. Klimatologie*, Bd. 3, 3. Aufl., Stuttgart, 1911, p. 643.
[3] *Wiss. Erg. d. Dan. Expd.*, 1912–13, Abt. 2, Meteorologie, Copenhagen, 1930, p. 496.

## The Harvard Museum Expedition to Australia.

THE announcement made by *Science Service*, and commented upon in NATURE of July 11, evidently gives a misleading idea of the objects sought by the Harvard Museum Expedition to Australia. It is not primarily an expedition to secure specimens for a museum, but for the study of the animals of the region when alive. Such work necessarily entails the killing of a limited number of forms, so as the better to understand their habits, feeding, movement, reproduction, and so on. But the 'bag' thus sought is trivial and not to be compared to the long series valued by philatelists and many former collectors of animals and plants. The idea of vastly long series is dead so far as

modern zoological museums are concerned, owing, amongst other reasons, to the fact that the public will not endow them sufficiently for such ends.

The museum at Harvard was built by Alexander Agassiz in memory of his father, Louis, these two of our greatest exponents of field work of the last century. It contains their collections, which are relatively small, although of enormous importance. Around them has been built what is essentially a teaching and research institution. The Louis Agassiz Museum is weak in Australian animals and doubtless would desire to complete its series, but it would obviously be more economical and efficient to order the specimens required from Australian dealers. This, however, in mammals, would not suit Glover Allen, who complains bitterly of his teaching handicap in never having himself seen the great marsupials in their own country.

The leader of the Harvard Expedition is W. M. Wheeler, one of the greatest of American zoologists, formerly director of the Bussy Institute, and now attached to the Agassiz Museum. His name is quite sufficient to guarantee the character of this expedition, for he is one of the makers of modern scientific entomology, the dominant theme of which is the living insect. Also attached to the museum is Dr. Jackson, who has travelled widely in his studies of the fossil and living echinoderms in respect to their mode of life. On this side the Agassiz Museum recently sent an expedition to North Australian waters under Dr. H. L. Clark, to study them and other marine bottom-living invertebrates in their natural environments; this is also a side-line of the present expedition. The director of the Museum is Tom Barbour, a real naturalist, his speciality being the reptiles of America, which he has sought in all their haunts. Fisheries and oceanic biology centre in the living animals and plants, and are represented by Henry B. Bigelow, director of the new Oceanographical Institute at Woods Hole. It is useless to extend a list where one and all the staff have that field experience that is so necessary to give life to great museums. All take their share in teaching in the Harvard School of Biology, in which Profs. Parker and Crozier are dominant personalities, eminent in their experimental studies of living matter.

J. STANLEY GARDINER.

Aug 8.

### Training of Colonial Probationers in Anthropology.

IN 1930–31, the scheme arranged by the committee charged with the training of Colonial (African) probationers at Cambridge, provided forty hours lectures which were obligatory and twenty hours for optional consultation. My colleagues, Mr. R. U. Sayce and Mr. J. H. Driberg, have experience of African conditions and personal knowledge of administrative problems in Africa. For 1931–32, the Colonial Office has approved of an additional course of eight lectures on the principles of African customary law. Other subjects — languages, criminal law, Mohammedan history, evidence and procedure, common law, agriculture, phonetics, history, and geography—have to be provided for in the Michaelmas and Lent Terms, so that under present conditions the allotment to anthropology is as large as we can hope for. If the conditions change, we shall press for more, and even now are ready to provide more. There are other features in the scheme which I regard as needing modification, and hope that argument and persuasion will prevail in the long run.

I must also record the fact that early in the year we were asked to receive two officers for study leave and readily agreed to do so, subject to our existing commitments. One of them came to Cambridge and the other preferred London, and I have no reason to suspect that pressure is brought to bear upon officers to choose Oxford or Cambridge in preference to London for study leave. In Cambridge we do the best we can for them. We welcome them gladly, and—speaking for myself—we learn much that is important and interesting from them.

T. C. HODSON,
Reader in Ethnology, Cambridge.

10 Wood Lane,
Highgate, London, N.6,
Aug. 24.

### The External Meatal Notch as a Primitive Character.

THE majority of the many racial variations of the human tympanic bone result from the differing degrees of development of the lateral extensions of the annulus tympanicus. These lateral extensions typically develop as anterior and posterior elements which, by uniting at their ventral margins, complete the floor of the meatus acusticus externus.


FIG. 1.—Tympanic region of two Australian skulls. *A* and *B* are the anterior and posterior tympanic moieties separated by the external meatal notch.

Failure of union of these two processes at the median end of the tympanic plate results in the persistence of the foramen of Huschke. Such failure of union in the adult may be as frequent as 32 per cent in some racial series. Failure of union at the outer extremity of the bony meatus, though producing a characteristic condition, appears to have had but little, if any, attention devoted to it. When this failure of union occurs, the auditory meatus itself consists of an anterior tympanic moiety and a posterior moiety, separated by the *external meatal notch*.

This external meatal notch is of very frequent occurrence in Australian skulls, and two examples are shown in Fig. 1.

Failure of ventral union of the anterior and posterior moieties of the tympanic plate may therefore result in (1) a persistent foramen of Huschke, so frequent in the skulls of Chamorros, (2) persistent external meatal notch, such as is frequently present in the Australian, or (3) a continuous deficiency, such as characterises the normal child at about its second year, and persists in the adolescent skull of *Sinanthropus*.

FREDERIC WOOD JONES.

University, Melbourne,
July 3.

## Research Items.

**Class Distinction in the Society Islands.**—A study of traditional history and political grouping in the Society Islands, by Dr. E. S. Craighill Handy (*Bull.* No. 79, Bernice P. Bishop Museum), is devoted to the elucidation of the ethnic and cultural relations of the *manahune* (landless commoners) who dwelt mostly in the interior of Tahiti in the days prior to the breaking down of class distinctions by the missionary system. A preliminary investigation had indicated that they represented a survival of an earlier population that had been conquered and pushed back by the ruling dynasty, the *Hui Arii*, who were supreme in all the islands when they were discovered by Europeans. The customs and traditions of this invading dynasty were of an entirely different order from those of the earlier tribal culture. The *manahune*, who were the most numerous element in the population, were the serfs of the *arii* (feudal lords) and their supporters the *raatira* (landed proprietors). They were the wood-cutters for the royal family, the high-priest, and the warriors, the pickers of taro leaves, the fishers of eels and fresh-water fish. Of the two types of house, the rectangular and the apsidal, the former belongs to the earlier culture. The *manahune* were valley-dwellers, cultivating the taro and sweet potato on irrigation terraces. The warriors' house was probably their central social and political institution, and the chief cause of war was blood-revenge. Human skulls and jawbones were preserved and reverenced. Tane, Roo (Rongo), and Tu were worshipped as patrons of woodcraft, agriculture, and war respectively. On the other hand, among the *Arii* the furniture and domestic utensils of their apsidal houses were supported on legs, their boats were composite built-up vessels, and they were distinctly maritime and not agriculturists, excelling in sea fishing which was a royal sport. They wore the *pareu*, the short skirt, as opposed to the loin-cloth, and made fine mats, used for articles of clothing and other purposes. Their outstanding contribution to Tahitian religion was the god Taaroa, their ancestor, who assumed the position of creator and supreme god of the local cult.

**Pottery of Ancient Mexico.**—A study of certain characteristics of the pottery of ancient Mexico, referring particularly to the types and distribution of decorative motives on specimens in the Museo Nacional of Mexico, is contributed by Sr. Eduardo Noguera to the *Journal de la Société des américanistes de Paris*, N.S., t. 22 (fasc. 2). Taking the collection as a whole, without reference to cultures, 39·7 per cent of the pottery vessels showed no decoration, the next highest percentage being shown by those with geometric motives, 27·7 per cent; anthropomorphic motives came next with 19·7 per cent. Of the pottery objects, other than vessels, in the collection, 89 per cent were anthropomorphic, 5·6 per cent zoomorphic, and 4·1 per cent skeuomorphic. When the cultural grouping is taken into account, the Aztec pottery showed the highest percentage of decorated ware. It also showed the highest percentage with geometric decoration. It is suggested that this preponderance of geometric motives is due to the fact that in other cultures decorative art developed through the stylisation of a realistic symbolism. The small number of skeuomorphic motives is attributed to the relatively backward stage of industrial development. Here again the predominance in Aztec art is due to the later and more developed stage attained by the Aztecs before the Conquest. The low percentage of phytomorphs is noticeable, and may be due to the fact that the geographical zones occupied by these cultures were of a relatively high altitude and vegetation was not so luxuriant as in the coastal regions. It is possible that a study of Maya and Huaxtec pottery on these lines would show a high percentage of phytomorphs to correspond with the more abundant vegetation of their habitat. Following the same line of argument, it may be shown that the Toltec and Aztec potteries are inferior in the percentage of zoomorphs to the Zapotecan, Mixtecan, and Tarascan cultures, owing to the fact that the two former inhabited the Valley of Mexico, in which animals were less abundant than in the habitat of the latter.

**Detection of Syphilis.**—In a paper presented in the *Rendiconti della Reale Istituto Lombardo di Scienze e Lettere* (parts 6-10), Dr. L. V. Blina gives the results of the application of the Wassermann and Kahn reactions to 650 samples of blood sera from syphilitic and non-syphilitic patients. In a number of cases of syphilitic infection, the Kahn procedure reacted positive and the Wassermann procedure negative, and the tendency to give negative indications as a result of therapeutic treatment proved less pronounced with the Kahn than with the Wassermann reaction. The former reaction reaches its highest degree of positivity for secondary syphilis and often shows negative with the tertiary form. These experiments are in favour of the Kahn reaction as a means of detecting syphilis, and the simpler technique and more rapid execution of this reaction give it an added advantage over that of Wassermann.

**Mimicry in Indian Butterflies.**—The Punjab University proposes to publish in the *Bulletin of the Department of Zoology*, of which the first part has reached us, a series of papers devoted to an intensive study of the fauna within a radius of five miles of Lahore. The first contribution, by Dev Raj Puri, deals with the butterflies, which, probably because of the extremes of climate in the summer and winter months at Lahore, are abundant only during August, September, and October. Keys and descriptions are given for the identification of families, genera, and species, and these are supplemented by thirty excellent coloured figures. In such a work, however, the lengthy synonomy of specific names is unnecessary, and since it occupies as much space as the essential descriptions, it might be drastically reduced. The author observed several new examples of protective coloration and mimicry. In *Melanitis leda*, always found resting on dry bamboo leaves under bamboo trees, the undersides of the wings resembled the colouring of the leaves. *Junonia orithya*, a common species, has wings of brilliant colour, and in rest the colours are exposed on the spread wings, but on the approach of danger the wings are folded up and only the obscure dust-coloured undersides exposed. *Pareronia hyppia* and *Delias eucharis* females resemble each other and occur together, but since the former was always entire, while the latter had sometimes the edges of the wing torn by birds, the former would appear to be distasteful and the model. Another suggested case of mimicry is that between the female of two species of Pieridæ, *Huphina nerissa* and *Ixias pyrene*.

**The Evolution of the Excretory System in Cercariæ.**—Lieut.-Col. R. B. Seymour Sewell (*Rec. Ind. Mus.*, 32, part 4, Dec. 1930) discusses the evolution of the excretory system in certain groups of furcocercous cercariæ. A study of the evolution and development of this system tends to show that every flame-cell

pattern (that is, the number and arrangement of the flame-cells) is reached by the division of an original single-pair flame-cell system. Such a system is known only in certain miracidia: for example, of *Amphistomum*, *Fasciola*, *Gastrodiscus*, *Gorgodera*. The next stage in evolution is represented by the excretory system of the miracidia of the genera *Holostomum* and *Schistosoma*, in which the originally single flame-cell of each side has divided into two, so that four flame-cells altogether are present. A further division of each of these flame-cells would give four flame-cells on each side of the body, and it is such a system that seems to be the starting point in several different lines of evolution in the furcocercous cercariæ. This is the condition in the schistosomes, in which there are four pairs of flame-cells, three pairs in the body of the cercaria and the fourth in the tail-stem. The author, starting from this condition, traces the different modes of division of the flame-cells and of the grouping of the flame-cells so produced, dealing first with cercariæ which are apharyngeal and brevifurcate and then with those which are pharyngeal and longifurcate. This last series is subdivided into three groups. While recognising the difficulty of constructing a classification of the fork-tailed cercariæ based only on the excretory system, Lieut.-Col. Sewell is convinced that this system is the most important for the correct determination of the systematic position of any given species in the evolutionary series. The paper contains helpful diagrams illustrating the different modes of derivation from four flame-cells of the systems exhibiting five to twelve flame-cells, and the probable lines of evolution of the principal forms.

Chromosome Linkage in a Triploid *Œnothera*.—The triploid *Œnothera pycnocarpa*, which was supposed by Catcheside to have a ring of twenty-one chromosomes, has now been re-studied by him (*Jour. of Genetics*, vol. 24, No. 2) and a variety of arrangements found in diakinesis. This is the most detailed study that has yet been made of the diakinesis stage of meiosis in a triploid *Œnothera*. The great variety of linkages found is in harmony with the great range of genetic types, including many trisomic mutations, known through the work of de Vries to be obtained from triploids when selfed. As an example of the conditions, one nucleus is found to contain four ring pairs of chromosomes, two rod pairs, three univalents, one Y-shaped trivalent and a chain of three. Another contains five univalents, a chain of six, and a chain of eight with two attached to one of its ends. All the groupings, with one possible exception, conform to the segmental formula proposed, and are in harmony with the view that the chromosome linkages have originally arisen by crossing of species, followed by rearrangements of segments of the chromosomes.

Eocene Mollusca of North-west India.—A memoir on the molluscan fauna of the Laki and basal Khirthar Groups by L. R. Cox (*Trans. Roy. Soc., Edinburgh*, 57, pp. 25-92, pls. i-iv; 1931) is based mainly on a collection made in recent years by Lieut.-Col. L. M. Davies, but the author has also studied the material collected by earlier geologists, from 1834 onwards, with the important result that the horizons of most of the species described in the great work by d'Archiac and Haime (1853–54) can now be fixed. The fauna is of Ypresian age and includes nearly a hundred species of gasteropods and lamellibranchs. The Laki fauna is very distinct from that of the underlying Upper Ranikot beds, but this is due partly to difference in the facies of the deposits. On the other hand, there is no great difference between the faunas of the Laki and Khirthar groups. A considerable number of the species, especially of the gasteropods, are confined to India, and those with a wider range are mainly limited to the Tethyan province. A few, however, are found in the Eocene of Europe, and one even in Jamaica.

Jointing and Tectonics of the Craven Area.—In the *Quart. Jour. Geol. Soc.*, 1931, pp. 392-421, L. R. Wager describes the jointing of the Great Scar Limestone of Craven and its relations to the tectonics of the area. The joints fall into two sets that are nearly at right angles to each other and fairly constant in direction. They are interpreted as shearing fractures due to a maximum horizontal compression in an approximately north-west–south-east direction. The jointing was produced in the early part of the interval between the Coal Measures and the Permian, and is contemporaneous with the Dent Fault, the North and Middle Craven Fault-systems, and the folding in South Craven. The North Craven Fault-system is a tear-fault, and the drag due to the relative horizontal movement has caused a local modification of the joint directions in the neighbourhood of the fault. The deep burial of the pre-Carboniferous floor in South Craven and the shallower burial of this floor in North Craven are responsible for the different reactions of the two areas to the Hercynian compressive forces. Renewed sinking of the South Craven area took place in post-Permian times, partly along the early faults and partly along newly initiated faults which followed one or other of the directions of jointing.

Photographic Vibrograph.—Messrs. Askania-Werke A.-G. Bambergwerk, Berlin-Friedenau, Kaiserallee 87-88, have issued a pamphlet (Geo. 105E) describing their latest pattern vibrograph. The instrument, which consists of two units joined by a light-tight tube, employs a photographic recording system. One unit comprises the camera, utilising 6 cm. wide bromide paper and a 4-volt lamp for illumination. Various paper speeds are obtainable, and short lengths of record can be cut off with a knife and removed in daylight for subsequent development. The vibrograph proper is normally constructed so that all three components of motion, vertical and two horizontal, are recorded side by side on the paper. Instruments can also be supplied which record only two or one of the components. The natural frequency of the units is stated to be five cycles/second, a value sufficiently low for most practical work on roads and in buildings, and variable liquid damping is provided. A useful feature is an arrangement whereby the mechanical magnification of the instrument can be altered in the ratio of ten to one. In addition, a choice of three lenses is available, thus permitting in all a choice of six values of magnification, varying from 125 to 3000 times.

Atomic Weights Deduced from Mass-Spectra.—Some new values for the atomic weights of a number of elements are given by Dr. F. W. Aston in an account of an investigation of their mass-spectra which appears in the August number of the *Proceedings of the Royal Society*. In the majority of cases these agree with the accepted chemical values. Amongst these is rhenium, which is perhaps of particular interest, Dr. Aston's value being $186 \cdot 22 \pm 0 \cdot 07$ and Hönigschmid's 186·31. For the three elements selenium, tellurium, and osmium, there are, however, serious discrepancies; the atomic weights found by the mass spectrograph for these are $78 \cdot 96 \pm 0 \cdot 04$, $128 \cdot 03 \pm 0 \cdot 1$, and $190 \cdot 31 \pm 0 \cdot 06$ respectively, against chemical values of 79·2, 127·5, and 190·9. It remains to be seen if the chemical values are actually inaccurate, but it will be recalled that in two other instances—krypton and xenon—more recent redeterminations by classical

methods have tended to support the validity of the values found electrically.

**Conductivity of Tetraethylammonium and Ammonium Salts.**—The August number of the *Proceedings of the Royal Society* contains some data for the conductivity of various ammonium and tetraethylammonium salts in methyl alcohol, which have been obtained by Sir Harold Hartley and a number of collaborators. The measurements were made at 25° C. and show the rather curious result that the mobility of the complex ethyl ion ($NEt_4^+$) is seven per cent greater than that of the relatively simple ammonium ion ($NH_4^+$). With a single exception, the results for the eleven salts studied agree with the prediction of the Debye theory of electrolytes that the molecular conductivity should change in a linear manner with the square root of the concentration; the rate of change of conductivity with concentration also affords evidence for the essential accuracy of some recent developments of Debye's theory, observed and calculated values of the rate of change agreeing on an average to within twenty per cent. The general trend of the results, and particularly the behaviour of the good conductor tetraethylammonium perchlorate, indicates that the magnitude of the deviations from theory increases with the speed of the ions present.

**Insulin Therapy.**—Although our knowledge of the mechanism of the action of insulin in the body is very incomplete, there is no question of its value in the treatment of diabetes mellitus. The principles of its practical use are well defined, although the actual details may vary; in every case it is necessary to ensure a balance between the diet and dosage of insulin, such that the blood-sugar is kept within normal limits and none is excreted in the urine. The amount of insulin required will naturally vary according to the severity of the disease and the amount of food taken. The details, which vary according to the physician in charge of the case, are concerned with the methods of determining the amount of insulin required and of calculating the diet. A convenient account of the treatment of diabetes with insulin is given in a small brochure recently issued by the manufacturers of "A.B." Brand Insulin (British Drug Houses, Ltd., and Allen and Hanburys, Ltd.). Simple methods for estimating sugar in blood and urine are described, as well as a simple dietary scheme. The practical use of insulin is given in detail. Sections are devoted to the treatment of the various conditions which may complicate the disease. Although insulin rarely cures, it can undoubtedly prolong life when properly employed; a cure can only be expected when the affection of the pancreas passes off without damaging the organ permanently. In such a case insulin may tide the patient over the infection and permit of recovery of function by the gland. In many cases, however, the timely use of insulin may promote a definite improvement in the condition of the pancreas. In all, its use permits of a better dietary being prescribed, with greater comfort to the patient. Insulin has also found a use in the treatment of various nondiabetic conditions: it is employed to improve the metabolism of carbohydrate, and may be used in states of malnutrition and when it is advisable to stimulate the metabolism of these food-stuffs, as in various forms of vomiting and in liver affections. The booklet may be recommended to those in search of a short and readable account of insulin treatment, based on selected excerpts from current medical literature.

## Astronomical Topics.

**A Daylight Meteor.**—A brilliant meteor was observed by Mr. J. R. Clarke, University, Sheffield, just before sunrise, from Loch Doon, Ayrshire, on Aug. 26 at about $4^h\ 15^m$ G.M.T. It travelled from west to east with very low apparent velocity, and was visible for about half a minute. No other reports are to hand at present.

**Stellar Photometry.**—Some years ago the photographic magnitudes of stars in the zone $+90°$ to $+73°$ declination were obtained by Parkhurst at Yerkes, and this work has now been continued by A. S. Fairley at the same observatory over the zone $+75°$ to $+60°$. The method used is that of extra-focal images, obtained 6 mm. inside the focus of a Zeiss 14·5 cm. doublet of 81 cm. focal length. A series of fourteen accurately graded artificial images was impressed on each plate before development, thus providing an independent scale for the comparison of densities, which were measured in a Hartmann microphotometer. The zero point was calculated for each plate from stars in the Potsdam Photometric Durchmusterung, the magnitudes of which were first corrected for colour index (assumed from spectral type) and then reduced to the international scale. The methods employed are described in the *Astrophysical Journal*, vol. 73, p. 125, in which Fairley gives the resulting photographic magnitudes of 2354 stars down to magnitude 8·25 within the above-mentioned zone.

**The Apparent Recession of the Spiral Nebulæ.**—*Leaflet* 37 of the Astronomical Society of the Pacific gives an account by Mr. Milton L. Humason of the methods now adopted at Mount Wilson of measuring the radial velocities of the distant spiral nebulæ. A new spectrograph lens, designed by Dr. W. B. Rayton, has been brought into use, which greatly shortens the exposures; these, however, still have to be continued on several successive nights in the case of the fainter nebulæ. The photographic plates measure $\frac{5}{8}$ inch by $1\frac{1}{2}$ inch, and the length of the spectrum varies from $\frac{1}{25}$ inch to $\frac{1}{12}$ inch, according to the prisms used.

Up to three years ago the measures of distance extended up to 6 million light-years; they now reach 105 million. Reasons are given for assuming that the smaller and fainter nebulæ are the more distant, and it is then shown that these small faint nebulæ have also the largest velocities of recession. The question whether the recession is real, or arises from the properties of space, does not affect the use of the shift to the red as a measure of distance.

A photograph, taken with the 100-inch reflector, is reproduced, showing a group of faint nebulæ in Leo. The brightest of these is of magnitude 15·5, and is stated to be the faintest and most distant object for which a measurable spectrum has been photographed. The deduced distance is 105 million light-years, and the measured recession is 12,000 miles per second, or $\frac{1}{15}$ of the velocity of light.

Measures are given of seven other nebular groups, in which 30 nebulæ were examined. The results show that the distances estimated from apparent brightness and diameter are in excellent agreement with those deduced from the velocities of recession. So far as the results extend at present, they indicate a fairly uniform distribution of nebulæ in different regions of space.

## The Nature of Cohesion.*

LIKE all other branches of physics, the subject of cohesion has been profoundly modified by the advent of wave mechanics. When atoms were regarded as miniature solar systems, there was no mathematical machinery capable of dealing with their mutual interaction. But now the outlook is different. There is no attempt in wave mechanics to follow the life-history of electrons in atoms. Rather does it give a statistical average of their distribution in space, from which may be inferred the probability that an electron may be found here or found there. Mathematically, if not physically, electrons in atoms are smeared out. Where once was thought a solar system played, is now a shimmering haze.

Wave mechanics does not give the density of these charge distributions directly. It gives instead, when only one electron is being considered, a quantity $\psi$, called a wave function, which may be real or complex, and the density $\rho$ of the electron distribution is equal to the square of the modulus of $\psi$ or to $\psi\bar{\psi}$. The quantity $\psi$ is a function of the co-ordinates of the electron, and these are four in number, three being necessary to specify its position in space, and the fourth its direction of spin. The probability of finding the electron in an element of volume $d\tau$ is $\rho d\tau$.

When there are several electrons in an atom, its configuration may in an approximate theory be specified by a number of wave functions, $\psi_\alpha$, $\psi_\beta$, . . . $\psi_\nu$, each a function of the four co-ordinates of an electron. For a reason not yet understood, Nature places a restriction on the choice of these wave functions: no two of them may be the same. This exclusion principle, first enunciated by Pauli, seems to be of very general validity in physics, and, in particular, accounts in a very remarkable way for many of the observed properties of atoms and molecules.

If one of the electrons, say electron 1, were alone, the probability of finding it in an element of volume $d\tau_1$, would be $\bar{\psi}_\alpha(x_1)\psi_\alpha(x_1)d\tau_1$ or $\rho_\alpha(x_1)d\tau_1$, where $x_1$ denotes its four co-ordinates. Similarly the probability of finding electron 2 in an element of volume $d\tau_2$, if it were alone, would be $\rho_\beta(x_2)d\tau_2$. It might be supposed that the probability of finding an electron in $d\tau_1$, another in $d\tau_2$, and so on, simultaneously, were the product of these separate probabilities, namely, $\rho_\alpha(x_1)\rho_\beta(x_2)$ . . . $d\tau_1 d\tau_2$. . . . But this result is not true. It is untrue because an important principle has been ignored, namely, that all electrons are identical and that interchanges of the electrons may occur without observable effects. Electron 1 may be associated with wave function $\psi_\beta$, or in fact with any of the set of wave functions $\psi_\alpha$ to $\psi_\nu$. The correct expression for the probability may, in certain cases, be expressed quite simply, as has recently been shown by Dirac. It is $\rho d\tau_1 d\tau_2$ . . . , where $\rho$ is a determinant of $N$ rows and columns, a typical term of which is $\rho(x_j, x_k) = \Sigma_\alpha \bar{\psi}_\alpha(x_j)\psi_\alpha(x_k)$. This determinantal form for $\rho$ contains the expression given above as its leading term, but there are many other terms not previously given by an atomic theory.

The probability of finding an electron in $d\tau_1$ independently of the position of all other electrons is then obtained by integrating $\rho$ over the co-ordinates of all the electrons except one, and may be shown to be $\Sigma_\alpha \rho_\alpha(x_1)d\tau_1$. This expression is the sum of the densities of the probability patterns of the separate electrons, and, moreover, contains the co-ordinates of one electron only, so that, apart from the spin co-ordinate it may be represented in ordinary three dimensional space. It justifies us in constructing a picture of an atom by superimposing the patterns of the individual electrons of which it is composed. Such pictures are very instructive and have been used in a variety of ways with striking success. One important result is that the distribution of electron density in the inert gases and, indeed, in many other atoms is spherically symmetrical, and so the early pictures of them as minute spheres are to some extent justified. The halogen atoms, on the other hand, are not spherical. They are like the familiar meteorological forecast, " Unsettled, with bright intervals ".

The importance of the new form for the probability function $\rho$ becomes evident when calculations are made of the *energy* of electronic systems. Electrons exert electrostatic forces on each other and the average value of the electrostatic energy can only be calculated when we know the probability that any pair of electrons will be at a specified distance apart. A detailed calculation of the energy of an atom or the interaction energy of two atoms depends then very closely on the probability function $\rho$.

The probability of finding two electrons in specified places independently of the other electrons proves to be $\{\rho(x_1, x_1)\rho(x_2, x_2) - \rho(x_1, x_2)\rho(x_2, x_1)\}d\tau_1 d\tau_2$, with the definitions of $\rho(x_1, x_2)$, etc., already given. The mutual energy of two electrons consists then of two terms; the first is the average of $(e^2/r)\rho(x_1, x_1)\rho(x_2, x_2)$ integrated over the whole space of electrons 1 and 2; the second is the average of $(e^2/r)\rho(x_1, x_2)\rho(x_2, x_1)$. Apart from certain terms of these expressions which cancel, the first represents the Coulomb interaction of the individual distributions of electric charge $\rho_\alpha$, $\rho_\beta$, etc. This may be called the *Coulomb energy*.

The second term in the above expression is new. It has proved of the greatest importance in the theory of atomic and molecular structure. It is difficult to describe its physical nature. All that can be said is that it is the natural outcome of introducing two physical concepts into the mathematical scheme, namely, the principle of the identity of electrons, and the exclusion principle of Pauli. It is sometimes described as the 'exchange' term and the term in the energy expression arising from it as the '*exchange*' *energy*.

The 'exchange' energy depends on the spin of the electrons, while the Coulomb energy does not. It is this property of the exchange term which has made it of so much importance in the theory of atoms and molecules. In a two-electron system, as in an excited helium atom, for example, the electrons may have the same or opposite spins, and, owing to the exchange term, the energy of the states with the same spins is lower in every case than the corresponding states with opposite spin. The hydrogen molecule is another two-electron system, and here the energy is lowest when the electrons have opposite spin. This appears to be the case in the interaction of most atoms. For certain interatomic distances the energy is lowest, and, therefore, the cohesion greatest, when the electrons of one atom are 'paired' with those of the other atom. The energy of two interacting nitrogen atoms is highest when the spins of the three outer electrons of the atoms are all of them the same, and lowest when the three electrons of one atom are paired with those of the other. This latter condition corresponds to the normal nitrogen molecule, held together—as the chemist describes it—with a triple bond.

The pairing of electrons is thus brought into close

* From two lectures delivered recently by Prof. J. E. Lennard-Jones, one on "Cohesion", before the Physical Society of London, and the other on the "Quantum Mechanics of Atoms and Molecules", before the London Mathematical Society.

connexion with the valency rules of the chemist, and *chemical homopolar forces* are elucidated to this extent —that they are seen to be a consequence of the same mathematical and physical principles which have been formulated for other branches of physics. This result may conceivably come to be regarded as one of the greatest achievements of the present formulation of quantum mechanics.

The new theory has been successful in explaining other forces, the nature of which was formerly little understood. For a long time it has been known that atoms, which are chemically inert, exert attractions on each other; so much so, that they aggregate together as liquids and solids if the temperature is lowered sufficiently. These attractive forces, usually called *van der Waals forces*, have now in one or two simple cases been calculated deductively from the electronic structure of the atoms. These attractive forces seem to be due not to a static polarisation of the atoms by each other but rather to a rapidly fluctuating mutual polarisation. Atoms are not actually continuous distributions of space charge. They are only to be regarded so on the average. When two atoms are subject to each other's influence, the motion of the electrons in one modifies that of the electrons in the other. They tend on the average to move in phase.

Suppose, for the sake of illustration, that an atom were represented by a linear oscillator, that is by an electron vibrating along a line through the nucleus. Such a system requires only one co-ordinate $z$ to specify it. Then the probability-distribution of the electron in its lowest energy state is a Gaussian error curve ($e^{-\alpha z^2}$), symmetrical about the origin. If two such electronic systems, vibrating along the line joining the nuclei and specified by co-ordinates $z_1$ and $z_2$, are allowed to interact, the new probability-distribution is not simply a combination of the two undisturbed probability-distributions of the isolated systems. Calculation shows that as a result of interaction the probability of finding $z_1$ and $z_2$ with the same sign has increased, while that of finding them with the opposite sign has decreased. Now dipoles which point in the same direction attract, and those which point in the opposite direction repel. The net result is that the two electronic systems on the average attract. The attractive force for this model and for actual atoms proves to be proportional to the inverse seventh power of the distance.

All atoms and molecules exert on each other an attractive field of this type, but usually this attraction is masked by other larger attractive fields. Only in the case of inert gases or saturated molecules does it become predominatingly important. It is likely that many substances, such as the halogen hydrides, are held together in the solid state by forces of this type. There is a growing recognition, too, of the importance of van der Waals fields in many phenomena at surfaces such as in adsorption.

The problem of *ionic cohesion* largely resolves itself into explaining why some atoms have an affinity for electrons. Such atoms are usually unsymmetrical charge distributions and the nature of the affinity can be understood, though actual calculation of the magnitude is difficult.

*Metallic cohesion* seems to be due partly to the Coulomb interaction of space charge distributions (the Coulomb attraction referred to above), partly to the 'exchange' phenomenon, and partly to van der Waals attraction. Little is as yet known as to the relative extent to which these various factors contribute to the cohesion of a metal. The general principles seem to be understood. What is now required is a mathematical technique capable of applying them to particular cases.

## Selection of Engineering Apprentices.*

HOW far is it practicable to use psychological tests in the selection of boys for the engineering trade? An attempt to provide an answer to this question has recently been made by the Birmingham Education Committee, under the auspices of which an investigation was conducted by Miss E. P. Allen and Mr. Percival Smith. A report describing the tests used, the methods adopted, and the results obtained has now been published.

Such a report will be of especial value to local education authorities responsible for juvenile employment. Indeed, the Malcolm Committee on Education and Industry has already directed attention to the necessity for this kind of research by authorities upon whom that responsibility rests. The present report deals with one aspect of the wide problem with which such authorities are faced: its authors have also been engaged upon a second experiment, involving still wider issues—the extent to which a series of psychological tests can be of practical use in offering vocational guidance to children when they leave elementary schools.

So far as the engineering trade is concerned, however, one of the first points to be decided was what that all-embracing term meant. In Birmingham, as elsewhere, it covers a multiplicity of occupations, ranging from those followed by practically unskilled manual workers to those needing highly skilled technical experts. For the former, the chief requirement is a varying amount of manual dexterity, and tests of such dexterity would, in their case, probably be sufficient. For those engineering branches which require skilled apprentices, however, the qualities to be sought are a combination of intelligence, mechanical aptitude, ability, and dexterity. With that combination in mind, the report uses throughout the term 'apprentice ability'. Tests were therefore used which would depend *inter alia* on mental processes, but would be definitely associated with mechanical ability.

This primary difficulty of deciding the type of qualities to be sought in connexion with so wide an industry as engineering is, of course, well known to engineers. We stress it here not merely to show its complications, but also as an indication of the care with which the investigators dealt with their problem—a care which will go far towards building up methods and results upon which confidence may fairly be placed.

The groups of individuals selected included third and fourth year apprentices (average age nineteen years) attending part-time courses at the Birmingham Central Technical College; entrants and leavers (fourteen to sixteen years of age) of a school with an engineering bias (Handsworth Junior Day Technical School); of a school with a commercial bias (Aston Commercial School); and of a general secondary school (Yardley Secondary School).

This selection of pupils from differing types of post-primary schools possesses a special interest in view of the present reorganisation of education, which

* City of Birmingham: Education Committee. Selection of skilled Apprentices for the Engineering Trades. Report of Research. By E. Patricia Allen and Percival Smith. Pp. iv+35. (Birmingham: Education Committee, 1931.)

is striving to relate the work of such schools to the needs of industry and commerce. Each has recently tended to make special claims concerning the aims and results of its syllabus. The following summary, taken from Section IV. of the report, would appear, so far as the engineering trades are concerned, to support the claims already made by the junior technical school: "(1) Boys who have had a purely academic training do not improve in ability to tackle these tests to the same extent as boys of a somewhat lower intellectual level who have received further education with an engineering bias. (2) Boys who have had further education with a different vocational bias (commercial) do not improve in ability to tackle these tests to the same extent as boys of a slightly lower intellectual level who have received further education with an engineering bias."

It is to be noted that the investigators did not use only the method of 'tests'. Criteria of apprentice ability of the individuals were supplied by instructors and the test results were compared with the respective criteria.

## Priestley as a Pioneer.

UNDER the title, "Joseph Priestley and his place in the History of Science", Sir Philip Hartog delivered a discourse at the Royal Institution on April 24, a reprint of which, with a postscript dealing with some additional points, has been received. Sir Philip traces the main events in Priestley's life, bringing out the fact that he was more than a man of science; he was a teacher, theologian, politician, and defender of liberal thought. His scientific work has been variously assessed and perhaps some aspects have tended to have been overshadowed by his discovery of oxygen. Priestley made some important experiments in electricity, and his work on the "History of Electricity" includes, among other matters, a statement that the inverse square law is contained in the experimental fact that there is no electrification inside an electrified metal vessel. This was probably the starting point of Cavendish's better known investigations. Priestley also made experiments on electric discharges, which are now seen to have raised fundamental issues.

Priestley's attitude to hypotheses in science is examined, and in his indifference to his own theories and those of others, he is thought to have been influenced by Franklin. In his chemical investigations he accepted the phlogistic theory as a pupil, with docility, since he was "no professed chemist". His practical investigations of gases, although preceded by important publications of Cavendish, led to the acquisition of much new knowledge on gases. This formed the basis of Lavoisier's theoretical revolution in chemistry. Sir Philip Hartog is inclined to allow Lavoisier more originality in the matter of the discovery of oxygen than has been usual, although he admits in more than one instance that the memoirs of Lavoisier as they finally appeared had been amplified from the original communications, a circumstance which makes it necessary to use the greatest care in dealing with this author. Although Priestley's intelligence "remained intact, bright and lively to the end", Sir Philip thinks his memory was failing him when he wrote his well-known complaint of Lavoisier's claims some years before his (Priestley's) death.

Sir Philip Hartog's discourse makes it clear that Priestley more than once was tempted to adopt Lavoisier's new view of the chemistry of combustion, but that he was restrained by the results of experiments, these being either faulty in themselves or wrongly interpreted. He nearly reached a true conception of the composition of water from his own experiments, but says he "was taught by Mr. Watt to correct this hypothesis", an event which does not help in the attempts which have been made to credit Watt with the discovery of the composition of water. One of Priestley's greatest stumbling-blocks was his confusion of the two inflammable airs, hydrogen and carbon monoxide, which was only cleared up by Cruickshank in 1801. Priestley's work on respiration and that on the growth of plants were the starting points for investigations of others, the first for Lavoisier's great researches on animal respiration.

Sir Philip Hartog believes that it is easy to understand why Priestley's work and his character have been under-estimated in the past. His electrical work and his clear views on the use of hypothesis and on scientific theory generally have been eclipsed by his chemical work, in judging which it is no simple task to divest his language of the enveloping veil of the phlogistic theory. He deserves a greater place in the history of science than he has hitherto been accorded.

## Some Phenomena of the Upper Atmosphere.

THERE are three layers in the upper atmosphere in which dissociation is produced by the absorption of solar radiation. These are the layer of ozone, with its maximum concentration at about 50 km., and the two ionised layers at about 100 km. and 220 km. The absorption of solar radiation of any kind in a gas of which the density varies exponentially with height $h(ae^{-h/H})$ has a definite distribution relative to the level of maximum absorption; this distribution depends only on $H$. It is shown that the main regions of absorption associated with the three layers are well separated, though the dissociation of molecular oxygen which results in the formation of the ozone layer has an important influence on the whole of the overlying atmosphere, in which atomic oxygen is a permanent constituent, its concentration increasing with height. The concentration of ozone, on the other hand, must decrease with height above a certain level, a conclusion which bears on the maintenance of a high temperature in the upper atmosphere.

Milne's theory of photoelectric ionisation is applied to the earth's atmosphere, assuming that the sun's radiation even in the far ultra-violet is that of a black body at 6000°. It suggests that the ionisation of the upper layer is due to the absorption of ultra-violet radiation, probably by atomic oxygen.

Considering both magnetic and radio evidence, it is inferred that the agent responsible for ionising the lower layer consists of neutral atoms from the sun, emitted from the sun at the same time as the charged atoms that are responsible for magnetic disturbance, the number of the two kinds of particles varying in unison, from time to time. They travel together from the sun until within a few earth-radii distance from the earth, when the charged particles are deflected by the earth's magnetic field towards the polar regions, there producing auroræ, while the neutral atoms travel straight on and ionise the sunlit hemisphere.

On considering the origin of the green light of the night sky, making use of Rayleigh's recent measure-

ment of the absolute photometric intensity of the light, it is inferred that the excited atoms that emit the light are produced continuously during the night, the energy coming from energy of dissociation or ionisation stored up during the day. The level of the emission may be assigned as between 100 km. and 200 km.

[1] Abstract of the Bakerian Lecture delivered before the Royal Society on June 25, by Prof. S. Chapman, F.R.S.

## Birthdays and Research Centres.

Sept. 14, 1849 (old style), or Sept. 26.—Prof. I. P. PAVLOV, For.Mem.R.S. and Nobel laureate in 1904 for physiology and medicine, director of the Institute of Experimental Medicine, Leningrad.

I am continuing the investigation of the highest nervous activity by the method of conditioned reflexes. This investigation includes in its scope the study of the normal activity, as well as that of different pathological states, which we are provoking intentionally, and the recovery of the normal after them.

Sept. 17, 1859.—Prof. F. D. ADAMS, F.R.S., emeritus professor of geology, dean of the faculty of applied science, and vice-principal of McGill University.

I am at present engaged in a study of the historical development of our knowledge of certain phenomena of physical geology and of our views on the nature and classification of minerals in the time antedating the rise of historical geology at the close of the eighteenth century; also in a study of certain points in connexion with the geological relations and petrography of the Palæozoic intrusions of the Monteregian Hills.

One of the most important pieces of work which could be undertaken at the present time in geology would be a comparative and at the same time comprehensive study of the great developments of the Pre-Cambrian exposed in certain typical areas such as those in North America (the Canadian Shield), Finland and Scandinavia (the Baltic Shield), and in South India and Ceylon, as recently suggested by Dr. Sederholm, of Helsingfors, with the view of advancing, so far as possible, our knowledge of the geological succession as set forth in these ancient records of the beginnings of the history of the earth.

Sept. 17, 1870.—Lieut.-Col. S. P. JAMES, F.R.S., I.M.S. (retired), medical officer and adviser on tropical diseases, Ministry of Health.

At the Malariotherapy Centre which was established by the Ministry of Health and the London County Council at Horton in 1925, psychiatric studies on the effect of induced malaria on general paralysis go hand in hand with investigations into the malarial infection itself, its natural history in man and in mosquitoes, its treatment, and its prevention. Recently attention has been devoted chiefly to chemotherapeutic experiments with a view of improving the treatment of obstinate cases of malignant tertian malaria, and to chemoprophylactic experiments having for their object to ascertain whether any known or reputed antimalarial remedy is a true preventive of human malarial infection contracted in the natural way by the bites of mosquitoes. The former experiments have not, as yet, yielded a noteworthy result, but from the latter the striking fact has emerged that the German synthetic preparation 'plasmoquine', when taken in suitable doses before and after a person is bitten by infective mosquitoes, possesses the remarkable property of preventing him from becoming infected.

These and other experiments now being conducted at Horton indicate that a subject to which attention might usefully be given is the revision of the classical chemotherapeutic method of testing antimalarial drugs (the method devised and practised so diligently by the late Dr. Roehl) in the light of the new knowledge that not all the different phases or forms of the malaria parasite which occur in the human host are amenable to the same drug, and that the problem of controlling malaria by the use of drugs is not so much a problem of finding a drug which is more effective than quinine against the fever-producing forms of the parasite as it is of finding other drugs that will be effective against the sporozoite stage, the sexual stage, and the stage responsible for relapses.

Sept. 18, 1854.—Sir RICHARD GLAZEBROOK, K.C.B., F.R.S., formerly director of the National Physical Laboratory.

The date that stands above, Sept. 18, 1854, will tell my friends that I can no longer ask their interest in or their support for personal investigations. The time for these is over, but in the future there are many problems I would wish them to carry forward to a complete solution.

Thirty years of a not inactive life have been given to the endeavour to bring home to all the need that, if we are to maintain our place in the world, we dare no longer trust to the natural advantages of our position and to the fact that during the past century great Englishmen have been the foremost to advance natural knowledge. We must apply to our daily wants the truths they wrested from Nature.

This lesson was never more necessary than to-day. There are among us men most skilled in unveiling Nature's secrets; others there are well fitted to apply the knowledge so gained to the problems of each day's life. I wish to see the work of these men helped onwards by all means in our power, while at the same time our leaders, and those they lead, grasp the truth that it is on such foundations that they must build.

Sept. 18, 1865.—Sir ALEXANDER HOUSTON, K.B.E., C.V.O., F.R.S., director of water examinations, Metropolitan Water Board.

Systematic search might usefully be made for the presence and numerical abundance of the microbes of epidemic water-borne disease (typhoid and paratyphoid) in sewages, sewage effluents, and in sewage polluted rivers. Very little is known of this subject despite the pioneer work carried out by Wilson, Gray, Begbie, and Gibson, and the Metropolitan Water Board.

The extensive work already achieved in the examination of the dejecta of enteric fever patients and of 'carriers' should be greatly extended in the direction of estimating the number and not merely the presence of the germs of enteric disease. In positive cases, the opportunity should be seized of determining the vitality of these 'uncultivated' pathogenic organisms in the materials examined at different temperatures.

Turning next to a totally different problem. Is there not room for further research on the cause, prevention, and treatment of that painful and often most intractable disease herpes zoster, and its alleged relationship with chicken-pox?

Sept. 18, 1881.—Prof. ARTHUR M. TYNDALL, Henry Overton Wills professor of physics, and director of the Wills Physical Laboratory, University of Bristol.

The activities on the experimental side of the Wills Physical Laboratory at Bristol are mainly concentrated upon three subjects: spectroscopy, magnetism

and conduction through gases. In each of these branches groups of workers are engaged. My own investigations lie in the last of these, and in the mobility of gaseous ions in particular. We have recently shown that minute traces of impurity may have a profound effect upon the mobility of positive ions. Thus the mobility of positive ions in helium is raised fourfold by the elimination of all impurities. We are therefore engaged upon a re-investigation of the whole subject with improved technique. We also find that the method may be used to analyse the ions present in the various inert gases when contaminated by small amounts of known impurities, and we are thereby obtaining useful information on the phenomena of electron capture and of ionisation by collisions with metastable atoms.

## Societies and Academies.

PARIS.

**Academy of Sciences**, July 15.—The president announced the death of Albert A. Michelson, foreign associate.—**Ch. Fabry**: An interferential level without an air bubble. A liquid, preferably oil, is contained in a vessel the bottom of which is a platinised glass spherical surface of very large radius (500 metres). By means of the interference rings produced, this can be used as a level of high precision.—**C. Camichel** and **P. Dupin**: The various modes of contraction of a liquid stream at the commencement of an efflux.—**Henri Lagatu** and **Louis Maume**: The variation of the physiological relations between the mineral constituents of a plant species.—**M. Ghermanesco**: The $n$-metaharmonic functions.—**René Pallu**: Study of the system $H_3PO_4$, $Ba(OH)_2$, $CO_2$, $H_2O$.—**Agostino Puppo** and **Pietro Longo**: The storm of July 24, 1930, in the Treviso-Udine district. A correction of a misprint in the *Comptes rendus*, June 8, 1930.—**A. Guilliermond**: The mode of formation of the anthocyanic pigments in the flower of *Iris germanica*. The anthocyanic pigments in the flower of *I. germanica* are preceded by the production of oxyflavonols.—**Léon Binet** and **J. Magrou**: Sulphur and growth. The high proportion of glutathione in tissues during the period of proliferation suggested a study of the influence exerted on growth by various sulphur compounds. The activating action of sodium hyposulphite on growth has been demonstrated in the case of cress and of the tadpole.—**C. Levaditi, J. Bardet, A. Tchakirian**, and **A. Vaisman**: The distribution of gallium in the organism. From the point of view of its distribution in the blood and tissues (rabbits) gallium behaves like bismuth, tellurium, and mercury.—**Bordier**: The remarkable action of diathermic d'Arsonvalisation at a distance.

July 20.—**G. Ferrié**: *Compte rendu* of the general meeting of the International Radio-Scientific Union held at Copenhagen on May 27–June 6, 1931. Details of the various committees and the work allotted to each.—**L. Blaringhem**: A mutation of the common wallflower (*Cheiranthus Cheiri*).—**Gabriel Bertrand** and **P. Serbescu**: The toxic power of aluminium compared with that of iron, nickel, and other metals. Aluminium and iron possess about the same toxic power, both much less than that of nickel and copper. There is no definite proof that small repeated doses of aluminium are toxic.—**M. de Broglie** and **L. Leprince-Ringuet**: The artificial disintegration of aluminium.—**C. Sauvageau**: The rôle of Aglaozonia of parthenogenetic origin.—**H. Milloux**: Certain integral functions and their derivatives.—**Lucien Féraud**: Arithmetical study of the permanent stability in the neighbourhood of an equilibrium point.—**Alfred Rosenblatt**: The movements of viscous liquids symmetrical with respect to an axis.—**Pierre Dive**: An exclusive property of ellipsoidal homoids.—**G. Fayet**: The orbits of the planets Neptune and Pluto.—**Auguste Claude**: The use of geometric loci for the representation of observations of passage in the meridional telescope.—**L. Bouchet**: The electromotive forces of two liquid batteries and their variations with the dilution of the solutions.—**F. Holweck** and **P. Chevallier**: A 150-kilowatt triode capable of being taken apart.—**Horia Hulubei**: A system of bands of mercury in the neighbourhood of its resonance ray.—**J. Cabannes** and **Mlle. D. Osborne**: The depolarisation of lines of the $CO_3$ ion in the spectrum of the light diffused by a calcite crystal.—**Jean Becquerel** and **Louis Matout**: The decomposition of the absorption bands of xenotime by a transverse magnetic field. The conditions of symmetry in relation with the crystalline symmetry. A new interpretation of the magneto-electric effect.—**Constantin Salceanu**: The invariant of magnetic rotation of some organic substances in the fused state.—**Mlle. Quintin**: The hydrolysis of copper sulphate.—**René Audubert**: The rôle of water in photovoltaic cells. The experiments detailed establish that water plays an essential part in photovoltaic phenomena, its influence being mainly exercised in the adsorption layer at the surface of the electrode.—**Tcheng Datchang**: The purification of the protactinium fixed on tantalum oxide, with reference to the estimation of protactinium in radioactive minerals. In determining the proportions of protactinium present in radioactive minerals, it is essential that radium, ionium, and polonium should first be removed. Details of satisfactory methods of separation of these three elements are given.—**Albert Portevin** and **Pierre Chevenard**: The graphitisation of steels at a low temperature.—**P. Laffitte** and **M. Patry**: The deflagration and detonation of mercury fulminate.—**Georges Lévy**: α-Ethylnaphthalene and its hydrogenation products.—**A. Mailhe** and **Creusot**: The transformation of toluene and of xylene into methane. A quantitative study of the hydrogenation of these two hydrocarbons in the presence of reduced nickel as catalyst at varying temperatures.—**Émile André** and **Charles Vernier**: The rotatory power of ricinolamide.—**F. Dupré la Tour**: The polymorphism of malonic, succinic, and glutaric acids as a function of the temperature. Each of these acids exists in two forms, with a definite transition temperature.—**Louis Glangeaud**: The structure of the primary massif of Algiers.—**J. Malavay**: The geology of Mauritania of the Nord.—**Y. Milon** and **M. Sire**: The interdependence of the Tertiary and Quaternary formations in the Vilaine and Mayenne valleys.—**Ch. Poisson**: Phenomena due to the meeting of a monsoon and a trade wind on the southern Indian Ocean.—**H. J. Maresquelle**: The action of *Bacterium tumefaciens* on regeneration, in the root of *Taraxacum dens leonis*.—**Pierre Gavaudan** and **Robert Cazalas**: New observations on the spermatogenesis of the Characeæ. The nature of the granulated band and the appearance of carotene and of chlorophyll in certain spermatocytes.—**Charles Pérez**: Organogenesis of the substitution buds in *Chlorogaster*, parasite of the hermit crab.—**A. Policard**: Histochemical researches on the initial lesions of experimental pulmonary silicosis (silica plaques).—**Aloncle**: The synergism of hypophysine and thymine.—**A. Leulier, B. Pommé**, and **R. Delaye**: The distribution of potassium in healthy or pathological muscle.—**E. Roubaud**: Cyclic evolutive fatigue and tireless strains in the common green fly *Lucilia seratica*.—**E. Chatton** and **Mme. M. Chatton**: The conjugation of *Paramœcium caudatum* determined

experimentally by modification of the associated bacterial flora.—**Mlle. D. van Stolk, J. Guilbert, and H. Pénau**: Carotene and vitamin A. The absence of xanthophyll in the carrot has been proved, also the presence of more than one carotene, differing in their physico-chemical properties, but all possessing physiological activity.—**A. Paillot**: The gattine of the silkworm.

GENEVA.

**Society of Physics and Natural History**, May 21.—**M. Decker**: The synthesis of Bichler and Napieralski. The author recapitulates the history of a very important synthesis in the field of the alkaloids. It had its origin in a work of Bichler, published in 1893, and appears again in the works of Pictet and of Decker in 1909; it served as the starting-point of the work of Robinson in England in 1915, and was presented as a novelty in 1930 by Späth of Vienna.—**Jean Deshusses and Louis Deshusses**: Some insects specially injurious to cultivation in French Switzerland. The laboratory of agricultural chemistry (Châtelaine-Genève) points out cases of new, or little known, parasitism, the agents of which are Diptera or Lepidoptera. Fifteen insects are described which cause damage to cultivation in Geneva and French Switzerland. The most interesting are: *Ophionya pinguis* and *Phytomyza continua* on chicory, *Argyroploce antiquana* on the Japanese artichoke, *Evetria buoliana* on various pines, *Dioryctria abietella* on the Douglas pine, *Perrisia violæ* on the cultivated violet.

LENINGRAD.

**Academy of Sciences**, *Comptes Rendus*, 1931, No. 2.—**G. Nadson and G. Filippov**: The formation of new stable races of micro-organisms under the influence of X-rays. (3) Formation of races in *Sporobolomyces*. The authors describe the regularities in the process of the dissociation of cultures of *Sporobolomyces* with the formation of new races described in a previous paper. The action of X-rays may produce organisms more complex than the original. For example, *Sporobolomyces* may be obtained from *Torula*, or from *Cryptococcus*. Forms with atavistic characters can also be obtained.—**G. Nadson and E. A. Stern**: The action of the ultra-violet and X-rays on the yeast cell. Both kinds of rays produce similar changes in the yeast cells, but the action of ultra-violet rays is more rapid than that of X-rays. The exposure results at first in an excitation, then in a depression, degeneration, and death. The rays act on the cell itself, not through the changes in the medium.—**W. Tranzschel**: An æcidium of *Puccinia pygmœa* Erikss. on *Berberis*. *Puccinia pygmœa* parasitic on *Calamagrostis* proved to be able to produce æcidia on *Berberis*. Differences of these æcidia from those of *P. graminis* are described. It is probable that *P. baryi* and *P. gibberosa* also produce æcidia on *Berberis*.—**G. Vereschagin**: The influence of Lake Baikal on the summer thermic régime of the river Angara. Determination of the temperatures of water in Lake Baikal and the river Angara flowing from it.—**N. S. Smirnov**: Two new species of Rotatoria from the Ussuri region. Descriptions of *Lepadella rezvoji* sp. n., and *Testudinella tridentata* sp. n.—**S. Tchernov**: The identity of *Gymnodactylus microlepis* Lantz and *G. fedtschenkoi* Strauch. Differences between the two species do not exceed the limits of individual variability in *G. fedtschenkoi*.

MELBOURNE.

**Royal Society of Victoria**, June 11.—**Charles Oke**: The Aculagnathidæ, a new family of Coleoptera.—**W. J. Harris and R. A. Keble**: Victorian graptolite zones, with correlations and descriptions of new species. Gives history in research in Victorian graptolithology, details of twenty zonal associations and tabulation, and an attempted correlation of zones with those of the northern hemisphere. Photographic illustrations of zonal species and descriptions of new species of zonal and subzonal importance include the following: *Diplograptus austrodentatus*, *Phyllograptus nobilis*, *Goniograptus palmatus*, *Brachiograptus etaformis*, gen. et sp.nov., *Didymograptus forcipiformis* Rued, and *D. dependulus*.—**A. B. Edwards**: The geology and petrology of the Black Spur area (Healesville). A series of acid igneous lavas (rhyolite and dacite) are mapped and described in this area. The lavas are intrusive into Silurian sediments and are considered as of Upper Devonian age. They include four varieties of dacite, one of which, a new Victorian type, contains phenocrysts of quartz and hypersthene. The dacites are part of a series associated with rhyolite and granodiorite. An explanation is given of the pyrogenetic reactions by which biotite is formed from hypersthene and also from ilmenite.

SYDNEY.

**Royal Society of New South Wales**, July 1.—**C. A. Sussmilch**: The Bathurst Senkungsfeld: The district immediately surrounding the town of Bathurst commonly known as the Bathurst Plains has an undulating surface with a general elevation of about 2400 ft. It is surrounded on all sides by higher tablelands. The change in elevation from the Bathurst region to the high tablelands surrounding it is everywhere an abrupt one, the dividing line being a well-marked scarp. It is considered that the scarps are fault scarps, and that the lower Bathurst block is a *Senkungsfeld* or 'sunk-land'. The most striking of these scarps is that separating the Mt. Lambie tableland from the Bathurst area. This consists of two faults with a combined throw of about 1700 ft. It is not considered that this area actually subsided, but that during the uplift which produced the existing tablelands, the Bathurst district lagged behind and was not uplifted as high as the surrounding regions. The Bathurst Senkungsfeld is drained by the Macquarie River, which leaves this lower area at its north-west corner by an almost impassable gorge which traverses the Orange tableland; the differential uplift was sufficiently slow to have enabled the Macquarie River to keep pace in cutting down its channel in the more rapidly uplifted Orange tableland.

VIENNA.

**Academy of Sciences**, July 9.—**E. Beutel and A. Kutzelnigg**: The deposition of sulphide films on metals.—**A. Kailin and H. C. Hardt**: The velocity of catalysed hydrogenation. Experiments were made with nickel precipitated on kieselgur as catalyst acting on the esters of cinnamic acid.—**A. Zeller**: Resistance experiments on red algæ. Mixtures of salts, isotonic with natural sea-water, but with one or more constituents missing, were used. The seaweeds were first immersed in the mixtures, then brought back into complete sea-water and the damage compared.—**K. Brunner**: New derivatives of 3·3-dimethylindolin.—**H. Schober**: The spectrum of rhenium. The arc spectrum in the visible region between λ5400 and λ8000.—**K. Graff**: The clearness of the winter sky during twilight on the island of Mallorca. **K. Graff**: Visual measurements of planetary colours. Various colours were met with from *B*7 (pure white) to *K*8 (red). Mars was one colour class redder, Uranus two classes bluer.—**E. Dittler and O. Kühn**: The genesis of bauxite in the Upper Sann valley. Bauxite is the last residue on solution of andesite.—Eleven separate communications follow from the Experimental Biological Institute; director, H. Przibram. These

concern the regeneration of limb-bones after operation on newts, and the regeneration of feet and antennæ after operation on locusts, etc.—(165). **L. Chen**: Regeneration of long bones after removal of one-third from within the limbs of the newt *Triton cristatus*.—(166) **L. Chen**: Regeneration after implanting of sixths of the femur of the salamander *S. maculosa* in the upper thigh of the newt *T. cristatus*.—(167) **J. Gebauer**: Autoplastic replacement of long bones in the limbs of *T. cristatus*.—(168) **H. Przibram**: Antenna and leg regeneration in the locust *E. herculeana*.—(169): Antenna and leg regeneration in the walking leaf insect *Phyllium siccifolium*.—(170): Antenna and leg regeneration in the European locust *Bacillus rossii*.—(171): Antenna and leg regeneration in the locust *Diapheromera femorata*.—(172): Antenna and leg regeneration in the locust *Dixippus morosus*.—(173) **H. Przibram** and **F. Friza**: Antenna and leg regeneration. Comparative inquiry on the position and rôle of Johnston's organ.—(174) **P. M. Suster**: Leg regeneration after extirpation of the ganglion in *Sphodromantis bioculata*.—(175) **P. M. Suster**: Antenna regeneration after extirpation of ganglion in *Sphodromantis bioculata*.—**P. Krüger** and **F. Fürlinger**: Histology and chemistry of tetanus and tonus substratum. It is suspected that the chemical metabolism of striated and smooth muscles may be different. Experiments have been made with frogs and analyses made of the phosphate and glucose contents of the different muscles.—**F. Duspiva**: The physiology of the melanophores of fish embryos.—**E. Schally**: The observation of streaks in chemical studies. (4) *D*-streaks and allied phenomena. When various liquids of like refractive indexes are mixed, transitory double-shaded streaks appear, depending in some cases on different velocities of diffusion.—**F. Hölzl** and **W. Stockmair**: The mobility of some iron-containing ions. Experiments on conductivity of nitro-prussides.—**F. Palm**: Geometrical research on graphical tables for the solution of complete cubic equations.—**K. Strubecker**: Cubic relations among non-Euclidean screws.—**G. Stetter** and **R. Premm**: Radium Institute Communication (279). Attempts to register $\alpha$-ray spectra of very weak intensity.—(280) **R. Premm**: Mass spectrum of the positive rays of thorium C.—(281) **F. Hecht**: Criticism of age determination by the lead method.—(282) **P. Krafft**: Absorption spectra of the *M*-series for the elements bismuth, lead, thallium, and gold.—(283) **M. Blau** and **E. Kara-Michailova**: The penetrating radiation of polonium.—(284) **M. Blau**: The fading of the latent image on exposure to $\alpha$-particles.—**H. Burchardt**: Regulation of the secretory activity of the seminal vesicle. Experiments on guinea-pigs and rats. The epithelial cells of the mucous membrane vary in height and width. Under pressure of undischarged semen they return to the resting stage.

## Official Publications Received.

BRITISH.

Cambridge Observatory. Annual Report of the Observatory Syndicate, 1930 May 19–1931 May 18. Pp. 3. (Cambridge.)

Live and Let Live: a Plea for the Preservation of Wild Life. Pp. 10. (Agra: Association for the Preservation of Game in the U.P.)

The University of Leeds. Report on the Department of Mining, Sessions 1928–30. Pp. 14. (Leeds.)

Uganda Protectorate. Annual Report of the Geological Survey Department for the Year ended 31st December 1930. Pp. 44. (Entebbe: Government Printer.)

FOREIGN.

Proceedings of the American Philosophical Society. Vol. 70, No. 2. Pp. 103-213. (Philadelphia.)

U.S. Department of Commerce: Bureau of Standards. Bureau of Standards Journal of Research. Vol. 7, No. 1, R.P. Nos. 329-338. Pp. 213. (Washington, D.C.: Government Printing Office.)

Journal of the Federated Malay States Museums. Vol. 16, Parts 3 and 4, July. Pp. 175-506. (Kuala Lumpur.)

Malayan Forest Records. No. 9: Growth of Malayan Forest Trees, as shown by Sample Plot Records, 1915–1928. By J. P. Edwards. Pp. ii+151. (Kuala Lumpur: Director of Forestry.) 2 dollars; 4*s*. 6*d*.

Collection des travaux chimiques de Tchécoslovaquie. Rédigée et publiée par E. Votoček et J. Heyrovský. Année 3, No. 7, Juillet. Pp. 333-378. (Prague: Regia Societas Scientiarum Bohemica.)

## Diary of Societies.

*FRIDAY*, SEPTEMBER 11.

INSTITUTE OF MARINE ENGINEERS. (As NATURE, Sept. 5.)

*TUESDAY*, SEPTEMBER 15.

LONDON NATURAL HISTORY SOCIETY (at London School of Hygiene and Tropical Medicine), at 6.30.—J. E. S. Dallas: Peasant Life in Alpine Districts.

*WEDNESDAY*, SEPTEMBER 16.

ROYAL AERONAUTICAL SOCIETY (at Science Museum, South Kensington), at 9.15 P.M.—Glenn Martin: The Development of Aircraft Manufacture (Wilbur Wright Memorial Lecture).

*FRIDAY*, SEPTEMBER 18.

FARADAY SOCIETY (at Chemical Society), at 5.30.—Prof. W. J. Müller: The Passivity of Metals.

### CONGRESSES.

SEPTEMBER 1 TO 19.

INTERNATIONAL ILLUMINATION CONGRESS. (For Programme see NATURE, Aug. 29.)

SEPTEMBER 6 TO 12.

INTERNATIONAL CONGRESS FOR TESTING MATERIALS. (For Programme see NATURE, Sept. 5.)

SEPTEMBER 9 TO 12.

INTERNATIONAL PROFESSIONAL ASSOCIATION OF MEDICAL PRACTITIONERS (at Budapest).

SEPTEMBER 13 TO 18.

INSTITUTE OF METALS. (For Programme see NATURE, Sept. 5.)

SEPTEMBER 13 TO 19.

INTERNATIONAL MEDICAL EDUCATIONAL CONGRESS (with special reference to Balneology) (at Carlsbad).

SEPTEMBER 16 TO 24.

INTERNATIONAL GEOGRAPHICAL UNION (at Paris).

SEPTEMBER 18 TO 20.

NATIONAL SMOKE ABATEMENT SOCIETY.

*Saturday, Sept.* 19, at 11 A.M.—R. Blackmore: The Progress of the Electrical Grid.

At 12 noon.—R. E. Gibson: Some Notes on the Production and Use of the New Smokeless Fuel 'Dryco' in Liverpool.

*Sunday, Sept.* 20, at 11 A.M.—Regional and Statutory Smoke Abatement Committees.

Councillor W. Asbury: The Sheffield, Rotherham and District Smoke Abatement Committee.

Dr. J. Johnston Jervis: The West Riding of Yorkshire Regional Smoke Abatement Committee.

Dr. J. Bennett: The Manchester and District Regional Smoke Abatement Committee.

The Greater London Joint Smoke Abatement Committee.

The Midlands Joint Advisory Council for Smoke Abatement.

SEPTEMBER 18 TO 21.

ASSOCIATION OF SPECIAL LIBRARIES AND INFORMATION BUREAUX (at Lady Margaret Hall, Oxford).

*Friday, Sept.* 18.—H. T. Tizard: Presidential Address.

Prof. A. M. Carr-Saunders: Some Problems of Professionalism.

*Saturday, Sept.* 19.—E. N. Simons: How the Manufacturer can Help the Librarian.

B. M. Headicar: Practical Methods of Arrangement, Indexing and Routine in the Business Library and Information Bureau.

Col. Sir Frederic Nathan: International Abstracting and Indexing.

Dr. Albert Predeek: An Ever-Ready Printed Catalogue.

Annual General Meeting.

F. A. Hoare: Films as a Medium of Information in Education, Science and Industry.

*Sunday Sept.* 20.—Sir Francis Goodenough: The Report of the Board of Education Committee on Education for Salesmanship.

C. A. Macartney: The Publications of the I.L.O. and the League of Nations.

Miss Margaret E. Cleeve: The Library and Information Department of the Royal Institute of International Affairs.

J. P. Maxton: The Sources of Information in Agricultural Economics.

G. A. A. de Voogd: Documentation in Business Organisation.

Dr. E. Shenkman: The Russian Five-Year Plan in its special relation to British Industry and Commerce.

SEPTEMBER 23 TO 26.

INTERNATIONAL CLIMATOLOGICAL COMMISSION (at Innsbruck).